Geodemographic Profiling of Culpable Drivers to Target Road Safety Interventions in Serious Injury Crashes

by

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Abstract

Injury caused by road traffic collisions impose significant human and financial burdens on society.

In the UK, several decades of concerted effort to reduce traffic injuries significantly reduced fatalities and injuries, however, that reduction plateaued from around 2010.

To further improve road safety in the UK county of Cambridgeshire, a Vison Zero approach to road safety has been adopted by the Vision Zero Partnership of the Cambridgeshire and Peterborough Road Safety Partnership and the Cambridgeshire Police and Crime Commissioner (Vision Zero Partnership, 2020).

As part of the reach toward improved measures for road safety improvement, this research explored and developed a new approach to reduce road traffic casualties by evaluating the potential use of geodemographic profiling to deliver targeted road safety interventions. The profiling, allowing the application of direct and social marketing methods, common in other fields, to the delivery of road safety interventions is proposed, with preliminary application of the technique. This technique is not currently applied to road safety interventions but has been instrumental in the fields of retail and business since its introduction. The research used injury collision data and hospital trauma patient data for the county of Cambridgeshire over a five-year period from 2012 to 2017.

Three studies were conducted to explore which factors could differentiate the motor vehicle drivers involved in the collisions. The first linked STATS19 police collision data to hospital trauma patient data to identify the collisions which resulted in a clinically serious injury at MAIS3+, to be explored further along with the collisions resulting in a

fatality. The second undertook culpability scoring of the motor vehicle drivers involved in the collisions identified. The third geodemographically profiled the motor vehicle drivers involved in the identified collisions.

The analysis undertaken provided information on the preliminary application of the technique as well as exploring the sample characteristics. The data linkage process successfully linked the patient data to the collision data. The culpability scoring tools available in the literature were successfully applied to the motor vehicle driver related collision data. This also led to the proposition of an alternative culpability scoring tool specifically designed for UK police collision data for the purpose of segmenting the drivers into culpable and non-culpable categories, which could be applied to bulk data.

The collision data contained sufficient postcode data to allow the profiling of the motor vehicle drivers. Analysis of the profile distribution identified profiles which occurred more frequently in the collision data, additionally, the majority of the most frequent were also overrepresented compared to the general population. The contributory factors involved in attributing motor vehicle driver culpability in the most frequent profiles showed similarity with the national statistics, where poor driving standards were primarily involved. The successful segmentation of the driver population opens opportunities to apply direct and social marketing methods to intervention application.

The data analysed was for one county in the UK, but overall, these studies showed that the methodology was applicable to any geographic construct within the UK, given suitable access to data. Importantly it would enable resources to be used more efficiently.

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Publications and Conferences

Nunn, J., Barnes, J., Morris, A., Petherick, E., Mackenzie, R. and Staton, M. (2018) ‘Identifying MAIS 3+ injury severity collisions in UK police collision records’, *Traffic Injury Prevention*, 19(sup2).

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Glossary of Terms

AIS	Abbreviated Injury Scale
ANOVA	Analysis of Variance
CF	Contributory Factor
CI	Confidence Interval
COPA	Metropolitan Police Services electronic case preparation system used to report collisions within their force boundaries
CRaSH	Department for Transport electronic collision reporting system
CTARP	Cambridgeshire Trauma Audit and Research Project
ES	Effect Size
HES	Hospital Episode Statistics
ICD	International Classification of Disease
IMD	Index of Multiple Deprivation
ISS	Injury Severity Score
K-S	Kolmogorov - Smirnov statistical test
KSI	Killed or Seriously Injured
MAIS3+	Maximum Abbreviated Injury Scale of 3 or above
M-W	Mann - Whitney statistical test
NHS	National Health Service
OR	Odds Ratio
PCV	Passenger Carrying Vehicle
PSNI	Police Service of Northern Ireland
S-W	Shapiro-Wilks statistical test
STATS19	Department for Transport dataset which records injury collisions in England and Wales
TARN	Trauma Audit and Research Network
TPB	Theory of Planned Behaviour
UK	United Kingdom
WHO	World Health Organisation
χ^2	Pearson's Chi Squared statistical test

Chapter One: Introduction

1.1. Introduction

This chapter introduces the problem of road traffic collision injury, issues defining the meaning of the term serious injury and background material relating to the county of Cambridgeshire, where the research was undertaken. The term collision being used in this thesis to describe a road traffic incident resulting in an injury or damage to property. Furthermore, it identifies the possible need for alternative approaches to deliver road safety interventions to prevent serious road traffic collisions. The aims, objectives and research questions of the thesis are presented, followed by an explanation of the structure of the thesis, setting out the content of each chapter.

This research presented in this thesis explores the development of a process to target motor vehicle drivers who are culpable for causing road traffic collisions which result in death or a serious injury, by exploring their socio-demographic characteristics in the form of geodemographic profiles. The focus of the research on the motor vehicle drivers derives from analysis of collision causation. Collision causation analysis demonstrably indicates human factors related to motor vehicle drivers are the overwhelming cause of road traffic collisions, see section 2.4. The emphasis on the motor vehicle drivers which contribute directly to the collision occurrence was by considering their culpability, see section 2.8. At present this level of targeting does not feature in UK intervention application.

The research presented in the thesis was conducted in partnership with three organisations, which have allowed access to information not in the public domain through detailed information sharing protocols. This rare access to data has allowed research to be undertaken with a unique combination of the parameters available and utilising layered methodologies to produce the dataset.

The research undertaken utilised these unique data sources and combined them with further public domain data with the objective of devising a method of targeting the culpable motor vehicle drivers in road traffic collisions which cause serious injury. The linking of official government collision statistics with appropriate medical data allowed the identification of the specific collisions where such injury occurred. This was followed by the determining of the culpability of the motor vehicle drivers concerned and then the geodemographic profiling of those individuals with comparison data from the motor vehicle drivers involved in fatal collisions.

There appears to have been no studies into the relationship between the geodemographics of culpable motor vehicle drivers involved in serious injury collisions and the application of casualty reduction interventions. This research aims to test this relationship to identify any patterns which may prove beneficial in targeting preventative interventions. The use of geodemographics delivered a broad spatial understanding of the individuals involved.

1.2. Road Traffic Injury

Globally, road deaths are very problematic, having both a human and financial impact, a burden of injury (Lyons, 2008; Kendrick *et al.*, 2013; Gabbe *et al.*, 2015), with estimates of around 1.3 million total deaths per year and the leading cause of death of people aged five to 29 years and account for 34 percent of all years lived with disability attributed to injury in 2010 (Lozano *et al.*, 2012; Murray *et al.*, 2012). The incidents are primarily caused by motor vehicle drivers, although there are significant variations between countries. The four safest countries globally, Norway, Sweden, Switzerland and the UK. All reporting less than three deaths per 100,000 population annually. This can be compared to countries like South Africa with a rate of 25 per

100,000 population annually, although not all countries report their deaths due to these causes. In the UK this was reported at 2.8 per 100,000 population for 2016 and was unchanged by 2019 (Department for Transport, 2017b; 2018b; 2019d; 2020d; International Transport Forum, 2018), this compares to an annual murder rate of between 1.0 and 1.2 per 100,000 (Scottish Government, 2018; Office for National Statistics, 2019b; 2020c). Such fatalities are considered preventable by the Office for National Statistics (2020a), preventable deaths account for 63 percent of the avoidable deaths and these account for 22 percent of all deaths. Dementia and Alzheimer disease remained the leading cause of death in England and Wales and in 2018 accounted for 12.8 percent of all recorded deaths at 126.5 per 100,000 population (Office for National Statistics, 2019a). In addition to the fatalities, serious injuries from road traffic collisions globally accounts for an estimated additional 20 to 50 million casualties (International Transport Forum, 2018; World Health Organization, 2018).

With such high numbers of casualties, the international focus explores both preventing collisions and reducing the impact if a collision occurs, through the United Nations and other bodies, in low and middle income countries. With 90 percent of the deaths due to motor vehicle drivers occurring in poorer countries, significant resources are being made available. However, in many of these countries the issues are structural, such as not having any road traffic regulations, that fundamental societal change would be required for reductions to occur? (International Transport Forum, 2018; World Health Organization, 2018).

1.2.1 Road Traffic Injury in the UK

Collisions account for a significant number of injuries in the UK. The latest available official figures for Great Britain, i.e. England, Wales and Scotland, are for 2019, and are published annually by the Department for Transport in the form of the Reported

Road Casualties Great Britain which are published between July and September of each year covering the preceding year, statistics for Northern Ireland are reported separately (Department for Transport, 2020d; Police Service of Northern Ireland, 2021). The statistics are derived from police injury collision data (STATS19), see section 2.3.1. where police officers report the circumstances of the collision, the parties involved and categorise the injured parties. The three injury categories available to the officers are fatal, serious or slight, with the serious and slight categories not clinically assessed but subject to guidance, see section 2.2.1 for an exploration of non-clinical assessment. Many of the yearly comparisons used in reports by the Department for Transport use a construct which combined the fatalities with those categorised as seriously injured as ‘Killed or Seriously Injured’ or KSI (Department for Transport, 2019d; 2020d)

The term serious injury can be used to categorise the injury an individual sustains, it has been used throughout section 1.2 which describes the problem of road traffic injury in the three geographic contexts of global, UK and the county of Cambridgeshire. However, the injury a casualty has sustained, to be categorised as having a serious injury, can vary depending on the context in which the designation has taken place. Casualty categorisation within the UK police collision data, a subjective determination by the reporting police officer, relies on individual interpretation of the guidance given on what injuries may fall within the serious injury category or the slight injury category (Department for Transport, 2010b; 2011; 2019d). There are issues created by the use of this type of non-clinical injury assessment, see section 2.2.1, with international comparison using clinical assessment, see section 2.2.2. This situation requires the UK government to estimate casualty numbers for international comparison (Department for Transport, 2015b; 2019d; 2020d).

According to these official statistics from 2019, some 27,697 people KSI on the roads of Great Britain (Department for Transport, 2020d) of which 1,752 were fatalities. This compares with 27,266 (1,784 fatalities) individuals in 2018 (Department for Transport, 2019c), the headline increase in KSI of 431 people or 1.6 percent, however, fatalities only reduced by 30 people or 1.7 percent (Department for Transport, 2019c; 2020d).

Since 2010 statistics indicate that the level of road deaths has plateaued, being in contrast to the significant reductions achieved in the years and decades up to that date. The annual fatality frequency between 1979 and 2018 are presented in figure 1.1 below. The lack of reduction since 2010 being evident, as well as the plateau evident during the 1990s, when compared to what had been accomplished since 1979 and the post-war peak of just under 8,000 in 1966 (Department for Transport, 2015c).

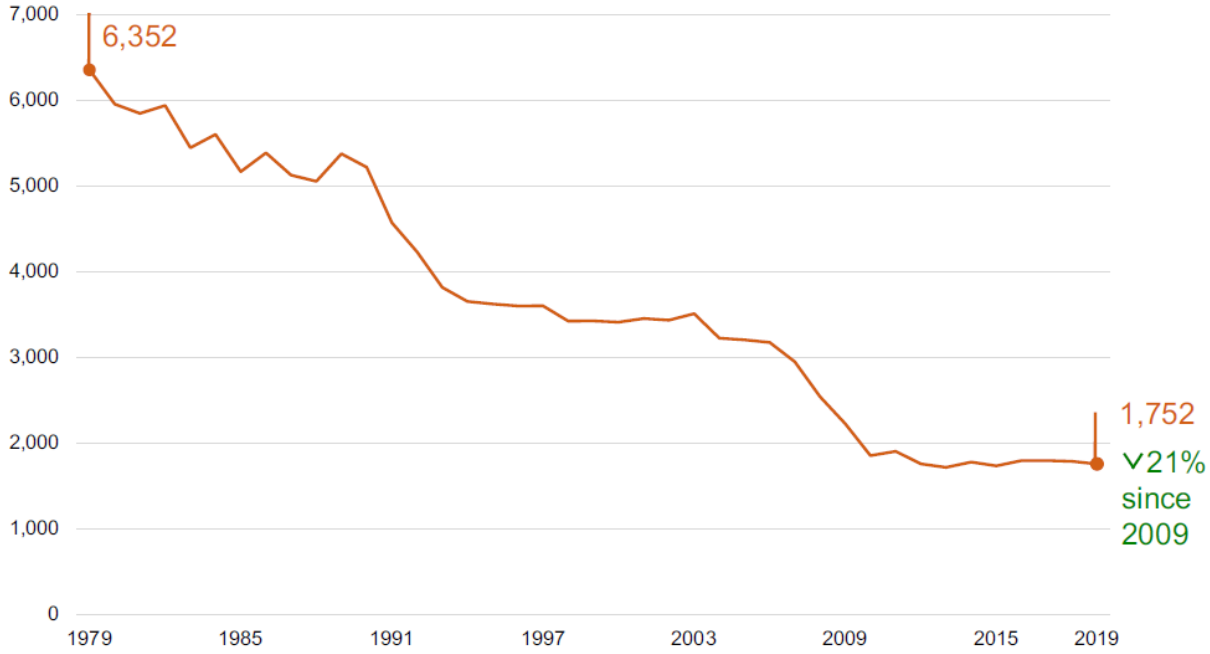

Figure 1.1 Fatalities in Great Britain from road traffic collisions 1979-2018 (Department for Transport, 2020d, p. 3)

Serious injury patterns followed similar reductions for many years like the earlier results for fatalities, presented in figure 1.1. In the case of serious injury collisions the reduction was from 80,544 in 1979 down to 25.484 in 2018, however, the steady reduction from 1979 again plateaus from 2010 (Department for Transport, 2019b; 2020d).

The injuries caused by road traffic collisions have a financial impact on the wider society. The UK government estimates these costs per casualty and per accident. The cost per casualty (2019 prices and values) for a fatal and serious injury collision being £2.0m and £228.0k respectively and per collision these figures are £2.3m and £261.4k (Department for Transport, 2012a; 2020a). The cost per collision value being higher, as on average, more than one casualty presents per collision and also other costs relating to policing, administration, insurance, and property damage were also included in these calculations.

The policing costs are based on an estimation of officer involvement, by number involved, rank and hours deployed , insurance costs are based on the average cost per claim including, handling the claim, allowances and overheads with property damage costs estimated from insurance claims and includes vehicle and other third party property damaged (Department for Transport, 2012a)

A revaluation occurs on an annual basis by the (Department for Transport, 2012a; 2020a) taking into account current prices. The valuation consists of three elements, the human costs, such as pain, grief and suffering, which forms the bulk of the valuation; Lost output, calculated as a measure of loss of productive capacity (Transport Research Laboratory, 1993a; O'Reilly *et al.*, 1994) and the medical costs associated with the casualty (O'Reilly *et al.*, 1994; Hopkin and Simpson, 1995; Chilton *et al.*, 1997; Department for Transport, 2012a; 2020a). The modelling used follows international guidelines (Transport Research Laboratory, 1995; Department for International Development, Transport Research Laboratory and Silcock, 2003) and contains the material, when subject to comparison with other countries, which can be considered to build a robust estimation (Elvik, 2000; Wijnen and Stipdonk, 2016).

Road transport collisions in the England and Wales feature in the top five most common causes of death in younger age groups, in Scotland they are not ranked. The distribution within the younger age groups for England, Wales and Scotland are presented in table 1.1 below.

Table 1.1 Road transport collision related death in younger age groups in England and Wales and Scotland in 2018 (National Records of Scotland, 2018; Office for National Statistics, 2018b)

Age group	**Male % of all deaths in the age category (position E+W)**	**Female % of all deaths in the age category (position E+W)**
England and Wales		
5-19 year olds	10.4 (2nd)	5.7) (5th)
20-34 year olds	9.7 (2nd)	4.1 (5th)
Scotland		
5-19 year olds	7.7	1.7
20-34 year olds	4.9	2.1

Pedestrians, motorcyclists, and cyclists are particularly and consistently vulnerable as the injured parties in collisions (Department for Transport, 2016; 2017b; 2018b; 2019d; 2020d). For fatalities in Great Britain in 2019 car occupants are the largest group accounting for 42.0 percent of the casualties. This is in contrast to the proportion of the traffic on British roads accounted for by cars being 78.0 percent. Oppositely, motorcyclists account for 19.2 percent of the fatalities yet only account for 0.8 percent of the traffic volumes with cyclists accounting for 5.7 percent of fatalities and 1.0 percent of the traffic volume, with almost no change over the previous year (Department for Transport, 2019d; 2019e; 2020e; 2020d).

Pedestrians do not feature in the road traffic estimates presented by the (Department for Transport, 2020e), however, the distance traveled by pedestrians has been estimated from the National Travel Survey (Department for Transport, 2020c). The estimation of distance travelled by road user groups allows a comparison of fatalities by distance, figure 1.2 presents the vulnerable road user group fatality rate by distance compared to other transport groups for Great Britain in 2019.

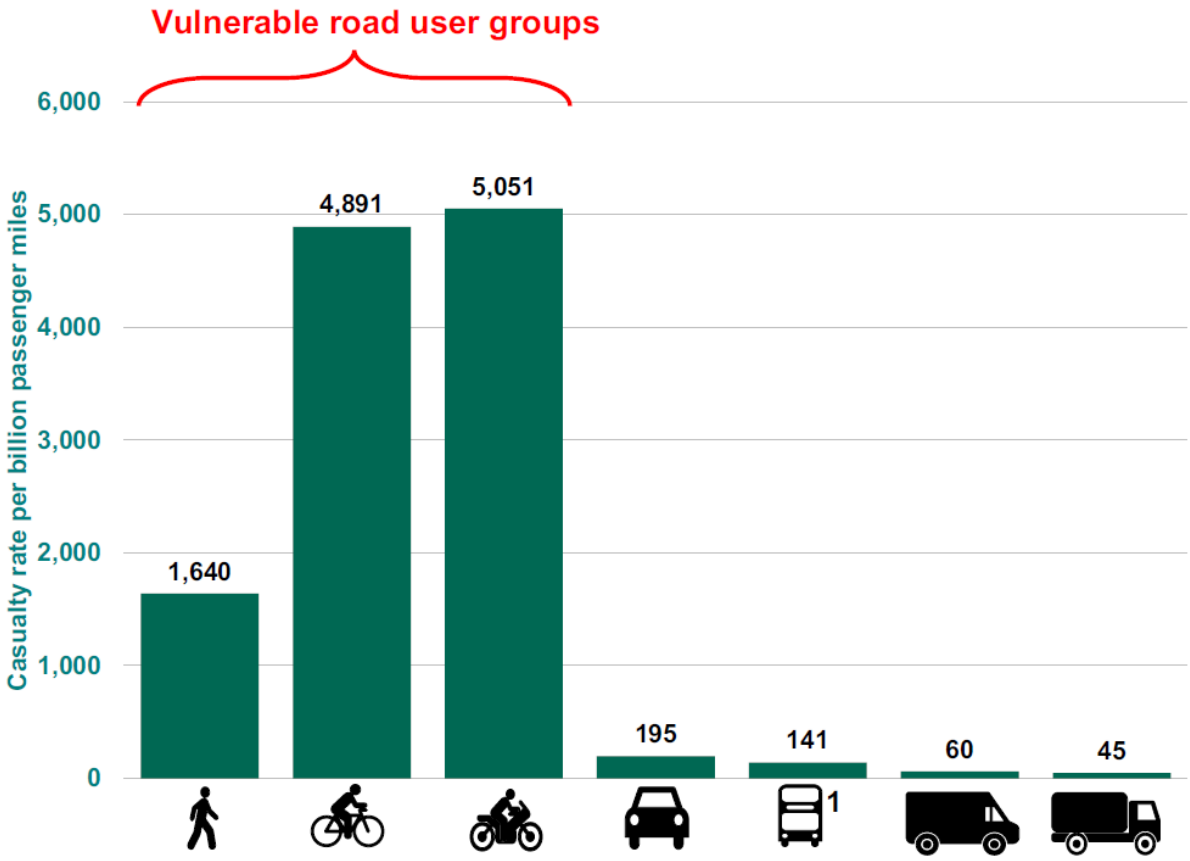

Figure 1.2 Fatality rate per billion passenger miles by road user type: GB, 2018 (Department for Transport, 2020d, p. 10)

The Department for Transport (2015c) examined the reduction in fatalities over the period 2005 to 2013. There were reductions within all four of the groups examined, pedestrians, cyclists, motorcyclists, and car occupants, however, what was found was that the decreases were not evenly distributed across the groups. The reduction for car occupants was the highest reduction at 43 percent compared to 36 percent for pedestrians, 27 percent for motorcyclists and 26 percent for cyclists.

The improvements in vehicle safety engineering as well as environmental engineering and education over the period had disproportionately benefitted car occupants but less so the unprotected road users, pedestrians, cyclists and motorcyclists (Elvik, 2010). However, mitigation of basic risk factors to reduce casualties has been successful, but there are limits to which unprotected road users can be protected from injury when involved in collisions (Elvik, 2010). Analysis of the causes of collisions, see section 2.4, show that human factors are involved in the cause of almost all collisions in Great Britain (Department for Transport, 2020b), therefore, actions to reduce the number of collision, rather than mitigating the impact, must focus on the motor vehicle driver.

1.2.2 Cambridgeshire

The data used in this research was provided by partner organisations involved in road safety in Cambridgeshire. The partner organisations were Cambridgeshire County Council, Cambridge University Hospitals, Addenbrookes and Cambridgeshire Constabulary. Specifically, the data that was provided was used to identify the motor vehicle drivers involved in collisions which resulted in a fatality or clinically serious injury, see section 2.2.2, and contains data that was collected from April 2012 to March 2017. Cambridge has an increased prevalence of RTA's compared to national data, which are described in detail in section 1.2.3.

Cambridgeshire forms part of the East of England region and highlighted in purple, with the East of England having the red boundary, shown in figure 1.3 below (Cambridgeshire Insight, 2018b). The county borders seven other counties, from the north east clockwise these are Norfolk, Suffolk, Essex, Hertfordshire, Bedfordshire, Northamptonshire, and Lincolnshire. These are referred to as the 'surrounding counties' throughout the thesis.

The county local government arrangements for Cambridgeshire are split with the bulk of the county administered by Cambridgeshire County Council and the north of the county administered by Peterborough City Council, a unitary authority (Peterborough City Council, 2019).

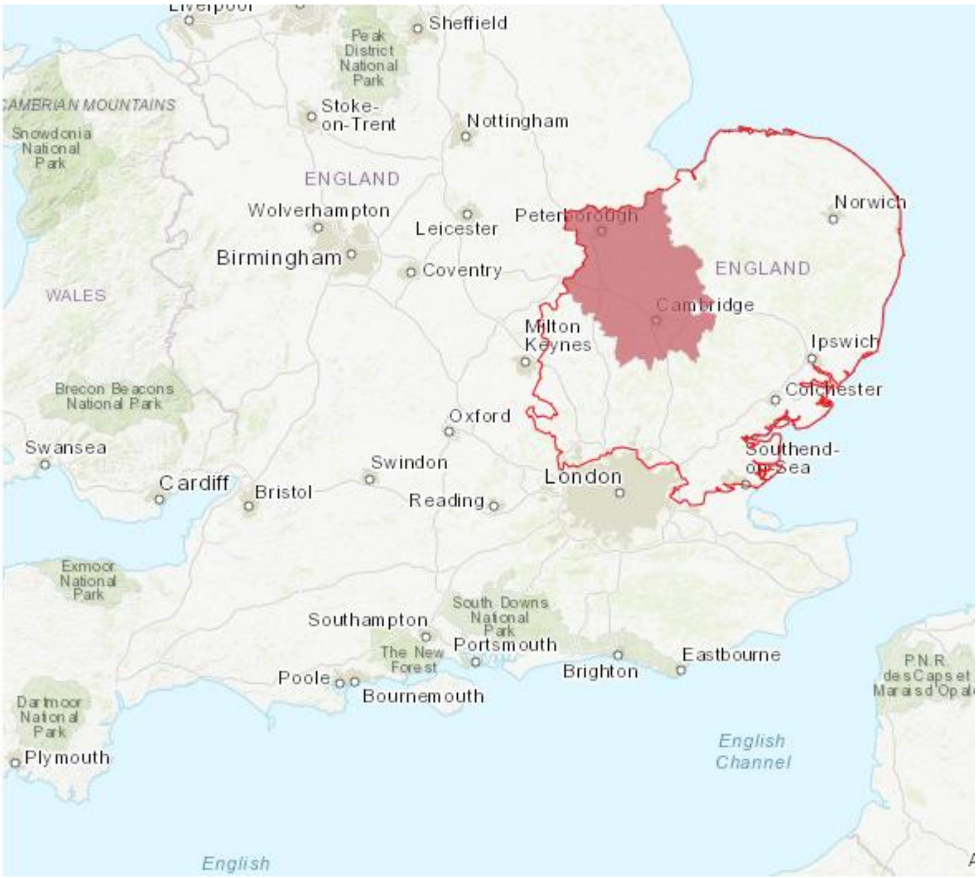

Figure 1.3 Map of Cambridgeshire's geographical location, within the East of England (Cambridgeshire Insight, 2018c)

The residential population of Cambridgeshire in 2017 was 847,151 (Cambridgeshire Insight, 2018c). There are two main urban centres, the cities of Cambridge and Peterborough with numerous smaller towns.

1.2.3 Road Traffic Injury in Cambridgeshire

In 2018 nationally 6.5 percent of the KSI were fatalities compared to Cambridgeshire with a rate of 7.6 percent (50 fatalities and 660 serious injury (Cambridgeshire Insight, 2019)). These correspond to a rate of 2.8 per 100,000 populations in Great Britain and 5.9 per 100,000 population in Cambridgeshire (50 fatalities and a population of 847k). The rate of fatalities in Cambridgeshire between 2015 and 2017 had shown some volatility (Cambridgeshire Insight, 2019). The fatality frequencies for 2015-2018 are presented below in figure 1.4.

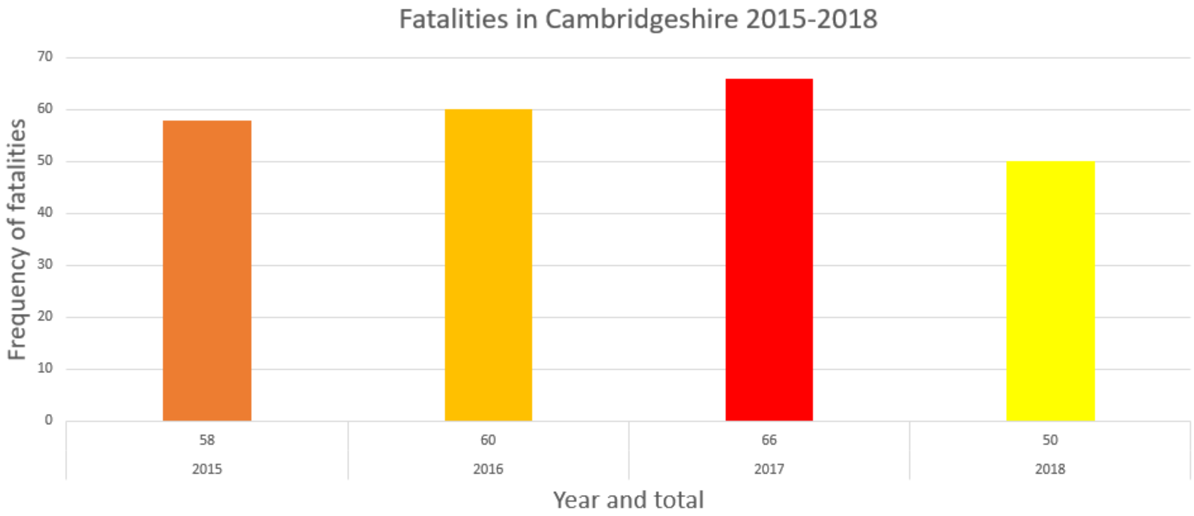

Figure 1.4 Fatalities in Cambridgeshire 2015-2018 (Cambridgeshire Insight, 2019)

The frequency of fatalities between 2015 and 2017 result in rates per 100.000 population of 6.8 in 2015, 7.1 in 2016 and 7.8 in 2017. The corresponding rates for Great Britain are 2.7 (2015), 2.8 (2016), 2.8 (2016) (Department for Transport, 2019b) and show that the fatality rates for Cambridgeshire are consistently over twice that of Great Britain as a whole

There has been similar fluctuation in the number of casualties designated as having serious injuries in the police collision data, with a general trend of increasing numbers between 2015 and 2018 (Cambridgeshire Insight, 2019), see figure 1.5 below.

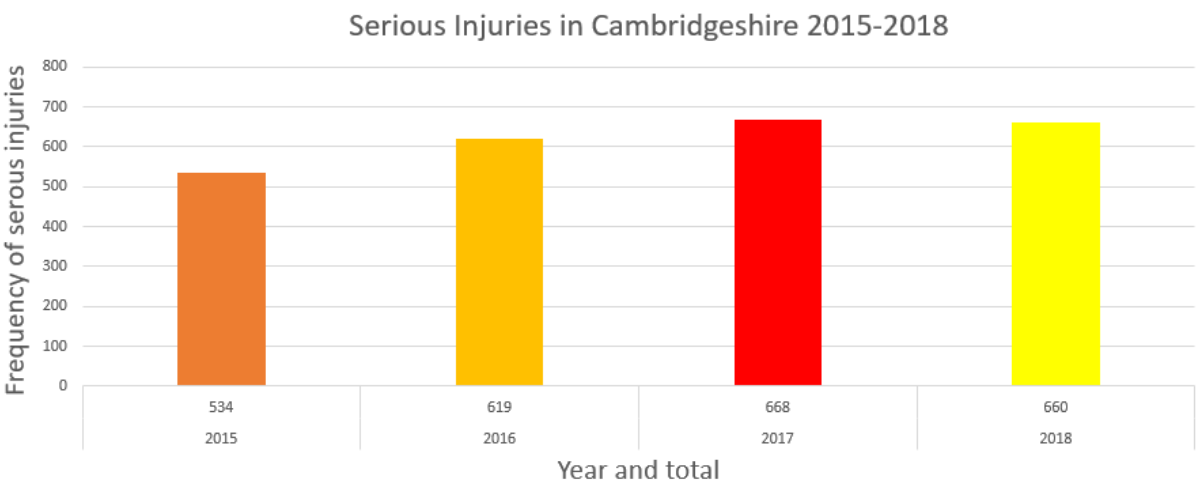

Figure 1.5 Serious injuries in Cambridgeshire 2015-2018 (Cambridgeshire Insight, 2019)

The overall UK rate from the 2018 for seriously injured casualties was 39.2 per 100,000 population, the rate for 2018 in Cambridgeshire was 77.9 (660 serious injuries and a population of 847k) per 100,000 population, again Cambridgeshire has a rate approximately double that of the UK. The 2015-2017 rates for Cambridgeshire were 63.0, 73.1 and 78.9 respectively, with the Great Britain rates for 2015-2017, 34.1, 37.1 and 38.2 respectively (Cambridgeshire Insight, 2019; Department for Transport, 2019b) follow this trend. Both fatalities and serious injury were consistently higher in Cambridgeshire than the rest of the UK and warrants further investigation and has led to the adoption of a vision zero by the Vision Zero Partnership between the Cambridgeshire and Peterborough Road Safety Partnership and the Cambridgeshire Police and Crime Commissioner (Vision Zero Partnership, 2020).

1.2.4 Road Safety Interventions

Although the UK has been one of the safest countries from a road safety perspective, the long-term reductions seen since the 1960s have not continued over the last decade (Department for Transport, 2020d). Elvik *et al.* (2009) identified 128 road safety measures applied internationally, in the UK the current toolkit of interventions deployed are maintaining the current level of injury, but if a return to reductions is to be achieved it may be that alternative approaches to the application of interventions may be required. What becomes clear from the meta-analysis undertaken by Elvik *et al.* (2009) was that the quantifying of the impact of individual measures was not straightforward, with them often intertwined and multi-layered in any particular circumstance. For example, consider assessing the impact of a speed enforcement intervention at a particular location. Before the speed enforcement takes place other road safety measures are already in place, such as, but not exhaustively, driving licencing, speed limit, vehicle engineering safety measures, road signage, road surface material selection, road engineering, including camber, drainage and so on, other local speed initiatives, such as cameras or traffic calming, current education campaigns and so on. The separation and allocation of effectiveness in reducing collision rates for each of the current measures or any new one applied can be problematic as each measure may have a different impact in different circumstances (Elvik *et al.*, 2009). Many current interventions have a broad application to motor vehicle drivers, such as annual Christmas drink drive campaigns (Department for Transport, 2014a; 2017a), and long term application can prove effective, for example, 2014 was the 50th anniversary of the first Christmas drink drive campaign with drink drive related deaths dropping from 1640 in 1967 to 230 in 2012 and survey data showed 92 percent of those surveyed stated they would feel ashamed if caught drink driving (Department for Transport, 2014a).

Road safety measures, as well as direct activity can also take the form of regulation. Some of this regulation applies to the whole of the driving population, an example of such regulation would be the *The Road Vehicles (Construction and Use) Regulations 1986*, the purpose of which was to regulate the condition and use of vehicles used on the road to a satisfactory safe level. Other regulation has a specific target audience, and example of this would be the *Road Traffic (New Drivers) Act 1995*. This set of regulations aims to kerb the behaviour of new motor vehicle drivers, that being individuals who have just passed their driving test for the first time, by stipulating a probationary period of two years during which the newly acquired full licence can be revoked if too many penalty points are accumulated by the committing of offences. Interventions are explored further in section 2.6.

1.3. Aims and Objectives

1.3.1 Aims

The overall aim of the thesis was to

i. investigate if geodemographic profiles can be used to differentiate motor vehicle drivers involved in fatal and serious injury (MAIS3+) collisions by their culpability.

ii. To investigate if the analysis of motor vehicle driver geodemographic profiles could allow direct marketing methods to be applied to road safety interventions.

1.3.2 Objectives

- To critically assess the current literature relating to road traffic collision injury, injury classification, data, causation, motor vehicle driver culpability, geodemographics and intervention targeting.
- Identify motor vehicle drivers involved in serious (MAIS3+) and fatal injury collisions, from police collision data and hospital trauma records using data linkage methods.
- Evaluate if current culpability scoring tools are viable for use with UK police collision data (STATS19).
- Assess the culpability of motor vehicle drivers involved in fatal and serious (MAIS3+) injury collisions.
- Determine the geodemographic profile of motor vehicle drivers involved in fatal and serious (MAIS3+) injury collisions.

- Determine if there are differences in demographic distributions between culpable and non-culpable motor vehicle drivers in fatal and serious (MAIS3+) injury collisions.
- Evaluate the potential for using geodemographic profiling to deliver targeted road safety interventions.

1.4. Research Questions

The thesis explored the research questions described below.

1. What sources of data in the UK can be used to identify serious MAIS3+ injury collisions?
2. What alternatives are available to culpability score motor vehicle drivers in the UK context?
3. Do motor vehicle drivers involved in fatal and serious (MAIS3+) injury collisions have different characteristics dependent on their culpability.
4. Do culpable and non-culpable motor vehicle drivers involved in fatal and serious (MAIS3+) injury collisions have different geodemographic profile distributions?
5. Do the geodemographic profiles of motor vehicle drivers involved in fatal and serious (MAIS3+) injury collisions allow for targeting of interventions using direct marketing principles?

1.5. Structure of the Thesis

The thesis chapter structure leads through the background material, studies undertaken, analysis and discussion of the results.

Chapter One: Introduction

Chapter one introduces the research, context, background material and thesis structure.

Chapter two presents the literature review and explored research question one, whilst general methodological context for the studies are presented in chapter three, the specific methodologies for each study are presented in the appropriate chapters.

The first study presented in chapter four, examined data linkage of the police collision data to the hospital trauma patient data, to allow the identification of the collisions required for the research and answered research question two. Descriptive analysis was undertaken on the collisions identified.

The second study, presented in chapter five, answered research question three. The study explored the culpability of the motor vehicle drivers involved in the fatal and serious injury (MAIS3+) collisions identified in study one. Once the collisions were identified in study one, these were examined alongside the fatal collisions from the STATS19 data, the motor vehicle drivers involved in those collisions were subject to a determination of culpability drawn from the circumstances of the collision and their specific involvement.

The third study, presented in chapter six, answered research question four. The study examined the process of geodemographically profiling the motor vehicle drivers involved in serious and fatal collisions. The geodemographic profile of each of the identified culpable motor vehicle drivers was ascertained. The application of geodemographics and how the process of societal segmentation was achieved are explained in full during the thesis.

Chapter seven presents analysis undertaken on the dataset produced by the three studies. The groups within the dataset were the two injury categorisations of fatal and serious injury (MAIS3+) and the motor vehicle driver culpability categorisations of culpable, contributory, and non-culpable. The analysis examined the motor vehicle drivers in the dataset using descriptive statistics, explored statistical differences between groups of motor vehicle drivers using demographic data, and culminating in examination of the geodemographic data with a risk index construct applied to the geodemographic profiling.

The findings of all studies were discussed in chapter eight where the implications of the group similarities and differences were explored with reference to the research aim and research question five was answered. The chapter draws all the material together to conclude the thesis and consider what further research may be required.

Chapter Two: Literature Review

2.1. Introduction

The aim of the literature review was to give the reader an understanding of the issues surrounding road traffic collision injury to allow the research contained in this thesis to be placed in context of the wider literature. The contexts which were explored during the literature review were grouped under broad headings.

- Injury. Exploring what constitutes injury, injury classification and the source of the patient data used in study one.
- Collision data. Collision data in general as well as UK collision data that was used in this research.
- Collision causation. Exploring the research that has been undertaken to try to understand what factors influence the occurrence of collisions.
- Exposure. Exploring exposure in a collision context.
- Interventions. Methods and techniques employed to reduce the impact of collisions.
- Data linkage. The bringing together of data to allow examination of matters not available in the source data.
- Culpability. Exploring the assessment of motor vehicle driver's responsibility of the occurrence of collisions.
- Geodemographics. Geodemographic segmentation of the population.
- Indexation. Examining the use of indexation to present data.

The review draws on diverse material including books, journals, and grey literature from both local, national, and supranational organisations, such as Cambridgeshire

County Council, the UK Department for Transport, and the International Transport Forum.

Road safety concerns and reducing the casualty rates on the roads are of global interest (Organisation for Economic Co-Operation and Development, 1997; International Transport Forum, 2018; Department for Transport, 2019i). The UK, being in a far better position than many countries, has a current low fatality rate of 2.8 per 100,000 population, see section 1.2, (International Transport Forum, 2011; 2018; 2019b; Bates, Soole and Watson, 2012; Stanton, 2019; Department for Transport, 2020d) but this position has not generated complacency, with a remaining focus on casualty reduction (Department for Transport, 2019i). The global nature of the issues are reflected in the geographical diversity of the research material, although different jurisdictions suffer from casualty distributions dependent on their own specific circumstances, much of the research, however, may be relevant to similar circumstances irrespective of location (Elvik *et al.*, 2009).

2.1.1 Accident, Collision and Crash

There remains a lack of consensus regarding the terminology used to describe an occurrence on the road between objects. Most terms are used interchangeably including accident, collision, crash or incident, for example, the most recent road casualty report for Great Britain, (Department for Transport, 2020d) uses both accident and collision, at one point both in the same paragraph (p. 41). Whereas the International Transport Forum (2018) in their annual road safety report use crash as the primary descriptor but also collision. A recent example of the use of all three terms can be found in Plant, Mcilroy and Stanton (2018) in their examination of road safety approaches. However, use of the term accident has been subject to both criticism and support. This section explores the use of the terms and changes in attitude to the terminology over time.

The oldest term in use being accident, which has been used since the first *Road Traffic Act 1930*. This term was also used in the *Road Traffic Act 1988* to describe road incidents where contact between two objects occurs. When this act was drafted many of the provisions were merely carried over from the *Road Traffic Act 1960* including the term accident and much of that act carried over from the *Road Traffic Act 1930*.

There are some interesting observations on the use of the term 'accident' in Haddon (1968), where he considers the term pre-scientific in nature and misses the aetiological nature of incidents on the roads which cause injury or damage. Haddon (1968) groups accident with other 'concepts formerly applied to much of human experience' (p.1431) such as luck, chance and mishap with their extrarational overlay, events without rational explanation and unplanned in nature. These ideas do not fit with the presence of injurious etiologic agents in the scenarios which makes the term accident inappropriate to work seeking to explain road incidents in scientific terms (Haddon, 1968). Langley (1988) concludes his critique of the term by suggesting that the use of accident in relation to unintentional injury events should stop and recommends its removal from use by international organisations, being replaced by crash or collision, as it creates misunderstanding surrounding public health issues.

Yet, even though the term accident can be considered problematic definitionally, suggesting the option that no one may be to blame, it remains in constant use in current governmental reports, such as the annual casualty figures for example (Department for Transport, 2020d) and academic literature (af Wåhlberg, 2009; Elvik *et al.*, 2009) with one of the major journals in the field having the title Accident Analysis and Prevention. Elvik *et al.* (2009) defends the term accident based on the inability to predict their occurrence, concluding the defence by stating ‘’Accident’ is the right word for a road crash, precisely because it connotes randomness’ (p.5), however, the randomness does not imply they cannot be prevented.

The term crash has been in use in the United States since the 1960s (Stewart and Lord, 2002) and becoming more widely used in the UK, to the extent where it was selected for use as the acronym for the Department for Transports electronic collision (C) reporting (R) and (a) sharing (SH) system (CRaSH) now being widely used by UK police services as their mechanism for reporting and collecting collision data, replacing paper forms (Civica, 2018; 2019), see section 2.3.1.

The term collision became widely adopted as an alternative to accident in the UK by police services and beyond after the publication of the Road Death Investigation Manual in 2007, with traditional job titles such as Accident Investigator or AI being changed to Collision Investigator or CI as defined in the manual, although there are no explanations in the manual justifying the change in nomenclature. This manual was intended to professionalise and standardise the investigation of road deaths, putting in place procedures and defined responsibilities for the individuals involved, and was based partly on the Murder Investigation Manual which was published the year before (Association of Chief Police Officers, 2006; National Policing Improvement Agency, 2007).

The primary data source for the research presented in the thesis are police collision data, and therefore in the remainder of this text the term generally used was collision unless one of the other terms are specifically used in context. To all intents and purposes the terms accident, collision and crash are considered interchangeable and no implication drawn, whichever used.

2.2. Injury

Broad agreement exists that injury can be defined as the damage caused by transfer of energy to the human body (Organisation for Economic Co-Operation and Development, 1997; Centers for Disease Control and Prevention, 2001). With Holder *et al.* (2001) defining an injury as 'the physical damage that results when a human body is suddenly or briefly subjected to intolerable levels of energy' (p.4). Langley and Brenner (2004) expanding the construct to include '….damage to the body produced by energy exchanges that have relatively sudden discernible effects.' (p. 69) and Baker *et al.* (1992) proposing 'Injuries are caused by acute exposure to physical agents such as mechanical energy….interacting with the body in amounts or at rates that exceed the thresholds of human tolerance' (p. 4). For collisions this invariably means the transfer of mechanical energy, although, thermal, electrical and chemical energy may also be involved (Haddon, 1968) with the rate of transfer dictated by the acceleration/deceleration, often termed Delta-V or ΔV (Sobhani *et al.*, 2011; Ji and Levinson, 2020). Haddon (1968) explored the construct of an accident [collision] on an aetiological basis, concluding it '…is the various forms of energy exchange which must occur in excess of body injury thresholds for the injuries which make the field of such current social concern to occur.' (Haddon, 1968, p. 1433).

There can be wide variation in the nature and severity of injury (Baker, Robertson and O'Neill, 1974; Haddon, 1980) and the higher the energy transfer over the shorter time frame generally, the more severe the injury (Elvik, 2004; Sobhani *et al.*, 2011; Ji and

Levinson, 2020). This explains why energy management becomes so important in roadside safety design and devices (Transportation Research Board, 2012).

Collisions occur with some form of coming together of objects in motion. In a road traffic context, resulting in an injury, this can be framed as three separate collisions during which an energy exchange occurs. The first being between the vehicle containing the occupant and another object, be it another vehicle, structure or obstacle or pedestrian, subsequently the occupant of the vehicle coming together with the internal structure of the vehicle and lastly the internal organs of the occupant coming into contact with their skeleton or chest wall (Haddon, Suchman and Klein, 1964; Organisation for Economic Co-Operation and Development, 1997; FIA Foundation, 2009; Abbas, Hefny and Abu-Zidan, 2011) with the interactions grounded in Newtonian Mechanics. An object in motion has energy and when two objects collide energy transfer occurs according to the law of conservation of momentum (Evans, 1994; Sobhani *et al.*, 2011). The energy concerned, kinetic energy, being a combination of two factors regarding the object and described by the formula: -

$$K = \frac{1}{2}mv^2$$

The kinetic energy K measured in Joules (1 Joule = 1 kg m^2/s^2), with m being the mass of the object in kg and v the velocity in m/s. Velocity being a vector quantity has both magnitude and direction. To all intents and purposes the magnitude being distance in relation to time, or speed and direction only becoming relevant with a change in the direction of travel. Therefore, from the formula, the amount of energy an object has whilst in motion directly relates to its mass and its velocity (Halliday, Resnick and Walker, 2003; Elvik, 2004). When an object collides, there can be a change in velocity and therefore a change in the amount of kinetic energy. Changes in velocity are acceleration, the level of acceleration is related to the amount of force applied and it has been shown there is a relationship between ΔV and injury severity (Sobhani *et al.*, 2011; Jurewicz *et al.*, 2016; Ji and Levinson, 2020).

When the energy of a moving object transfers to the human body, by exerting a force, an injury can occur, generally the more energy transferred, over the shortest period, i.e. higher the ΔV, the greater the injury likely (Sobhani *et al.*, 2011; Ji and Levinson, 2020). Injury reduction can encompass any activity that reduces the energy available for transfer during a collision, towards reducing the amount of available energy transferred during the collision or extending the timeframe over which any energy is transferred, or lowering ΔV. Examples of such energy transfer reduction systems are body restraint systems, reducing vehicle speed (velocity) or controlling the amounts of energy released by using crumple zones in vehicles. These are likely to reduce injury sustained (Foldvary and Lane, 1974; Draheim *et al.*, 2005; Baker *et al.*, 2008; Elvik *et al.*, 2009; O'Neill, 2009; Jurewicz *et al.*, 2016). The avoiding of the collision in the first place could be by far the best option for reducing injury (Haddon, Suchman and Klein, 1964; Haddon, 1970), with Elvik *et al.* (2009) bringing the two strands together describing the bifurcation of road safety measures as being those designed to reduce the number of collisions or those reducing the severity of injury when collisions do occur, albeit that some measures can impact both, such as area-wide traffic calming (Elvik *et al.*, 2009; Cleland *et al.*, 2019; Daniels *et al.*, 2019).

The engineering solutions which reduce the amount of energy transferred to the human body can have a significant impact on the level of injury sustained. These engineering developments, in many cases and jurisdictions, have become legal requirements before a vehicle can be retailed. These include items such as seat belts, airbags, crumple zones, rigid passenger cells and so on. All designed to reduce the transferred energy and hence reduce injury (Elvik *et al.*, 2009). Because these requirements do not apply in all jurisdictions they result in different injury and death rates in different countries globally.

Haddon (1973), in considering energy transfer, broadened the impact to include both animate and inanimate objects interacting with other bodies describing in ecologic circumstances as 'Energy Damage Processes' and described them as, 'The phenomena of concern are those involved when energy is transferred in such ways and amounts, and at such rapid rates, that inanimate and animate structures are damaged' (p. 357) with this being a significant advance in the theoretical defining of injury (Langley and Brenner, 2004).

Injury, therefore, has an external energy and time element with the damage caused during a relatively short energy transfer process. Contrast this with the construct of disease which tends to focus on the deviation from normal function and structure of the body with a specific cause and to be more long term in nature (Dorland, 2011, p. 527; British Medical Association, 2018, p. 176). Trauma can be a much wider construct involving 'exposure to catastrophic or aversive events' (American Psychiatric Association, 2013, p. 265), often framed in the emotional response (American Psychological Association, 2019; National Health Service, 2019b) rather than injury. Although physical trauma, often without the prefix of physical, can, in many instances, be interchanged with injury, for example, in the National Health Service standard for major trauma services with trauma contextualised as injury (National Health Service, 2013, p. 2).

The debate within Nosology, the branch of medicine involved in the classification of diseases, regards the correct definition of injury and this may depend on the medical stance of the individual concerned (Langley and Brenner, 2004).

2.2.1 Police Non-clinical Injury Severity Classification

Subjects who receive injuries during a collision can either die or survive. Death can occur at the scene of the collision or sometime later as a result of the injuries sustained. The amount of time elapsing between the collision and the death may dictate whether the death can be attributed to the collision for injury severity classification purposes. In the UK the death must occur at the time of or less than 30 days after the collision to fulfil the definition of ‘fatal’, and hence a ‘fatal collision’, with this definition also used internationally (Department for Transport, 2011; International Transport Forum, 2011; European Transport Safety Council, 2018). When the fatality occurs subsequent to the incident the Coroner becomes involved. The Coroner’s office refers the death to the police service for the area where the death occurred, likely to be the police service which reported the collision, though not necessarily. The police service initiates a fatal collision investigation or the current ongoing investigation into the collision, should there be one, can be escalated to a fatality, depending on the 30 day rule set out above, STATS19 may be updated to reflect the change of injury severity status (Ministry of Justice, 2014; College of Policing, 2020).

In the UK, injury collisions are reported by individual police services, and the data used to populate a dataset called STATS19, see 2.3.1, administered by the Department for Transport. The data being compiled by the reporting police officer. The classifications ascribed form the basis of the UK national collisions statistics (Department for

Transport, 2019d). STATS19 has been used in numerous studies and these are described in section 2.3.1.

When reporting the collision, the officer has the option of three injury categories (subject to the 30 day revision set out above). The three categories available are set out below.

Fatal

Serious

Slight

The criteria for each category of injury are set out in guidance published by the Department for Transport for the completion of STATS19 using non-clinical terms (Department for Transport, 2011). Examples of what the guidance deems to be a serious injury include a ‘severe head injury, unconscious’, ‘loss of a limb (or part)’, to less severe injury such as a ‘fracture’ or ‘deep cuts/laceration’. It also includes shock requiring hospital treatment. Hospitalised patients who die 30 days or more after the collision, remain serious injuries and do not become fatalities with the STATS19 injury severity classification. Examples of slight injuries are whiplash or neck pain, through bruising to slight shock requiring roadside treatment (Department for Transport, 2011, p. 72).

It should be noted that at the time of writing, approximaitly half of UK police services have adopted the CRaSH electronic reporting system (Civica, 2018; 2019; Department for Transport, 2019d), see section 2.3, where selection of the injury severity category has been partially automated and based on an injury selection. The Metropolitan Police Service are currently using their own system called the Case Overview and Preparation Application (COPA) which also has an injury based function. This has led to some variation in categorisation between CRaSH/COPA data and non CRaSH data. The differences are reported in the annual statistics with police services using the injury based function systems having a higher proportion of serious injury collisions than those relying solely on the officers subjective assessment (Department for Transport, 2020d). The Department for Transport (2020d, p. 5) produce a graph of serious injury frequency which also includes and estimation of the serious injury frequency had all police services been using the injury based systems, as more police services adopt the system the estimation and actual are drawing closer together, the upward adjustment to the serious injury category results in a corresponding estimated downward adjustment to the slight injury category (Department for Transport, 2019c; 2020d). Cambridgeshire constabulary adopted CRaSH in May 2017 (Department for Transport, 2019d).

Unfortunately the lack of medical specificity in this categorisation process can cause issues with international comparisons, where clinically assessed injury severities are specified under commitments to the European Commission (Department for Transport, 2006b; 2015b; 2019c; Aarts *et al.*, 2016). This being acknowledged by the Department for Transport, and to allow comparison, results in an estimation of what the clinically assessed MAIS3+ level of injury could be being included in the annual statistics (Department for Transport, 2015b; 2019d; 2020d).

2.2.2 Clinical Injury Severity Classification

The use of accepted classification systems for disease and injury is widely acknowledged. For injury specifically the ‘classification by type and severity is fundamental to the study of its magnitude, distribution and determinants’ (Stevenson *et al.*, 2001, p. 10), allows for direct comparison of data from different sources, removes ambiguity, allows tracking across national boundaries and a wider global view (Association for the Advancement of Automotive Medicine, 2017a; World Health Organization, 2020).

In the UK there are two main clinical classification tools which are used to classify the extent and level of injury; however, one being a wider disease classification tool that includes the classification of injury and the other being specifically an injury classification system. The two tools examined are the International Classification of Diseases (ICD) and the Abbreviated Injury Scale (AIS), the former briefly examined, to give context, with a wider examination of the latter, the latter being used primarily for research into injury epidemiology (Alexandrescu, O'Brien and Lecky, 2009; Lecky *et al.*, 2014), evaluating burden of injury (Lyons *et al.*, 2007; Kendrick *et al.*, 2012; Gabbe *et al.*, 2015) and during this research. The two tools were constructed for different reasons but use the same basic principle. There are dictionaries, individual to each tool, containing specific clinically defined conditions, be it disease or injury, each of which has been allocated a code. For each of the tools there are examples of how the codes are constructed. There are other discipline specific medical injury scales which do not relate to the research presented in this thesis, these are briefly explored in appendix one.

2.2.2.1 The International Classification of Diseases

The World Health Organisation (WHO) has a global responsibility for monitoring health trends and reporting health statistics and was born out of collaboration within the United Nations (Holder *et al.*, 2001; World Health Organization, 2019; 2020). To undertake this role a standardised diagnostic classification system was needed which allowed disease data from around the world to be compared. The ICD, with continual review process, issues regular updated versions, the version of ICD being designated by the use of a suffix after ICD containing a hyphen and then the issue number, for example ICD-10.

There had been an International List of Causes of Death, administered by the International Statistical Institute since 1893 and in 1948 the WHO took over that administrative role publishing ICD-6. The current version being ICD-11, released in May 2018, although ICD-10, released in May 1990, remains in use with the WHO as they are not scheduled to use ICD-11 for reporting purposes until January 2022. (World Health Organization, 2010; 2020).

The WHO describes the ICD as ‘the foundation for the identification of health trends and statistics globally, and the international standard for reporting diseases and health conditions. It is the diagnostic classification standard for all clinical and research purposes. ICD defines the universe of diseases, disorders, injuries and other related health conditions, listed in a comprehensive, hierarchical fashion…’ (World Health Organization, 2020). ICD codes can be very specific in identifying disease, such as in ICD-10 the code E10.21 denotes Type I diabetes mellitus with diabetic nephropathy, and specific injuries, such as the ICD-10 code S62.032A denotes a fracture (traumatic) of proximal third of scaphoid bone, left wrist, initial encounter. The example injury code S62.032A being constructed from a number of elements; S62.03 denotes a fracture, traumatic, proximal third of scaphoid bone in wrist; the next 2 denotes left: The A demotes initial encounter. However, the code for the injury does not contain a severity element to allow comparison with other injury (World Health Organisation, 2019).

2.2.2.2 The Abbreviated Injury Scale

The AIS was born initially out of research into air crash injury where there was a need to specify injury scaling numerically to allow for statistical analysis of multiple injured subjects (Ryan and Garrett, 1968; Petrucelli, States and Hames, 1981). It was seen that the work undertaken on air crash injury could be used to explore injury caused by road traffic collision and this was combined with a desire to improve road safety in the late 1960s (Braunstein, 1957; Ryan and Garrett, 1968; States *et al.*, 1971; Petrucelli, States and Hames, 1981). Although developed within a road injury environment it has application in the scaling of trauma caused by other mechanisms, such as falls, in various circumstances (Petrucelli, States and Hames, 1981; Steedman, 1989; Kendrick *et al.*, 2015; Cox *et al.*, 2017).

The AIS was devised by the Association for the Advancement of Automotive Medicine as a method of assessing and recording injury in road traffic collisions and has been adopted by organisations involved in researching trauma, as well as those involved in road safety. For example, the Trauma Audit and Research Network (TARN) in the UK, an organisation dedicated to the improvement of trauma services, for all trauma, not just road traffic, in England and Wales. TARN use AIS to identify and quantify all the trauma patient injuries in their data. Although there have been later releases, in 2008 and 2015 the Trauma Audit and Research Network use the 2005 revision of AIS, referred to as AIS 2005 (The Trauma Audit and Research Network, 2020).

Also, injuries classified using AIS as serious, see below, are those used for international comparison by both the European Commission and the Organisation for Economic Co-operation and Development, through the International Transport Forum (International Transport Forum, 2011; 2018; Department for Transport, 2015b; Aarts *et al.*, 2016; Association for the Advancement of Automotive Medicine, 2017b). AIS classification is also used to explore the burden of injury globally (Lyons *et al.*, 2007; Lyons, 2008; Kendrick *et al.*, 2012; 2013; Murray *et al.*, 2012; Gabbe *et al.*, 2015)

The AIS system works from an anatomical base and allocates coding to specific injuries by body region, the pre-dot six digit code, in conjunction with a clinical assessment of the severity of that injury on an ordinal scale of one to six, as the post-dot single digit. Coding should be undertaken by individuals who have undertaken training available from the Association for the Advancement of Automotive Medicine (2020b). The distribution of AIS body regions with example codes and the severity categories are set out in appendix two.

As noted at the beginning of this section, AIS was developed to allow the statistical analysis of multiple casualties at an injury severity level, something which was not possible with ICD codes (Ryan and Garrett, 1968; Petrucelli, States and Hames, 1981). However, unlike the ICD code dictionaries which are available as an open source web tool, for example the ICD-10 2019 version being available from the World Health Organisation (2019), the AIS code dictionaries require purchasing from the Association for the Advancement of Automotive Medicine (2020) online bookstore.

The National Health Service keeps records of patients attendance at hospitals and describes these as episodes, statistics regarding these episodes, Hospital Episode Statistics (HES), are published and the episodes are grouped according to the type of attendance; admitted patients, accident and emergency, outpatients and adult critical care (National Health Service, 2018b; 2019a). The National Health Service uses ICD-10 coding to compile HES, for all patients not just road traffic injury, from which the Department for Transport then estimates the number of road casualties at the AIS severity level of three or above for international comparison from the ICD codes in the HES data, the latest estimation suggests that around 16 percent of the casualties categorised as seriously injured by the police correspond to MAIS3+ injuries (Department for Transport, 2015b; 2019c; 2020d; National Health Service, 2018a; 2019a).

Lecky *et al.* (2014, p289) in comparing the two tools observes ‘in general the AIS is felt to be a superior way of describing the threat to life from anatomical injuries when compared with the international classification of disease as it describes severity and anatomical location of each injury’. In comparison to AIS, the ICD was designed to classify and code diagnoses rather than quantify the severity of single injuries, this can mean that ICD codes are generally less specific than AIS codes (Alexandrescu, O’Brien and Lecky, 2009; Lecky *et al.*, 2014; Association for the Advancement of Automotive Medicine, 2018). Therefore, when considering how a factor may mitigate the severity of an injury, but not necessarily negate the injury completely AIS allows for the distinction. Tools are available to map ICD codes to AIS, however, the process can be problematic as the severity can only be estimated from the ICD coding rather than subject to the specific severity classification within AIS coding (Linn, 1995; Broughton *et al.*, 2008; 2010; Alexandrescu, O’Brien and Lecky, 2009; Clarke *et al.*, 2010a; International Transport Forum, 2011; Department for Transport, 2012b; 2019d; Pérez *et al.*, 2016; 2019; Association for the Advancement of Automotive Medicine, 2017a; 2018).

2.2.2.3 Multiple injuries

Casualties with multiple injuries to multiple body regions have multiple applicable AIS scores, AIS does not fulfil the role of a multiple injury scale (Petrucelli, States and

Hames, 1981). As a result there are a number of systems in use which combine AIS scores, and/or other data to produce a single score for a patient as a predictor of morbidity, the most commonly used scales are presented in the following sections (Baker *et al.*, 1974; Petrucelli, States and Hames, 1981; Glancy *et al.*, 1992; Osler, Baker and Long, 1997; Brenneman *et al.*, 1998; Stevenson *et al.*, 2001; Roy *et al.*, 2016; Hendre, Mali and Kulkarni, 2020). However, in comparison there may be little difference in the predictive performance between the scales (Nuyttens *et al.*, 2016).

2.2.2.4 Maximum Abbreviated Injury Scale (MAIS)

To overcome the AIS limitation regarding multiple injuries the committee on injury scaling responsible for the administration of the scale proposed the use of the construct Maximum Abbreviated Injury Scale (Petrucelli, States and Hames, 1981), this refers to the most severe injury, i.e. the individual highest AIS score sustained by a subject. For example, a subject who has an AIS 4 head injury, an AIS 3 chest injury and an AIS 2 extremities injury would have a MAIS of 4. MAIS being used as an overall descriptor of any combination of injuries for overall injury severity. For example, MAIS has been used with some success to explore disability adjusted life years after road traffic collisions where a level of MAIS3+ captures 54 percent and MAIS2+ captured 80 percent of the disability adjusted life years (Polinder *et al.*, 2015). Subjects with a MAIS of 3 or above (MAIS3+) are considered to have a clinically serious injury and comply with the standard adopted across Europe for comparison (Department for Transport, 2015b; Aarts *et al.*, 2016).

2.2.2.5 Injury Severity Score (ISS) and related scores

Where multiple injuries occur AIS alone may not be helpful in assessing the combined effect, which resulted in the adoption of MAIS (Petrucelli, States and Hames, 1981; Hendre, Mali and Kulkarni, 2020) The Injury Severity Score was developed as a means of assessing the combined effect of multiple-injuries to patients, based on AIS, to predict mortality. It has been used to assess the quality of care of hospital patients, remains widely used and has use in comparing outcomes across trauma centres (Baker *et al.*, 1974; Glancy *et al.*, 1992; Stevenson *et al.*, 2001; Roy *et al.*, 2016). However, it has been proposed that ISS may not the best construct at predicting survival, with alternatives, these being the Trauma Injury Severity Score (TRISS) (Champion *et al.*, 1981) and the New Injury Severity Scale (NISS) (Osler, Baker and Long, 1997; Brenneman *et al.*, 1998; Stevenson *et al.*, 2001), TRISS and NISS are described later in this section.

The scoring produced from the individual anatomical regions being combined to produce the ISS score; to construct ISS the AIS scores are examined in six body regions. The six body regions used to calculate ISS are set out in appendix two.

The ISS being calculated from the sum of the squares of the highest AIS code in each of the three most severely injured ISS body regions. Injury Severity Scores range from 1 to 75. With an injury assigned an AIS of 6 (identifying a currently untreatable injury), the ISS process automatically assigns the highest score of 75 (Stevenson *et al.*, 2001). An example of how ISS would be constructed from the body region AIS scores using some of the example codes in appendix two.

The National Health Service (NHS) definition of ‘Major Trauma’, being an example of an application of ISS (National Health Service, 2013, p. 2), specifies the use of ISS as the scoring tool and puts major trauma as an ISS score of greater than 15 (ISS>15), with ISS of 9-15 designated as moderately severe trauma. ISS has been considered to be both a simple measure to compare injury (Linn, 1995), an accurate way of assessing injury (Watson, Watson and Vallmuur, 2013) and a good indication of mortality risk (Sampalis *et al.*, 1995), although more refined processes, such as the TARN probability of survival model use ISS in combination with other factors to explore outcomes (The Trauma Audit and Research Network, 2019).

The TRISS are an alternative process to assess trauma injury based on a combination of the Triage Index (Champion *et al.*, 1980), ISS and the patients age. As with the other assessment tools presented in this section TRISS has been subject to updates, amendments and adjustments over time (Champion *et al.*, 1981; Schluter, 2011; Domingues *et al.*, 2018).

The NISS uses a simplified method of calculating an overall assessment of injury. Rather than consider body regions in the manner of ISS, see table 2.4 above, the NISS merely takes the three highest AIS scores, regardless of body region and applies the same calculation used in the ISS calculation. Therefore, NISS scores are the simple sum of the squares of the three highest AIS scores (Osler, Baker and Long, 1997; Brenneman *et al.*, 1998; Stevenson *et al.*, 2001). NISS are used widely, for example, by the Swedish Trauma Register (Wihlke *et al.*, 2019) and also by The Trauma Audit and Research Network (2020) but in the latter case only for reference.

2.2.3 Injury Severity Comparison

The use of non-clinical injury severity classification by police officers in reporting collisions was described in section 2.2.1, the results of those processes can be compared to those of clinical injury severity classifications, described in section 2.2.2. Difficulties arise when the non-clinical classification were used and the clinical was required, below are two examples of where these difficulties arise and in the case of the former, how the issues are resolved in practical terms. These examples clearly provide support for the inclusion of a clinical injury assessment in collision data, or at the very least a simplified process to link the required data removing the need for additional processes or estimations.

Reported road casualties in Great Britain

The Department for Transport publishes the annual report on road casualties in Great Britain. This report uses the injury severity categorisation reported by the police in the STATS19 data as the primary source. The report separates the three injury severity categories, fatal, serious injury and slight injury, and reports them separately. The report also contains an adjusted level of serious injury frequency. The first relates to the actual frequency recorded in the data and this was presented with an adjusted estimate of what the level would be taking account of the differences in the serious injury category between the assessment undertaken manually by the reporting officer and those where the severity was selected by the reporting system, either CRaSH or COPA, see 2.3.1. (Department for Transport, 2019d)**.**

Cambridgeshire Trauma Audit and Research Project (CTARP)

There has been a previous examination of the relationship between subjects on the TARN database and those featuring in the STATS19 data. The CTARP examined Cambridgeshire data from the 2000-2004 periods (University of Leicester, 2005). Examining the CTARP research review shows some disparity between the police assessment of severity and the clinical assessment, the total number of individuals classified as KSI in the STATS19 data was 3320. This contained some 336 fatalities (referenced with Coroners records) and the rest; some 2984 formed the SI, of the KSI total. However, when these were compared with the TARN criteria, some 2083 did not fulfil those criteria. This left some 901 severely injured individuals. Now if this 901 represents the actual number of severely injured people that the NHS treated from these data then that was only 30 percent, signifying an over reporting of serious/severe of 70 percent. The 30 percent was higher than the Department for Transport (2019d) estimation of 16 percent. The CTARP data flow diagram is presented in appendix two.

Since CTARP was undertaken, there have been a number of changes to how some of the data are recorded. For example, there have been changes to how police report injuries in the STATS19 data (Department for Transport, 2010b) and this has been further complicated by the partial adoption of alternative electronic reporting systems (Department for Transport, 2018b) which result in larger numbers of casualties being categorised with serious injuries compared to the earlier non-clinical categorisation, see section 2.2.1. The extra serious categorisation comes from the slight categorisation and could impact on the proportion of serious injury categorised collisions which would be clinically categorised as MAIS3+. (Department for Transport, 2019c). The AIS has been revised over time, in 2005 and 2008, for example, which in like for like comparison lowered the recorded level of trauma (Barnes *et al.*, 2009;

Tohira *et al.*, 2011). For the purpose of the research presented in this thesis there was also a requirement to link the data held on STATS19 with the data held on the TARN database, see chapter four. However, the changes described did not impact the current research described in this thesis.

2.2.4 Trauma Audit and Research Network

The Trauma Audit and Research Network (TARN) is an organisation dedicated to the improvement of trauma care. To undertake research TARN maintains a database of patients treated at NHS Major Trauma Centres for trauma from all sources (The Trauma Audit and Research Network, 2000).

This database records the level of injury with a score derived from the Injury Severity Score (ISS) process, as well as the specific body region Abbreviated Injury Score (AIS) data from which it was derived, TARN codes to AIS (2005) standards (Baker, Robertson and O’Neill, 1974; Stevenson *et al.*, 2001; The Trauma Audit and Research Network, 2020).

As with using other hospital records (Pérez *et al.*, 2016) the data held on the TARN dataset did not capture all MAIS3+ injuries as some patients may not be hospitalised, or hospitalised for insufficient time, to meet the TARN entry criteria. In addition to this, the TARN dataset does not encompass psychological injury as the lay assessment does, see 2.3.3, therefore, any dataset of MAIS3+ injuries using the TARN data underestimates the total number of MAIS3+ injuries. However, due to the TARN entry criteria it reflects the most serious that have been in contact with the health service.

2.3. Collision Data

Collision statistics are produced from the data collected relating to collisions which occur on roads, depending on the jurisdiction in which the collision occurred the records may only reflect injury collisions, as in the UK (Department for Transport, 2011; 2019c). Any activities to reduce casualties are based on the analysis of this data, this can only occur where sufficient quality data has been collected (International Transport Forum, 2018; 2019a). The collection of the data, especially road related death, falls on the police services in the UK and across Europe (Risksol, 2012; European Transport Safety Council, 2018).

2.3.1 UK Police Collission Data STATS19

In the United Kingdom (UK), collision data are collected by the relevant police services, 43 in England and Wales, Police Scotland and the Police Service of Northern Ireland (PSNI). Collisions are generally reported by police officers at the scene, although reporting can be done by members of the public at police station front counters to police officers and more recently online. The data from Northern Ireland are reported separately, the remaining data are reported as Great Britain. The data being submitted in England, Wales and Scotland using the dataset called STATS19, administered by the Department for Transport. The PSNI collects and administers the Northern Ireland data on a dataset derived from STATS19 (Department for Transport, 2019d; Police Service of Northern Ireland, 2021).

STATS19 forms the continuation of the collection of collision data which started in 1926 with the current format being introduced in 1979, the latest guidance on completion of the data was issued in 2011 (Department for Transport, 2011). The data collected within STATS19 are primarily circumstantial, such as date/time, weather conditions, type of roads and so on. However, there are two sections which allow the reporting officer to give their subjective interpretation of the available evidence (circumstantial and witness) in setting out what happened and what factors contributed to that happenstance.

The descriptive free text section allows the officer to describe the collision and how the narrative progressed, it often contains commonly used abbreviations, such as V1 for vehicle 1 (as numbered in the report), V2 and so on, or EBC for east bound carriageway, for example it might contain something similar to ‘V1 was travelling west along the High Street towards the town centre, V2 was travelling north along The Avenue towards the junction with High Street where there are give-way lines. V2 failed to give-way and drove into the path of V1 causing the collision’. Although they are often much briefer.

The second section containing the officer’s subjective interpretation of the available information relates to what are described as ‘contributory factors’ (abbreviated to cf or CF). These are pre-defined explanations of factors from a finite list which the officer feels contributed to the collision and can be attributed to the vehicles (and hence motor vehicle drivers) involved in the collision. Each of the contributory factors are numbered and the designated number included in the report, for a full list of the contributory factors see Department for Transport (2011). For example, if we look at the collision described in the previous paragraph the contributory factor 302 ‘Disobeyed “Give Way” or “Stop” sign or markings’ would be allocated to V2. The contributory factors are groups together and numbered in sequences depending on the nature of the factors, so, codes 101-110 relate to environmental factors, 201-206 relate to vehicle defects, 301-310 to injudicious actions by the motor vehicle driver and so on.

Currently the Department for Transport are conducting a review of STATS19 focusing on:

- Make recommendations for modifications to Stats19 variables with a view to improving the quality/value of the data to users and to reducing reporting burdens on the police
- Identify areas where the Stats19 specification can be streamlined and modernised in order to reduce burdens, including improving validation at source and therefore overall increase the quality of data collected and speed up the ability to report/ produce findings
- Consider the scope and opportunities for better use of technology, data sharing and matching to modernise road casualty data. This is both with a view to reducing the amount of data needing to manually rather than automatically input by the police, but also to enrich the data available to generate insight to improve road safety interventions.
- Develop a roadmap for any longer term data changes needed to improve the evidence base for road safety interventions

(Department for Transport, 2019c, pp. 30–31).

STATS19 data has traditionally been collected as a hard copy form, however, an electronic reporting system has been introduced. These electronic systems have an injury severity selection process which does involve the selection of injuries from a pre-defined list rather than the police officer's subjective decision. This change in process has had an impact on injury severity categorisation and online reporting has impacted on improving data quality, with a reduction in missing data (Department for Transport, 2011; 2019d). The suggested format of the STATS19 form, presented in appendix three (Department for Transport, 2011, pp. 110–113), shows all the variables that are collected within the STATS19 dataset.

Analysis of STATS19 data has been employed in research which examined diverse paradigms including; collision frequency, collision severity, the predicting of different severities at different geographic locations (Wang, Quddus and Ison, 2011), child injuries (Jarvis *et al.*, 2000), collisions crash-speed relationships (Imprialou *et al.*, 2016), the relationship between deprivation and collision risk (Graham, Glaister and Anderson, 2005; Edwards *et al.*, 2006), exploring if graduated driving licence could reduce casualties (Jones, Begg and Palmer, 2013) and geographic distribution of road casualty injuries (Steinbach, Edwards and Grundy, 2013) amongst many others. However, it has been recognised that STATS19 data has limitations in both quality and completeness (Department for Transport, 2011; 2020d; Imprialou and Quddus, 2017) which means that any analysis using this data source never provides a complete picture.

As well as never providing a complete picture of those injured in collisions the format of STATS19 and the post collision reporting process means that not all factors which lead to the collision are explored. Collision causation is dealt with in the next section, however, there are factors, such as driver attitudes and perceptions or their emotional state leading up to the collision which it is not possible for the reporting officer to detail. Additionally, drug driving can only be detected after a roadside screening with the level of screening being limited by the cost and availability of the devices, with devices only screening for two drugs. So, even with the level of screening being undertaken the representation in STATS19 of drug driving as a contributory factor is likely to be an underestimation of the true scale of the problem (Department for Transport, 2013a; Parliamentary Advisory Council for Transport Safety, 2021).

2.4. Collision Causation

Road traffic collisions are complex events (Wagenaar and Reason, 1990) which can include multiple actors and layers of circumstance. They are multi-facetted constructs with complex narrative scripts (West, 1997), spatial events which happen in a context (Loo and Anderson, 2016) and are not homogenous (Babarik, 1968; Barrett and Thornton, 1968; McBain, 1970; Ball and Owsley, 1991; af Wåhlberg, 2009). This means that no two collisions can ever be considered to be the same, although factors may be common to many.

The complex nature of collisions and the endeavour to understand how they occurred leads to the need for recording multiple factors in collision datasets such as STATS19. In the UK the only data available to explore such factors are STATS19. There also has to be an understanding of how the factors interact, as well as the circumstantial data surrounding the event. The police officer reporting the collision has the option to append contributory factors and allocate them to individual motor vehicle drivers if applicable, these causation factors give insight into what the reporting officer considers to have led to the collision (Department for Transport, 2006b; 2011; 2019d).

Some of the contributory factors available to the officer give a description of the bare facts, such as ‘Failed to give-way’ (Department for Transport, 2011), however, what they are unable to do was give behavioural insight into why the individual may have done or failed to do something. For any collision analysis to be successful there must be careful categorisation of the data (Cercarelli *et al.*, 1992) and clear taxonomies for collisions categorisation. Injury severity, vehicle involved or causation, for example, are sensible constructs and allow the collisions to be classified or categorised which in turn allows comparison (af Wåhlberg, 2009). There are also recognised issues of the under-reporting of collisions which means any analysis of official collision data underestimates the actual impact. Although, the more serious the injury sustained the more likely the collision was to be reported (Bull and Roberts, 1973; Transport and Road Research Laboratory, 1980; James, 1991; Transport Research Laboratory, 1993b; 1996; 2002; Cryer *et al.*, 2001; Roberts *et al.*, 2008; Broughton *et al.*, 2010; International Transport Forum, 2011; 2018; Yannis *et al.*, 2014; World Health Organization, 2018), but, because not all injury collisions are reported any analysis provides an incomplete picture and this must be recognised.

Researching causation factors such as fatigue (see 2.4.6) or intoxicants (see 2.4.5) involving human subjects in real world driving scenarios rightly raises ethical concerns, meaning much of the research which could create such risk has been undertaken using driving simulators. Boyle and Lee (2010) undertook a comparison of simulator use and real-world driving situations and concluded that the use of simulators was a viable method as an alternative to real world driving.

2.4.1 Motor Vehicle Driver Behaviour

Human behaviour forms a complex construct. It can be explored from a psychological processes perspective as well as a social and personality perspective, encompassing social attitudes, behavioural dispositions and cognitive self-regulation (Ajzen, 1991).

In the UK the role and status of the driver of a vehicle was clarified during legal proceedings as the person who uses the vehicles controls to guide its movement (‘R v MacDonagh' (1974) *59 Cr App R*. 55M), with the driver remaining the driver even when the vehicle was stationary or there was a short interruption in motion ('Pinner v Everett' (1977) *64 Cr App R*. 160).

> …a driver has an inherent accident liability (or proneness) that predisposes him/her towards having a certain mean level of incidents. However, this is not a totally stable trait, but could rather be seen as a mean around which the values fluctuate. (af Wåhlberg, 2009, p. 97).

The very broad paradigm of motor vehicle driver behaviour encompasses a multitude of human factors (Shorrock, 2017a; 2017b; 2017c; 2017d), such as, attitudes to drug or alcohol consumption and risk taking (Bernhoft, 2011), through the impact of intoxicants (Mathijssen and Houwing, 2005) to the impact of emotional state or fatigue (Fell, 1976), which need to be taken into consideration when considering the causes of collisions. In the Great Britain 2019 police collision data, for example, 66 percent of all collisions referenced motor vehicle driver or rider error or reaction as a causation factor, 23 percent behaviour and inexperience, 20 percent injudicious action and 15 percent impairment or distraction (although it should be noted that the last three categories described all had higher proportions in fatal and serious injury collisions). The motor vehicle driver failing to look properly was the highest individual factor being cited in 37 percent of all reports and also the highest in all injury severity classifications (N.B. collision reports can specify more than one factor) (Department for Transport, 2020b), resulting in human factors forming the basis for road safety policy (Department for Transport, 2019i).

The research in this area can be further sub-divided into the following groups: infraction; risk taking; inattention; fatigue; human error; negligence; personality; emotional state; activity; detection failures; boredom; attitude; car and motor vehicle driver stereotypes and aggressiveness. Possibly several, if not many, of these factors combine in an individual (Babarik, 1968; Baker, Robertson and O'Neill, 1974; Fell, 1976; Brown, 1990; Parker *et al.*, 1995; Wang, Knipling and Goodman, 1996; West and Hall, 1997; Petridou and Moustaki, 2000; Hendricks *et al.*, 2001; Sullivan and Flannagan, 2003; Fuller, 2005; Wilson *et al.*, 2006; af Wåhlberg and Dorn, 2009; Stanton and Salmon, 2009; af Wåhlberg, Dorn and Kline, 2011; Curry *et al.*, 2011; af Wåhlberg, 2012; Markkula *et al.*, 2012). What can be observed, from the diversity in this list and combined with the variety of contributory factors available to police officers reporting collisions in the UK, are the complexities of human involvement in the circumstances which result in collisions. Multiple factors can often combine, with many difficult to determine by a reporting officer, for example from the list above, a risk taking nature or boredom. This means that any causations determined by an officer reporting a collision for inclusion in the STATS19 data are unlikely to reflect a full understanding or report on every factor affecting the motor vehicle drivers involved. Therefore, the use of STATS19 data never fully explains how a collision occurred beyond those factors which are obvious in the limited time the officers interact with the motor vehicle drivers. They may well be able to determine what happened but not fully the why.

2.4.2 Habitual Behaviour

Many individual aspects of the act of driving become habit. Habitual behaviour can be framed within the wider field of 'attitude-behaviour models', and has been contextualised within the 'Theory of Planned Behaviour' (TPB) (Ajzen, 1991; Tseng, Chang and Woo, 2013).

TPB proposes that even the choice of a mode of transport, in this case driving, results from a combination of attitude, subjective norm, perceived behavioural control and behavioural intention (Ajzen, 1991; Bamberg and Schmidt, 2001; 2003; Tseng, Chang and Woo, 2013). Many of the activities undertaken whilst driving, such as listening to the radio, and the act of driving can be habitual in that they are undertaken almost subconsciously to the point where cars just seem to ‘drive themselves to work’ in the morning (Brantingham and Brantingham, 1993, p. 261). Therefore, the TPB can be used as a model for the organizing and understanding of potential factors which may influence the intentions of individuals towards driving behaviour and law compliance (Yagil, 1998; Victoir *et al.*, 2005; Poulter *et al.*, 2008), this links in well with constructs such as self-selection policing, where criminal rule breaking extends to all aspect of behaviour, including driving (Roach and Pease, 2016; Roach, 2019).

Some common offending seen on the roads can be framed as habitual behaviour, such as; seat belt use (Jonah and Dawson, 1982; Budd, North and Spencer, 1984; Thuen and Rise, 1994; Şimşekoğlu and Lajunen, 2008) and the failure to use car child restraint devices (Godin and Kok, 1996); or exceeding speed limits (Parker *et al*, 1992a; Parker, Manstead and Stradling, 1995; Elliott, Armitage and Baughan, 2003; Letirand and Delhomme, 2005; Forward, 2006; De Pelsmacker and Janssens, 2007; Warner and Åberg, 2008). In many cases the habitual element of the reasoning process was at least as strong as any conscious decision making. A number of studies framed motor vehicle driver offending as a wider construct of offending, rather than specific offences. These were able to draw similar conclusions, in that a poor attitude towards offending influenced behaviour and increased risk, was linked to a previous poor driving history, often a result of habitual offending and an increased risk of collision culpability (Parker *et al*, 1992a; Parker *et al*, 1992b; Parker, Manstead and Stradling, 1995; Forward, 2006). Banks *et al*. (1977).

Evans and Norman (1998) and Díaz (2002) examined pedestrian road crossing behaviour. This linked the actions of those studied to their subjective attitude, such as attitudes to finding a safety place to cross the road, and norms they displayed. It was examined by perceptions of approval or disapproval by hypothetical observers of their behaviour, which took precedence over the objective assessment of the risk posed by the situation, this was also linked to the age of the subject (Diaz, 2002).

Drinking and driving constitutes a dangerous activity, which can be rooted in habitual behaviour, as it increases the likelihood of being involved in a collision and has been shown to be a significant factor in fatal collisions (Smith and Popham, 1951; Banks *et al.*, 1977; Clarke *et al.*, 2010a; Department for Transport, 2010a; 2015a; Mann, Stoduto, Vingilis, *et al.*, 2010; Bernhoft, 2011; Hels *et al.*, 2011; Bernhoft *et al.*, 2012; Poulsen, Moar and Pirie, 2014). It results from a combination of an individual's drinking habits and their subjective moral norms. Individual previous experiences of the possibility of detection can subjectively influence decision making processes negatively (Parker, Manstead, Stradling, Reason, *et al.*, 1992; Åberg, 1993; Parker, Stradling and Manstead, 1996; Sheehan *et al.*, 1996; Marcil, Bergeron and Audet, 2001; Armitage, Norman and Conner, 2002). Certainly, within the UK there has been a concerted long-term effort to change social norms in relation to drink driving which has been generally successful in making the behaviour socially unacceptable, resulting in a long term reduction in drink driving as a contributory factor in injury collisions (Department for Transport, 2010a; 2014a).

Motor vehicle drivers can display an aggressive demeanour whilst driving, manifesting in behaviours such as tailgating, speeding or overtaking in poor situations, either reported by other motor vehicle drivers or self-reported; this can be considered habitual and usually based upon personal attitudes and norms (Underwood *et al.*, 1999; Jonah, Thiessen and Au-Yeung, 2001; Miles and Johnson, 2003). In some subjects it may even be perceived as a positive trait, however, there are links to an increase in the risk being involved in a collision (Parker, Manstead and Stradling, 1995; Parker, Lajunen and Stradling, 1998; Underwood *et al.*, 1999; Tasca, 2000; Miles and Johnson, 2003; Stephens and Groeger, 2014).

2.4.3 Attitude and Perception

Speeding has been well-documented as a motor vehicle driver behaviour which impacts on collision risk, the more speed involved in driving the higher the risk (Aarts and van Schagen, 2006; Imprialou *et al.*, 2016). Yet there are complex relationships between motor vehicle driver attitude towards compliance, that being obeying the speed limit of the road, and enforcement with the well documented risk (Blincoe *et al.*, 2006).

As well as how a motor vehicle driver behaves, there has been considerable research into motor vehicle driver perceptions and how these may influence how a motor vehicle driver behaves, the relationship with risk and the risk of collisions (Barrett and Thornton, 1968; Quimby *et al.*, 1986; Häkkänen and Summala, 2001; Williams *et al.*, 2012). Perceptions are flexible constructs that can change with emotional state and mood, this aspect has been explored and shown to have influence on levels of traffic related offending and risk taking behaviour, with higher emotional states and low mood causing increases. The impact of such volatile factors can have a short term impact, albeit very difficult to quantify which are layered on top of a motor vehicle drivers normal level of risk and are difficult to externally impact (Parker, Manstead, Stradling, Reason, *et al.*, 1992; Underwood *et al.*, 1999; Lu, Chou and Lee, 2000; af Wåhlberg, 2009; Hu, Xie and Li, 2013; Jeon, Walker and Yim, 2014; Roidl, Frehse and Höger, 2014).

Perceptions can be framed by the personality of the individual (Iversen and Rundmo, 2002). Some motor vehicle drivers, for example, see the act of driving as an opportunity for thrill or sensation seeking, others considering they have superior ability, and this affects their perception of risk and danger, this may not be the case for most motor vehicle drivers (Jonah, 1997; Jonah, Thiessen and Au-Yeung, 2001; Forward, 2006).

Changes in perception can influence many factors both pre or post a collision and can influence the effectiveness of interventions, with motor vehicle drivers having an increased perception of risk after a collision, without the collision experience safety messages may have less impact (Chipman, 1982; Cercarelli *et al.*, 1992; Chapman and Underwood, 2000; Kiefer, Flannagan and Jerome, 2006; Davey *et al.*, 2008; Werneke and Vollrath, 2012), therefore, road safety messaging must address the individuals perceptions (Tuokko *et al.*, 2007; Ram and Chand, 2016).

2.4.4 Distraction

There are many ways to define distraction, however, considering it as ‘a diminished safety margin associated with the overlap of the distribution of attention demanded by the road and that devoted to the road’ (Lee, Young and Regan, 2009, p. 38), i.e. the demand for attention by the driving task was not met because another matter was utilising some of the required attention, allows for a number of factors to be considered.

In the UK there has been recent media attention on one particular distraction nexus in the form of mobile telephone use whilst driving, as perceived by the media as an ongoing public concern (Christodoulou, 2018; Chillingsworth, 2019; Lancefield, 2019).

Burns *et al.* (2002) using a driving simulator found in respect of some aspects of the driving task, such as speed control, the use of mobile telephones more impeding than intoxication. However, distraction encompasses a much wider field of nexus than just mobile telephones; it encompasses any of the matters which may draw the motor vehicle driver's attention away from concentrating on the task of controlling the motor vehicle and processing all the information required to make appropriate decisions. For example, research has determined that distraction can have a significant impact on reaction times to road signage and causes greater numbers of motor vehicle driver errors (Holahan, Culler and Wilcox, 1978; Young, Salmon and Cornelissen, 2013).

Driving has both mental and physical aspects; it produces a heavy cognitive load and requires the manipulation and coordination of the vehicular controls. Distraction has an impact on both these aspects of driving and results in error (Young and Salmon, 2012) and impairment to driving performance (Donmez, Boyle and Lee, 2008). Studies have shown that distraction has a significant impact upon driving due to periods when the motor vehicle driver's 'eyes are off the road' or periods of 'glance' at distractions, significantly increasing the risk of being involved in a collision (Klauer *et al.*, 2006; Horrey and Wickens, 2007; Donmez, Boyle and Lee, 2008; Young and Salmon, 2012; Peng and Boyle, 2015).

The impact of distraction, as well as appearing to induce errors (Young, Salmon and Cornelissen, 2013), relates directly to time. That being time distracted as well as the reaction time of motor vehicle drivers (Summala, 2000), and hence the movement of a vehicle and the relationship that movement has on the relative position of the vehicle to any hazard present within the road environment and any attempt to stop the vehicle (Summala, 2000). The most straightforward construct to allow comprehension of the issue can be consideration of the time, speed and distance relationship, needed to calculate stopping distances (Green, 2000).

With a vehicle in motion, time directly relates to the distance travelled by the vehicle, for example 30mph equates to 13.41m/s (conversion of mph to m/s x 0.447). Green (2000) suggests reaction times to common signals of around 1.25 to 1.5 seconds, yet, if a motor vehicle driver takes their eyes off the road of just one second, to be added to any reaction time, whilst travelling at that speed, they are 13.41m closer to any hazards when they look back. Peng and Boyle (2015) observed the longest period when a high risk motor vehicle driver had their eyes off the road was four seconds which results in a distance of 53.64m or around 13 and a half car lengths (using the 4 metre car length from the Highway Code breaking distances, rule 126 (Department for Transport, 2015e)). At 40mph the one second glance extends the distance to 17.88m and the four second to 71.52m or just under 18 car lengths.

This distance, therefore, then needs to be added to the distance covered whilst the motor vehicle driver thinks about what they are then seeing. Even if the motor vehicle driver does not take their eyes of the road the cognitive load already being used for the distraction results in an extended ‘thinking time’ in reaction to any hazard (Transport Research Laboratory, 2002a). If the final reaction transpires to be application of the brakes, the further distance required to stop in the prevailing conditions must be considered, as vehicles do not stop instantly. The extra distance taken during the distraction period (possibly with eyes off the road) and then the thinking time means that when action finally occurs the vehicle has moved much closer to the hazard. (Choudhary and Velaga, 2017; Horrey *et al.*, 2017; Lee *et al.*, 2018; Australian Road Research Board, 2019; D'Addario and Donmez, 2019; Louie and Mouloua, 2019; Zhang *et al.*, 2019).

2.4.5 Intoxicants

Some kind of Intoxication forms the regular daily practice for the majority of members of society (Bancroft, 2009), the taking of the substances aims to produce an 'artificially induced change in consciousness' (Becker, 1967). The everyday intoxicants, such as nicotine or caffeine produce mild effects (Bancroft, 2009).

An intoxicant, in relation to collision research encompasses a chemical substance, either natural or synthetic, which has the capability at a certain dose of impeding the function of the brain, usually described as psychoactive substances (Silverstone, 1974; Holder *et al.*, 2001; Department for Transport, 2010a; 2013a; Cooper *et al.*, 2011; Asbridge, Hayden and Cartwright, 2012; Aarts *et al.*, 2016). As a group of substances, it can contain legal substances such as alcohol, solvents, and medication as well as illicit substances such as narcotic drugs. The intoxication usually results from the interruption of neural transmitters or receptors. The level of impairment, to which neural functions, and hence the cognitive ability to drive safely depends on the substance involved. The neural impairment externally manifests in different ways and can be substance and dose related, such as, poorer judgement of speed and distance, slower reaction times or motor function or an increased acceptance of risk, amongst many (Berghaus, Sheer and Schmidt, 1995; Department for Transport, 2010a; Giorgetti *et al.*, 2015).

As well as impacting on neural function and psychomotor skills the substances can also effect mood, judgement and inhibition which may result in the individual behaving at odds with their normal behaviour patterns resulting in a higher acceptance of risk (Moskowitz, 1976; Terhune *et al.*, 1992; Fishbain *et al.*, 2003; Ronen *et al.*, 2010; Jeon, Walker and Yim, 2014). Many of these factors were taken into account by the panel of experts which reported to the UK government prior to the recent changes in drug drive legislation (Department for Transport, 2013a).

With regard to intoxicants there are two bodies of research. Specific research has been undertaken looking at the impact of particular drugs or combinations of drugs. This research gives a body of evidence in relation to the impact of the intoxicants on the ability of individuals to drive safely and has often been achieved through direct experimentation. Subjects have been given regulated drug doses and then their ability to drive assessed (Moskowitz, 1976; Berghaus, Sheer and Schmidt, 1995; Logan, 1996; Hadorn, 2004; Kelly, Darke and Ross, 2004; Macdonald *et al.*, 2008; Lenné *et al.*, 2010; Hartman and Huestis, 2013; Huestis, 2015) with this type of research ethical considerations have always been paramount. Although there are variations of affect with drug and dose the consensus being that intoxicating substances impede cognitive function resulting in higher risk of collision

The other body of research involves the epidemiological examination of the prevalence of intoxicants in incident statistics, and often considers the findings in terms of increased risk. The research clearly shows an increased risk of involvement in collisions if intoxicating substances are present in the body (Smith and Popham, 1951; Warren *et al.*, 1981; Terhune, 1983; Robertson and Drummer, 1994; Drummer *et al.*, 2004; Bernhoft, 2011).

Although variation occurs within the research into particular intoxicants, regarding the specific severity of effect or the multiplication in risk, the consensus that the mixing of intoxicants and the act of driving are incompatible with safety can be drawn, with evidence of impairment to both cognitive and psychomotor skills and the resulting clear evidence of an increase in the risk of collision and injury (Department for Transport, 2013a).

2.4.6 Other Factors Affecting Cognitive and Psychomotor Function

The impact of fatigue and tiredness on both the cognitive function and psychomotor skills of motor vehicle drivers are well understood, with comparisons to impairment by intoxicants and the relationship between the human body clock to time of day (McBain, 1970; Brown, 1994; Knipling and Wang, 1994; Summala and Mikkola, 1994; Bunn *et al.*, 2005; May and Baldwin, 2009; Road Safety Observatory, 2013; Balasubramanian and Jagannath, 2014; Heslop, 2014). Fatigue was recorded as a contributory factor in four percent of fatal and two percent of serious injury (STATS19 categorisation) collisions in the 2019 road casualties in Great Britain (Department for Transport, 2020b). ‘Don’t Drive Tired’ or ‘Tiredness Kills take a break’ legends are commonly seen on UK motorway display systems.

When a motor vehicle driver has a pre-existing medical condition, this can impact on any number of the human functions required to safely operate a moving vehicle. Examples of medical conditions that have been explored are described below.

Vision only in one eye, where McKnight, Shinar and Hilburn (1991) found that although monocular vision did have impacts on depth perception and some significant reductions in visual capabilities it did not significantly increase collisions risk. Lindsey and Baldock (2008) in examining fatal collisions in Adelaide identified eight conditions which had potentially put the motor vehicle drivers at risk, these being; epilepsy, cardiovascular conditions, dementia, cerebrovascular accidents, diabetes, and eye conditions such as cataract and glaucoma, the medical conditions accounted for the main causal factor in 13 percent of the collisions examined. McDonald, Sommers and Fargo (2014) examining mental health in late adolescents and young adults did observe more risk taking behaviours. The European Commission (2015) observed increased physical fragility in some older motor vehicle drivers with medical conditions which resulted in them driving less and for shorter distances with increased relative risk with many conditions, such as angina. El Farouki *et al.* (2014) found attention-deficit/hyperactivity disorder in subjects resulted in an increased level of responsibility for collisions. The factors described in this paragraph can be recorded in the STATS19 collisions data using a contributory factor code of 505 (Illness or disability, mental or physical) and in 2019 this contributory factor was recorded against eight percent of fatal and three percent of serious injury (STATS19 categorisation) collisions in Great Britain (Department for Transport, 2020b)

Older motor vehicle drivers have been the focus of a number of studies. The proportion of the UK population over 65 stands at 17.3 percent and estimated to reach 23.0 percent by 2043 with the population of over 85s expected to grow from the current 1.6 million to around 3 million by mid-2043 (Office for National Statistics, 2019c). As the older population grows and living longer the number of older people driving also grows (Ball and Owsley, 1991; Department for Transport, 2001; 2018a; Mayhew, Simpson and Ferguson, 2006; Clarke *et al.*, 2010b). The research by Ball and Owsley (1991); Dulisse (1997b; 1997a) and the European Commission (2015) combined multiple factors to examine overall risk.

Whilst others explored specific risk factors; Mayhew, Simpson and Ferguson (2006) examined the condition and locations where older motor vehicle drivers were involved in collisions and noted the increased risk at junctions but found the combination of physical and cognitive impairment which led to the collision was unclear. Clarke *et al.* (2010b) also examined the increased incidents of junction collisions in older motor vehicle drivers and proposed that the cause appears to be reduced cognitive function creating change blindness, namely the inability to perceive changes in what they were observing. In Cooper *et al.* (2011) a literature review of the impact of psychotropic medication on older motor vehicle drivers suggested that there were several medications which can have an impact on collision risk. Older motor vehicle drivers may be at higher risk due to functional, cognitive or perceptual decline (Mayhew, Simpson and Ferguson, 2006; Clarke *et al.*, 2010b; European Commission, 2015), with some motor vehicle drivers understanding their limitations and self-regulating by limiting their driving to daylight or good weather for example (Ball and Owsley, 1991).

The statistics make it clear that older motor vehicle drivers are involved in fewer collisions than younger motor vehicle drivers (Department for Transport, 2018a); however, they also drive fewer miles so the rate of collisions per billion miles appears comparable with young inexperienced motor vehicle drivers with the 86+ years age group exceeding that of the 17-24 year olds (Department for Transport, 2018a). In 2016 in Great Britain, 10 percent of injury collisions involved an older motor vehicle driver, this was up from 5 percent in 1990, as well as the proportion of injury collisions which involved an older motor vehicle driver increasing the total number of collisions the age group were involved in increasing over the same period. The increase was 5 percent, this was in contrast with an overall decline in the total number of injury collisions of 48 percent (Department for Transport, 2018a).

2.5. Exposure

Exposure can be explored on two levels but can be broadly considered to be the probability of a collision occurring for any given use of a transport system (Hauer, 1982). At the macro level, exposure can be considered ideally to describe the relationship between traffic volumes and collision frequency, which usually involves increases in traffic volume corresponding to increased collisions. Although not a linear relationship, reducing traffic volumes can have an impact on collision frequency (Elvik *et al.*, 2009). At a macro level, the exposure of different classes of road user, such as motorcyclists or cyclists, can further emphasise vulnerability, these analyses of exposure being used in the annual casualty statistic for Great Britain (Elvik *et al.*, 2009; Department for Transport, 2019c).

There are some issues with macro level exposure measurement, although system traffic volumes can demonstrate broad contexts, they lack the sensitivity to deal with variation in traffic flows throughout the day or at specific locations, these situations may require more detailed traffic surveying (Elvik *et al.*, 2009).

On a micro level, exposure has been considered in relation to individual people and how much driving had been undertaken, or presence on the road network in the case of non-drivers, impacts on collision risk, with Chipman (1982) considering it a concept which can be easy to understand, measurement however, being difficult. (Chapman, 1973; Chipman, 1982; Hauer, 1982; Wolfe, 1982; Janke, 1991; Transport Research Laboratory, 2010).

There are a number of matters which may present problems when exploring exposure. For motor vehicle drivers, a non-linear or proportional relationship appears to exist between exposure (mileage) and collisions. The relationship usually being described as curvilinear (Maycock, 1996; Daigneault, Joly and Frigon, 2002; Hakamies-Blomqvist, Raitanen and O'Neill, 2002; Parmentier *et al.*, 2005; af Wåhlberg and Dorn, 2009; af Wåhlberg, 2011) as noted above. This implies that as exposure increases the rate of collision increases, however, as the mileages increase the rate of increase in collisions slows to a plateau at the higher mileages where the number of collisions does not increase and the rate for any given exposure starts to fall.

The main problem being the resultant curvilinear relationship and the interpretation of the curvilinear relationship between exposure and collisions (af Wåhlberg, 2009) with highly exposed motor vehicle drivers having a low collision to distance relationship (Maycock, 1985; Daigneault, Joly and Frigon, 2002; Parmentier *et al.*, 2005) with the opposite of low expose high collision rate also found (Alvarez and Fierro, 2008). It has been suggested that the curvilinear relationship itself was created by biases in the methodologies used (Staplin, Gish and Joyce, 2008; af Wåhlberg, 2009) and when these are accounted for, there was little curvilinearity remaining which may be accounted for by experience factors (af Wåhlberg, 2009). Further, the reliability of exposure has been questioned, the main issue being the reliance on survey data, which may not be a genuine reflection of actual exposure, as people do not keep records of their exposure over time they are relying on memory when completing the survey and often under-report collisions (Brown and Berdie, 1960; Harano, Peck and McBride, 1975; Owsley *et al.*, 1991), there are also concerns that there may be a low mileage bias (Wolfe, 1982; af Wåhlberg, 2009; 2011).

Anderson (2005) frames risk exposure as directly linked to short term travel mobility, that being the mode of travel, times of travel and so on. Therefore, the risk exposure for different groups who use the road varies. For example, contrast the risk exposure between a child walking to school with a child being driven to school as a passenger in a car. Children walking to school, are unprotected as they are not in vehicles, although whilst on the footway are safer than when they are crossing the carriageway. They may not be road safety aware yet may be supervised by adults who are. Their route may have designated crossings and may have areas where there are barriers separating vehicular traffic on the carriageway from the pedestrian traffic on the footway. Their conspicuity varies according to what they are wearing, the light conditions, which vary during the year and so on, although the distance travelled may be lower than that of a child driven to school. The child passenger in the car, assuming legal compliance, enjoys the protection of the vehicle and depending on the year of manufacturer this may incorporate all the active and passive safety engineering currently available. The motor vehicle driver being a person who has been subject to all the licencing and training safety measures currently in force who has been subject to road safety messaging. The risk exposure of these two children differs when all these factors are considered.

Af Wåhlberg (2009) explored the balance between motor vehicle driver behaviour and exposure in determining collision risk, so, how they drive compared to how far they drive. Taking account of the relationship between collisions and exposure not being a curvilinear as previously described and much more linear in nature it can be interpreted that exposure does not have a great impact on collision variance, and that individual differences (behaviour) are a much stronger determinant of collision risk.

The individual differences being so strong that the exposure considerations can be considered noise. Therefore, collision risks are more related to who the motor vehicle drivers are rather than their exposure.

The relationship between age and mileage exposure, shown in figure 2.2 below, presents the number of car drivers involved in collisions, by age, miles driven per person and the rate of car drivers involved in collisions per billion vehicle miles travelled in England during 2016. This formed part of a report into older motor vehicle drivers by the Department for Transport (2018a) using data from STATS19, National Travel Survey, and the National Road Traffic Census. The figure showing the data is presented in appendix two.

The report notes the marked rise in collision rate at older ages when exposure was decreasing, however, the data shows the increased risk for younger motor vehicle drivers with lower exposure. The report also highlighted that other factors involved in any construct of exposure have impact beyond purely the distances driven, the time of day, and day of the week impact on the risk of being involved in a collision, therefore, exposure based on distance alone may be too course to deal with risk at any given situation. With older motor vehicle drivers this may be a function of cognitive ability as previous discussed in section 2.5.6 (Ball and Owsley, 1991; Dulisse, 1997b; 1997a; Mayhew, Simpson and Ferguson, 2006; Clarke *et al.*, 2010b; Cooper *et al.*, 2011; European Commission, 2015).

The Transport Research Laboratory (2010) explored how graduated driving licences may reduce the high collision rate in younger motor vehicle drivers, as demonstrated in figure 2.2 above, and recommended their adoption in all jurisdictions. Rather than considering exposure in terms of total mileage the report considers exposure to higher risk situations where the young motor vehicle driver's lack of experience, skill and training could increase their risk of collision. The conclusion that collisions are caused in high risk situations because of the person factors revolving around experience support af Wåhlberg's (2009) assertion regarding individual differences outweighing exposure to such a degree that the exposure element could be considered noise.

2.6. Interventions

Interventions are commonly understood to refer to the actions taken by an agency which are designed to prevent or mitigate the impact of collisions. There are multiple points at which the antecedent events, the matters or factors leading to the collision, can be disrupted by some form of intervention to steer them away from resulting in a collision (Wagenaar and Reason, 1990; Phillips, Ulleberg and Vaa, 2011), however, it can be difficult to pinpoint the effect on any particular characteristic of the motor vehicle driver and how an intervention may interact with that characteristic (McKnight, Shinar and Hilburn, 1991). There has been acknowledgement that injuries, as a result of collisions, are preventable so appropriate actions can reduce the number of casualties, casualties are not inevitable (Haddon, 1980; Holder *et al.*, 2001).

There are three considerations when framing the utility of a road safety intervention, the selection of the right intervention to deal with the identified problem (Phillips, Ulleberg and Vaa, 2011), the application of the intervention in the right location (Armstrong *et al.*, 2017) and finally the application of the intervention to the right audience (Bingham, Elliott and Shope, 2007; Portman *et al.*, 2013; Møller, Haustein and Prato, 2015).

At which point the intervention intersects the events leading to a collision depends on the intervention proposed. Elvik *et al.* (2009) have produced a compendium of road safety measures, setting out in full the principles involved. Groeger (2011) frames interventions within the widely used constructs of education, enforcement and engineering or the three Es, not always in that order, and this has been expanded in recent years to include a fourth E (Road Safety Authority, 2007; Transportation Research Board, 2007; Federal Highway Administration, 2011; City of London Canada, 2014; Road Safety GB, 2019). However, what constitutes that fourth E can depend on who defines it. For example Road Safety GB (2019) considers the fourth E to refer to evidence, the Irish Republics Road Safety Authority (2007) evaluation and in other contexts it may be considered to refer to emergency medical service, emergency response or a similar construct involving post collision medical attention (Transportation Research Board, 2007; Federal Highway Administration, 2011) or as alternative as empathy (City of London Canada, 2014).

There are further alternatives to the fourth E or additional Es which include more factors in addition to the traditional three E’s, such as economics, emergency response, enablement and ergonomics, all of these are considered in a safe system approach to road safety (Plant, McIlroy and Stanton, 2018). With work towards intervention modelling and decision making, for example, being undertaken on a European level (Thomas *et al.*, 2016), though not globally (International Transport Forum, 2019b).

Education primarily acts as a preventative tool based on the idea of changing the attitudes, norms and thought processes of individuals who may be involved in collisions so that they do not create the situations where collisions may occur.

Education can take many forms and be aimed at very different audiences depending on the issue being tackled. For example, the education of motorcyclist regarding their conspicuousness, i.e. the wearing of high visibility clothing or a white helmet, may not be a legal requirement but features as advice in the Highway Code (Hurt, Hancock and Thom, 1984; Department for Transport, 2015h).

Enforcement varies between jurisdictions, being dependent on the requirement to enforce safety related law and regulations by appropriate governmental authorities to induce compliance in the road using population, and hence improve safety. Enforcement can form part of a long term aim to change the norms and attitudes of road users (Bates, Soole and Watson, 2012). This enforcement often, but not exclusively, falls on the policing organisations within the jurisdiction. However, for example, in the UK as well as police enforcement there are also Vehicle Examiners of the Vehicle and Operator Services Agency who primarily deal with large good vehicles and in some areas certain offences have been de-criminalised and are dealt with by local authorities (Parker, Stradling and Manstead, 1996; Gains *et al.*, 2005; Poulter *et al.*, 2008; Quddus, 2008b; Bogstrand *et al.*, 2012; Bradford *et al.*, 2015; Transport Research Laboratory, 2015; Department for Transport, 2019i).

Enforcement attempts to work on a number of levels, with deterrence as well as an attempt to set norms of compliance (Grasmick and Bursik, 1990; Grasmick, Bursik and Arneklev, 1993; Zaal, 1994; Rose, 2000; Rice, Peek-Asa and Kraus, 2004; Freeman *et al.*, 2006; Bates, Soole and Watson, 2012; B Watson *et al.*, 2015; Transport Research Laboratory, 2015; B. Watson *et al.*, 2015; Roach and Pease, 2016; Allen, Murphy and Bates, 2017; Roach, 2019). The impacts of enforcement are mixed, for example, the enforcement of construction and use regulation, keeping vehicles roadworthy compared to speed enforcement. In 2019 vehicle defects were noted as contributory factors in two percent of fatal and two percent of serious injury (STATS19 categorisation) collisions, yet, excess speed was noted as contributory in 15 percent with travelling too fast for the conditions noted in nine percent (Department for Transport, 2020b). It has been observed that a reduction in enforcement correlates to increased collisions involving the related factor (Her Majesty’s Inspectorate of Constabulary and Fire and Rescue Services, 2020).

Deterrence and compliance are central to the criminal justice enterprise (Zimring and Hawkins, 1973; Kennedy, 2008), which have a foundation in the long standing criminological concepts of choice and routine (Felson, 1986). Theories which involve choice and routine suggest that an individual chooses to offend as part of their normal routine behaviour (Felson, 1986; 2002; Cornish and Clarke, 2014). However, with sufficient chance of apprehension and punishment these factors interdict in the choice process and act as a deterrent, the presence of a capable guardian, be it police or other enforcement options, such as cameras, increase the deterrent effect (Felson, 1986; Birkbeck and Lafree, 1993; Kennedy, 2008). The choice process and decision making are also influenced by an individual’s self-control or lack of it in cases of low self-control, with self-control linked to learned behaviour (Cohen and Felson, 1979; Felson, 1986; Akers, 1990; Gottfredson and Hirschi, 1990; Stafford and Warr, 1993; Cornish and Clarke, 2014). Deterrence can be both general, i.e. producing an overall deterrence for all offending, or specific, in deterring one offence or type of offence (Ross, 1982; Stafford, 2015), with Walker (1979), conceptualising general deterrence as a function of imagination and specific deterrence a function of memory. Ajzen (1985; 1991; 2005) proposed that choices, which were presented as binary, objective and bounded within wider social constructs in some of the alternative theories, i.e. undertaking an act as being either right or wrong, a good idea or not or maybe anti-social or not, were actually framed and guided by an individual's attitudes, perceptions and subjective norms and linked to habitual behaviour.

Andenæs (1952; 1974) proposed a theory of general prevention, founded on an emphasis towards shame and embarrassment as mechanisms. Shame was found to have an apparent longer-term deterrence impact as part of a re-integrative shaming process (Braithwaite, 1989), being the basis for restorative justice. The principle being that the primary stakeholder, i.e. the victim, cooperates in determining how best to repair the harm caused by the act (McCold and Wachtel, 2003). Although restorative justice has become an integral part of the UK criminal justice system, with some success, there are still shortcomings. The shortcomings centre on victim involvement, the role of the community, which was integral in the indigenous people's practices that led to the theory, and its use for only relatively low level offences (Hoyle and Rosenblatt, 2016).

Both education and enforcement are aimed at creating behaviour change, i.e. encouraging motor vehicle driver's behaviour, see section 2.4.1, to change the way they drive to reduce the risk of collision or mitigate the impact when a collision occurs and make safe driving their norm (Conner and McMillan, 1999; Stead *et al.*, 2005; Nasvadi, 2007; Elliott and Armitage, 2009; Elliott *et al.*, 2013; Ellison, Bliemer and Greaves, 2015). However, facilitating behaviour changes are not straightforward or quick (Department for Transport, 2006c; Ellison, Bliemer and Greaves, 2015) with persistence being essential (Department for Transport, 2006c; 2014a; 2017a), although evidence suggests that involvement in incidents such as a collision does change behaviour (Mayou, Simkin and Threlfall, 1991).

Engineering of the physical road network can produce significant benefits towards road safety (Ogden, 1996), simple measures such as better or more visible signage can reduce collisions (Navin, Zein and Felipe, 2000) or the changing of junction design (Hydén and Várhelyi, 2000). There have also been many huge improvements in the engineering of vehicles which have increased survival rates and reduced injury severity, such as, the introduction of rigid safety cells, airbags, and crumple zones. All designed to improve the ‘packaging’ of the occupants (Haddon, 1968).

The three Es and other interventions can be framed in a safe system approach which takes a holistic approach to the use of the roads, with an acknowledgement that humans are fallible and make mistakes, and failures in the ‘system’ result in collisions and injury (Parliamentary Advisory Council for Transport Safety, 2016; Towards Zero Foundation, 2019; The Royal Society for the Prevention of Accidents, 2021).

Interventions are therefore devised to interfere at some stage during the collision script or narrative, the aetiological sequence of events (Haddon, 1968; Williams, 1999), to either prevent the collision or mitigate the impact and can act on any of the five elements. Examples of interventions in each of the elements are presented below.

- Safe roads and roadsides – interventions could include separation of traffic in opposite directions or separation of vulnerable road users such as cyclists from the remaining traffic through to improved barrier design.

- Safe speeds – legislation, enforcement, and education regarding speed with appropriate limits through to the re-engineering of roads to reduce speed through traffic calming for example.
- Safe vehicles – passive measures such as seatbelts or airbags through active measures such as emergency braking or lane departure warning and appropriate legislation, enforcement, and education to ensure the vehicles being used on the road are as safe as possible.
- Safe road use – legislation, enforcement and education regarding the safe use of the road, this could include legislation, enforcement and education regarding the safe use of the road and appropriate safe motor vehicle driver behaviour, such as not drinking and driving or driving under the influence of drugs.
- Post-crash response – improvements in emergency service and medical response to trauma to improve car and outcomes.

Road safety concerns are longstanding, for example, in the UK, concerns over the number of collisions involving motor vehicle drivers who had drunk too much alcohol prompted legislation in the form of the *Road Traffic Act 1930.* But this was not then updated until the *Road Safety Act 1960* and introduction of the concept of being unfit to drive. The *Road Traffic Act 1962* followed quickly introducing for the first time the power to obtain a sample of breath, blood or urine and enabled the use of such evidence against an accused. This legislation still required the motor vehicle driver to be unfit with the level of intoxicant only present to reinforce this position (Department for Transport, 2010a). The Government then announced on 18 June 1965 that there would be drink driving legislation introduced with a prescribed limit (BBC, 2018) this would mean that police officers would no longer have to prove impairment but could rely on a device and a blood test to prove the offence, this came in the form of the *Road Safety Act 1967*.

Although there have been amendments and enhancements to the legislation over time the current offences contained within the *Road Traffic Act 1988* are essentially the same. The legislation forms only one aspect, there has been constant campaigning by the government and road safety charities focussed on changing attitudes (Department for Transport, 2010c; 2014a; 2015i; 2017a; 2020f). Over the proceeding 50 years since 1967 the persistence has produced societal change of attitude in the UK, with drink drive now generally considered socially unacceptable (Department for Transport, 2014a). Although action can be taken at a governmental level to legislate for safety it can often take a considerably longer time to effect societal change to support it (Department for Transport, 2010a; 2014a; 2017a).

The key point with interventions being that whichever framework was used and whatever interventions are implemented there are no single interventions which in themselves are the panacea for reducing death and injury on the road. Only by combining interventions and applying them in the right situations to the right individuals do they have the cumulative effect required.

The application of interventions can be enhanced by the use of social marketing (Smith, 2006; Bird and Tapp, 2008; Tapp *et al.*, 2013) where once the target audience has been identified the interventions are tailored to the segments ''worldview' (culture, attitudes, beliefs and behaviours)' (Tapp *et al.*, 2013, p. 150) with the methods successfully applied to young drivers segmented crudely by socio-economic status (Tapp *et al.*, 2013).

2.7. Data linkage

Data linkage describes studies which bring together information held on two datasets, with a belief that records held on both datasets belong to the same entity, using identifiers or quasi-identifiers (Shlomo, 2019).

The process of data linkage has synonyms which have developed within different fields, for example, artificial intelligence, refers to it as database hardening (Cohen, Kautz and McAllester, 2000) or name matching (Bilenko *et al.*, 2003). Other terms used include in business applications data heterogeneity (Chatterjee and Segev, 1991) and data cleaning (Sarawagi, 2000); in the database industry data scrubbing (J. Widom, 1995); in genetics and family history entity resolution, record linkage or record matching (Newcombe *et al.*, 1959; Newcombe and Kennedy, 1962; Newcombe, 1967; 1988; Tepping, 1968; Fellegi and Sunter, 1969); in data mining and related topics merge purge (Hernández and Stolfo, 1998); in consumer dataset analysis data integration, re-identification, entity heterogeneity, merge/purge, data deduplication (Sarawagi and Bhamidipaty, 2002); in data engineering instance identification (Wang and Madnick, 1989) and coreference resolution and duplicate record detection (Elmagarmid, Ipeirotis and Verykios, 2007). Despite the diversity of terms, the foundation being built on the combining of two datasets to discover records in each which are common to an individual or entity.

Datasets are created to fulfil a specific objective, and are legally obliged to do so, and as such the objective restricts the information held (*Data Protection Act 1998*; *Data Protection Act 2018*). However, different datasets often hold information regarding the same individual. The art of data linking being the bringing together of data about individuals that allow examination of relationships which would not be available from the individual datasets.

For example Abrahams and Davy (2002) undertook a linkage process between hospital maternity records and the data relating to registered births. Although the two datasets both have data in common, such as date of birth and birth weight other data such as the mothers gestational age, ethnic origins and previous medical history are not. Linking the data was envisaged as a way to enhance the statistical understanding around birth outcomes. The examination of these relationships can be insightful with the insight created by the richness of the dataset after linkage (Abrahams and Davy, 2002; Grannis, Overhage and McDonald, 2002; Department for Transport, 2012b; Dipnall *et al.*, 2014; Harron, 2016; Harron, Dibben, *et al.*, 2017; Gilbert *et al.*, 2018). The data produced by the linkage may require secondary analysis to yield value and the linking process needs to be systematic (Dawes, 1996; Anderson, 2005; Bohensky *et al.*, 2010; Zapilko, Harth and Mathiak, 2011; Department for Transport, 2012b; Dipnall *et al.*, 2014; Hagger-Johnson *et al.*, 2015; Harron, Goldstein and Dibben, 2016; Loo and Anderson, 2016; Hagger-Johnson *et al.*, 2017). For example, in linking the details of individuals injured in collisions to geodemographic data (see section 2.9) the secondary processing of the geodemographic data allows for comparison to the general population distributions to determine risk (Anderson, 2005; 2010). An understanding of the product of the secondary analysis was the basis for the linkage.

The perceived benefits of linking data together were contemplated before data was held electronically and computing power made the linking of huge datasets a practical proposition (Dunn, 1946). The principles of linking records which relate to an individual were developed during manual linking of non-electronically held data during the decades after the Second World War with such wide reaching implications that they have been considered by the United Nations (Newcombe *et al.*, 1959; Newcombe and Kennedy, 1962; Fellegi and Sunter, 1969; United Nations, 1991), with the United Nations (1991) presenting many examples including use in epidemiological studies (p.15) where death records can be a retrospective starting point that can allow for the testing of hypotheses which relate to disease causation and links between etiological factors and diseases.

The nature of the data, and the quality of the data, are crucial in the methodological choice used to link data. For example, where a unique identifier common to both datasets or a number of non-unique common variables (*quasi-identifiers* or *partial-identifiers*) between datasets, and the quality of the data allows, a deterministic method can be employed with the link based on the exact matching of the selected variables in both data according to a set of rules (Dal Maso, Braga and Franceschi, 2001; Abrahams and Davy, 2002; Grannis, Overhage and McDonald, 2002; Mears *et al.*, 2010; Department for Transport, 2012b; Sariyar, Borg and Pommerening, 2012; Harron, Goldstein and Dibben, 2016; Shlomo, 2019).

Deterministic processes are popular as they lend themselves to automation (Grannis, Overhage and McDonald, 2002; Harron, Goldstein and Dibben, 2016; Hagger-Johnson *et al.*, 2017). As deterministic processes are based on exact matches it produces a low rate of mis-matches, with Hagger-Johnson *et al.* (2015) obtaining a mis-match rate of 0.2 percent in the study as well as a missed match rate of 4.1 percent. If there are issues with data quality then deterministic processes may be too restrictive and miss possible matches, however, if data quality improves the missed match rate reduced, Hagger-Johnson *et al.* (2017) found that between 1998 and 2015 as data quality improved the missed match rate fell from 8.6 percent to 0.4 percent.

Where there are issues with data quality, for example where the two datasets were constructed by different organisations with different data standards or formats, a probabilistic process may provide the linkage required (Dulisse, 1997a; Bohensky *et al.*, 2010; 2011; International Transport Forum, 2011; Deka and Quddus, 2014; Connolly, Grigg and Desouza, 2018). A probabilistic process examines the data using a weighting system which allocates weight on the ability of a value to determine a match or non-match and minimise false-matches. Weights have to be subject to manual review before being set, with reviewers suitably trained to minimise any subjectivity, an element of trial and error may be required in setting the weights (Newcombe *et al.*, 1959; Dal Maso, Braga and Franceschi, 2001; Harron, 2016). A probabilistic process can be used to follow a deterministic process to deal with any missed matches caused by data quality issues (Fellegi and Sunter, 1969; Zhu *et al.*, 2009; Amorim, Ferreira and Couto, 2014; Zhu *et al.*, 2015; Harron, Goldstein and Dibben, 2016; Winkler, 2016; Hagger-Johnson *et al.*, 2017).

The data used to achieve the linking depends on availability in the datasets. The simplest linkage can be performed using a deterministic linkage process utilising a common identifier. The common identifier could be something such as a National Insurance number in the UK but as Grannis, Overhage and McDonald (2002) in their American based study termed Social Security Number (SSN), where they matched SSN to link hospital patient records to death records which both contained the individual's SSN. In the UK, the National Health Service Number has been used (Hagger-Johnson *et al.*, 2015; 2017; Gilbert *et al.*, 2018).

However, data quality can impact the use of such data and the deterministic process may need support from a probabilistic process to deal with this (Hagger-Johnson *et al.*, 2017). Deterministic process can also be used on a combination of other variables which may not be unique identifiers but their combination would result in the identification of an individual, these could include, although not exhaustively, variables such as date of birth or combinations of data such as year of birth, a date or time attached to both records, surname, gender and postcode (Abrahams and Davy, 2002; Tromp *et al.*, 2008; 2011; Mears *et al.*, 2010; Amorim, Ferreira and Couto, 2014; Hagger-Johnson *et al.*, 2015; 2017; Harron, 2016; Gilbert *et al.*, 2018).

The probabilistic process also needs to use data common to both the datasets so would utilise the same data as a deterministic process, however, the manner of treatment of the data changes. In the probabilistic process the data or even parts of the data are weighted to allow combinations of less than full and exact matches to flag as possible matches, for example gender may have a high weight as it may contribute more evidence of agreement than the time of an incident but maybe less than a date of birth (Amorim, Ferreira and Couto, 2014; Harron, 2016).

The process can also allow for variation in nominal data, for example the day element of a date may be allowed to vary by a predetermined number of days and still flag as a possible match (Amorim, Ferreira and Couto, 2014) or incorporate alternative spelling, miss-spellings or abbreviations (Newcombe, Fair and Lalonde, 1989a; 1989b; Winkler, 1995; Grannis, Overhage and McDonald, 2004; Elmagarmid, Ipeirotis and Verykios, 2007; Harron, Dibben, *et al.*, 2017).

The aim of any data linkage, that being to identify a record relating to an individual in one of the datasets which matches a record in the second dataset which relates to the same individual, can be variously described as a 'linked', 'true-link', 'true linkage', 'match', 'true-match' ,'true-matches' or 'correct matched' with records that do not relate to the same individual being a 'non-linked', 'non-match', 'non-matched', 'non-matches' or 'unmatched' (Doll, 1968; Dulisse, 1997a; Dal Maso, Braga and Franceschi, 2001; Grannis, Overhage and McDonald, 2002; Leiss, 2007; Méray *et al.*, 2007; Elmagarmid, Ipeirotis and Verykios, 2007; Qayad and Zhang, 2009; Tromp *et al.*, 2011; Department for Transport, 2012b; Wasi and Flaaen, 2013; Amorim, Ferreira and Couto, 2014; Alexandersson, 2017; Harron, Dibben, *et al.*, 2017; Hagger-Johnson *et al.*, 2017; Gilbert *et al.*, 2018; Shlomo, 2019). However, data linkage processes are not perfect. Errors occur and their nature depends on the process being used and the quality of the data, without unique identifiers it may not be possible to ascertain the extent (Harron, Goldstein and Dibben, 2016; Hagger-Johnson *et al.*, 2017). The types of error that can occur are summarised and presented in the table 2.1 below (Doll, 1968; Dulisse, 1997a; 1997b; Transport Research Laboratory, 2001; Elmagarmid, Ipeirotis and Verykios, 2007; Leiss, 2007; Tromp *et al.*, 2008; Petridou *et al.*, 2009; Wasi and Flaaen, 2013; Hagger-Johnson *et al.*, 2015; 2017; Harron, 2016; Harron, Dibben, *et al.*, 2017; Gilbert *et al.*, 2018).

Table 2.1 Linkage error types

Type of error	**Circumstances**
'False match', 'False matches', 'mismatches', 'False link' or 'False linkage'	This type of error occurs when two records are matched when in fact, they should not be
'Missed match' or 'false non-link'	This type of error occurs when there are two records which should be matches as a pair but for a systematic or data reason the match not recognised

2.7.1 Police and Hospital Data Linkage

From the literature review it was evident there have been studies which linked police collision data and hospital data in the UK, as well as other countries (Transport and

Road Research Laboratory, 1984a; Rosman and Knuiman, 1994; Petridou *et al.*, 2009; Wilson, Begg and Samaranayaka, 2012; Amorim, Ferreira and Couto, 2014). In the UK the police collision data was almost always in the form of STATS19, however, the hospital data that has been used has varied between the studies. The UK based research which involves the linkage of police collision data and hospital data being presented in appendix two.

In comparing the methodology used in these papers there are themes evident. The series of papers produced by Transport and Road Research Laboratory (1980; 1984b; 1987) and continued by the rebranded organisation, Transport Research Laboratory (1993b; 1996; 1999; 2001; 2002b) all use the method used in Transport and Road Research Laboratory (1984b) which in itself was a revised version of the method used in Transport and Road Research Laboratory (1980). This method in common with the remainder of the papers was a deterministic process based on the common variables available within the datasets to be linked. Age and gender feature in all the processes, with other variables, such as incident date or incident regions used as available in the data with all process utilising four or five variables. This commonality of method format suggests this as the most effective available when dealing with police collision and hospital patient data.

Even the earliest research by Bull and Roberts (1973) identified the under reporting of injury collisions, in that patients presenting with injury at hospital which was attributed to a collision did not appear in police collision data. Consistently, the under-reporting proportions vary with injury severity, fatal collisions are, in almost all cases, reported, serious injury collisions are reported in the region of 75-85 percent of the time, with slight injury collisions in the region of 60-65 percent reported (Bull and Roberts, 1973;

Transport and Road Research Laboratory, 1980; James, 1991; Transport Research Laboratory, 1993b; 1996; 2002b; Cryer *et al.*, 2001). Consistency also occurs when MAIS3+ casualties are examined or estimated as a proportion of the STATS19 serious injury severity category, at somewhere in the 8-22 percent region (Transport and Road Research Laboratory, 1984b; 1987; Transport Research Laboratory, 1999; 2001), also being consistent with Department for Transport (2015b; 2019d, p.22) estimations of around 11 percent for 1999 to 2010 rising to 16 percent in 2016. There are also issues with misclassification of serious injury by the police officer (Transport Research Laboratory, 1993b; 1996; Cryer *et al.*, 2001; Department for Transport, 2012b). However, what was clear was that as injuries become more serious there was more likelihood that the collision was reported by the police (Transport and Road Research Laboratory, 1980; Cryer *et al.*, 2001; Department for Transport, 2012b).

2.8. Culpability

Road safety interventions, see section 2.6, in the form of enforcement, focus activity towards those that undertake behaviours which have been linked to factors which influence collisions occurring or impact on the severity, such as speed (Transport Research Laboratory, 2015). Yet, other forms of intervention, such as education often have a much wider audience, either the whole driving population, or a segment differentiated by a broad criteria such as age (Department for Transport, 2019i). The only way to explore which motor vehicle drivers caused or were responsible for causing collisions, and hence who to target with interventions, would be to undertake an assessment of each motor vehicle driver's culpability for the collision.

> Failure to control for the factor of culpability in accident research is a serious methodological error which can obscure meaningful associations or otherwise lead to erroneous conclusions. (Banks *et al.*, 1977, p. 13).

The use of culpability studies, also termed responsibility, are one of the four common epidemiological observational study designs used in road safety analysis, the three others being case-control, case-crossover and quasi-induced exposure designs (Kim and Mooney, 2016). A useful definition of culpability comes from af Wåhlberg (2002),

> Only an accident where the …driver could clearly not have avoided the accident would he be 'acquitted' of responsibility. (af Wåhlberg, 2002, p. 640).

The earliest study exploring culpability was undertaken by Smith and Popham (1951) exploring the impact of alcohol on collision causation. A summary of the four designs being presented in appendix two, the key issue separating the designs are the risks of bias.

The use of culpability analysis, given a suitably robust process, with explicit written rules, can be used to compare the culpable motor vehicle drivers involved in collisions with the non-culpable motor vehicle drivers (Dorn and af Wåhlberg, 2019). Yet, despite the need to understand which motor vehicle drivers may be culpable, the majority of the research which utilises analysis of culpability does so from the perspective of understanding the impact of an aggravating factor on the risk of causing a collision, be it various forms of intoxication through to personality traits. What it has not been used for in any of the available studies was as a segmentation tool to allow focus only on motor vehicle drivers deemed culpable for a collision and no such use has been found in the literature. A summary of literature which has considered culpability as a stage of the research, the factor which the research was examining, and the culpability method described are presented in appendix two.

In all available studies the factor being explored did have the impact of increasing the likelihood of being culpable for the collisions which occurred. It was clear from an examination of the methodology employed in the studies that the culpability scoring tool devised by Robertson and Drummer (1994) has been utilised in more studies than any of the other available tools.

The idea that interventions focused on motor vehicle drivers because of their propensity to be involved in collisions can only be a valid approach if there are some correlations between the individual’s stable variables (driving behaviour, personality, risk taking, geodemographic status, and so on), often framed as accident proneness, and an ability to predict future events (Babarik, 1968; Terhune, 1983; Jonah, 1997; Organisation for Economic Co-Operation and Development, 1997; af Wåhlberg and Dorn, 2007; af Wåhlberg, 2009). In all likelihood unstable individual variables (such as bereavement, relationship breakdown, employment interruptions and so on) have an impact on the propensity to be involved in collisions, however, as a predictive tool these are likely to be difficult to use unless knowledge of any such events can be overlaid on previous knowledge of individuals (af Wåhlberg, 2009). The clear conclusion from the meta-analysis undertaken by af Wåhlberg (2009) being that ‘…humans do indeed exhibit…a collision rate that is very stable over time’ (af Wåhlberg, 2009, p. 81).

However, research needs to be over longer periods to be valid due to the low frequency of collisions motor vehicle drivers experience, periods in excess of three years are needed for validity (af Wåhlberg, 2009). This stability in an individual’s propensity to be involved in collisions appears to often be assume in the axiom of the research into collisions rather than either providing evidence to support it directly or relying on other studies that have done so. This aspect also closely and directly links to the construct of culpability and the ability to apportion it to an individual. The importance of using culpable collisions during post collision analysis being that these are the collisions that the motor vehicle driver had some influence over and the ones that can be dependent on individual characteristics (Wilson *et al.*, 2006).

The construct of culpability and the exploration of causation and human factors goes further than concepts of active/passive involvement. Active/passive involvement being a subjective judgement of whether any individual motor vehicle driver actively contributed to the collision occurring or were merely the passive recipient of another motor vehicle drivers actions, as used by West (1997), West and Hall (1997) or Parker *et al.* (1995) or constructs such as ‘to blame’ (Quimby *et al.*, 1986). This negates the under-recording of culpability inherent in the active/passive process (af Wåhlberg, 2002; 2009). Blame can be shared, it being quite likely that more than one party can be held culpable. Culpability should be considered on a sliding scale, as sensitivity could be lost if an assumption of culpability being a dichotomy exists and processes just have a simple fault-no fault classification with only one motor vehicle driver to blame (af Wåhlberg and Dorn, 2007). Weak criteria, such as a simple active/passive judgement, produced culpability levels that have provided unreliable results in many historical studies (af Wåhlberg, 2009). It seems likely that culpability can be apportioned to around 70 to 80 per cent of motor vehicle drivers involved in collisions (af Wåhlberg, 2009). Therefore, culpability can be considered to be the sum of factors relating to an individual motor vehicle driver which together indicate that the motor vehicle driver contributed to the circumstances which resulted in a collision occurring.

If the culpability of a motor vehicle driver was to be used as one of the variables explored during research, then it was essential that there was a method, or tool, for assessing that culpability. There are three published culpability scoring tools which feature in the literature, see table 2.9 above, and rely on the detail of the incident.

These tools are those devised by Terhune (1983), Robertson and Drummer (1994) and Brubacher, Chan and Asbridge (2012), see sections 2.8.1 to 2.8.3 for an explanation of each tool. The tools are usually used independently but on occasion Terhune (1983) has been used in combination with Robertson and Drummer (1994). Brault and Dussault (2002) examined the Terhune (1983) and Robertson and Drummer (1994) tools and concluded the latter as being the more accurate as it was less subjective, subjectivity being the interpretation of material contained in the collision reports by the individual applying the tool. The less subjective interpretation involved in the tool, the more likely the results can be duplicated if applied by another researcher. All three tools assess '… the driver's role as a causal agent in his own accident.' (Brault and Dussault, 2002, p. 238).

2.8.1 Terhune (1983)

The Terhune (1983) tool was originally designed to assist with understanding the impact of drink and drug driving on collision culpability. It specifically states that 'fault' and 'culpability' are not implied although they may be similar (Terhune, 1983, p. 238). The categorisations from Terhune (1983) are presented below,

(1) Culpable – The subject vehicle was the first to create the dangerous situation.
(2) Culpable/contributory – Driver had some responsibility, but it is not clear whether he was culpable or contributory.
(3) Contributory – Another vehicle or agent created the dangerous situation, but the subject driver could have avoided the crash by a normal avoidance manoeuvre.
(4) Contributory/neither – At most, driver's responsibility was only contributory.
(5) Neither culpable nor contributory – Driver had no responsibility for the accident. (Terhune, 1983, p. 240).

This scoring tool relies on a subjective judgement by the individual assessing the collisions data with Terhune (1983, p. 240) noting that the two coders involved in the research were 'inexperienced in accident research' and had to be 'trained to rate responsibility'. There being clear indication of the impact of the subjectivity and that for this scoring process to be successful there must be a level of experience in the coders. The subjective nature of this tool was noted in their assessment by Brault and Dussault (2002).

Terhune (1983) makes a number of recommendations which are derived from the limitations in the tool, these being that the process of responsibility analysis be improved with a better definition of responsibility [culpability] with finer scaling, the use of experienced investigators as verifiers and assumptions in interpreting the collision data should be minimised.

2.8.2 Robertson and Drummer (1994)

The Robertson and Drummer (1994) tool, being the most commonly found in the literature (Salmi, Orriols and Lagarde, 2014), starts from a position of culpability and then scores mitigation; it was originally designed to assist with understanding the impact of drink and drug driving (Robertson and Drummer, 1994).

This model looks at eight factors (mitigating categories), these are: the condition of the road; the condition of the vehicle; the driving conditions, the type of accident; witness observations; road law obedience; the difficulty of task involved and the level of fatigue. Within these categories there are several statements relating to the circumstances of the collision and a related score. These circumstances are linked to the data available from the police reports, for example, was the collision during the day and were there showers and or rain. Each mitigating factor being given a score of one to four, where no mitigation achieves a score of one through to four for mitigating. Therefore, the lowest achievable score being eight and the highest being 32.

The scoring system works as such: one or less mitigating factor = culpable, two = contributory, more than two exonerated. Therefore, a score of eight-12 = culpable, 13-15 = contributory; and over 15 non-culpable. For the system to work there must be five or more mitigating categories present to score. If there are less than eight categories, then the scores from the ones present are multiplied by eight and then divided by the number of categories present. The criteria and related scores are set out in a table for ease of use.

The Robertson and Drummer (1994) overcomes some of the limitations inherent in the Terhune (1983) tool. The scoring scaling being finer, albeit that with this tool there are only three outcome categories, however, these are defined. The tool allows for the removal of some of the subjectivity, however, this scoring tool includes a number of constructs which require interpretation, so a level of subjectivity remains, these constructs are explored in chapter five.

2.8.3 Brubacher, Chan and Asbridge (2012)

The most recent scoring tool in the literature, that of Brubacher, Chan and Asbridge (2012), was again developed with a focus on collisions involving drink drive matters. Designed to work in a similar fashion to the Robertson and Drummer (1994) tool, which formed the basis for the design, adapted for winter conditions in Canada. This tool was also designed to work with bulk data from the Canadian national collision database. It was later applied to collisions involving mobile telephone use (Asbridge, Brubacher and Chan, 2013). The tool examines seven factors (mitigating categories). The categories are the road type; the driving conditions; the vehicle condition; unsafe driving actions; contribution from other parties; the type of collision and the task involved. Again, within these categories there are circumstantial statements and the related score. As a divergence from the Robertson and Drummer (1994) tool the Brubacher, Chan and Asbridge (2012) tool uses scores from one to five, with one being the least mitigating. Additionally, no calculation requirement occurs if a category cannot be scored, with this tool the simple adding together of the presenting category scores produces the results as the overall score. Scores of 13 or less categorise the motor vehicle driver as culpable, scores of 14 or 15 are indeterminate and scores of 16 and over categorise the motor vehicle driver as non-culpable.

The Brubacher, Chan and Asbridge (2012) overcomes some of the limitations inherent in the Terhune (1983) tool in the same way as the Robertson and Drummer (1994) tool. Similarly, this scoring tool includes a number of constructs, albeit different ones from the Robertson and Drummer (1994) tool, which require interpretation, so again a level of subjectivity remains, these constructs are explored in chapter five.

2.8.4 Culpability Discussion

The assessment of culpability can be an effective and strong tool in collision research, it allows the assessment of the effect of a factor on the likelihood of a motor vehicle driver creating the circumstances leading to a collision to be determined (Brubacher, Chan and Asbridge, 2014; Dorn and af Wåhlberg, 2019). There are some limitations, with the main focus on setting strict criterion, the removal of subjectivity (Brault and Dussault, 2002; Dorn and af Wåhlberg, 2019) and that the scoring tools can only look at the factors recorded in the collision reports, this means that many factors which research suggests can influence collisions risk, such as habitual behaviour or attitudes and perceptions, see sections 2.4.2 and 2.4.3 above are not directly taken into account. However, these factors may manifest in the circumstances leading to the collision. The tool takes account of the actions, or lack of them, leading to the collisions but not why the motor vehicle driver took those actions. The use of culpability scoring produces a control group of non-culpable motor vehicle drivers which can be considered a proxy for the general driving population (af Wåhlberg and Dorn, 2007; Kim and Mooney, 2016; Dorn and af Wåhlberg, 2019).

Examination of culpability allows for the differentiation of the motor vehicle drivers who were culpable for creating the circumstances which resulted in a collision, however, there are further opportunities for segmentation to develop the targeting of interventions at the segments of the population containing the culpable motor vehicle drivers.

2.9. Geodemographics

Geodemographics involves the segmentation of a population on multiple characteristics, such as financial or purchasing, and frames the material in a geographical context (CACI Limited, 2014; Experian, 2017). Geodemographics are primarily a tool for marketing and used to design future strategies for many major retailers (Leventhal, 2016). Although geodemographics were developed primarily as a marketing tool they can and have been applied to many facets of UK society, and have been found to be effective in predicting choices and behaviour (Leventhal, 2016; Webber and Burrows, 2018). Commercial geodemographic profiling systems are applied at postcode level. Postcodes allow geographical identification of groups of individual UK addresses but do not concord with other geographical constructs such as county or local authority areas, the constructs do not share boundaries (Office for National Statistics, 2018a), so using postcodes in combination with other geographical constructs can create some confusion, this means that if examining geographic constructs, such as counties, as in the case of this research, care must be taken to ensure that all the postcodes required are identified, this data was available from census data (Office for National Statistics, 2020b).

Postcodes are a UK wide system, maintained by Royal Mail, to identify postal delivery areas. Many postcode postal ‘area’ designations, the first letter string in the code, do relate to the general geographical area and appear to be abbreviations of a local town, city, or area, for example, many Cambridgeshire postcodes start with CB. However, they do not respect county boundaries and in the case of CB postcodes there are many which are located in surrounding counties. The county of Cambridgeshire as well as containing CB postcodes also contains PE (Peterborough), MK (Milton Keynes) and SG (Stevenage) postcodes (Cambridgeshire Insight, 2018a). The postcode structure is presented in appendix two.

2.9.1 Geodemographics and Collisions

Researchers have examined UK collisions from a geodemographic perspective and the population characteristics chosen being as diverse as the population itself (Anderson, 2005; 2010; Quddus, 2015; Loo and Anderson, 2016). Some encompass a number of factors, such as propensity for collision involvement and location zoning (Anderson, 2005) where as others focus on specific ones, such as injury severity (Quddus, 2015).

There has been focus in previous literature on groups which appear to be more vulnerable to injury than other road users such as pedestrians (Pitt *et al.*, 1990; Preusser *et al.*, 2002), vulnerable motor vehicle drivers (Otte, Jänsch and Haasper, 2012), young motor vehicle drivers (Hasselberg and Laflamme, 2005; McCartt *et al.*, 2009; Jones, Begg and Palmer, 2013) or child casualties (Maasalo *et al.*, 2016).

There has also been a focus on social factors which indicate an increase in vulnerability to injury in collisions such as, deprivation, social status or place of residence (Abdalla *et al.*, 1997; Blatt and Furman, 1998; Lu, Chou and Lee, 2000; Braver, 2003; Noland and Quddus, 2004; Graham, Glaister and Anderson, 2005; Hasselberg and Laflamme, 2005; Laflamme *et al.*, 2005; Edwards *et al.*, 2006; Vingilis and Wilk, 2007; Anderson, 2010; Pilkington *et al.*, 2014), home and school background (Murray, 1998) or even a general economic recession (Lloyd, Wallbank and Broughton, 2015). The findings generally concur that individuals from lower socio-economic groups and especially the children from those groups are at a higher risk of being the casualty in collisions.

Personal demographic factors can influence a propensity to be involved in collisions, either as motor vehicle drivers or casualties, such as, age, sex, marital status and racial background (Summala and Mikkola, 1994; Clarke, Ward and Jones, 1998; Kim *et al.*, 1998; Kposowa and Adams, 1998; Laapotti and Keskinen, 1998; 2004; Campos-Outcalt *et al.*, 2003; Lardelli-Claret, Del Castillo, *et al.*, 2003; Lardelli-Claret, Luna-Del-Castillo, *et al.*, 2003; Lardelli-Claret *et al.*, 2005; Bunn *et al.*, 2009; Rhodes and Pivik, 2011) or if they have previous convictions (Gebers and Peck, 2003). For motor vehicle drivers, there was an increased risk of involvement and culpability in younger and older motor vehicle driver groups, being male and having previous convictions. For casualties, race did appear to have an impact in US studies as did marital status with some groups, such as Hispanic and African-American men both at raised risk of being pedestrian casualties and divorced individuals at higher risk of being involved in collisions as motor vehicle drivers.

The journey being undertaken at the time of the collision has been seen to have a relationship with the risk of collision with variation between urban to urban, urban to rural and rural to rural journeys (Khorashadi *et al.*, 2005; Quddus, 2015) or where on the road network the collision occurred (Quddus, 2008a; Wang, Quddus and Ison, 2011; Steinbach, Edwards and Grundy, 2013; Deka and Quddus, 2014; Imprialou, Quddus and Pitfield, 2014) as well as the times of day the journey are undertaken (Quddus, 2008b) or the purpose of the journey (Dorn and Af Wåhlberg, 2008; Clarke *et al.*, 2009). Differences in the risk of injury and severity were found, with motor vehicle drivers from urban areas at higher risk of more severe injury if they travel to rural areas, injury severity increases if the collision occurs in areas with high car ownership, with motor vehicle drivers from lower socio-economic groups and motor vehicle drivers driving in a work capacity more blameworthy. There are also locations at which more collisions occur than others and collisions occur close to the home of those involved.

Other factors relating to the collision have been examined, such as how changes of speed limit impact on collision frequency (Transport Research Laboratory, 2003; Imprialou, Quddus and Pitfield, 2016) showing a negative collision speed relationship and a reduction in collisions in lower speed limit areas, or the presence of passengers in the vehicle causing distraction and increased risk of collision (Rueda-Domingo *et al.*, 2004; Australian Road Research Board, 2019; Department for Transport, 2019i).

Geodemographics as a tool has been applied to the provision of public services. Singleton (2004) explored the application of geodemographics to higher education, considering that it could be applied to create fairer access. Longley (2005, p.62) considered that geodemographics could be used to develop ‘rationalities, performance metrics and change measures' in public policy debate. Ashby and Longley, (2005) explored the use of geodemographics in the application of local policing by analysing the impact of crime on the geodemographic segments of the population to identify clustering, allowing the allocation of suitable resources. Both Farr, Wardlaw and Jones (2008) and Petersen *et al.* (2011) explored local public health applications for geodemographics, the former describing a successful methodology for tackling a common health problem using a marketing program and the latter targeted public health campaigns. Cambridgeshire County Council used geodemographics in their report relating to community safety issues which had presented in the village of in Littleport in the east of the county (Cambridgeshire County Council, 2019a). The use of the geodemographic profiles allowed direct comparison with other areas within the county. The local delivery of the Think Communities initiative was guided by the data. The implication for this thesis being that if health related education and local service initiatives can be targeted using geodemographics then road safety education targeted using similar principles could also be successful.

The factors subject to analysis in the preceding research do not sit in isolation from each other. Individual vulnerabilities are likely to be multi-factorial. Consideration of a specific set of circumstances can give insight into how some of these factors may combine. For example, consider a young child pedestrian casualty on the way to school. The casualty being a child would be the first consideration. Certain populations have higher numbers of children than other populations, young children are also an indication of a younger adult population, the distribution of these populations can be identified with geodemographic profiles, they are often found in inner cities where there are higher traffic flows. Younger adults may well be of working age, this may be a factor in the supervision of the child on the way to school, or on low incomes which can have an impact on housing choice and availability of vehicular transport, hence the child being a pedestrian. Therefore, the geodemographic profile of a child can be an indicator of their relative risk of being a child pedestrian casualty, being an indicator of both exposure, relative deprivation and environmental factors which influence the risk (Abdalla *et al.*, 1997; Noland and Quddus, 2004; Anderson, 2005; 2010; Graham, Glaister and Anderson, 2005; Edwards *et al.*, 2006; Steinbach, Edwards and Grundy, 2013). The identifying of the segments of the population it the highest risk allows those tasked with reducing the risk to understand the distribution of the risk and target resources accordingly.

There are commercial geodemographic databases, such as Mosaic run by Experian (Experian, 2017) or Acorn administered by CACI (CACI Limited, 2014; 2017). The Office for National Statistics also categorises census data; known as the Output Area Classification or OAC (Office for National Statistics, 2011), although not described directly as a geodemographic profile system it does work in a similar fashion classifying the areas in terms of their 'demographic structure, household composition, housing, socio-economic characteristics and employment patterns' (p.2). However, OAC does not explore this data at a postcode level, an Output Area has a target size of around 50 households, with the size varying, whereas a postcode usually contains around 15 households, therefore the OAC segmentation would not be as sensitive to local variation as segmentation based on postcode (Webber and Burrows, 2018; Office for National Statistics, 2020b). In addition to the OAC various indices of deprivation are also applied to Lower-layer Super Output Areas (LSOA), combinations of around five Output Areas, with 32,844 in England. These indices are combined into the Index of Multiple Deprivation (IMD), the LSOAs are ranked from one, the most deprived to 32,844, the least deprived and this ranking structure was then segmented into deciles. Therefore, IMD has values from one (most deprived) to 10 (least deprived) with each value representing 3,284 LSAOs (Ministry of Housing Communities and Local Government, 2019), again due to the larger geographical areas contains within LSAOs IMD was less sensitive to local variations in the population. For the purpose of this research the most sensitive segmentation was utilised in the form of geodemographic profiles as these had previous been successfully used in exploring injured parties in collisions and the application of public health education and policing allocation (Anderson, 2005; Ashby and Longley, 2005; Petersen *et al.*, 2011; Loo and Anderson, 2016).

The identification of the geodemographic profiles involved in the collisions being examined in this research will allow the tailoring of interventions using established social marketing methods (Smith, 2006; Bird and Tapp, 2008; Tapp *et al.*, 2013).

2.10. Indexation

The use of indexation to present relationships between data can allow a quick comparison of a comparable variable between groups with a baseline, and has been used by government departments, organisations and academics with specific examples described below showing different applications. The use of this method allows both a snapshot comparison and also longer term tracking of trends (Home Office, 2018; Department for Transport, 2020d). The creation of an index requires a predetermined value, representing the baseline, which acts as the central point above and below which the data to be presented fluctuates. Indexation allows for comparison of data which would not otherwise be directly comparable (International Transport Forum, 2017)

Road safety research requires the presentation of relationships, relative to a baseline or standard, being regularly achieved using indexation. For example, the Department for Transport (2018, p. 9) presents, in the form of a graph, the number of killed car occupants compared to the number of miles driven by cars and taxis on a single graph with both data indexed to 100 with this representing the 2010-2014 average, see appendix two, figure four.

The International Transport Forum (2017, p. 146), the road safety section of the Organisation for Economic Co-operation and Development applies the same method to present the relationship between five variables. In this case the presentation examines the movement of fatalities, injury crashes, motor vehicle number, vehicle kilometres and GDP in Denmark from a baseline of the values in 1990, the index point of 100, to 2015. See appendix two, figure five. In this nexus the graph clearly shows that although vehicle numbers, use and the country's wealth are increasing casualties in both injury severity categories are falling steadily.

As part of the presentation of results from their work on the CTARP the University of Leicester (2005) used an index centred at 100 to present the frequency of individuals from specific groups defined by their membership an IMD quintile group (The Department for Communities and Local Government, 2015) compared to the distribution in the population. This was done because the raw frequency data showed that more casualties came from the least deprived groups within society. It was suspected that these frequencies were masking the actual impact on the lower two, most deprived, groups. The raw frequency data was presented in a bar chart reproduced in appendix two, figure six. Additionally, by presenting the indexed data comparing the frequencies to the background population over and under representation are more evident. The horizontal bar chart used, reproduced in appendix two, figure seven, to present the data shows the indexed scores above and below 100.

By using indexation as the method of presenting the data it was possible to demonstrated visually and with little ambiguity that the lowest IMD quintile group was significantly over-represented in the casualties.

Indexation can be used to present the relationship of those involved in the matter being explored with a general population, where there are comparable data for the sample and the population, such as a residential area designation or geodemographic profile. Quddus (2015) examined the relationship between the frequency of motor vehicle driver's involvement in road traffic collisions using six local authority district categories related to the population and a district descriptor. The categories contained three for urban residence graduated for population and three for rural residence again graduated for population. For example, Major Urban was where the population was over 750,000 of which either 100,000 or over 50 percent were in the urban conurbation. Quddus (2015) created what was described as an index of concentration as a measure of the populations involvement in collisions (Blatt and Furman, 1998).

The index score for each group was calculated by using the formula presented in the figure 2.1 below.

$$Index\ = \left(\frac{\%\ of\ population\ subgroup\ involved\ in\ traffic\ crashes}{\%\ of\ the\ subgroup\ population\ in\ the\ whole\ population}\right) \times 100$$

Figure 2.1 Index of concentration equation (Quddus, 2015)

In this case the percentage values were used to create the ratio which was then converted into the index score.

Other road safety related use of indexation looked at different aspect of collisions, such as exposure, culpability in relation to drugs or alcohol or place of residence (Cerrelli, 1973; Warren *et al.*, 1981; Janke, 1991; Blatt and Furman, 1998; Biecheler *et al.*, 2008).

Anderson (2005) examined the relationship between the distribution of Mosaic geodemographic profiles, see Experian (2017) for a full explanation of the Mosaic profiles, although they work in a similar fashion to Acorn profiles with the finest granularity containing 66, within road traffic casualty data and compared this to the distribution within the overall population of London. The research divided London using a series of concentric rings emanating from Charing Cross station and three miles in thickness (called buffer zones in the paper). The method of indexation allows for the results to be presented graphically.

The first stage was to calculate what the expected number of a specific Mosaic type should be present in a sample. This was done using the equation presented below with separate values calculated for casualties and motor vehicle drivers, see figure 2.2 below.

$$Expected\ value = \frac{Total\ postcode\ count\ casualty\ or\ driver\ (buffer\ zone) \times Individual\ Mosaic\ total}{Total\ base\ population\ househole\ for\ the\ buffer\ zone}$$

Figure 2.2 Expected value equation (Anderson, 2005)

Having determined the expected value, the next stage was to calculate the index, this was done using the equation in figure 2.3 below.

$$Index\ value\ = \frac{Casualty\ or\ driver\ total\ for\ each\ Mosaic\ type\ \times 100}{Expected\ value}$$

Figure 2.3 Index value equation (Anderson, 2005)

It was then possible to present the Mosaic types in terms of over or under representation within the collision statistics compared to the actual population within each of the designated zones. This was presented in the form of a vertical bar graph with bars on the x axis intersecting the y axis at the index central point of 100. Those bars above the line show over-represented groups within the collisions data and likewise, bars below the line show under representation. The graph showing the distribution for the central buffer zone being reproduced in appendix 2, figure 8. This shows the differences in the risk for each of the geodemographic types presented from over-representation at almost twice what would be expected to under-representation at about half what would be expected.

Anderson (2010) undertook a further examination of collisions risk London-wide utilising the same methods and again presenting the results in an indexed form. On this occasion the analysis was undertaken without the concentric ring differentiation and using the Office for National Statistics (2011; 2015; 2020b) Output Area Classification in addition to Mosaic, this study was further reported in Loo and Anderson (2016). Both Quddus (2015) and Anderson (2005; 2010) demonstrated how effective this method can be in identifying segments of the population which were over-represented in the collision data explored.

In examining crime distribution across the Mosaic types in the Devon and Cornwall police area during the 1999-2000 period Ashby and Longley (2005) used a process where the propensity of a crime type in a particular Mosaic type was compared to the average value across command units and standardised to an index of 100. In the same fashion as Anderson (2005) and Quddus (2015) a value of over 100 shows over representation of the crime type in the Mosaic type and scores lower than 100 show under representation. As well as overall crime, specific crime types were examined and for the North and East Devon Basic Command Unit the burglary propensity for individual Mosaic types Ashby and Longley (2005, p. 70) were presented. The results were presented in the form of a vertical bar graph, similar to that used by Anderson (2005) with the x axis intersecting the y axis at the index of 100. In this case all the Mosaic types were represented on the x axis in order of most affluent adjacent to the y axis through to the most deprived. The graph presented in the paper being reproduced in appendix two, figure nine.

This presentation of the data clearly depicts the over and under representation of burglary in specific Mosaic types, this presentation shows how data recorded by police in relation to incidents involving members of the public can have this presentation technique applied to it and how the relative impact of incidents on different geodemographic profiles can be presented.

The Acorn geodemographic profiling system utilised in the third study, see chapter six, make use of indexation when describing categories. In the user guide (CACI Limited, 2014) each Acorn type presents a summary graph comparing the type concerned to national averages on six categories. The comparative categories are internet enabled phones; new technology purchasers; median house price; senior managerial/professional; benefits and proportion with high BMI. The information, presented as a horizontal bar graph, has the index score represented on the x axis and the y axis intersection the x axis at the 100 tag. In the guide there are graphs for each of the 62 Acorn types available to categorise the population. An example is presented in appendix two, figure ten.

As can be seen from the material presented the use of indexation can be a versatile tool for presenting data in an accessible form and was utilised to present the geodemographic analysis undertaken and presented in chapter seven.

From the examples provided it can be seen that the use of indexation can allow the straightforward presentation of the relationships between data, from a baseline appropriate to the data presented, be it a starting point, often time related or in comparison to averages from a dataset. Geodemographic profile analysis of sub-populations, i.e. motor vehicle drivers involved in collisions or pedestrian casualties from collisions, can produce results which can then be compared to the geodemographic profile distribution of the general populations by the creation of a composite score, or index (Bhattacherjee, 2012). There was clear application to data, regarding individuals involved in incidents, be it collisions or crime, recorded by police to show variation in the risk between geodemographic profiles, indicating the suitability of the technique to the research presented in this thesis.

The benefit of indexation being the possibility of comparing data, once indexed, which could not be directly compared in its unindexed form. Indexed data can be presented graphically in a number of ways which allows straightforward comparison of the direction of a trend compared to a baseline. However, once indexed the material does not allow comparison of actual frequencies.

2.11. Literature Summary

The considerable volume and diversity of literature relating to collisions reflects the complexity of the paradigm. Collisions have a significant impact on society which has resulted in processes being developed to record, differentiate, and mitigate them. Collisions as individual events may appear straightforward, such as a car leaving the road and hitting a tree, but they are not. The complexity of factors creating the backdrop to the event have been described in the literature examined.

In the UK injury collisions are recorded by the police with statistical data reported to the Department for Transport. Although STATS19 can be considered a rich source of data and the basis for the governments annual statistics it in not without its issues (Department for Transport, 2019d). The issues which are apparent in the system are recognised by Department for Transport who administer the system. These include, data quality, injury severity classification, under-reporting and the current combination of variables and contributory factors. These are subject to the current review, with some already being addressed with the development of a coherent electronic reporting system which has been adopted by around half the UK police services (Department for Transport, 2006a; 2010b; 2015b; 2019d).

The current injury severity classifications are not compatible with the European standards for international comparison requiring the Department for Transport to estimate the levels of MAIS3+ injuries (Department for Transport, 2010b; 2015b; 2019d). This position has been reinforced by studies where police collision data has been linked to hospital data, these have invariably been done to examine levels of reporting, but have shown that a relatively low proportion of the collisions categorised by police officers in STATS19 as ‘serious’ are categorised as clinically serious

(MAIS3+) (Transport and Road Research Laboratory, 1984b; 1987; Transport Research Laboratory, 1999; 2001).

The differentiating of injury severity in the STATS19 data by non-clinically trained police officers (acting as coders) proves problematic due to the subjectivity allowed in the assessment. This has been overcome to some degree by the injury based process employed in the electronic reporting systems, this has however created the need to evaluate the differences in casualty numbers produced by the two processes and these differences are reported in the annual statistics as an underestimation of the frequency of casualties that should be in the serious injury category (Department for Transport, 2010b; 2019d; 2020d).

Injury severity can be clinically assessed and coded by suitable trained individuals, the coding system chosen for international comparison was AIS, at the level of MAIS3+ (International Transport Forum, 2011; 2018; Department for Transport, 2015b; Aarts *et al.*, 2016; Association for the Advancement of Automotive Medicine, 2017b). In many cases, however, injury coding using ICD, as in HES data, requires conversion or an estimation to be made without direct conversion (Department for Transport, 2010b; 2012b; 2015b; 2019d; Association for the Advancement of Automotive Medicine, 2018).

There are two broad perspectives within which collision research can be placed. The first being the understanding of what causes collisions to occur, allowing them to be prevented, or the risk reduced, the classic example of this being the understanding of the link between alcohol consumption and the risk of collision, remove the alcohol and the risk reduces (Terhune, 1983; Robertson and Drummer, 1994; Longo *et al.*, 2000a; Ogden and Moskowitz, 2004; Watson, Watson and Vallmuur, 2013; Dubois *et al.*, 2015). The second of the perspectives, the mitigation of the impact of collisions, invariably involves the control of energy transfer to vehicle occupants, such as the use of airbags (Organisation for Economic Co-Operation and Development, 1997; Centers for Disease Control and Prevention, 2001; Aarts *et al.*, 2016; The Royal Society for the Prevention of Accidents, 2021).

Many of the factors explored under the first perspective are motor vehicle driver related, these can include short term behavioural elements such as distraction or much longer standing attitudes towards risk with a proneness for collision involvement being stable over time so difficult to change (Babarik, 1968; Terhune, 1983; Organisation for Economic Co-Operation and Development, 1997; af Wåhlberg and Dorn, 2007; af Wåhlberg, 2009). Culpability assessment can be a valuable epidemiological tool for determining the impact of factors involved in the narrative of collisions, thus differentiating the motor vehicle drivers who contributed those factors from the motor vehicle drivers who are representative of the general driving population (Brubacher, Chan and Asbridge, 2014; Dorn and af Wåhlberg, 2019).

The mitigation of the factors identified under both of the perspectives are complex with interventions framed in the three Es of education, enforcement and engineering (Groeger, 2011), with some proposing a broadening of the three E's construct (Road Safety Authority, 2007; Transportation Research Board, 2007; Federal Highway Administration, 2011; City of London Canada, 2014; Plant, McIlroy and Stanton, 2018; Road Safety GB, 2019). The complexity of collision events dictates that there are no single solution options to reduce or eliminate them. The safe system approach, explored in section 2.6, being founded on the understanding that humans make mistakes and collisions occur. The diversity of interventions reflects the complexity, with individual actions endeavouring to have an impact on a specific factor which has been identified by research. With this multitude of factors influencing the narrative there needs to be a similarly diverse toolkit of interventions available. These interventions can be used at a number of points along the script to impact on the overall risk. Not all interventions are applicable to every narrative and not all the interventions applied work on every narrative. There are limits to what society can do to impact collision risk in terms of scope, scale, and success. The human involved in the equation often being the limiting factor (Elvik *et al.*, 2009).

Interventions can be short-term, such as enforcement of traffic regulation at a specific location in response to a collision or the use of safety messages on roadside displays, or more long-term, such as the extended campaigning to change societal attitude towards drink drive, the introduction of regulation requiring active or passive safety features on vehicles or the re-engineering of a location to separate traffic (Jones, 1990; Evans, 1994; Transport Research Laboratory, 1998; 2015; Bates, Soole and Watson, 2012; Department for Transport, 2014a; 2015i; 2017a; 2019i). With the combination of interventions applied in the UK producing a reduction in the number of casualties over time (Department for Transport, 2019d; 2020d).

Geodemographics have been used successfully in both marketing paradigms and on a smaller scale within the public sector to target products and services (Ashby and Longley, 2005; Harris, Sleight and Webber, 2005; Longley, 2005; Petersen *et al.*, 2011; Leventhal, 2016; Webber and Burrows, 2018), as well as a tool in collision research, examining risk (Noland and Quddus, 2004; Anderson, 2005; 2010; Graham, Glaister and Anderson, 2005; Quddus, 2008a; 2008b; 2015; Deka and Quddus, 2014; Imprialou, Quddus and Pitfield, 2016; Loo and Anderson, 2016). However, the use of geodemographics to target interventions to best effect by targeting culpable motor vehicle drivers in the most serious of injury collisions has not been presented in the literature and would add to the available intervention options for road safety professionals, this can only be achieved by the linkage of datasets to allow the extraction of the required material.

Therefore, the literature suggests three stages to be investigated:

- To understand the relationship between collision causation and injury outcome the STATS19 police collision data must be linked to hospital data.
- The collision causation, set out in STATS19 police collision data, related to the individual motor vehicle driver, however, STATS19 does not formally determine culpability, therefore, culpability assessment must be undertaken on the STATS19 data.
- Interventions need to be focussed on the motor vehicle s that cause the collisions, therefore, applying a tried and tested segmentation system allows the culpable motor vehicle drivers to be targeted.

This thesis brings together three studies which deal with these matters. The linkage of hospital trauma patient data and police collision data to identify the MAIS3+ injury severity collisions which can then be explored alongside the collisions which resulted in a fatality (Study one, see chapter four). Although there are issues with STATS19 data, as discusses in section 2.3, the data for a five-year period for Cambridgeshire was made available through an information sharing agreement as was the TARN data for road traffic collisions for the same period for the East of England region. The motor vehicle drivers from the identified MAIS3+ collisions and fatal collisions are subject to a culpability scoring process (Study two, see chapter five). As discussed in section

2.8, considerations of culpability are essential to allow the focus of interventions towards the motor vehicle drivers who contributed to the collisions rather than those who were merely present. The final study (Study three, see chapter six) explores the geodemographic profiling, see section 2.9, of the identified motor vehicle drivers, this follows the successful use of this process to identify and target interventions and resources in other fields, such as medical education or policing, to allow for the targeting of road safety interventions.

Chapter Three: Methodological Context

3.1. Methodological Context

This section does not detail the methodologies used in each of the studies in the thesis, each study has a dedicated chapter which sets out the methodology used, this section sets out the broader methodological context in which the research presented within this thesis sits.

Injury, a medical phenomenon caused by damage to the human body by energy, see section 2.3, fits within the wider construct of disease (Haddon, 1968; 1980; Baker, Robertson and O'Neill, 1974; Waller, 1987; Baker *et al.*, 1992; Organisation for Economic Co-Operation and Development, 1997; Centers for Disease Control and Prevention, 2001; Holder *et al.*, 2001; Langley and Brenner, 2004; Ason *et al.*, 2005; World Health Organization, 2010; 2020). The study of the 'epidemic' or the distribution of disease and prevention are the fundamentals of epidemiology (Ross, 1916). Within epidemiology the injury, or often termed trauma, can be categorised in aetiological terms with an understanding of the causes (Haddon, 1968), The research presented in this thesis falls under the broad methodological umbrella of epidemiology in that the research examines the distribution of the injury causing factors within a population with the aim of identifying preventative measures.

The research presented in this thesis can be considered, primarily, as a descriptive multiple case study using secondary data analysis, exploring the involvement and distribution of a population involved in road traffic collisions resulting in injury at a specified level of severity using uni-, bi- and multi-variant analysis, and quantitative in nature (Miles and Huberman, 1994; Greene and Caracelli, 1997; Newman and Benz, 1998; Tashakkori and Teddlie, 1998; 2003; Creswell, 2003; Tashakkori and Creswell, 2007; Bhattacherjee, 2012).

Chapter Four: Linking Collision Data to Hospital Patient Data (study one)

4.1. Introduction

Road traffic collisions are complex events which may be the culmination of multiple factors (Babarik, 1968; Barrett and Thornton, 1968; McBain, 1970; Wagenaar and Reason, 1990; Ball and Owsley, 1991; West, 1997; af Wåhlberg, 2009; Loo and Anderson, 2016). Collisions can result in material and physical damage. Human factors can be considered to encompass all the top ten contributory factors, see section 2.3.1, for both fatal and STATS19 categorised serious injury collisions in Great Britain for 2019, nine relating to motor vehicle drivers and one to pedestrians (Department for Transport, 2011; 2020b). Note this being the non-clinical STATS19 'serious injury' categorisation, see section 2.2.1.

Within the STATS19 serious injury category, only one of the top ten contributory factors was environmental, but it could be argued that failing to take account of environmental factors by a motor vehicle driver also constitutes a human factor. Therefore, dealing with environmental factors are considered as a motor vehicle driver's responsibility in the Highway Code (Department for Transport, 2015h). In this case the environmental factor was that there was a slippery road, due to the weather. In such circumstances a careful and competent motor vehicle driver, i.e. someone following the guidance in the Highway Code to take additional care in such circumstances, should mitigate the risk posed by this factor by modifying their driving style accordingly (Department for Transport, 2015d).

Table 4.1 below presents the contributory factors that were reported for fatal and STATS19 serious injury collisions in the collision statistics for Great Britain for 2019, factors are presented in descending order of frequency of collisions where they were recorded by the reporting officer. The reporting officer has the option of recording up to six contributory factors for each collision, each can be attributed to a particular motor vehicle driver, the factors are not ranked within each collision report and with no compulsion on the reporting officer to use all six opportunities (Department for Transport, 2011).

Table 4.1 Top ten contributory factors in 2019 fatal collisions in Great Britain (Department for Transport, 2020b)

Fatal contributory factor	**Recorded as a factor in a STATS19 fatal collision (% of records)**	**STATS19 serious injury contributory factor**	**Recorded as a factor in a STATS19 serious injury collision (% of records)**
Driver/Rider failed to look properly	359 (25)	Driver/Rider failed to look properly	6369 (34)
Loss of control	323 (23)	Driver/Rider careless, reckless or in a hurry	3384 (18)
Driver/Rider careless, reckless or in a hurry	264 (19)	Driver/Rider failing to judge other person’s path or speed	2977 (16)
Exceeding speed limit	215 (15)	Loss of control	2451 (13)
Driver/Rider failing to judge other person’s path or speed	185 (13)	Pedestrian failed to look properly	2124 (11)
Poor turn or manoeuvre	161 (11)	Poor turn or manoeuvre	2099 (11)
Travelling too fast for the conditions	133 (9)	Exceeding speed limit	1392 (7)
Pedestrian failed to look properly	127 (9)	Driver/Rider impaired by alcohol	1261 (7)
Driver/Rider impaired by alcohol	117 (8)	Travelling too fast for the conditions	1189 (6)
Aggressive driving	110 (8)	Slippery road (due to weather)	1110 (6)

As can be seen in table 4.1 human factors, that being things people do or do not do, are the primary cause of both fatal and STATS19 serious injury collisions (Department for Transport, 2020d). This being widely acknowledged and accepted, it was, therefore, important to be able to examine the motor vehicle drivers involved (Transport and Road Research Laboratory, 1981; Lewin, 1982; West, 1997; Petridou and Moustaki, 2000; Department for Transport, 2019c).

The purpose of the research presented in this chapter was to identify collisions in the data which resulted in a MAIS3+ injury (as opposed to the non-clinical STATS19 ‘serious injury’ categorisation, see section 2.2.1) and hence the related motor vehicle drivers, using linked data from both police and hospital sources. The most clinically serious of injuries being those with a MAIS of 3 (the level defined as serious in the AIS scale) and above, referred to as ‘MAIS3+’ (see section 2.3.4.2 for a full explanation of AIS and section 2.3.4.4 for the material related to MAIS) (Association for the Advancement of Automotive Medicine, 2017a). The identification of the MAIS3+ collisions and those already identified as fatal and the related motor vehicle drivers allows analysis of the collision circumstances. This circumstantial material can then be compared to other available collision circumstance data to determine if the sample of collisions has similarity. The identification of the collision sample and related motor vehicle drivers supports the thesis aim of exploring the geodemographic profiles of such motor vehicle drivers in the data and the related objective to identify such motor vehicle drivers, see sections 1.3.1 and 1.3.2.

The material relating to the motor vehicle drivers was be obtained from STATS19 data, see 4.1.1. below and sections 2.3, the material related to identifying casualties from collisions and their related AIS score and if they reach the MAIS3+ threshold was be obtained from TARN data, see 4.1.2 below and section 2.2.

4.1.1 STATS19

The STATS19 dataset contains records of all personal injury road traffic collisions involving motor vehicles (see *s. 185, Road Traffic Act 1988* and ‘Coates v Crown Prosecution Service' (2011) *EWHC* 2032 (Admin)) in the UK, which are reported to the police under the obligations on motor vehicle drivers to report injury collisions set out by *s. 170 Road Traffic Act 1988*. The records contain details of where the collision occurred, and circumstances, as well as all vehicles and parties involved. The Department for Transport administers the STATS19 dataset (Department for Transport, 2012b; 2018c). Police services in the UK record collisions which occur within their jurisdictional boundaries, there are facility to transfer collisions to other services in cross border recording instances. Each recorded collision contains details of the police service area in which the collision occurred. Data collected by English police forces passes to the Department for Transport directly, Welsh forces to the Welsh Government, Scottish forces to the Scottish Government and the Police Service for Northern Ireland performs the role within its jurisdiction (Department for Transport, 2013b; 2018c).

There are some limitations with STATS19, it being widely accepted that not all injury collisions are reported to the police (Alsop and Langley, 2001; Amoros, Martin and Laumon, 2006; Department for Transport, 2006a; 2012b; Roberts *et al.*, 2008; Watson, Watson and Vallmuur, 2013; Yannis *et al.*, 2014), that the non-clinical classification of injury severity by non-medically trained reporting agents can be problematic (Morris *et al.*, 2006; af Wåhlberg, 2009; Department for Transport, 2010b; 2012b; 2013b) and this does not assist in international comparisons. The standard for a serious injury has been set in Europe using the medically determined AIS, see 2.2.2.4 (Stevenson *et al.*, 2001; International Transport Forum, 2011; Aarts *et al.*, 2016). However, STATS19 does not record injury severity using the AIS but rather uses a non-clinical injury severity categorisation process, see 2.2.1.

4.1.2 TARN

The Trauma Audit and Research Network (TARN) database holds information on patients which are treated at major trauma centres, for injury received by any means, in England and Wales and fulfil certain criteria, see figure 4.1 below. The TARN data records injuries and severity using AIS, see section 2.2.2.2, and the mechanism by which the patient received the injury (The Trauma Audit and Research Network, 2000) so injuries caused during road traffic collisions can be sampled.

There are other patient databases such as Hospital Episode Statistics (HES) data which records hospital admissions in England for all causes. HES data for accident and emergency, and subsequently admitted patients filtered for ‘external cause of injury – subgroup of transport accidents’, has been linked to STATS19, however, there were a number of issues with the linking quality producing false matches. A further limitation of this study was that it only examined inpatient records so was not a complete picture of casualties as those attending emergency departments may not be admitted (Department for Transport, 2012b).

As well as accident and emergency patients, HES data for other patient categories including admitted patient care, adult critical care, outpatients and maternity are available (National Health Service, 2018b). HES data uses ICD coding (World Health Organization, 2010; 2020; Department for Transport, 2012b; National Health Service, 2018b; 2019a). Mapping from ICD to AIS can be done, however, as the ICD was developed to monitor disease epidemiology rather than specifically describing trauma the mapping may not be straightforward or exact as severity categorisations *per se* are not a criteria (Association for the Advancement of Automotive Medicine, 2017b; 2018).

The TARN dataset can be considered a unique set of data, containing the trauma patients which fulfil the entry requirements, set out below in figure 4.1, however, this means that it does not contain all trauma patients.

2.1 INCLUSION CRITERIA:

The decision to include a patient should be based on the following 3 points:

A. ALL TRAUMA PATIENTS IRRESPECTIVE OF AGE

B. WHO FULFIL ONE OF THE FOLLOWING LENGTH OF STAY CRITERIA

DIRECT ADMISSIONS	PATIENTS TRANSFERRED IN
Trauma admissions whose length of stay is 3 days or more OR Trauma patients admitted to a High Dependency Area regardless of length of stay OR Deaths of trauma patients occurring in the hospital including the Emergency Department (even if the cause of death is medical) OR Trauma patients transferred to other hospital for specialist care or for an ICU/HDU bed.	Trauma patients transferred into your hospital for specialist care or ICU/HDU bed whose combined hospital stay at both sites is 3 days or more OR Trauma admissions to a ICU/HDU area regardless of length of stay OR Trauma patients who die from their injuries (even if the cause of death is medical) *Patients transferred in for rehabilitation only should not be submitted to TARN.*

Figure 4.1 TARN entry criteria (The Trauma Audit and Research Network, 2017a).

For this study, anonymised TARN data encompassing the period 1st April 2012 to 31st March 2017 was supplied for all road traffic collision patients. Names and date of birth were removed but to enable linkage the first string of their postcode was provided (Postcode District). This version of the dataset contained data from 1907 subjects over 43 variables, see appendix four.

The data recorded for individual subjects includes the AIS score for individual body regions and the Injury Severity Score (ISS), derived from the AIS data, see section 2.2.2.2). The ISS, see section 2.2.2.5, allocated to each patient fell within one of three bands of scores (1-8, 9-15 and >15) in line with the specification of the NHS Major Trauma Contract (National Health Service, 2013; The Trauma Audit and Research Network, 2017b).

4.2. Research Aim, Objective and Research Question

The study presented in this chapter supports the aim of the thesis to:

i. investigate if geodemographic profiles can be used to differentiate motor vehicle drivers involved in fatal and serious injury (MAIS3+) collisions by their culpability.

The related thesis objective being to:

- Identify motor vehicle drivers involved in serious (MAIS3+) and fatal injury collisions, from police collision data and hospital trauma records using data linkage methods.

The identification of the collisions resulting in MAIS3+ injury allows the identification of the related motor vehicle drivers, this data can then be utilised in conjunction with the data from the fatal collisions and the related motor vehicle drivers, which forms the sample that proceeds to the second and third studies in the thesis.

Having identified the sample containing the fatal and MAIS3+ collisions from the original data the motor vehicle driver demographic and circumstantial data relating to these collisions was explored to test the following hypothesis, which if supported will aid the generalisability of any findings.

Hypothesis: The sample of collisions from which the motor vehicle drivers are drawn are not an unusual set of collisions in that the motor vehicle driver's involved and the distribution of collisions, chronologically and spatially are similar to other sets of UK collisions available in the literature.

The results of the study and analysis of the sample of collisions will support the exploration of the first research question presented in section 1.4:

1. What sources of data in the UK can be used to identify serious MAIS3+ injury collisions?

4.3. Methodology

4.3.1 Introduction

Individual datasets can have limited use, specifically focussed on the justification for their creation. When datasets are linked together they can give insight and richness to the resulting data which were not envisaged, either when the original data was created or when the linking process was proposed and go beyond original research questions (Abrahams and Davy, 2002; Department for Transport, 2012; Dipnall *et al.*, 2014; Harron, 2016; Harron, *et al.*, 2017a; Gilbert *et al.*, 2018).

The use of linked data has a long history (Dunn, 1946). With the increased use of technology and computing power, as well as the availability of large administrative datasets and ‘big-data’, the technique has become a powerful tool for research. Data linkage provides significant benefits to policy-making and public services, often after secondary analysis (Dawes, 1996; Zapilko, Harth and Mathiak, 2011; Department for Transport, 2012b; Hagger-Johnson *et al.*, 2015; Harron, Goldstein and Dibben, 2016; Hagger-Johnson *et al.*, 2017). Therefore, essentially the data linkage process must follow a clearly defined protocol which produces consistent data of high integrity (Dipnall *et al.*, 2014).

Many of the current techniques can be traced back to the 1950s and 60s. Fellegi and Sunter (1969) describe the process:

> A comparison is to be made between the recorded characteristics and values in two records (one from each file) and a decision made as to whether or not the members of the comparison-pair represent the same person or event, or whether there is insufficient evidence to justify either of these decisions at stipulated levels of error (Fellegi and Sunter, 1969, p. 1183).

The process consolidates 'facts concerning an individual or an event that would not be available in any separate record' (United Nations, 1991, p. 86). Fellegi and Sunter (1969) devised a mathematical model which expressed the ideas that had been originally proposed by Newcombe *et al.* (1959) and Newcombe and Kennedy (1962).

Depending on the field within which the data linkage occurs it has many synonyms; entity resolution; record linkage; data integration; record matching; re-identification; entity heterogeneity; merge/purge; data deduplication; instance identification; database hardening; name matching; coreference resolution and duplicate record detection (Elmagarmid, Ipeirotis and Verykios, 2007; Christen, 2012; Dipnall *et al.*, 2014). Ideally the results of the linking process are either a 'link', 'true-link' or 'true-match' where the records are classified as belonging to the same individual or event or 'non-link or match' where they are not attributable to the same individual or event. However, linkage processes may produce other results which can be considered as linkage errors, such as, 'false-links' or 'false-matches' where two records are linked when they should not be or 'missed-links or matches' where records should be linked but are not, however, it can be difficult without unique identifiers, to know the extent of the errors (Hagger-Johnson *et al.*, 2017). The results are directly linked to the quality of the data and linkage processes employed (Harron, Goldstein and Dibben, 2016).

Methodologically, linking can be divided into two forms. 'Deterministic record linkages are based on the exact correspondence (matching) of some identifying information…' (Dal Maso, Braga and Franceschi, 2001, p. 388) where a common unique identifier for individuals in datasets can be linked. In the absences of such identifiers, it also encompasses the linking of multiple non-unique specific attribute variables (partial identifiers such as names, sex, date of birth) exactly across the two datasets to be integrated according to a set of rules or protocols (Department for Transport, 2012b; Sariyar, Borg and Pommerening, 2012). The rules or protocols may include rules or protocols which must be applied in a particular order, or succession (Dal Maso, Braga and Franceschi, 2001; Abrahams and Davy, 2002; Mears *et al.*, 2010), the rules or protocols may include, for example, the order in which variables are examined, whether a variable must be an exact match or if variations in a value are allowed, i.e. an exact time or plus or minus a time frame.

The rules or protocol may also include the ‘n-1’ procedure which allows a link to be made if all but one of the variables examined match, however, the number of variables required to produce true matches depends on the data to be linked. The non-unique identifiers are referred to as *quasi-identifiers* or *partial-identifiers*. There are options to combine parts of *quasi-identifiers*, variables relating to an individual but not unique, into a string to form a pseudo-identifier; this may be a combination of data, such as the first letters of words such as a forename or surname, J and H for example, or the day or year of birth or of another event, for example 20 and 78 forming a string such as J20H78, thus creating a new variable combining information from a number of other variables relating to an individual which may be unique.

One of the disadvantages of using *quasi-identifiers* being that matches can be missed, however, typically the rate of false matches will be low as records are unlikely to match by chance, with the false match rate varying between different combinations of data (Grannis, Overhage and McDonald, 2002; Winkler, 2009; Harron, Goldstein and Dibben, 2016). Grannis, Overhage and McDonald (2002), for example, found that by varying the content of their quasi-identifiers whilst linking hospital patient records to death records the false match rate could be as high as 29.9 percent but could be reduced to as little as 8.3 percent by careful selection of the data combination. Deterministic linkage does lend itself to automation, which makes it a popular choice (Grannis, Overhage and McDonald, 2002; Harron, Goldstein and Dibben, 2016; Hagger-Johnson *et al.*, 2017). Deterministic process can be considered too restrictive in matching records; however, it needs to be considered that missed match rates may be low within systems that have common identifiers, such as the NHS, with Hagger-Johnson *et al.* (2015) reporting a level of just 4 percent and in a later study (2017) of just 2.3 percent in NHS data, primarily due to missing data.

‘Probabilistic linkage procedures are based on weights assigned to key matching variable values according to their ability to discriminate matched and unmatched pairs’ (Dal Maso, Braga and Franceschi, 2001, p. 388). Probabilistic methods of data linkage, described by Newcombe *et al.* (1959) as record linkage, can link non-unique identifiers and may have advantages where poor data quality or where missing data make the deterministic linkage of records unviable. A probabilistic linkage can be used to follow a deterministic linkage to reduce the level of missed matches produced in the preliminary linkage; however, it may need to be restricted to one or two variables which have problems (Fellegi and Sunter, 1969; Harron, Goldstein and Dibben, 2016; Winkler, 2016; Hagger-Johnson *et al.*, 2017).

4.3.2 Requirements

In this chapter, the first study of this thesis, there was a requirement to integrate two heterogeneous datasets without a common identifier. The first dataset consists of information gathered by the police in their reporting of road traffic collisions, STATS19, see section 2.3.1 and 4.1.1. The research focussed on the collisions within the linked construct, whereby, STATS19 was the dataset from which specific collisions were identified during the linking process by the application of data from the second dataset and therefore forms the ‘Master’ dataset in this process. The second dataset, produced by recording information regarding the trauma patients treated at Cambridge University Hospital who met the entry criteria for the Trauma Audit and Research Network (TARN) database, see section 2.2.5 and 4.1.2, was used in the linkage process to determine links hence this dataset forms the ‘using’ dataset in the process.

The process used to link these two datasets was an application of that presented by Dipnall *et al.* (2014) as ‘Data Integration Protocol In Ten-steps (DIPIT), see section 4.3.7 below, however, for consistency of terminology through the thesis the term linkage was used in preference to integration. DIPIT follows a clear and systematic process to minimise errors.

4.3.3 Dataset Comparison

Cambridgeshire County Council supplied the full STATS19 dataset for this research study, this was anonymised with names, dates of birth and full addresses removed prior to being supplied to the Council by the police, for the period 1st April 2012 to 31st March 2017. The geographical bound of this data was the Cambridgeshire Constabulary policing area which encompasses the county of Cambridgeshire and includes the Peterborough Unitary District as well as the rest of the county subject to Cambridgeshire County Council administration, see section 1.2.2. The Department for Transport (2011) produced a document, STATS20, which acts as a data dictionary for the STATS19 data.

Access to the STATS19 data from the County Council and Constabulary was arranged through specific data sharing protocols with each organisation and Loughborough

University. Each protocol was bespoke and although built on a general template addressed specific concerns expressed by each organisation, see appendix five.

To conclude, STATS19 contains a large amount of information on police recorded collisions, see Department for Transport (2011). Despite some limitations, and lacking suitable alternatives, they are the primary data source for road safety research in the UK (af Wåhlberg, 2009; Department for Transport, 2012b; 2013b; Imprialou and Quddus, 2017).

The TARN data used was supplied by Cambridge University Hospitals, Addenbrookes Hospital. Addenbrookes Hospital being the regional major trauma centre for the East of England. The East of England area encompasses the six counties of Bedfordshire, Cambridgeshire, Essex, Hertfordshire, Suffolk, and Norfolk. Patients may be taken straight to Addenbrookes Hospital; or if the initial journey would be too long or patients require stabilisation, they may be treated at one of the other 12 trauma units in the area before transfer. The description of Cambridgeshire in section 1.2.2 also contains a map showing the county in the context of the East of England.

The data was provided under the control of a specific data sharing protocol between Loughborough University and Cambridge University Hospitals for this specific research, see appendix five. The data provided was not in the public domain and therefore the research would not have been possible without the data sharing protocol being in place.

The STATS19 and TARN study datasets are compared below in Table 4.2.

Table 4.2 Dataset comparison.

	STATS19	**TARN**
Owner and scope	Department for Transport, UK wide data	Trauma Audit and Research Network, England and Wales.

Geographical boundaries of the research data	Cambridgeshire	East of England – Counties of; Bedfordshire, Cambridgeshire, Essex, Hertfordshire, Suffolk and Norfolk
Contents	Police reported injury collisions data	Road traffic collision clinical trauma Patient data
Reporting Agents	Cambridgeshire Constabulary, police officers	Cambridge University Hospitals – Addenbrookes Hospital, AIS trained coders

4.3.4 Validation

The validity of any linkage results obtained or evaluating linkage error '… denotes the degree to which research approximates the truth.' (Elvik *et al.*, 2009, p. 99). The only study to undertake the linkage of STATS19 data and TARN data, Transport Research Laboratory (2001), using older versions of both datasets, did not explore either validation of the resulting linkages or linkage error. Other studies compared trends in the casualties recorded in different datasets, including STATS19 and TARN but did not link the data to identify the records in each dataset attributable to the same individual (Department for Transport, 2007; Lyons *et al.*, 2008).

The construct of validation was sparsely reported. This issue was specifically reported by the International Transport Forum (2011) with regard to data linkage specific to collision data where their literature review failed to find any validated linkage (International Transport Forum, 2011, pp. 59–61). Harron *et al.* (2017b) propose the use of a gold standard for quantifying error, this being the use of material 'from an additional data source with complete identifiers, from a subsample of records that have been manually reviewed or otherwise determined to be matches (or non-matches)' (p.1702), however, in the presented research the whole of their dataset was used as the gold standard and no suggestion of what an appropriate 'subsample' might constitute in other contexts.

It was not uncommon for papers involving the substantial linking of collision and hospital data, such as Alsop and Langley (2001) with New Zealand data, Rosman

(2001) with Australian data or, Lujic *et al.* (2008) also with Australian data, to fail to mention validation at all. Af Wåhlberg (2009) observes that it was common practice to place matters of validation in terms of a future study or push it towards other researchers. Yet a validation process was vital if the linkage was to be trusted (Méray *et al.*, 2007). With external validation, using material not contained in the original data to check matches, the most accurate but most time consuming (Tromp *et al.*, 2008; Qayad and Zhang, 2009; Bohensky, 2016) or as Harron, *et al.*, (2017b) describes it ‘the gold standard’. With the overarching principle of the need for external validation being essential if the methods or findings of any collision research are to be generalised (Elvik *et al.*, 2009).

Within the medical field there have been a number of data linkage validations undertaken which specify the methodology. There appears to be no standard sample size on which the validation was undertaken. For example, Qayad and Zhang (2009) undertook validation of three sets of linked data relating to child births, deaths and medical insurance claims. Each of the linked sets varied significantly in scale, for example in one exercise, from n=61113 for matches between the births and medical insurance claims, to n=1216 for the matches between the infant death rate and the birth records. The methodology chosen by Qayad and Zhang (2009) was to create a randomly selected subset of n=100 pairs from each subset of matched pairs for manual validation irrespective of the overall size. For example, the birth record to insurance claims linkage, using a nominal weighting cut point, produced n=61113 above the threshold of which a sample n=100 represents 0.2 percent, the same linkage process produced n=1289 linkages below the threshold of which the n=100 sample represents 7.8 percent.

Rosman *et al.* (2002) examined data linking quality in the Western Australia Data Linkage System, a regularly updated set of around 3.7 million records linking six population-based data sources. They used a random sample of 5000 hospital admission records for manual validation, where each line of data used to link the records was subject to a detailed clerical assessment to identify possible errors, this represented approximately 1 percent of that data source and 0.1 percent of all the records in the linkage system.

Victor and Mera (2001) validated a random sample of 1000 from each of their merged datasets, however, these ranged between 1.7 to 8.5 million records, so the validated sample would equate to 0.05 percent to 0.01 percent of the population.

Tromp *et al.* (2008) examined an external validation process on a linked dataset relating to Dutch perinatal records. The dataset contained 30082 records. There validation sample contained 191 records which was some 0.6 percent of the total. The validation process was time consuming but did result in understanding that the linkage was 100 percent accurate.

Tromp *et al.* (2011, p. 567) discuss the linking process in terms of gains and risks. This was in terms of true and false links. Processes which produce more links by allowing more variation in the variable values away from exact matches also produce more false links. The only way to know the level was by external validation. There was also a discussion regarding how using the n-1 option on the linking variables, i.e. allowing one not to match, see 4.3.7, produces less robust links than a probabilistic process. Interestingly although there was mention of an external validation there was no explanation.

Cirera *et al.* (2001) does not explore validation within the body of the text until right at the end of the discussion section when validation was described as the next step without setting out detail (Cirera *et al.*, 2001, p. 236), yet there does not seem to be such a paper in existence.

In Dipnall *et al.* (2014) does not use the term validation specifically but describes, in stage 9, a requirement to document any variable mismatch, i.e. validate the matches and mismatches. Later in the piece on p. 241 there was discussion regarding assessing the quality of the linkage by using a random sample (no proportion of the population was suggested) and testing the quality of the matches, although there was no detail about how this should be done. However, Dipnall *et al.* (2014, p241) then cite Xu *et al.* (2012) who used 10 percent of their non-matches as their control sample. Xu *et al.* (2012) used a sample of 1000 from their total population of 102064, just below 1 percent, for validation. However, Xu *et al.* (2012) do not explain how the match validity was undertaken, just the low level of false positives and negatives.

What does appear to be clear from the research literature surveyed, was that there was no formal structure used across the field. The examples have a validation sample size which was dictated by availability of external validation data, the time available to undertake the process and a judgement as to whether the sample size satisfies observers.

4.3.5 Inclusion/exclusion Criteria

For this chapter's study, the boundary of the English county of Cambridgeshire, see 1.2.2, provides geographical scope for the five-year period from 1st April 2012 to 31st March 2017. STATS19 was available for the county of Cambridgeshire as a stand-alone dataset, see 4.1.1 and 2.3.1, TARN was available for the East of England (six counties including Cambridgeshire, see 1.2.2), see 4.1.2 below and 2.2.5, filtered for road traffic collision injury.

4.3.6 Feasibility Study Methods

Prior to the data linking process taking place using the linking capability within the statistical software package Stata (Acock, 2016), a manual linkage feasibility exercise was undertaken. The manual process involved taking data from individual subjects included in TARN and comparing the available variables with those in STATS19. Once the available variables were identified, the STATS19 data was examined to explore if any exact matches were present, each available variable individually did not produce matched pairs with multiple matches. However, as the available variables were combined the number of matches decreased. When all four variables common to both datasets were considered, single matched pairs were produced.

This process identified that there was no common identifier in both datasets but that there were common variables. The common variables, *quasi-identifiers*, were subject age, sex, the date of the incident and the home postcode of the subject. A comparison of the common variables are presented in table 4.3 below.

Table 4.3 Common variable comparison.

Variable	**STATS19**	**TARN**	**Agree**	**Modification for linking**
Age	Whole years only	1 decimal place	No	New age variable created in TARN with whole integers only
Sex	M/F	M/F/Unknown/Error	No	New sex variable created in TARN with same coding at STATS19
Postcode	Whole postcode (i.e. AB12 3CD)	First String (Postcode District) only (i.e. AB12 or AB1)	No	New abbreviated postcode variable created in STATS19 with first string only
Incident date	DD/MM/YYYY	DD/MM/YYYY	Yes	

The TARN dataset did not have a variable representing the county in which the patient received their injuries, and therefore contains data for patients from all six East of England counties as described in table 4.3 above.

4.3.7 Data Linkage Process

The process used to implement the data linkage was an application of that presented by Dipnall *et al.* (2014) as 'Data Integration Protocol In Ten-steps (DIPIT). DIPIT follows a clear and systematic process to minimise the production of erroneous outcomes. How each step was undertaken are explained, in table 4.4 below.

Table 4.4 Data Integration* Protocol In Ten-steps (DIPIT) (Dipnall et al., 2014, p. 239)

DIPIT Step	**Action**	**Strategy**	**Standard**
1	Define the data requirements	• _ Define research hypotheses • _ Establish files to integrate • _ Assess data quality	Documentation of research hypotheses, files needed to integrate and data quality issues
2	Establish ethical, legal and privacy issues	Establish ethical, legal and privacy issues for each data file to integrate	Documentation of standards met
3	Order the files to integrate	Set up a flowchart for all files to be integrated, incorporating all file names	Flowchart of file hierarchy
4	Establish the file formats	Amend the flowchart in step 3 to document the file format for each file integrated and the final master file	Inclusion of all file formats in flowchart
5	Define the variables of interest	Create a table containing the variable of interest for research containing as a minimum: • _ Final variable name • _ Original variable name • _ Source file of variable • _ Preliminary file(s) for variable • _ Description of variable	Table of variables of interest for research incorporating a standard naming format, structured order and identification of file source
6	Table of variables of interest for research incorporating a standard naming format, structured order and identification of file source	Create a table containing the variable(s) links and linkage method(s) used containing as a minimum: • _ Link variable(s) • _ Method of linkage • _ Automation used (if applicable)	Table of data file links, variables used and linkage method
7	Document the integration* path	Document the structure of the path taken for integration* to include as a minimum: • _ The integration* of the primary files • _ The saving of the Master file format in a standard file naming structure • _ The variables of interest to be retained • _ The variables standard naming format • _ The merging of all files into the Master file • _ A log of statistics of the key variables, and missing data analysis	Documentation of path of data file integration* hierarchy incorporating primary and secondary files, logs and naming convention
8	Flowchart the type of integration*	Document on flowchart type of integration*: • _ one-to-one • _ many-to-one • _ one-to many • _ many-to-many	Method of integration* included in flowchart and linkages used

9	Document the integration* outcome	Define linkage quality measure. Table of mismatches of records by variable to contain as a minimum: • _ Variable name • _ Source of mismatch • _ Reason for mismatch	Documentation of degree of variable mismatches (e.g., log): which variables, percentage matched/mismatched. Document linkage quality measure (e.g., F-measure graphs)
10	Check variables and missing data	Initial data inspection to include as a minimum: • _ Analysis of key variable(s) • _ Missing data analysis	Document initial investigation of variables. Define minimum percentage of missing data acceptable for research based on industry convention and document future handling of missing data

*Note that for consistency of terminology through the thesis the term linkage was used in preference to integration.

Step 1: Define the data requirements

Individual trauma patients represented in the TARN dataset were also represented in the STATS19 dataset, the linking of the two datasets to identify the individuals allows for the identification of collisions where the severity of injury reached the study threshold of MAIS3+. The identification of these collisions allows the further analysis of the circumstance and individuals concerned. Both primary datasets were provided in electronic format. The outcome of the data linkage was intended to be a dataset that contains all the data from both originating datasets that relate to collisions which resulted in MAIS3+ injury.

Step 2: Establish ethical, legal and privacy issues

The data was provided by partner organisations. There were no ethical issues relating to individual participant, with ethical approval given by Loughborough University, as this process involves the linkage of bulk data. The bulk data was subject to information sharing protocols with the partner organisations and as part of that process the data was limited to that which was required by the process and does not contain any information which could lead to the identification of individuals. Data was transferred and stored securely and encrypted and these requirements for part of the information sharing protocols in place with the partner organisations.

Step 3: Order the files to integrate.

Once the information sharing protocols were put in place the data was requested form the individual partner organisations. Collision data are presented for the whole of Great Britain annually by the Department of Transport, for example Department for Transport (2017) or Department for Transport (2018a). These national statistics are always presented in terms of calendar year and the data initially supplied covered the years 2012 to 2016.

However, the TARN data was processed using the financial year, i.e. 1st April of one year to the following 31st March. The initial dataset provided covered the period 1st April 2012 to 31st March 2013 (2012-13 for ease). The following years data came in the same chronological format to 2016-17.

To allow direct comparison and to keep the full 5-year analysis STATS19 data up to and including 31st March 2017 was requested and provided.

Step 4: Establish the file format

The datasets were provided in Excel file format (.xlsx). Data linkage was conducted using Stata software and converted into Stata file format (.dta) (Acock, 2016).

Step 5: Define the variables of interest

The attribute variables of interest in this data linkage were those which allow the appropriate collisions to be identified. Both datasets in their raw form contain multiple variables; STATS19 has 175 variables and the TARN dataset 43.

There were common variables between the two datasets which were date of the incident, sex, age, and home postcode (although only the first string (Postcode District) in TARN). Therefore, to maximise the opportunity to obtain correct matches when the merge process takes place all four variables were used.

Unfortunately, in each dataset the variables to be used did not have the same variable label and in some cases, were not in the same format. The cleaning and standardisation of the variables to be used was crucial to the success of any linking process (Christen, 2012). Stata allows variable names containing upper- and lower-case letters as well as numerals. They must have no gaps, any gaps that are required are represented by an underscore (Acock, 2016). In importing .xlsx files into Stata to create .dta files there are a number of options. The first was to use the first line as variable names; this allows the variable names in Excel to be converted directly into the variable names in Stata. The second option was to convert all variable names into lowercase. For the importation of the two datasets both of these options were selected, the first to maintain continuity between the two versions of the data and the second because Stata only manages variable names in lower case.

It should be noted that there was no missing data in the variables under examination in the linkage process with all comparable variables being formatted to conform with Stata naming conventions and formats (i.e. no gaps between variable names or the use of underscore as a separator).

Step 6: Set up link(s) for linkage

As there were no common identifiers present in the datasets. The four common variables (which were the incident date, the subject's age, gender and the first string of their home postcode) shared by the two datasets were instead used as quasi-identifiers for the linkage. There was no missing data in all four variables to be used in either dataset; therefore, the only use of probabilistic linkage would be to find links where there was an error in the data, in this case the use of an estimated by inaccurate age for the casualty. Note Hagger-Johnson *et al.* (2017) used date of birth, sex and postcode as deterministic factors with some acceptance of partial date of birth. Previous research also undertaking the linkage of police and hospital data in Porto, Portugal found that age can be considered a rigid variable with no tolerance required to get the optimum level of true matches, age should be used in conjunction with sex and date at deterministic variables (Amorim, Ferreira and Couto, 2014).. The linkage was conducted using the ‘reclink2’ command in Stata (Wasi and Flaaen, 2013).

The software package used for this analysis, Stata, can be used to undertake both deterministic and probabilistic methods (Acock, 2016), Tromp *et al.* (2011, p. 565) contains a simple explanation of function of the two methods. The linkage was undertaken using the ‘reclink2’ linking function within Stata which allows for both deterministic and probabilistic matching processes dependent on weighting function used (Acock, 2016).

The weighting function within the ‘reclink2’ command, uses the ‘wmatch’ option. The weighting has values from one to 20, with 20 being the highest and are applied to each of the variables used in the linking process. The default, with no ‘wmatch’ option specified reverts to a level of 20 for each variable. During the examination of the feasibility of using this command to undertake both the deterministic and probabilistic linkage and to minimise the linking error of the probabilistic process, there was evaluation of a number of trial linkage processes that were undertaken with varying weighting.

The weighting trials were conducted using a sample containing the 2012-13 STATS19 and Tarn datasets. To verify that in the absence of the 'wmatch' option the default position of all variable weights set at 20 occurred the sample was examined without the 'wmatch' option specified, and again with the 'wmatch' specified with the weighting for the four variables all at 20, this appears as 'wmatch (20 20 20 20)' in the command line, both produced the same dataset. This dataset was the result of the deterministic process where all four variables had equal weighting and matches resulted for exact matches of the four variables. In this sample this resulted in 58 matches. Of these 58 matches 54 reached the MAIS3+ threshold, however, for the purpose of this stage in the process the threshold was not required. The process aim was to optimise true matches and minimise false matches within the overall linking process.

The probabilistic linkage process was undertaken to capture any potential true matches that had been missed by the deterministic process because one of the variables was not an exact match. The sample (n=4997) had the deterministically linked subjects (n=58) removed to discount the option for one of these subjects to be linked again leaving n=4939 records available for the probability weighted linkage. To verify that all deterministically linkable records had been removed, the linkage was run with maximum weighting on the remaining records, and this returned no matches.

A number of linkage runs were undertaken with varying combinations of weighting, with many of the processes produced large numbers of matches which were clearly false, such as a weighting combination of (15 5 15 20) which produced 107 matches, with many only two variables matched; however, equally, many combinations did not give further linked records. Given that the one variable where the original manual linking suggested there might be error was in the age variable in STATS19 the weighting for age was varied whilst keeping the other three variable weightings at maximum. Dropping the age weighting to 15 and then 10 did not produce any matches, however, in dropping the weighting to five this produced the 46 matches. These 46 matches were then subject to a manual assessment and application of the ± five year criteria for age variance. This weighting combination, with age weight set at 5 and the remaining three variable weights set at 20, minimised false matches but still produced records with the variance in STATS19 age of ± five years for the age variable (Hagger-Johnson *et al.*, 2017; Gilbert *et al.*, 2018).

Step 7: Document the linkage path

The linkage path involved in this study was straightforward. There were two files which required merging which did not need to be combined with any others prior to the linkage process, see figure 4.2 below.

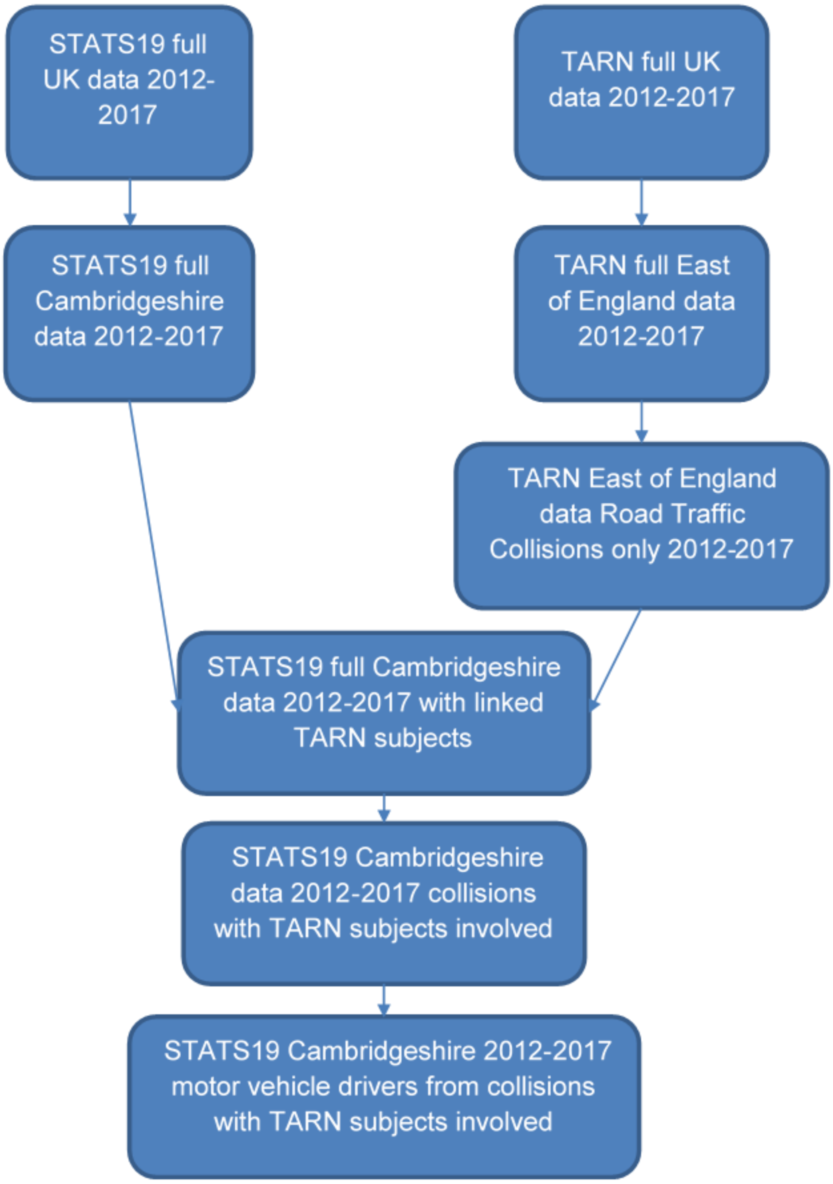

Figure 4.2 Data Process flowchart. For step 7

Step 8: Flowchart the type of linkage.

There are four file matching types that can be used during linkage of a merge/using dataset with a master dataset. The types can be described as:

- A one-to-one match based on a single variable common to the master and merge/using file. (For example, linking of files both holding a unique identifier for an individual, such as NHS number or National Insurance number on each dataset.)

- A one-to-one match based on more than one variable common to both the master and the merge/using file. (For example, the linking of datasets using a combination of variables such as surname, initial, age, sex and so on.)
- A one-to-many match which links a variable in the merge/using file with more than one data string in the master file. (For example, linking a patient file at a general practice to a number of hospital accident and emergency visit files.)
- A many-to-one match which links a number of data strings in the merge/using file with a single string in the master file (For example, a number of individual hospital visits to a master patient file held at a general practice.)
- A many-to-many linking with multiple individual strings in one dataset are linked with other multiple strings in another (For example, the cross referencing of datasets containing insurance claims with other datasets of insurance applications which may detect fraud.)

(Adapted from Dipnall *et al.*, 2014, pp. 241–242)

In this linkage process a one to one match option based on more than one common variable was used to utilise the four common variables available maximising the opportunity for true matches where one individual patient can be linked to a particular collision. The common variables being sex, age, date of incident and the first part of the home postcode, see figure 4.3 below.

Incident Identifier	Sex	Age	Date	Home Postcode
1	m	28	01/01/2031	AB1
2	m	46	02/01/2016	CD2
3	m	67	01/01/2013	EF3
4	f	18	02/01/2013	GH4
5	f	54	03/01/2013	IJ5

Incident Identifier	Sex	Age	Date	Home Postcode
1	f	54	03/01/2013	IJ5
2	f	18	02/01/2013	GH4
3	m	28	01/01/2031	AB1
4	m	67	01/01/2013	EF3
5	m	46	02/01/2016	CD2

Figure 4.3 Linking process illustration

Step 9: Document the linkage outcome

The evaluation of the linkage process was recorded and presented as proportions of the data linked. This was presented for both the master and using data file. In this case the master dataset was the STATS19 data for the period concerned and the using dataset was the TARN dataset. Match rates are not reported as there was no expectation that all the records in each dataset should have a match. For the STATS19 data only a small proportion of the collisions represented would involve casualties which received injuries to the required level. The TARN data covers six counties so only a proportion of the patients would have been involved in collisions in Cambridgeshire. Therefore, producing match rates from the total number of subjects in each dataset would not reflect on the quality of the linking process. Likewise the actual number of either collisions, from STATS19, or patients, from TARN, that should be matched was unknown and therefore it was not possible to generate a match rate using this context (Harron, Goldstein and Dibben, 2016).

Step 10: Check variables and missing data

The variables used in the linkage process did not present any missing data, all fields were present. This allowed all four selected variables, sex, age, date of incident and the first part of the home postcode, to be utilised.

The results present the total number of linked records, the number of these records which reach the MAIS3+ injury severity level, how many collisions resulted in these injuries and finally the number of motor vehicle drivers involved in those collisions.

Validation of true-matches was undertaken, fully explained in section 4.3.8, using a 10 percent sample of the linked data selected using the random selection command built into the Stata software. The result of this validation was reported as a percentage of the matches being true-matches.

The linkage process takes a number of stages and there was reporting during the process. It was useful to represent this process diagrammatically to allow clarity. Gilbert *et al.* (2018) provide a useful template for this purpose, see figure 4.4 below. There was analysis of data at three points during study one at steps one to three. At step one the variables available for linkage, suitability and compatibility were reported; at step two the results of the linkage were reported and at step three the linked data and resulting collisions identified were explored.

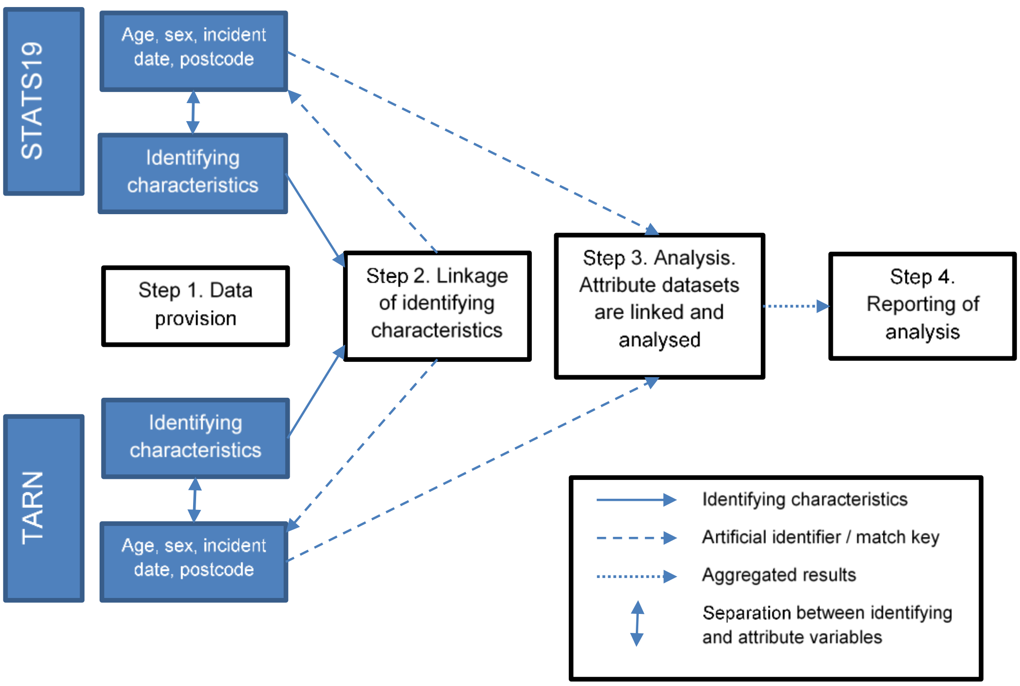

Figure 4.4 Analysis process. Adapted from (Gilbert et al., 2018)

The linked dataset retains the format of the ‘master’, in this case STATS19, dataset with the variables from the ‘using’ dataset, TARN, appended to the right. The linked record data was shown on the appropriate row. The process also generates a number of new variables, each was positioned on the master dataset to the right of the variable used in the linkage. The new variable has a capital U appended to the beginning of the original variable name it was adjacent to, for example, ‘Uage’ was generated next to ‘age’. Where there has been a link the ‘U’ variable contains the data in that row which has been used in the link. This allows the accuracy of the match to be assessed with a visual comparison.

4.3.8 Validation Protocol

The validation process for this study involved the use of additional information from the data sources and the participation of one organisation to manually check corresponding data, the process would constitute a gold standard assessment of the valid matches and error rate (Harron *et al.*, 2017b). The additional data involved individual level personal data which was subject to considerable control and restricted access. The protocol constructed for the process, was therefore developed to take account of the above factors and requirements at each stage. The full validation protocol being set out in table 4.5 below.

Table 4.5 Validation protocol

Stage	Method
1	The deterministic linked pairs for the five-year 1st April 2012 to 31st March 2017 period were collated into one dataset.
2	10% of the deterministic linked MAIS3+ pairs were required for the validation process. The random selector function (sample command) within Stata was used to select the sample.
3	The 10% sample subset of randomly selected linked pairs from the deterministic process was saved as the basis for the validation sample subset.
4	All of the probabilistic linked pairs were then combined with the deterministic randomly selected linked pairs to create the validation sample subset.
5	The validation sample subset, which contained the anonymised collision data reference, was used to obtain further external data from the police collision records. This involved the manual recovery of

	the surname of the injured person, by a police member of staff with access to the systems in conjunction with the author, that was linked as a potential match in the trauma data.
6	A dataset was then created from the validation subset. This dataset contained only two of the available variables. The two variables are the TARN reference and the surname linked to this in the linkage processes.
7	The dataset containing the two variables was submitted to Cambridge University Hospital (CUH) via encrypted and password protected email.
8	CUH staff examined the full medical record linked to the TARN reference and confirm if the surname was a match or not. No further information was passed to the recipient.
9	The results were examined to determine the proportion of true matches.
10	Once the process was completed the name variable was deleted as it was no longer required.

4.3.9 Sample Analysis

This study identified the sample of collisions within the STATS19 data which correspond to injuries at the MAIS3+ level of severity, the collisions which resulted in a fatal injury are also identifiable directly from the original STATS19 data. Descriptive statistics were used to present the collision circumstances of these two sets of collisions which make up the sample of collisions used during the remainder of the thesis. This allowed comparison with other available UK collision data to determine if the collisions represented in the sample are unusual, this having a bearing on the generalisability of the analysis of the sample.

4.3.9.1 Collision Related Descriptive Data

Collisions are heterogeneous events. The distribution of the collisions being presented using histograms plotting the frequency or percentage of collisions against the factor being examined, with collisions differentiated by collision injury severity. The factors explored are:

- Distribution of number of motor vehicles involved in the collisions and other parties involved,
- Chronology, month, day and hour. Hour considered in relation to weekdays and weekends,
- Road type, main road designation from STATS19

- Carriageway type, designation from STATS19
- Junction type, designation from STATS19
- Speed limit, as recorded in STATS19
- Weather, designation from STATS19
- Vehicle type, designation from STATS19 (presented in table format)

4.3.9.2. Motor vehicle driver demographic data

There are two demographic variables for each of the motor vehicle drivers in the data, these are age and gender are presented descriptively.

The age distribution of all the motor vehicle drivers in the sample and Cambridgeshire resident motor vehicle drivers in the sample, as recorded in STATS19, as well as five and ten year age groups, are presented in histograms, followed by the motor vehicle drivers differentiated by collision injury severity classification.

The gender distribution for all motor vehicle drivers in the sample and Cambridgeshire resident motor vehicle drivers in the sample differentiated by collision injury severity and motor vehicle driver culpability are presented as frequencies and percentages.

4.4. Results

4.4.1 Data Linkage Results

The data linkage process was successful in identifying the collisions represented in the STATS19 data which resulted in an injury at the MAIS3+ severity level. Of the 10498 collisions in the original data 253 collisions involving motor vehicles were identified as containing a MAIS3+ casualty before the results were validated and duplicate collisions also containing a fatality were removed.

The results of the two linkage processes after validation, deterministic and probabilistic are presented in the table 4.6 below

Table 4.6 Linkage process, raw results.

Linkage process, raw results						
	STATS19 n=? give a total n	Tarn n=?	All linked records	Linked MAIS3+ records	MAIS3+ Collisions involving motor vehicles	Motor vehicle drivers involved in MAIS3+ collisions
Deterministic	23741	1907	295	257	232	399
Probabilistic	23445	1628	29	22	21	35
Totals			324	279	253	434

4.4.2 Validation Process Results

The validation protocol was set out in section 4.3.8. To determine the validity of the linkages a 10 percent sample of the deterministic linkages and all the probabilistic linkages were examine, see section two of the protocol. The total number of MAIS3+ linked records were n=257, this resulted in a 10 percent sample of n=25 records. In section four of the protocol all the probabilistically linked records were added, n=29. The two subsets were examined, with results presented separately, to give a validation sample containing n=54 records. Of these, it was only possible to validate 53 of the matches as one surname, from the deterministic sample, was not available from police records.

The validation process gave a true-match rate of 23/24 for the deterministic validated (95.8 percent validity, 4.2 percent error rate) and 17/29 for the probabilistic validated (58.6 percent validity, 41.4 percent error rate percentage).

The probabilistic process allowed for variation in the recorded age of the injured party in the STATS19 data, therefore, all age differences recorded on STATS19 and TARN for each linked pair were examined. All the Deterministic linkages were positive and less than one year, as would be expected as the TARN age was rounded to one decimal place so would always be older than the recorded STATS19 age. All Probabilistic matches were either negative or positive more than one year showing that the probabilistic process had captured the pairs where there was a discrepancy in the STATS19 age variable from the age recorded on TARN derived from the subject's date of birth.

The validation process results are presented in table 4.7 below.

Table 4.7 Linkage process, validated results

Linkage process, validated results					
	STATS19, n=	Tarn, n=	Linked MAIS3+ records, n=	MAIS3+ Collisions involving motor vehicles, n=	Motor vehicle drivers involved in MAIS3+ collisions, n=
Deterministic	23741	1907	256	230	399
Probabilistic	23445	1628	12	8	13
Totals			268	238	412

The original STATS19 data contained records for n=14101 casualties in all injury severity categories with n=1823 casualties categorised as having a serious injury. The n=268 represent 1.9 percent of all the recorded casualties in the STATS19 data and 14.7 percent of those casualties categorised as having a serious injury in the STATS19 data.

Although the collisions identified contained a casualty with a MAIS3+ injury a number of these collisions also resulted in a fatality. Therefore, the MAIS3+ casualties from collisions which also resulted in a fatality will be included in the fatal collision data and the MAIS3+ duplicates removed so that collisions are not double counted. The validated results after the duplicates have been removed are presented in table 4.8 below.

Table 4.8 Linkage process validated results with duplicates removed

Linkage process, validated results after duplicates removed					
	STATS19, n=	Tarn, n=	Linked MAIS3+ records, n=	MAIS3+ Collisions involving motor vehicles, n=	Motor vehicle drivers involved in MAIS3+ collisions, n=

Deterministic	23741	1907	234	202	347
Probabilistic	23445	1628	12	8	13
Totals			268	210	360

4.4.3 Collision Related Descriptive Analysis Results

This section presents the results of the methods described in section 4.3.9.1.

Both the fatal and MAIS3+ collisions represented in the sample involved between one to five motor vehicles, they also included other parties. The distribution of the number of vehicles involved n the collisions and other parties involved are presented in table 4.9 below.

Table 4.9 Distribution of motor vehicles and other parties

	Number of motor vehicles in the collision	**Frequency of collisions in the sample n=**	**Proportion of collisions within severity category %**	**Other parties involved n= and description**
Fatal Collisions				
	1	55	34.8	13 x single pedestrian, 1 x two pedestrians, 5 x single cycles, 1 x two cycles
	2	78	49.4	1 x cycle
	3	14	8.9	
	4	8	5.1	
	5	3	1.9	
	Total	158		
MAIS3+ Collisions				
	1	92	43.8	22 x single pedestrian, 1 x deer, 29 x single cycles, 1 x child's scooter
	2	94	44.8	
	3	17	8.1	
	4	6	2.9	
	5	1	0.5	
	Total	210		

The fatal and MAIS3+ collision distribution across months, days and hours of the day are presented below. The frequencies of collisions by month stratified by collision injury severity group are presented in figure 4.5 below. These results indicated a greater variation in MAIS3+ injuries and less variation in fatal injuries per month. No one month was shown to have higher frequencies of both fatal and MAIS3+ injuries, with peaks varying for both.

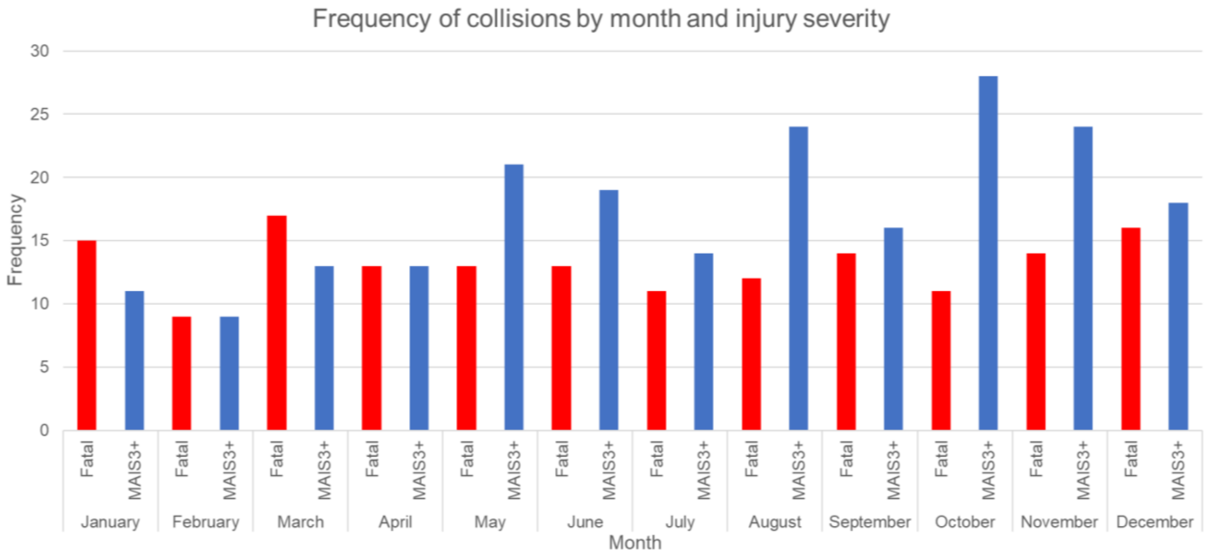

Figure 4.5 Frequency of collisions by month and collision injury severity

The distribution by months as a percentage of the total number of collisions within the motor vehicle driver group for the two collision injury severity categories are presented in figure 4.6 below.

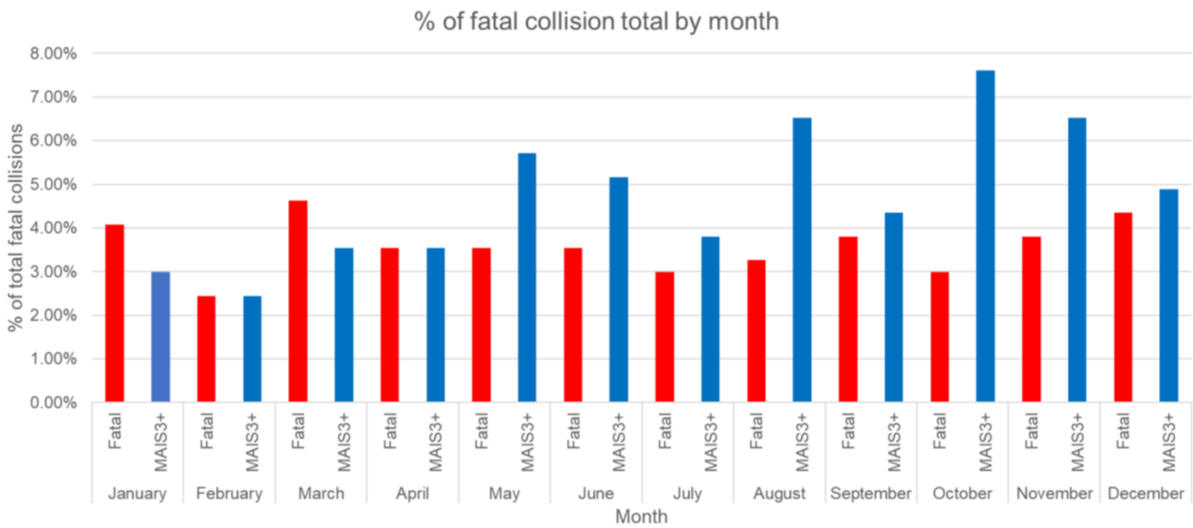

Figure 4.6 Distribution of the total frequency of fatal and MAIS3+ collisions by month

More variation in distribution within the MAIS3+ collisions can be observed compared to the fatal collisions.

The collision frequencies by day for each of the collision injury severity categories are presented in the figure 4.7 below.

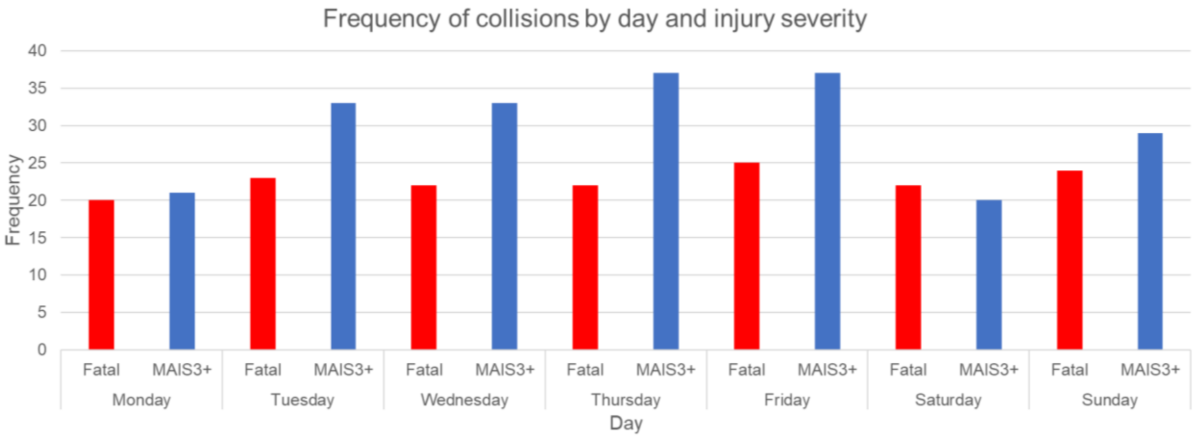

Figure 4.7 Frequency of collisions by day and collision injury severity

The distribution of the collisions by day shows more variation in the distribution of MAIS3+ collisions. For all days except Saturday the MAIS3+ collision frequency was higher than the frequency of fatal collisions.

The distribution of collisions across the hours of the day varied. The initial examination looks at the hour distribution across all the days of the week. Although the frequencies are lower for fatal collisions the general shape of the distributions for each category are similar. It can be observed that there are peaks in the frequencies at times which correspond to the commonly considered constructs of the morning and evening rush hours (peak traffic flows) as well as around lunch time. The frequency distribution of collisions, differentiated by collision injury severity, throughout the day are presented in figure 4.8 below.

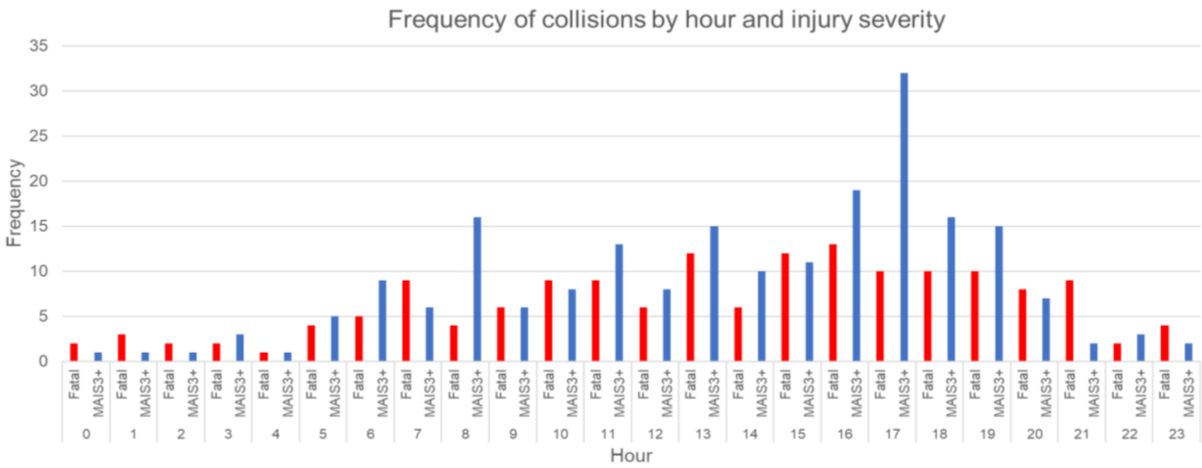

Figure 4.8 Frequency of collisions differentiated by hour of the day and collision injury severity category

The two collision injury severity groups show a similar distribution across the hours of the day with the MAIS3+ collisions showing more variation with higher peaks than the fatal collisions.

To allow understanding of the proportional distribution of collisions across the hours of the day the percentage of collisions by hour for the two collision injury severity categories are presented in figure 4.9 below. The three peaks observed in the comparison above are present in each category, although more distinct in the MAIS3+ collisions.

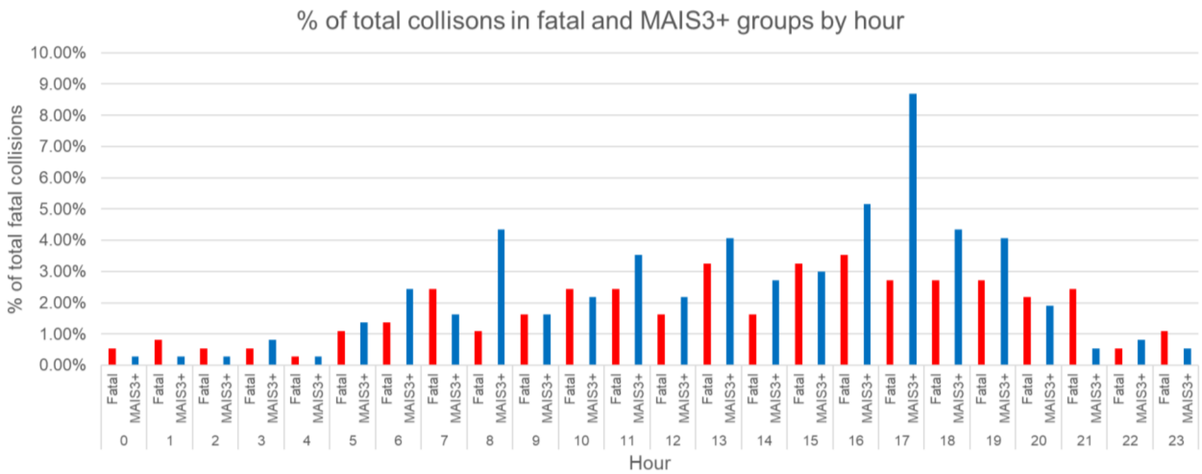

Figure 4.9 Distribution of collisions differentiated by hour of the day and collision injury severity category

Although the graph has the same distribution as that plotted for the frequency above the proportion percentage on the y axis may be useful as sometimes raw frequencies are not helpful in picturing a problem. In this case the proportions show that 18.2 percent of all the collisions represented in the data are MAIS3+ collisions occurring between 4 and 7pm, and if the fatal collisions for this time period are included the collisions during this time period account for 27.2 percent of all the collisions. There were three observed distinct peaks for MAIS3+ collisions, the highest at 5pm, however fatal collisions did not have a distinct peak at any time.

The analysis of the collision distribution across the days of the week presented in figure 4.10 indicated higher frequencies on weekdays. Having observed that there are peaks in frequency and proportion which appear to correspond to morning and evening peak traffic flow, see figures 4.10 and 4.11, which can be considered to be related to the Monday to Friday working week a further examination of the hour data shows if this may be the case.

Analysis using the construct of weekday and weekend does indeed show the distributions are centred around different time frames. The collision weekday and weekend distributions, differentiated by collision injury severity, are presented below, in figures 4.10 and 4.11, as a percentage of the total collisions within that collision injury severity category.

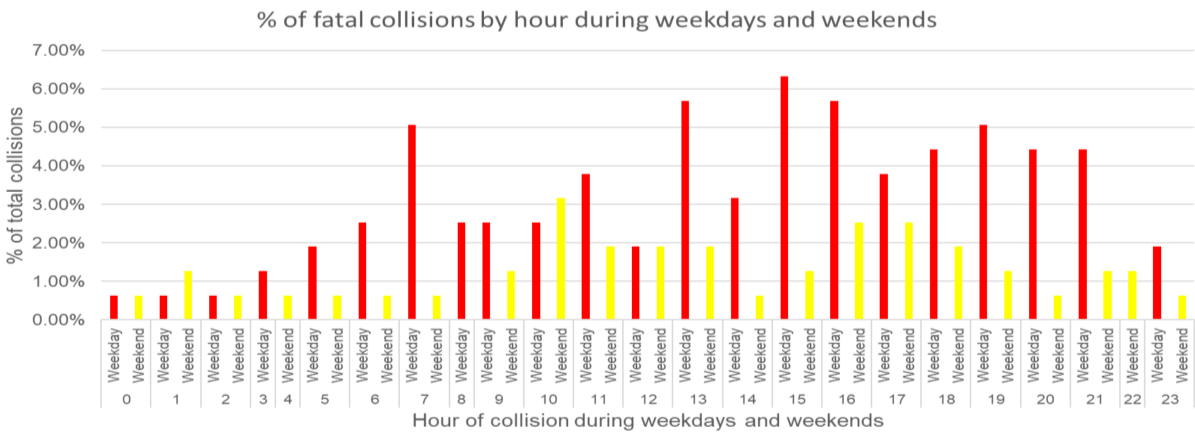

Figure 4.10 Distribution of fatal collisions by hour during weekdays and weekends

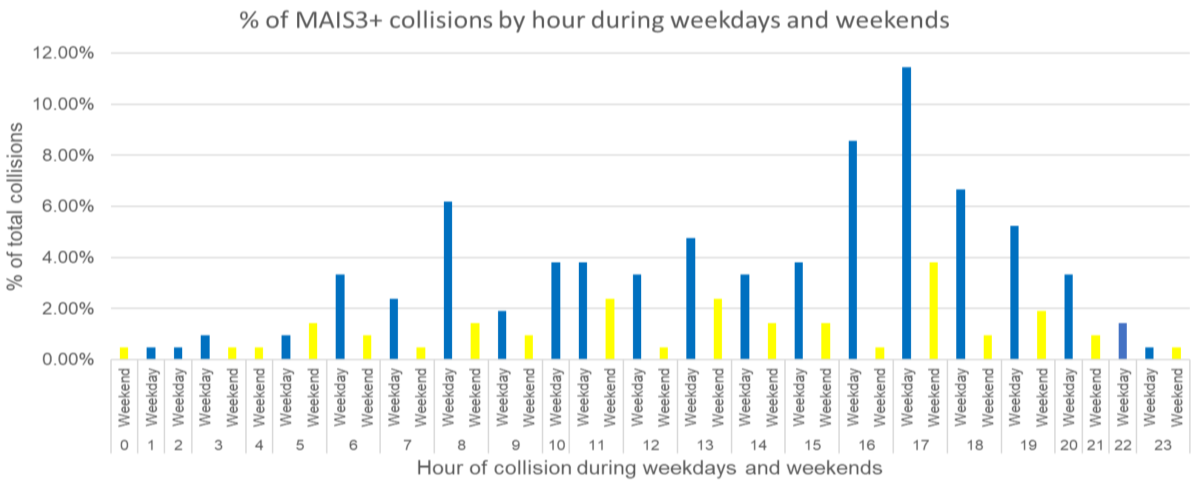

Figure 4.11 Distribution of MAIS3+ collisions by hour during weekdays and weekends

When comparing the fatal and MAIS3+ collisions for time of day and day of the week it was found that for both collision injury severity groups, the weekday peaks still correspond to those observed in the whole week data, i.e. the morning and evening peaks. Also, for both collision injury severity groups the weekend distributions have a first peak which starts later in the morning, 1000-1100 for fatal collisions and 1100-1200 for MAIS3+ collisions, and although all distributions have peaks in late afternoon the weekday persistence of collisions in both injury severity group frequency through the evening cannot be observed at the weekend.

There are four variables which allow for the placing of the collision within context of the road structure. These four factors are the main road class, what speed limit the road may be subject to, the constitution of the carriageway at the location and the positioning of any junction and its type.

The collision distributions by road class are presented in figure 4.12 below.

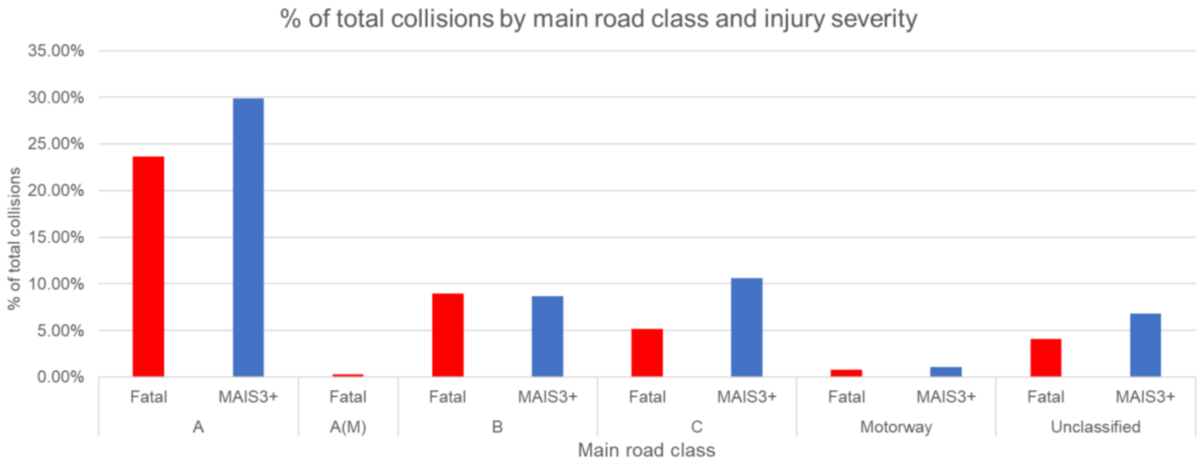

Figure 4.12 Distribution of total collisions by main road class and collision injury severity

Over half, 53.5 percent, of the collisions occurred on an A-class roads, despite A roads only accounting for 9.5 percent of the total Cambridgeshire road network (Cambridgeshire County Council, 2019b).

The collision distributions by speed limit class are presented in figure 4.13 below.

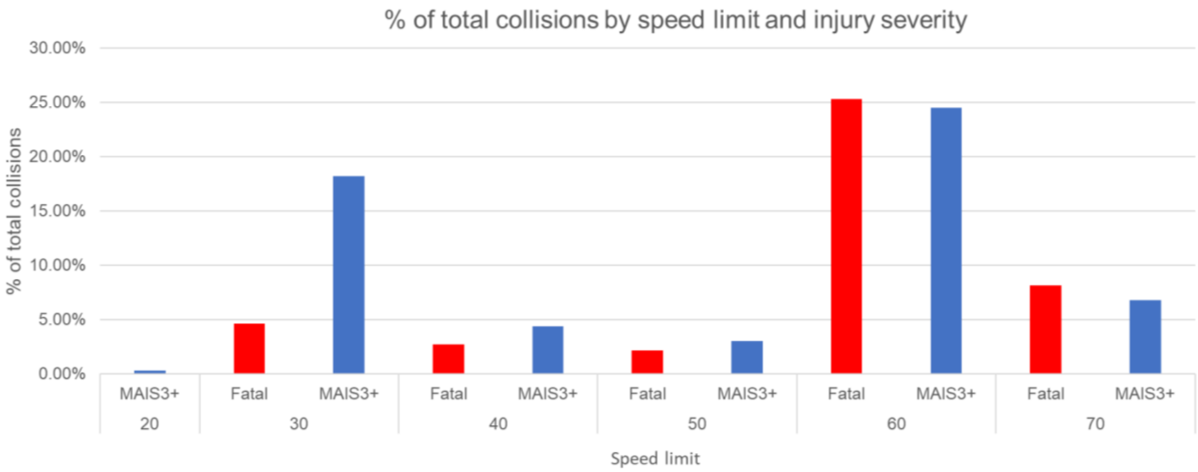

Figure 4.13 Distribution of total collisions by speed limit and collision injury severity

Examination of the speed limit of the road where the collisions occurred show that 49.7 percent of the collisions occurred where the limit was 60mph with a further 15.0

percent on 70mph limit roads and that the pattern of distribution appears consistent between the two collision injury severity groups except for collisions in 30 mph limit roads where there were three and a half times as many MAIS3+ collisions as fatal collisions.

Each classes of road can contain roads subject to different speed limits. For example, A class roads can be subject to 30, 40, 50, 60 and 70 mph limits. The distribution of the collisions can be explored by combining the road type data and speed limit data into one histogram. The distributions of all the collisions, irrespective of collision injury severity, across the road types and speed limits are presented in figure 4.14 below.

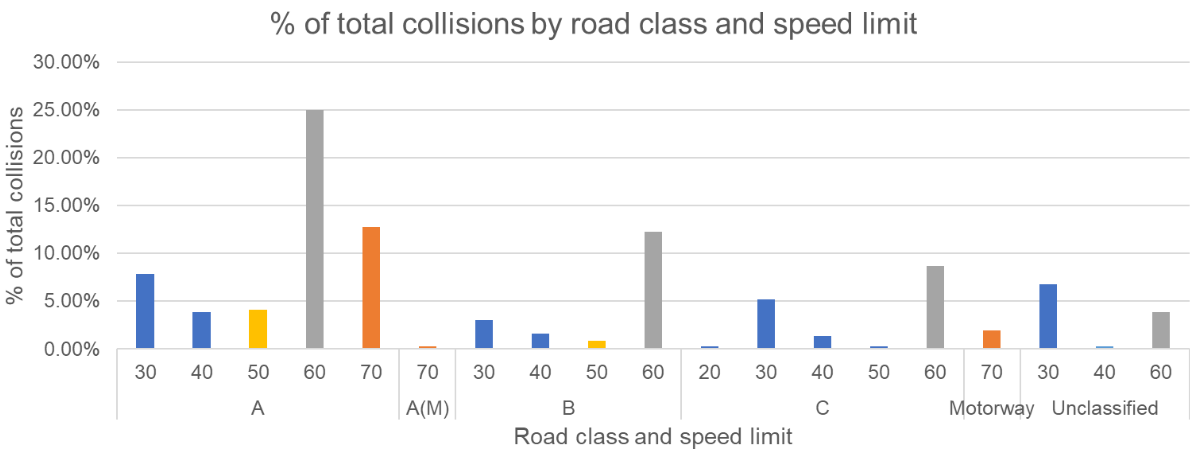

Figure 4.14 Distribution of all collisions by road class and speed limit

The distributions within each collision injury severity category are presented separately in figures 4.15 and 4.16 below.

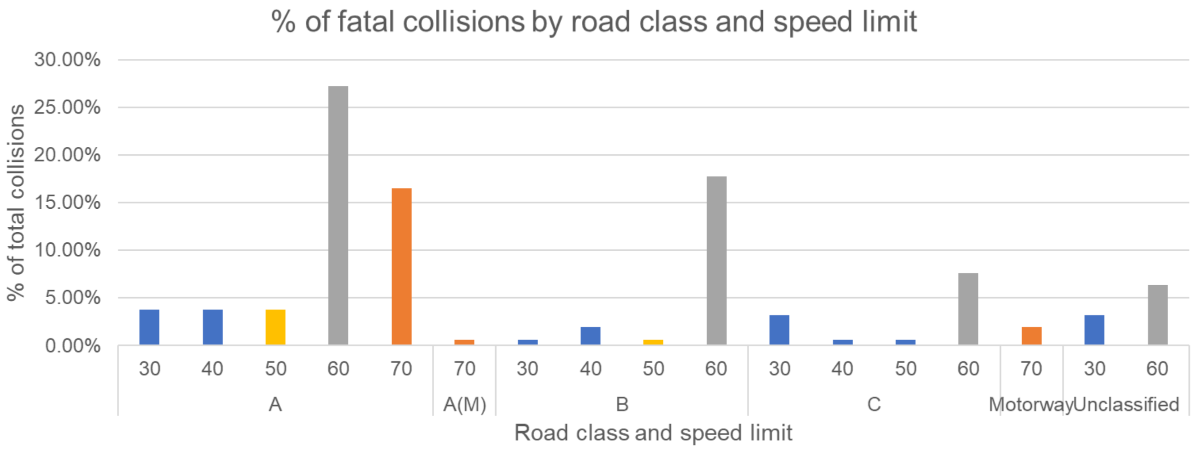

Figure 4.15 Distribution of fatal collisions by road class and speed limit

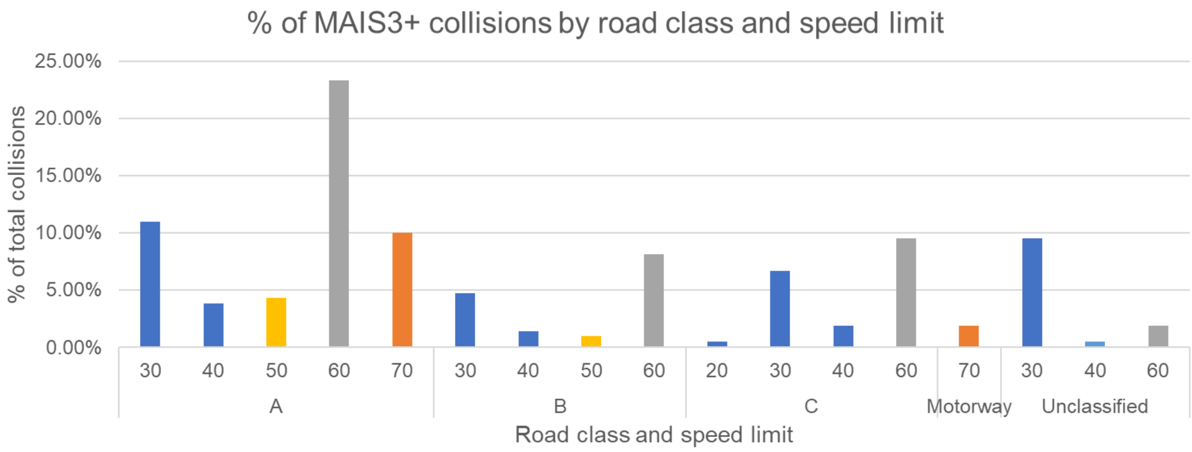

Figure 4.16 Distribution of MAIS3+ collisions by road class and speed limit

A number of matters can be observed from the analysis presented in figures 4.14 to 4.16. The first being that A class roads dominate, collisions on A class roads represent 53.5 percent of all the collisions, 55.1 percent of fatal and 52.4 percent of the MAIS3+ collisions. The second being that for all collisions 70.5 percent of the collisions on A class roads are in 60 and 70mph speed limits, 37.7 percent of all the collisions. This gives more insight into the distribution of the 64.7 percent of all collisions occurring of 60 and 70mph roads presented in figure 4.14. For fatal and MAIS3+ collisions on A class roads the 60 and 70 mph speed limit represent 79.3 percent and 63.5 percent of the collisions respectively with the proportion of all the collisions in the respective collision injury categories 43.7 percent and 33.3 percent respectively. Roads with a

30mph speed limit account for 22.8 percent of all collisions with these spread across the four road classes where this speed limit can be applied. For fatal collisions 60mph roads in all road classes produced the highest proportion of collisions totalling 58.9 percent, with 30mph roads only accounting for 10.8 percent, but for MAIS3+ collisions the balance of distribution changed, although 60mph roads still accounted for 43.0 percent of the MAIS3+ collisions 30mph limit roads were more prevalent accounting for 31.9 percent.

The distributions all collisions by carriageway type by collision injury severity category are presented in figure 4.17 below.

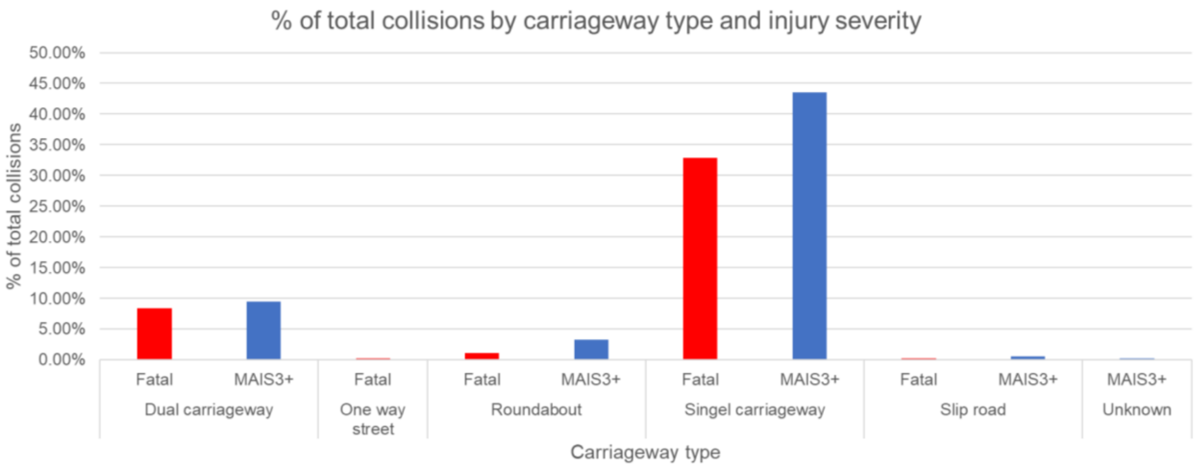

Figure 4.17 Distribution of total collisions by carriageway type and collision injury severity

The distribution of the collisions across the carriageway types shows that 76.4 percent of collisions occur on single carriageway roads, that being a road without a central divide between oncoming traffic, with a further 17.9 percent on dual carriageways. In examining this analysis in combination with the road speed limit distribution above it should be noted that only dual carriageway roads are subject to a 70mph speed limit, therefore the 15.0 percent of collisions occurring on 70mph speed limit roads would account that proportion of the 17.9 percent of dual carriageway collisions presented earlier with the remaining collisions on dual carriageways subject to another speed limit.

Examining how the types of carriageway relates to both the road classes and speed limits are presented below in figure 4.18 and 4.19.

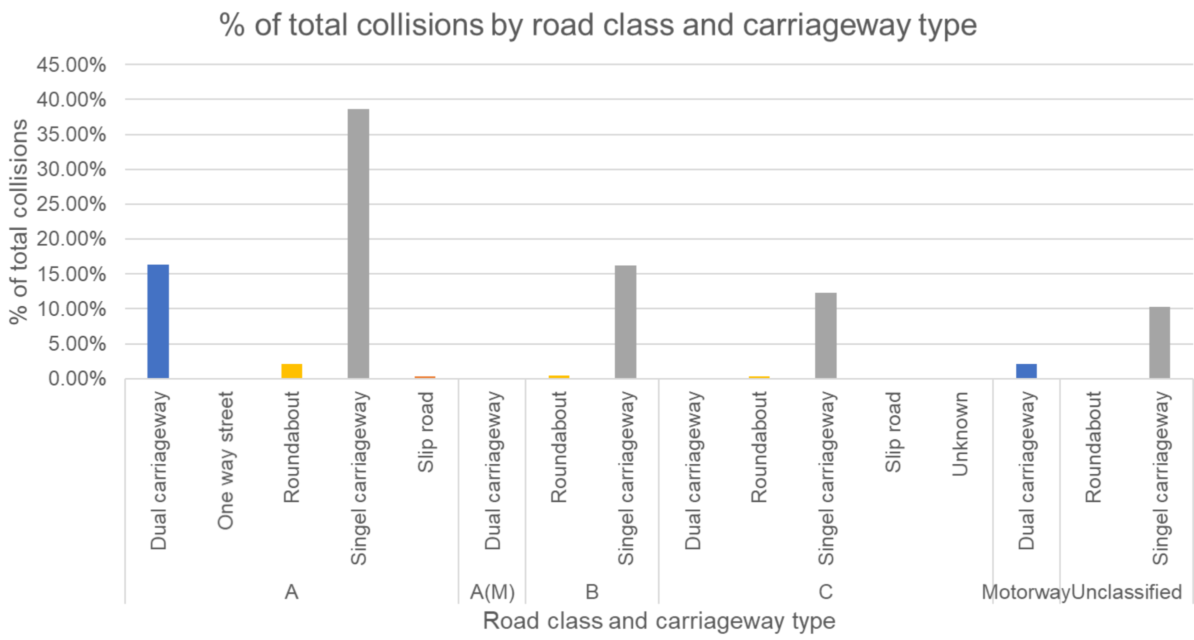

Figure 4.18 Distribution of all collisions by road class and carriageway type

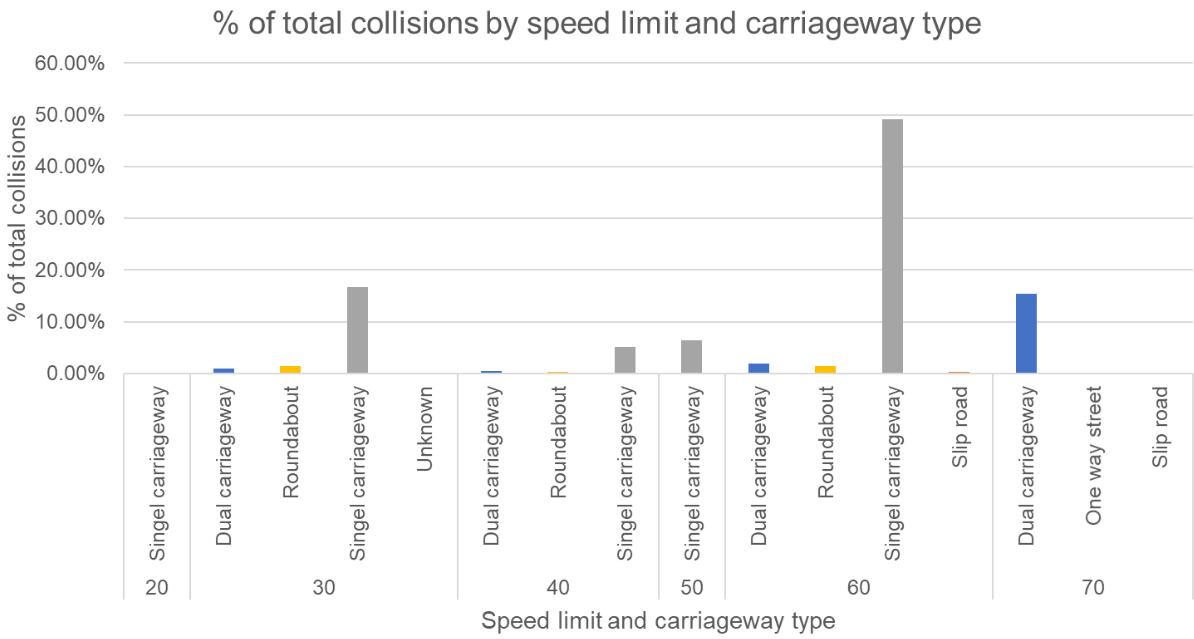

Figure 4.19 Distribution of all collisions by speed limit and carriageway type

The distribution of collisions by road class and carriageway type as well as the distribution of collisions by speed limit and carriageway type, for each of the collision injury severity categories, follows the same pattern of distribution at the distribution of all collisions. Single carriageway roads, when present in a category, are where the majority of collisions occur. These finding led to a re-examination of the original data to explore some of the combination which the above findings might suggest. The combination of A class, single carriageway subject to a 60 mph speed limit accounted for 21.7 percent of all the collisions, with single carriageway roads subject to a 60mph speed limit accounting for 45.8 percent of all collisions, A class roads subject to a 60mph limit accounting for 24.9 percent and A class single carriageways accounting for 34.1 percent.

The distributions of junction types by collision injury severity category are presented in figure 4.20 below.

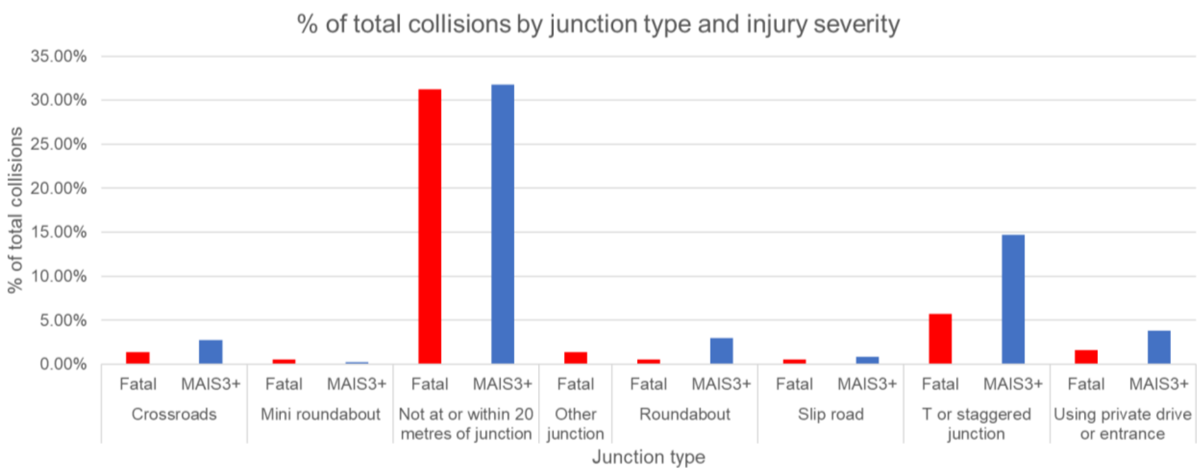

Figure 4.20 Distribution of total collisions by junction type and collision injury severity

Examination of the junction type where the collisions occurred show that 63.0 percent of the collisions occurred at a location without a junction and that the pattern of distributions are consistent across the two collision injury severity categories. Of the 37 percent where there was a junction involved, there consistently more MAIS3+

collisions than fatal collisions with T or staggered junctions accounting for 20.4 percent.

Examination of the weather conditions at the time of the collisions show that 80.4 percent of the collisions occurred in fine weather without high winds and the between collision injury severity comparison shows that the pattern of distributions are consistent across the two groups. The distribution of weather condition categories are presented in figure 4.21 below.

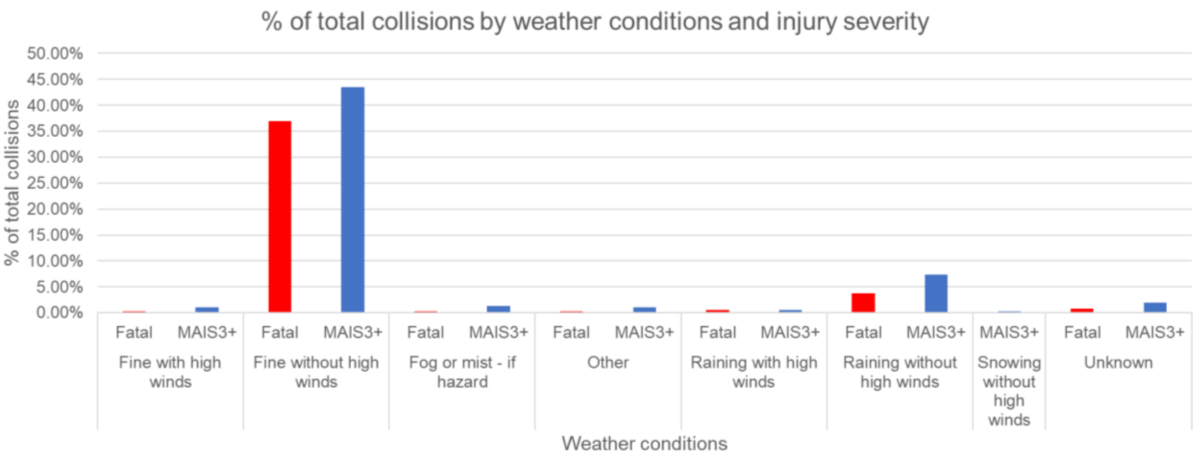

Figure 4.21 Distribution of total collisions by weather conditions and collision injury severity

The vehicle categories presented in the data only reflect motor vehicles as the data only contains records for motor vehicle drivers. The vehicle type distributions for all the motor vehicle drivers in the data are presented in table 4.10 below.

Table 4.10 Vehicle type distribution by collision injury severity for all motor vehicle drivers in the data

Vehicle type	**Fatal Collisions (n= / % of motor vehicle driver group total)**	**MAIS3+ (n= / % of motor vehicle driver group total)**	**Total (n= / % of total)**
Agricultural vehicle (includes diggers etc.)	3/ 1.9	1/ 0.5	4/ 1.1
Bus or coach (17 or more passenger seats)	3/ 1.9	2/ 1.0	5/ 1.4
Car	107/ 67.7	144/ 68.6	251/ 68.2
Goods vehicle - unknown weight	0/ 0.0	2/ 1.0	2/ 0.5
Goods vehicle 7.5 tonnes mgw and over	16/ 10.1	10/ 4.8	26/ 7.1
Goods vehicle over 3.5 tonnes and under 7.5 tonnes mgw	1/ 0.6	5/ 2.4	6/ 1.6
Minibus (8-16 passenger seats)	1/ 0.6	0/ 0.0	1/ 0.3

Motorcycle over 125cc and up to 500cc	6/ 3.8	6/ 2.9	12/ 3.3
Motorcycle over 500cc	7/ 4.4	22/ 10.5	29/ 7.9
Motorcycle over 50cc and up to 125cc	6/ 3.8	9/ 4.3	15/ 4.1
Other vehicle	0/ 0.0	1/ 0.5	1/ 0.3
Taxi/Private hire car	2/ 1.3	0/ 0.0	2/ 0.5
Van/Goods vehicle 3.5 tonnes maximum gross weight (mgw) and under	6/ 3.8	8/ 3.8	14/ 3.8
Total	158	210	368

The dominant vehicle presented was the motorcar in both collision injury categories at 67.7 percent and 68.8 percent respectively. Powered two wheelers are split into different categories depending on engine size, however, if these are combined, they account for 12.0 percent of the vehicle in fatal collisions and 17.7 percent of vehicles in the MAIS3+ category. In total all goods vehicles categories account for 14.5 percent of the vehicles involved in fatal collisions and 12.0 percent of the vehicles involved in MAIS3+ collisions.

The motor vehicle drivers involved in the collisions designated a purpose of the journey they were undertaking to the reporting officer, however, there are limited options and most journey types fit into the other category. The distribution of the journey purpose data are presented in table 4.11 below.

Table 4.11 Journey purpose data distribution

Journey purpose	**Fatal Collisions (n= / % of motor vehicle driver group total)**	**MAIS3+ (n= / % of motor vehicle driver group total)**	**Total (n= / % of total)**
Incorrect input	2/ 0.7	0/ 0.0	2/ 0.3
Journey as part of work	72/ 24.0	82/ 22.8	154/ 23.3
Commuting to/from work	27/ 9.0	55/ 15.3	82/ 12.4
Taking pupil to/from school	1/ 0.3	2/ 0.6	3/ 0.5
Other	160/ 53.3	207/ 57.5	367/ 55.6
Not known	38/ 12.7	14/ 3.9	52/ 7.9
Total	300	360	660

The ‘other’ category which includes all journeys which do not fit within one of the specified purposes accounts for more than half of the journeys recorded in the data.

4.5. Summary of Findings

The aim of this study was to identify motor vehicle drivers involved in collisions resulting in injuries at the MAIS3+ level of severity, by the linkage of STATS19 police collision data with TARN hospital trauma patient data. The determining of MAIS3+ collisions from the STATS19 data alone not being possible. TARN has been linked to STATS19 data in one previous study, Transport Research Laboratory (2001), however, in that instance the identification of MAIS3+ collisions within the STATS19 data was not an aim, although there was analysis of the clinical data it was not linked to the collision data apart from the injured parties role, i.e. car driver, pedestrian etc. The identification of the MAIS3+ injury collisions allows examination of an alternative clinically categorised set of collisions to those involving a fatality. Within the data the MAIS3+ collisions represented a larger sample than the fatalities and allows for direct comparison with other data involving MAIS3+ collisions without having to estimate the MAIS3+ collisions, being the case if HES data are used. The linkage process was followed by the exploration of the collisions identified to test the hypothesis that the collisions presented in the sample are not unusual when compared to other available data relating to injury collisions.

The study involved linking the two sets of data using a combined deterministic and probabilistic matching approach. The linkage process produced a dataset containing n=324 linked records, each record representing an individual casualty. Each TARN record contained the casualty’s body region AIS scores, when all the linked records were examined to determine the number which reached the MAIS3+ threshold this was found to be n=279, these results were then subject to validation.

The resulting linked records were subject to a gold standard validation and error rate process (Harron, *et al.*, 2017b), which allows for confidence in the results obtained. The process involved selecting a sample of the linked records and manually obtaining further information on the subjects held externally to the original datasets. This was achieved by manually collecting surnames from the police collision reports which was not contained in the STATS19 record and was found to be time consuming. The sample surnames were then submitted to Cambridge University Hospitals for comparison with the patient records.

The validation process produced a low error rate (4.2 percent) for the deterministically linked records, however for the probabilistically linked records the error rate was much higher (41.4), this was not unexpected, the allowed variance in the recorded age of the injured party in the STATS19 data of ± 5 years allowed for siblings involved in collisions together to all be captured when only one was the MAIS3+ casualty. The use of a gold standard evaluation of the validity and error rate of the linkage process gives confidence in the process involved and the results obtained (Harron, *et al.*, 2017b). The validation was then applied to the raw linkage results to produce the sample to be taken forward to study two and three. The validated number of MAIS3+ linked records was n=268, the relationship between the validated MAIS3+ casualty frequency and the total number of casualties in the Cambridgeshire STATS19 data is presented in table 4.12 below.

Table 4.12 Relationship of MAIS3+ casualties to the total and STATS19 seriopus injury casualties

Total casualties in Cambridgeshire STATS19 sample n=	Validated MAIS3+ casualties n=	Proportion of total casualties %	STATS19 Serious injury casualties in Cambridgeshire STATS19 sample n=	Proportion of STATS19 serious injury casualties %
14101	268	1.9	1823	14.7

The level of MAIS3+ collisions within the serious injury category are in line with those estimated by the Department for Transport at 16 percent, see section 2.21 and 2.24 (Department for Transport, 2018b; 2019c). Therefore, the number of casualties recorded as resulting from road traffic collisions in the STATS19 non-clinical serious injury category are not a good representation of the casualties with clinically serious injuries from the given set of collisions. The n=268 MAIS3+ casualties identified were the result of involvement in n=238 separate collisions and these collisions involved n=412 motor vehicle drivers. Once MAIS3+ collisions that also resulted in a fatality were removed the number of collisions only containing a MAIS3+ casualty were n=210 involving n=360 motor vehicle drivers.

Chapter Five: Motor Vehicle Driver Culpability Scoring (study two)

5.1. Introduction

The research presented in his chapter examines the culpability of all the motor vehicle drivers involved in the fatal and serious (MAIS3+) injury collisions, irrespective of their personal injury status as a result of the collision, it does not explore the culpability of any other parties to the collisions. Culpability has been defined as a motor vehicle driver providing an element of the collision narrative, without which the collision would not have occurred, and considers the persons responsibility in performing an action. The action itself, or a combination of actions, could, but not necessarily, have legal connotations whereby the motor vehicle driver had been culpable for causing a collision due to breaking a law, for example drunk driving. This study only considers the motor vehicle driver's interaction with the circumstance of the collision rather than any legal construct (see section 2.9). The working definition of culpability employed here was given by (af Wåhlberg, 2002, p. 640) as: 'Only an accident where the …driver could clearly not have avoided the accident would he be 'acquitted' of responsibility'. Culpability has been far from straightforward to determine, where subjectivity may influence individual observation, and judgements of individual culpability (Köhnken and Brockmann, 1987).

The scoring of culpability has been used in a number of studies (Terhune, 1983; Robertson and Drummer, 1994; Brubacher, Chan and Asbridge, 2012), see section 2.9, to determine the impact of factors relating to individual motor vehicle drivers on the circumstances resulting in a collision. In many studies the role of the culpability scoring, sometimes termed as responsibility, was to allow the assessment of an external factor, such as alcohol or drug consumption, on the risk of being culpable for a collision. No studies were found that grouped motor vehicle drivers by culpability so the demographic characteristics of the motor vehicle drivers in the culpability groups could be examined, or purely that the culpable motor vehicle drivers can be targeted with interventions to reduce future risk.

The tool devised by Terhune (1983), although structured, still required the subjective interpretation of the collision narrative. The Robertson and Drummer (1994) tool was found to be the tool which appeared in the literature most frequently and had also been judged to be superior to that of Terhune (1983), being much less subjective (Brault and Dussault, 2002).

Brault and Dussault (2002) examined the two scoring tools that featured in the literature up to that time, that of Terhune (1983) and Robertson and Drummer (1994), see section 2.9) in relation to their subjectivity. Subjectivity was considered to be the interpretation of the definitions in the scoring scales and personal judgements on the circumstantial weights of individual factors (i.e., the use of expert opinion) and concluded that Robertson and Drummer (1994) was less subjective and therefore the more accurate.

The tool devised by Brubacher, Chan and Asbridge (2012) was an adaptation of the Robertson and Drummer (1994) tool specifically tailored for a Canadian Paradigm. Of the three validated tools available in the literature the tools devised by Robertson and Drummer (1994) was the one relied upon in more studies and assessed as the least subjective.

The final and most recent tool represented in the literature was that devised by Brubacher, Chan and Asbridge (2012) which was an adaptation of the Robertson and Drummer (1994) tool to suit a Canadian paradigm. The Brubacher, Chan and Asbridge (2012) tool does not feature in the literature as widely as the Terhune (1983) tool but does retain the advantage, that was inherited from the Robertson and Drummer (1994) tool, in being less subjective. The tool which has been most often cited was the tool devised by Robertson and Drummer (1994), this was also considered the most precise and accurate in determining responsibility compared to the Terhune (1983) tool (Brault and Dussault, 2002) and the only tool recommended by af Wåhlberg (2009). This tool was selected to undertake the culpability analysis. The tool devised by Brubacher, Chan and Asbridge (2012) was selected as a comparison tool to examine the results produced by the Robertson and Drummer (1994) tool. The comparison was to allow a determination of culpability scoring consistency with the available data, radically different results may suggest one of the tools was not suitable and necessitate the exploration of further culpability scoring options. Culpability scoring can only be possible with sufficient data available about the collision circumstances.

The use of collision statistics as the sources of information to guide road safety and casualty reduction interventions and strategies has been well established (af Wåhlberg, 2009; Elvik *et al.*, 2009). These data can then be used to examine many aspects of the collision circumstance and allow determination, for example, of particular locations, and the types of collisions which occur there, to inform engineering and design. The examination of the information held on individual motor vehicle drivers, their involvement, actions, background and history can yield considerable information. This information can then be combined with theoretical constructs, such as deterrence (Cohen and Felson, 1979; Felson, 1986; Akers, 1990; Gottfredson and Hirschi, 1990; Stafford and Warr, 1993; Cornish and Clarke, 2014), to endeavour to change behaviour by framing specific interventions, such as enforcement, education and training. Prior to examining motor vehicle driver populations it should be considered essential to take into consideration the motor vehicle driver's individual culpability, this position being supported by what Banks *et al.* (1977) observed that not taking account of culpability was a serious methodological error leading to erroneous results. This could result in the analysis of data relating to motor vehicle drivers for whom involvement in a collision was purely the result of geography and timing rather than their actions and are therefore not culpable. The inclusion of these motor vehicle drivers in distributions could mask the distributions of culpable motor vehicle drivers, whose actions created the collision circumstances.

Any method of assessing the culpability of the drivers involved in collisions must be capable of differentiating individual collision circumstances rather than pre-defined constructs involving a purely active or passive involvement as historically employed by West (1997), West and Hall (1997) or Parker *et al.* (1995) or the even earlier binary consideration of a motor vehicle driver being ‘to blame’ or not for the collision (Quimby *et al.*, 1986). Clearly more than one motor vehicle driver may be culpable for a collision, possibly all those involved in some circumstances (af Wåhlberg, 2002; 2009). The inherent weakness of many historical constructs was likely to produce unreliable results, with more stringent and less subjective criteria more reliable results can be obtained and should produce a level of culpable motor vehicle drivers of around 70 to 80 per cent in any given population (af Wåhlberg, 2009), however, this may be influenced by the distribution of single and multi-vehicle collisions within the data.

Unfortunately, irrespective of the method of culpability scoring chosen or devised, the issue of subjectivity within the process can be impossible to avoid at some point, that being the application of a personal opinion on the circumstances of the collision. This starts with the reporting of the collision, where although there may be physical and witness evidence, the manner of information consideration, and the collision narrative which it constructs remains subjective. In re-examining the material, it would be ideal for the researcher to use a method which does not introduce a further layer of subjectivity.

5.2. Aim and Objectives

The aim of this study was to undertake culpability scoring of motor vehicle drivers involved in serious (MAIS3+) and fatal injury collisions, fulfilling the following objectives.

- Evaluate if current culpability scoring tools are viable for use with UK police collision data (STATS19).
- Assess the culpability of motor vehicle drivers involved in fatal and serious (MAIS3+) injury collisions.

5.3. Methodology

5.3.1 Introduction

The study explores the culpability of the n=660 motor vehicle drivers involved in fatal and MAIS3+ collisions which occurred in Cambridgeshire between 2012 and 2017. The dataset presents the two groups of motor vehicle drivers with n=360 motor vehicle drivers involved in the MAIS3+ injury severity collisions identified by the data linkage undertaken in the first study, see chapter four, and the n=300 motor vehicle drivers involved in the fatal collisions from the same Cambridgeshire STATS19 dataset. A new variable was created to identify the injury severity group, from which the motor vehicle driver originated. Case studies are used during this chapter to assist with understanding of the processes and as examples of the application of the processes.

There are currently no culpability scoring tools specifically designed to be used with STATS19 data. The two culpability tools to be applied to STATS 19 were the tools devised by Robertson and Drummer (1994) and Brubacher, Chan and Asbridge (2012). The scoring tools are designed to remove the bias which may enter a culpability determination process when that process purely relies on the personal judgement of an individual (Brault and Dussault, 2002). A second tool was utilised to allow the comparison of the consistency of assessment of the Robertson and Drummer (1994) tool.

Once the motor vehicle drivers have been culpability scored and allocated to a category the premise of the scoring process, that non-culpable motor vehicle drivers could only have avoided the collision by not being present, presents the proposition that the non-culpable motor vehicle drivers involved in the collisions are a random selection of the general driving population. If this was the case, then this cohort can be used as a proxy for the general driving population. This has been proposed by a number of authors (Cerrelli, 1973; Stamatiadis and Deacon, 1997; af Wåhlberg and Dorn, 2007). Comparative analysis of the culpable and non-culpable motor vehicle drivers involved in the collisions should identify differences between the culpable motor vehicle drivers and the general driving population.

5.3.2 Tool Overview

Both scoring tools identify each motor vehicle driver involved in a collision as either culpable, contributory or non-culpable. Culpable was defined as responsible for the collision; contributory as not fully responsible for the collision and lastly non-culpable exonerated fully from responsibility (Robertson and Drummer, 1994, p. 244).

Both culpability scoring tools work from the premise that the motor vehicle driver was culpable. The user then applies the tool to examine the circumstances of the collision relating to the actions of an individual motor vehicle driver, or how the circumstances of the collision, for example, weather conditions, may impact on that motor vehicle driver to identify mitigating factors towards that motor vehicle driver's culpability. Points are assigned to each motor vehicle driver for certain mitigating factors. If the score reaches a threshold, then the initial presumption of culpability was either downgraded to contributory, or removed, and the motor vehicle driver was designated as non-culpable. The thresholds differ between the two tools, and are explained fully for the Robertson and Drummer (1994) in section 5.4.1 and the Brubacher, Chan and Asbridge (2012) in section 5.4.2.

5.3.3 Culpability Scoring Process Phases

The process of culpability scoring the motor vehicle drivers present in the dataset was undertaken in four phases.

Phase 1: The purpose of the first phase of the process was to explore the availability and feasibility of using STATS19 data with the two tools and motor vehicle driver's culpability scored. This process being described in section 5.4.

Phase 2: This phase involved the comparison the consistency of culpability scoring in a sample of results using both scoring tools, this being set out in section 5.5.

Phase 3: This phase consisted of two separate components. Firstly, the inter-rater reliability of the application process was determined by observing which STATS19 variables would be selected by three independent experts compared to those selected by the author in order to be able to apply the scoring tool. Secondly, inter-rater reliability of the scoring results produced by the scoring tools utilising the applied data were compared between the author and the three independent experts. see section 5.6.

Phase 4: The final phase involved the culpability scoring of the n=660 motor vehicle drivers in the dataset comprising the motor vehicle drivers involved in the fatal and MAIS3+ collisions and set out in section 5.7.

5.3.4 Introduction to the Case Studies

The modelling of culpability presented in this chapter can be considered complex. Case studies are presented below to assist with comprehension and application of the process used within study two. The two collisions represented are drawn from the data and were also represented within the inter-rater reliability evaluation process sample data, explained later in the chapter.

The case studies are explored during phase one, see section 5.4, of the process to explore how each scoring criteria can be applied to produce an assessment of the culpability of each of the motor vehicle drivers.

5.3.5 Case Study One

This collision, resulting in an MAIS3+ injury, occurred on Queens Road, Cambridge (this being the A1134) at the junction with West Road, Cambridge, see figures 5.1 and 5.2 below, on a weekday in the autumn at 4.50pm. The road has a 30mph speed limit, comprises a single carriageway, with the junction being controlled by give way lines at the end of West Road where it abuts with Queens Road. The weather was fine without high winds; however, the road surface was damp or wet. It was dark and the street lighting that was present was lit.

Figure 5.1 Map showing Queens Road, Cambridge at the junction with West Road (*Google Maps*, 2019)

Figure 5.2 View of Queens Road Cambridge at the junction with West Road looking north (*Google Street View*, 2016)

Driver one. This person was a 25-year old man, he was riding a motorcycle with an engine of 500cc or over. He was driving along Queens Road north bound approaching the junction with West Road. There was stationary traffic along Queens Road north bound and driver one was filtering along (overtaking) the line of stationary vehicles on the offside. The purpose of the journey was recorded as other, which indicates it was not commuting for work.

Driver two. This car driver was a 48-year old man. He was driving east along West Road towards the junction with Queens Road intending to turn right and proceed south bound along Queens Road as part of his work, that is, a journey during the working day rather than commuting to or from work.

The collision occurred in the middle of the junction as driver one passed the end of West Road and driver two turned right into Queens Road. Driver two had made sufficient progress into Queens Road that the front of his vehicle moved into the path of driver one. The front of both vehicles came into contact with each other and the collision occurred resulting in an AIS level three limb injury to driver one.

5.3.6 Case Study Two

This collision, resulting in a MAIS3+ injury, occurred on the A1 Great North Road, Stamford, at the junction with the A43 Kettering Road on a Sunday in the autumn at 7.42pm. The road was a dual carriageway subject to a 70mph speed limit. At the junction there are two single-carriageway, single-direction slip roads, one to allow access to the A1 northbound from the A43 and the other to allow exit from the A1 southbound onto the A43. Although the A1 runs essentially north-south this orientation does not remain consistent and at the collision location the road runs almost east-west, see figure 5.3 below. The collision occurred on the slip road leading off the south-bound (east at this point) carriageway of the A1. Where the slip road joins the A43 give way lines control the traffic, there are no-entry signs prohibiting traffic from the A43 entering the slip road from that direction.

The weather was rain without high winds and the road surface was damp or wet. It was dark and there was no street lighting.

Figure 5.3 Map indicating the A1 Great North Road at the junction with the A43 Kettering Road, Stamford (*Google Maps*, 2019)

The slip road at this location measures approximately 220m and when entering from the A1 has an initial gentle left curve followed by a tighter right-hand bend to the junction with the A43. The slip road splits into two lanes after about 50 m, before the left-hand bend, with the left lane for vehicles turning left at the A43 and the right lane for the vehicles turning right onto the A43. Below are a series of seven figures with pictures of the slip road showing the slip road approaching from the correct direction along the A1. See figures 5.4 to 5.10 below which present a series of images depicting progress along the slip road from the A1 southbound.

Figure 5.4 Picture one of the A1 Great North Road South-bound at the junction with the A43 Kettering Road, Stamford showing the start of the slip road (*Google Street View*, 2016)

Figure 5.5 Picture two of the A1 Great North Road South-bound at the junction with the A43 Kettering Road, Stamford at the start of the slip road (*Google Street View*, 2016)

Figure 5.6 Picture three of the A1 Great North Road South-bound at the junction with the A43 Kettering Road, Stamford showing the first section of the slip road (*Google Street View*, 2016)

Figure 5.7 Picture four of the A1 Great North Road South-bound at the junction with the A43 Kettering Road, Stamford showing the central section of the slip road (*Google Street View*, 2016)

Figure 5.8 Picture five of the A1 Great North Road South-bound at the junction with the A43 Kettering Road, Stamford showing the central section of the slip road with the junction with the A43 in the distance (*Google Street View*, 2016)

Figure 5.9 Picture six of the A1 Great North Road South-bound at the junction with the A43 Kettering Road, Stamford showing the end of the slip road (*Google Street View*, 2016)

Figure 5.10 Picture seven of the A1 Great North Road South-bound at the junction with the A43 Kettering Road, Stamford showing the end of the slip road from the A43 Kettering Road (*Google Street View*, 2016)

Driver one. This car driver was a 46-year old woman. She had turned onto the A1 Great North Road off slip road from the A43 in error, contravening the no-entry signs. Realising her error, she then undertook a U-turn, turning to the left, on the slip road. The purpose of her journey was recorded as other, meaning it was not work related or commuting for work.

Driver two. This 50-year old man was riding a motorcycle with an engine of 500cc or over. He was driving south bound (east at this point) along the A1 Great North Road, Stamford, he entered the slip road leading to the junction with the A43 Kettering Road. The purpose of the journey was also recorded as other.

The collision occurred part way along the slip road as driver one undertook the U turn manoeuvre in front of the oncoming driver two on his motorcycle. Driver two on his motorcycle hit (frontal) into the offside of the car of driver one. Driver two deflected and left the carriageway to the offside, i.e. towards the A1 main carriageway, and then rebounded. This collision resulted in AIS level three injuries to the head, chest and limbs of driver two.

Throughout the remainder of the chapter the four drivers presented in the two case studies were used to demonstrate the application of the processes described and at the end of the chapter their overall scores are presented.

5.3.7 Study Sample

This study utilised the linked dataset created in study one. It comprised 660 motor vehicle drivers involved in either a serious (MAIS3+) injury or fatal injury collision in in Cambridgeshire between April 2012 and the end of March 2017.

Inclusion and Exclusion Criteria

There are no additional inclusion and exclusion criteria over those used for the first study

5.4. Phase 1: Applying STATS19 Data to Scoring Tools

The STATS19 database contains descriptive variables covering chronological and geographical data items which allow identification of the when and where the collisions occurred, as well as describing the weather or lighting and so on. There are variables which also describe the motor vehicle drivers, their vehicles and the movement of those vehicles and how they interacted with other parties. Each collision also has six contributory factor variables, each can contain a single contributory factor code from a possible n=78, or no code and codes can be entered more than once. The entry of these codes being at the discretion of the reporting agent so there may be one in each or any combination from none to six in any order. As previously discussed in this work it becomes vitally important to analyse the appropriate subjects involved in collision incidents to reinforce the validity of any subsequent findings. The STATS19 data provided for this study also contained the ‘description’ variable, see 5.4.1. This variable being one not publicly available and not part of the national STATS19 data release. All of these data items are inputted by the police officer reporting the collision.

5.4.1 Applying STATS19 to the Robertson and Drummer (1994) Scoring Tool

The Robertson and Drummer's (1994) culpability scoring tool was used as the reference material from which the process for applying STATS19 data to a scoring tool was determined. However, the same process was also subsequently applied to the Brubacher, Chan and Asbridge (2012) tool. The terminology used to describe the constituent parts of the scoring tool are set out below.

Criteria – These are the broad areas within the collision circumstances which the tool examines, for example, in the Robertson and Drummer (1994) the first criteria deals with the ‘Condition of road’.

Factor – within each of the scoring tool criteria there are individual factors which attract specific mitigation scores, for example, within the second Robertson and Drummer (1994) criteria of ‘Condition of vehicle’ one of the scoring factors relates to the condition of the vehicle being ‘Roadworthy’.

Construct and component – these terms relate to the structure of the factor, for example in Robertson and Drummer (1994) the third of the scoring criteria describes the ‘Driving Conditions’. Within this criterion there are factors which attract scores, for example ‘Night clear’. ‘Night clear’ being a construct with are two components. With ‘night’ being a component and ‘clear’ being a component.

Within STATS19 there are variables, contributory factors and the descriptive narrative. Each individual variable, individual contributory factor and the descriptive narrative can be considered an element within STATS19.

Due to the variation between the mitigating factors and elements in STATS19 and the perceived inability to directly apply one mitigating factor to one element it was necessary to review each mitigating factor separately. This approach was necessary to identify the 'best' application of variables and / or contributory factors and / or descriptive narrative material from STATS19 to each mitigating factor.

The method for applying the available STATS19 elements onto the scoring tools requires a number of stages for each mitigating component within each mitigating factor within each mitigation category present within the tool. Each component requires separate evaluation. Once all the component parts have been evaluated the STATS19 material for each factor can be brought together to build the construct and specific STATS19 variable codes determined for the specific factor.

The method presented in the process chart below, figure 5.11, includes all the stages required to determine if the components within each factor can be built from the data available in STATS19.

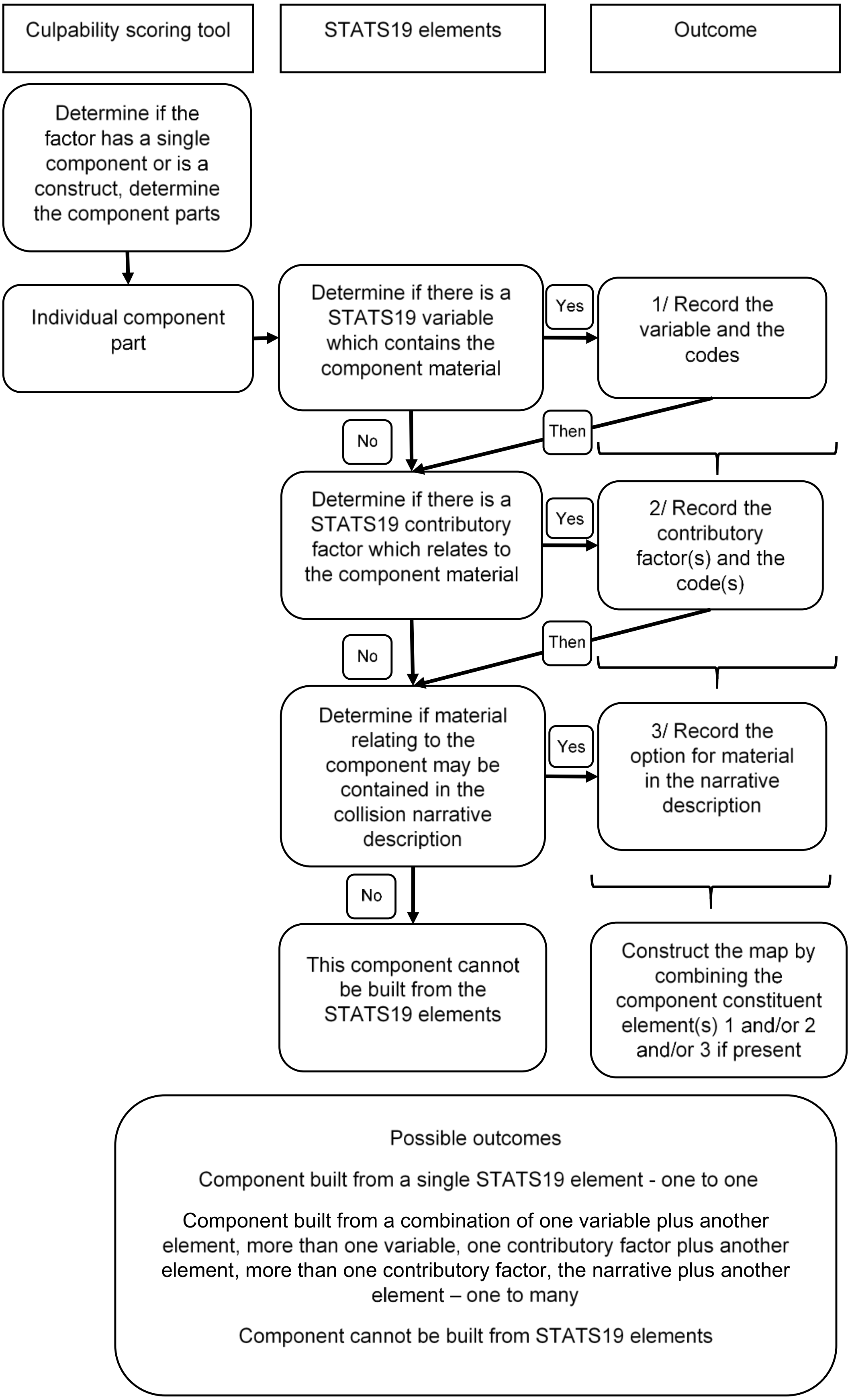

Figure 5.11 Application of STATS19 data to the scoring tool process chart

The first process required for this study was the application of the STATS19 variables, contributory factors and narrative content to the Robertson and Drummer (1994) culpability scoring tool.

The objective was to apply the variable data held on STATS19 with the mitigation criteria used within the Robertson and Drummer (1994) culpability scoring tool, the criteria are set out below within this section.

The process involved assessing which variables, contributory factors or narrative content present in the STATS19 dataset could be used to build each of the Robertson and Drummer (1994) mitigation category constructs, the aim being to use as many variables, combinations of variables or contributory factors as are required to gather the information.

There are some logistical complications which require explanation. The scoring tool contains a section related to witness observations. STATS19 does not contain such information in that form, however, when completing the report, the officer concerned takes into account witness observations in coming to conclusions regarding the contributory factors involved in the collision. Therefore, many of the assessment criteria contained within the witness observation section for the scoring tool are contained within the contributory factors allocated to the individual collision report.

The Robertson and Drummer (1994) was written in and applied to an Australian context and data. There are two matters which need to be considered at this stage although they do not change the manner in which the scoring tool works. Section one of the scoring tool examines the condition of the road and considers unsealed roads, that being a road not hard surfaced. In many Australian states a significant proportion, in many cases over 50 percent, of the roads on the network are unsealed (Australian

Bureau of Statistics, 2005; Australian Government: Infrastructure Australia, 2019), yet, STATS19 does not consider unmade roads in the road description variables. This was not an unreasonable position for those that constructed STATS19 to take, given that, for example, in the county of Cambridgeshire, the geographical bounds for this research, there are 5268km of roads of all types which only includes 133km (2.5 percent) of soft roads (Peterborough Highway Services, 2016; Cambridgeshire County Council, 2019b).

Also, section two of the tool deals with the condition of the vehicle, in Australia where the tool was devised the vehicle inspection regime runs on a state basis with varying requirements, for example, in the Australian Capital Territory Government (2020) inspections are not annual as long as the vehicle remains with one owner but required in certain circumstance, such as the clearance of a defect notice after being stopped by the police. This circumstantial testing being a contrast to the UK annual testing regime (Driver and Vehicle Standards Agency, 2019). However, the Australian Government (2020) does have Federal legislation in the form of Vehicle Standards (Australian Design Rules) which has a similar function to the *The Road Vehicles (Construction and Use) Regulations 1986* in the UK. Consideration of what constitutes a roadworthy vehicle in both jurisdictions are comparable (Victoria State Government, 2017; Driver and Vehicle Standards Agency, 2019)

The STATS19 data also contains a narrative variable, called the 'description', a free text option for the reporting officer to give a very brief summary of the collision, often using abbreviations or acronyms, such as 'V1 failed to give way at give way lines pulling into path of V2 on SBC' (south-bound carriageway). This variable has some subjectivity in interpretation. This becomes important as, on occasions, there are issues with data quality within STATS19 which manifests in collisions where the reporting agent has only completed the descriptive section and does not enter any contributory factors in the report.

The scoring system starts from a position of culpability for all motor vehicle drivers concerned and then scores mitigating factors which may negate that culpability (Robertson and Drummer, 1994; Brault and Dussault, 2002).

The Robertson and Drummer (1994) scoring tool looks at eight mitigating categories with each category split into a number of mitigating factors, these are examined in sequence in the remainder of this section. Each mitigating factor can be scored on a range of one to four, where one equates to not mitigating through to four, mitigating. The motor vehicle driver's scores are added together, therefore, the lowest score a motor vehicle driver can obtain being eight and the highest being 32.

The scoring system works as such: a score of eight to 12 = culpable, 13 to 15 = contributory; and over 15 = non-culpable. For the system to work there must be five or more mitigating categories present to score. If there are less than eight categories, then the scores from the ones present are multiplied by eight and then divided by the number of categories present. The eight mitigating criteria are set out in table 5.1 below. Each of the mitigating criteria within the scoring tool are dealt with separately to assist in the application process.

Table 5.1 Robertson and Drummer (1994) scoring guidelines used for responsibility analysis, the reference to 'Table A1' being from the original and has been left in place for completeness.

APPENDIX	
Table A1. Scoring guidelines used for responsibility analysis,	
Mitigating category	Score
1. Condition of Road	
Sealed road*	
Two or more lanes and smooth	1
Divided road	1
Two or more lanes and rough	2

Unmarked, thin and smooth	2
Unmarked, thin and rough	3
Unsealed road	
Smooth	2
Rough and/or corrugated	3
2. Condition of Vehicle	
Roadworthy	1
Unroadworthy (contribution to accident unclear)	2
Unroadworthy (contributing to accident)	4
3. Driving Conditions	
Day	
Clear and/or cloudy	1
*Fog and/or mist, clear and windy (>40 kph)	2
*Visibility good and road wet	2
Showers and/or rain	3
Night	
†‡Clear	1
‡Cloudy	2
Fog/mist/showers/rain/ice/wind	3
4. Type of Accident	
Single-vehicle	
No influence from other vehicles	1
Influence from other vehicles	3
Multi-vehicle	
Striking vehicle attempting to avoid	2
Striking vehicle not attempting to avoid	1
Struck vehicle in the wrong	1
Struck vehicle in the right	3
5. Witness Observations	
No apparent reason	1
Reckless	
Swerving	1
Irregular driving	1
Negligent	
Witnessed road infringement	1
Lack of road sense	1
Vehicle fault	3
Driver not to blame	4
6. Road Law Obedience	
Was driver obeying road laws?	
Yes	3
No	1
7. Difficulty of Task Involved	
Straight road or sweeping bend	1
§Across lanes in	
Heavy traffic	2
Light traffic	1
Winding road/sharp bend/U-turn	2
Overtaking	2
Avoiding unexpected traffic	3
8. Level of Fatigue	
Only if mentioned in police reports	2
* Add 1 if road has been newly surfaced.† If in heavy traffic, add 1 point. ‡ If not listed, add 1 point. § Scores 1, if under the guidance of traffic signals.	

Section 1. Condition of Road

Section one deals with the configuration and condition of the road where the collision occurred. Table 5.2 below contains the criteria present in section one of the Robertson and Drummer (1994) culpability scoring tool.

Table 5.2 Robertson and Drummer (1994) Condition of road criteria (Section 1).

1. Condition of Road
Sealed road*
Two or more lanes and smooth
Divided road
Two or more lanes and rough
Unmarked, thin and smooth
Unmarked, thin and rough
Unsealed road
Smooth
Rough and/or corrugated

STATS19 does not deal with the factors set out in this section specifically, but these can be deduced from a number of variables. In STATS19 there are no references to soft roads (unmade or green-lanes) as a road type, with what appears to be an assumption that roads are sealed, that being, that it has a conventional hard road surface such as tarmacadam or concrete. As STATS19 also deals with side roads, where the scene incorporates a junction, the factors considered should be for the primary road.

The number of lanes in the primary road are contained in the ‘Road Type’ variable. The STATS19 codes are presented in table 5.3 below.

Table 5.3 STATS19 ‘road type’ codes.

1.	Roundabout
2.	One way street
3.	Dual carriageway
6.	Single carriageway
7.	Slip Road
9.	Unknown

There are no specific codes relating to whether the road was smooth or rough or whether the road was unmarked. For roundabouts, code one, the option of divided road can be used. Within the ‘Special Conditions at Site’ variable, code five, which relates to ‘Road surface defective’, may be considered in this section if present.

There are also codes in the contributory factors which relate to the road environment and these may contribute to this section if present. The codes are presented in table 5.4 below.

Table 5.4 Robertson and Drummer (1994) section1 related STATS19 contributory factor codes.

101.	Poor of defective road surface

Any reference to unmade roads may require the examination of the narrative in the report. The footnote to the criteria table, denoted by an *, which explains that, for a sealed road, one point should be added if it has been newly resurfaced, there are no specific STATS19 variables or contributory factors relating to this circumstance, however, if it was a factor it may be mentioned in the collision narrative.

An example of the scoring for this category would be where the collision occurred on a single carriageway road, code six, without any of the contributory factors or mention of resurfacing scoring one.

The relationship of STATS19 variables, contributory factors and collision description to the scoring criteria for this section of the scoring tool are presented in table 5.5 below. Note that this form of presentation has been used for each section of both the scoring tools presented in this chapter. The score presented, in the score column, was that which relates to the mitigating factor in the original scoring tool, some scores have been retained in the table even though there are some factor constructs which cannot be built using the STATS19 data available.

Table 5.5 Applied STATS19 data and considerations for each Robertson and Drummer (1994) factor of road criteria

1. Condition of Road	**STATS19 data**			**Applied STATS19 data, considerations and assumptions**
	Variable	**Contributory factor**	**Narrative**	
Sealed road*				Assumed to be sealed unless stated in description
Two or more lanes and smooth	Yes	No	No	Road type variable– single carriageway (6) or slip road (7) if more than one lane or one-way street (2) if more than one lane
Divided road	Yes	No	No	Road type variable – dual carriageway (3) or roundabout (1)
Two or more lanes and rough	Yes	Yes	No	Road type variable – single carriageway (6) or slip road (7) if more than one lane or one-way street (2) if more than one lane combined with contributory factor – poor or defective road surface (101) or Special Conditions at site – Road surface defective (5)
Unmarked, thin and smooth	Yes	No	No	Road type variable – single carriageway (6), slip road (7) or one-way street (2) if either does not have separate lanes
Unmarked, thin and rough	Yes	Yes	No	Road type variable – single carriageway (6), slip road (7) or one-way street (2) if either does not have separate lanes combined with contributory factor – poor or defective road surface (101) or Special Conditions at site variable – Road surface defective (5)
Unsealed road				Assumed to be sealed unless stated in description
Smooth	No	No	Yes	Assumed to be sealed unless stated in description
Rough and/or corrugated	Yes	Yes	Yes	Assumed to be sealed unless stated in description combined with contributory factor – poor of defective road surface (101) or Special Conditions at site variable – Road surface defective (5)

Presented in table 5.6 below are how the considerations and application described in this section were produced results for the four motor vehicle drivers in the two case studies.

Table 5.6 Robertson and Drummer (1994) condition of road case study examples

Case Study	**Driver**	**Variables and contributory factors present**	**Robertson and Drummer (1994) criteria**	**Score**
One	One	Single Carriageway (6)	Two or more lanes and smooth	1
	Two	Single Carriageway (6)	Two or more lanes and smooth	1
Two	One	Slip Road (7) with two lanes	Two or more lanes and smooth	1
	Two	Slip Road (7) with two lanes	Two or more lanes and smooth	1

It should be noted that the condition of road criteria for any given collision applies to all the motor vehicle drivers, therefore although it contributes to the overall score for each motor vehicle driver it does not impact the relative culpability of the motor vehicle drivers.

Section 2. Condition of Vehicle

The second section of the scoring tool deals with the condition of the vehicles the motor vehicle drivers involved in the collision concerned were in control of at the time of the collision. The criteria for section two of the Robertson and Drummer (1994) scoring tool are set out in table 5.7 below.

Table 5.7 Robertson and Drummer (1994) condition of vehicle criteria (Section 2).

2. Condition of Vehicle
Roadworthy
Unroadworthy (contribution to accident unclear)
Unroadworthy (contributing to accident)

There are no references to vehicle condition in the section of variables which deal with the vehicle within STATS19. Vehicle defects are dealt with in the contributory factors section of the report. These vehicle defects are listed as contributory factors only if they contribute to the collision. Any non-contributory defects may be part of the narrative of the report. The STATS19 contributory factor codes relating to vehicle defects are presented in table 5.8 below.

Table 5.8 STATS19 vehicle defect contributory factor codes.

201.	Tyre illegal, defective or under-inflated
202.	Defective lights and indicators
203.	Defective brakes
204.	Defective steering or suspension
205.	Defective or missing mirrors
206.	Overloaded or poorly loaded vehicle or trailer
999.	Other contributory defect not listed above

Clearly, if there are no vehicle defect codes in the contributory factors and no reporting of defects in the descriptive narrative then the vehicle can be deemed to be roadworthy for scoring purposes.

The relationship of STATS19 variables, contributory factors and collision description to the scoring criteria for this section of the scoring tool are presented in table 5.9 below.

Table 5.9 Applied STATS19 data and considerations for each Robertson and Drummer (1994) condition of vehicle criteria

2. Condition of Vehicle	**STATS19 data**			**Applied STATS19 data, considerations and assumptions**
	Variable	**Contributory factor**	**narrative**	
Roadworthy				No vehicle defect contributory factors
Unroadworthy (contribution to accident unclear)	No	Yes	No	Contributory factors 201-206 or 999 present but no indication in the description of their influence
Unroadworthy (contributing to accident)	No	Yes	No	Contributory factors 201-206 or 999 present with indication in the description of their influence

Presented in table 5.10 below are how the considerations and application described in this section produced results for the four motor vehicle drivers in the two case studies.

Table 5.10 Robertson and Drummer (1994) condition of vehicle case study examples

Case Study	**Driver**	**Variables and contributory factors present**	**Robertson and Drummer (1994) criteria**	**Score**
One	One	No defect contributory factor present	Roadworthy	1
	Two	No defect contributory factor present	Roadworthy	1
Two	One	No defect contributory factor present	Roadworthy	1
	Two	No defect contributory factor present	Roadworthy	1

The condition of vehicle criteria does relate to individual vehicle and therefore can impact on the overall score for the related individual motor vehicle driver.

Section 3. Driving Conditions

Section three of the scoring tool examines the driving conditions experienced by the motor vehicle driver prior to the collision occurring, combining when the collision occurred and the weather conditions at that time. The criteria for section three of the Robertson and Drummer (1994) scoring tool are set out in table 5.11 below.

Table 5.11 Robertson and Drummer (1994) driving conditions criteria (Section 3).

3. Driving Conditions
Day
Clear and/or cloudy
*Fog and/or mist, clear and windy (>40 kph)
*Visibility good and road wet

Showers and/or rain
Night
†‡Clear
‡Cloudy
Fog/mist/showers/rain/ice/wind

This section requires a combination of STATS19 factors to be examined. STATS19 considers daylight and darkness within the entry for the 'Light Conditions' variable. The STATS19 light conditions codes are presented in table 5.12 below.

Table 5.12 STATS19 'light conditions' codes.

1.	Daylight
4.	Darkness: street lights present and lit
5.	Darkness: street lights present but unlit
6.	Darkness: no street lighting
7.	Darkness: street lighting unknown

In applying the variable, it can be considered that 'Day' in the scoring tool can equate to 'Daylight' in the STATS19 variable and 'Night' in the scoring tool corresponds to 'Darkness' in STATS19. The weather conditions are considered separately in the 'Weather' variable. The STATS19 weather conditions codes are presented in table 5.13 below.

Table 5.13 STATS19 'weather conditions' codes.

1.	Fine without high winds
2.	Raining without high winds
3.	Snowing without high winds
4.	Fine with high winds
5.	Raining with high winds
6.	Snowing with high winds
7.	Fog or mist – if hazard
8.	Other
9.	Unknown

STATS19 also has the contributory factor code 707 for 'Rain, sleet, snow or fog' which can contribute to building this picture. Section three also contains a number of footnotes and these need to be taken into account when formulating the final score for this category. For incidents which occur during the day and with specific weather conditions an extra point should be added if the road has been newly surfaced, with no specific variable code or contributory factor relating to the circumstance of resurfacing in STATS19, it may be contained in the collision narrative. With a light conditions code of one present the score may be affected by a wet road surface, the specific contributory factor code of 103 to indicate a wet road will be of use in these circumstances should it be present. For incidents during the night an extra point should be added where it was clear or cloudy but there no lighting present, these circumstances can be produced by STATS19 lighting conditions codes five, six and seven combined with a weather code of one, for weather codes of eight or nine with no explanation the motor vehicle driver can be dealt with as if weather conditions are adverse. The footnote notes that there should be an additional point under the specific combination of night, clear weather and heavy traffic, however, there are no specific variables or contributory factors within STATS19 for heavy traffic although there may be comment or it could be inferred from the collision narrative.

All the Robertson and Drummer (1994) section three options can be produced by a combination of these variables. For example, the Robertson and Drummer (1994) mitigation of ‘Day: Clear and/or/cloudy’, scoring one, would be a combination of STATS19 ‘Light Conditions’ variable, code one ‘Daylight’ and the STATS19 ‘Weather’ variable, code one ‘Fine without high winds’.

The relationship of STATS19 variables, contributory factors and collision description to the scoring criteria for this section of the scoring tool are presented in table 5.14 below.

Table 5.14 Applied STATS19 data and considerations for each Robertson and Drummer (1994) driving conditions criteria

3. Driving Conditions	STATS19 data			Applied STATS19 data, considerations and assumptions
	Variable	**Contributory factor**	**Narrative**	
Day				Light conditions variable – daylight (1)
Clear and/or cloudy	Yes	No	No	Light conditions variable – daylight (1) combined with Weather conditions variable – Fine without high winds (1)
*Fog and/or mist, clear and windy (>40 kph)	Yes	No	No	Light conditions variable – daylight (1) combined with Weather conditions variable – Fine with high winds (4) or Fog or mist – if hazard (7)
*Visibility good and road wet	Yes	Yes	No	Light conditions variable – daylight (1) combined with Weather condition variable – Fine without high winds (1) and Contributory factor – Wet road (103)
Showers and/or rain	Yes	No	No	Light conditions variable – daylight (1) combined with Weather conditions variable – Rain without high winds (2) or Rain with high winds (5)
Night	Yes	No	No	Lighting conditions variable -Darkness: street lights present and lit (4) or Darkness: street lights present but unlit (5) or Darkness: no street lighting (6) or Darkness: street lighting unknown (7)
†‡Clear	Yes	No	No	Lighting conditions variable -Darkness: street lights present and lit (4) or Darkness: street lights present but unlit (5) or Darkness: no street lighting (6) or Darkness: street lighting unknown (7) combined with Weather conditions variable – Fine without high winds (1)
‡Cloudy	No	No	No	There are no STATS19 data relating to cloudy conditions
Fog/mist/showers/rain /ice/wind	Yes	No	No	Lighting conditions variable -Darkness: street lights present and lit (4) or Darkness: street lights present but unlit (5) or Darkness: no street lighting (6) or Darkness: street lighting unknown (7) combined with Weather conditions variable – Rain without high winds (2) or Snowing without high winds (3) or Fine with high winds (4) or Rain with high winds (5) or Snowing with high winds (6) or Fog or mist – if hazard (7)

Presented in table 5.15 below are how the considerations and application described in this section produced results for the four motor vehicle drivers in the two case studies.

Table 5.15 Robertson and Drummer (1994) driving conditions case study examples

Case Study	Driver	Variables and contributory factors present	Robertson and Drummer (1994) criteria	Score
One	One	Darkness street lights present and lit (4) Fine without high wind (1)	Night-clear	1
	Two	Darkness street lights present and lit (4) Fine without high wind (1)	Night-clear	1
Two	One	Darkness no street light (6) Raining without high winds (2)	Night-Fog/mist/showers/rain/ice/wind	3
	Two	Darkness no street light (6) Raining without high winds (2)	Night-Fog/mist/showers/rain/ice/wind	3

As with the condition of road criteria the results for any collision are applicable to all the motor vehicle drivers involved in the collisions and therefore do not contribute to the differentiation of culpability between them.

Section 4. Type of Accident

The fourth section of the Robertson and Drummer (1994) scoring tool examines the circumstances of the collision from a vehicular perspective, including the number of vehicles, movement and infringements. The criteria for section four of the Robertson and Drummer (1994) scoring tool are set out in table 5.16 below.

Table 5.16 Robertson and Drummer (1994) type of accident criteria (Section 4).

4. Type of Accident
Single-vehicle
No influence from other vehicles
Influence from other vehicles
Multi-vehicle
Striking vehicle attempting to avoid
Striking vehicle not attempting to avoid
Struck vehicle in the wrong
Struck vehicle in the right

This stage of the process becomes a little more complex. The initial analysis of whether the collision was a single-vehicle or multi-vehicle appears to be straightforward in that STATS19 contains a variable for the number of vehicles and purely records the number of vehicles involved. However, it should be noted that the term vehicle, within STATS19 has a broad meaning and contains non-motor vehicles including pedal cycles, ridden horses, trams/ light rail and mobility scooters. This needs to be considered before relying on the number of vehicles concerned as definitive. For collisions with more than one vehicle, examination of the vehicle type variable was required to determine if each vehicle was a motor vehicle. The STATS19 vehicle type codes are presented in table 5.17 below.

Table 5.17 STATS19 'Vehicle type' codes

01.	Pedal cycle
02.	Motorcycle 50cc and under
03.	Motorcycle over 50cc and up to 125cc
04.	Motorcycle over 125cc and up to 500cc
05.	Motorcycle over 500cc
97.	Motorcycle – unknown cc
23.	Electric motorcycle
08.	Taxi/Private hire car
09.	Car
10.	Minibus (8 - 16 passenger seats)
11.	Bus or coach (17 or more passenger seats)
16.	Ridden horse
17.	Agricultural vehicle (includes diggers etc.)
18.	Tram/Light rail
19.	Van/Goods vehicle 3.5 tonnes maximum gross weight (mgw) and under
20.	Goods vehicle over 3.5 tonnes and under 7.5 tonnes mgw
21.	Goods vehicle 7.5 tonnes mgw and over
98.	Goods vehicle – unknown weight
22.	Mobility scooter
90.	Other vehicle

It should be noted that the reference to ‘Single-vehicle: Influence of other vehicles’ in the scoring tool would not be represented within STATS19 as a single-vehicle collision. If a collision occurred ‘owing to the presence’ of another vehicle, then that vehicle would be in the report and it would therefore be multi-vehicle. The involvement of other vehicles that did not impact a damaged vehicle could be ascertained from the ‘First Point of Impact’ variable code which contains the option of code zero which relates to ‘Did not impact’. Therefore, if there are multi-vehicle collisions where only one of the vehicles has a point of impact code and all the rest have a zero then this would fit this criterion. Equally, the variable for ‘Hit and Run’ which has an option of code two for a ‘Non-stop vehicle, not hit’ indicating involvement in the collision but no impact. The STATS19 hit and run variable codes are presented in table 5.18 below.

Table 5.18 STATS19 'Hit and run’ codes

0.	Other
1.	Hit and run
2.	Non-stop vehicle, not hit

The section regarding multi-vehicle events requires a combination of factors. The contributing factors code of 701 ‘Stationary or parked vehicle’ can be used where this vehicle, although not hit, contributed to the circumstance of the collision and may be present in conjunction with a ‘did not impact’ code in the first point of contact variable. The constructs of striking and struck would need to be formed from a combination of the first point of impact variable and the manoeuvres variable contextualised by the collision narrative. The STATS19 first point of contact variable codes are presented in table 5.19 below.

Table 5.19 STATS19 'first point of contact' codes

0.	Did not impact
1.	Front
2.	Back
3.	Offside
4.	Nearside

The STATS19 manoeuvres variable codes are presented in table 5.20 below.

Table 5.20 STATS19 'manoeuvres' codes

01.	Reversing
02.	Parked
03.	Waiting to go ahead but held up
04.	Slowing or stopping
05.	Moving off
06.	U turn
07.	Turning left
08.	Waiting to turn left
09.	Turning right
10.	Waiting to turn right
11.	Changing lane to left
12.	Changing lane to right
13.	Overtaking moving vehicle on its offside
14.	Overtaking stationary vehicle on its offside
15.	Overtaking on nearside
16.	Going ahead left hand bend
17.	Going ahead right hand bend
18.	Going ahead other

The relationship of STATS19 variables, contributory factors and collision description to the scoring criteria for this section of the scoring tool are presented in table 5.21 below.

Table 5.21 Applied STATS19 data and considerations for each Robertson and Drummer (1994) type of accident criteria

4. Type of Accident	STATS19 data			Applied STATS19 data, considerations and assumptions
	Variable	Contributory factor	Narrative	
Single-vehicle				
No influence from other vehicles	Yes	No	No	Number of vehicles = 1 or if the number of vehicles > 1 but in examining the vehicle type variable only one of the vehicles can be considered a motor vehicle
Influence from other vehicles	No	No	No	There are no options for direct mapping of this criteria as an influencing vehicle would be recorded in STATS19 as a vehicle and hence the collision be a multi-vehicle
Multi-vehicle				
Striking vehicle attempting to avoid	Yes	No	Yes	Number of vehicles >1 and examining the vehicle type variable indicates > 1 motor vehicle, combined with the first point of impact variable, the manoeuvres variable and content of the description.
Striking vehicle not attempting to avoid	Yes	No	Yes	Number of vehicles > 1 and examining the vehicle type variable indicates > 1 motor vehicle, combined with the first point of impact variable, the manoeuvres variable and content of the description.
Struck vehicle in the wrong	Yes	No	Yes	Number of vehicles > 1 and examining the vehicle type variable indicates > 1 motor vehicle, combined with the first point of impact variable, the manoeuvres variable and content of the description.
Struck vehicle in the right	Yes	No	Yes	Number of vehicles > 1 and examining the vehicle type variable indicates > 1 motor vehicle, combined with the first point of impact variable, the manoeuvres variable and content of the description.

Presented in table 5.22 below are how the considerations and application described in this section produced results for the four motor vehicle drivers in the two case studies.

Table 5.22 Robertson and Drummer (1994) type of accident case study examples

Case Study	Driver	Variables and contributory factors present	Robertson and Drummer (1994) criteria	Score
One	One	Number of vehicles indicates two, vehicle type variable indicates both motor vehicles, manoeuvres variable indicates turning right (09), first point of contact variable indicates front (1) impact, description indicates vehicle pulled out into the path of another vehicle.	Multi vehicle struck vehicle in the wrong	1
	Two	Number of vehicles indicates two, vehicle type variable indicates both motor vehicles, manoeuvres variable indicates overtaking stationary vehicle on offside (14), first point of contact variable indicates front (1) impact, description indicates vehicle overtaking at a junction with no contingency when the other vehicle pulled into the path of this vehicle.	Multi vehicle striking vehicle not attempting to avoid	1
Two	One	Number of vehicles indicates two, vehicle type variable indicates both motor vehicles, manoeuvres variable indicates u-turn (06), first point of contact variable indicates off-side (3) impact, description indicates vehicle undertaking a u-turn having travelled the wrong	Multi vehicle struck vehicle in the wrong	1

		way up a slip road in contravention of no entry signs, the u-turn was done in the path of the second vehicle.		
	Two	Number of vehicles indicates two, vehicle type variable indicates both motor vehicles, manoeuvres variable indicates straight ahead other (18), first point of contact variable indicates front (1) impact, post impact movement indicates deflection to the offside, description indicates driver was confronted with a vehicle undertaking a u-turn in front of them having travelled the wrong way up a slip road with insufficient time to stop	Multi vehicle striking vehicle attempting to avoid	2

Section 5. Witness Observations

Section five deals with what are described as witness observations. The criteria for section five of the Robertson and Drummer (1994) scoring tool are set out in table 5.23 below.

Table 5.23 Robertson and Drummer (1994) witness observations criteria (Section 5)

5. Witness Observations
No apparent reason
Reckless
Swerving
Irregular driving
Negligent
Witnessed road infringement
Lack of road sense
Vehicle fault
Driver not to blame

There are no specific variables which are directly attributable to witness observations within STATS19, instead the factors listed in this section may be constructed from a combination STATS19 data.

Some of the factors set out in section five do have specific contributory factor codes, such as ‘swerving’. However, the ‘lack of road sense’ criteria, not being defined by Robertson and Drummer (1994) in the paper, must, therefore, be dealt with on a practical basis with foundation in law and official advice. The standards of driving offences in UK law are presented in the *Road Traffic Offenders Act 1988* with advice on safe driving contained within the Highway Code. Therefore, actions or lack of appropriate action where required may be contained within this criterion and these may encompass many of the contributory factors or combinations thereof. For example, failing to take account of road spray, or any other external circumstance, may be considered a lack of road sense.

Note that 'vehicle faults' are likely to be within the scope of defect offences unless there has been a sudden component failure not linked to a pre-existing defect or poor maintenance which are covered in section two. Where an infringement was witnessed this would be covered within the contributory factors of STATS19 and dealt with under section six. A number of these codes which indicate circumstances in which a motor vehicle driver should take them into account and drive accordingly could also constitute offences contrary to standards of driving offences and also fit within section six but can also be considered as a lack of road sense under this section. The codes are presented in table 5.24 below.

Table 5.24 Robertson and Drummer (1994) section 5 related STATS19 contributory factor codes

102.	Deposit on road (e.g. oil, mud, chippings)
103.	Slippery road (due to weather)
401.	Junction overshoot
402.	Junction restart (moving off at junction)
406.	Failing to judge other person's path or speed
409.	Swerved
410.	Loss of control
601.	Aggressive driving
602.	Careless, reckless or in a hurry
603.	Nervous, uncertain or panic
604.	Driving too slow for conditions, or slow vehicle (e.g. Tractor)
605.	Learner or inexperienced driver/rider
606.	Inexperience of driving on the left
702.	Vegetation
704.	Buildings, road signs, street furniture
705.	Dazzling headlights
706.	Dazzling sun
708.	Spray from other vehicles
709.	Visor or windscreen dirty, scratched or frosted etc.
710.	Vehicle blind spot
801.	Crossing road masked by stationary or parked vehicle
802.	Failed to look properly
803.	Failed to judge vehicle's path or speed
804.	Wrong use of pedestrian crossing facility
805.	Dangerous action in carriageway (e.g. playing)
806.	Impaired by alcohol
807.	Impaired by drugs (illicit or medicinal)
808.	Careless, reckless or in a hurry
809.	Pedestrian wearing dark clothing at night
810.	Disability or illness, mental or physical

The first two of the codes, code 102 ‘Deposit on road (e.g. Oil, mud, Chippings)’ and code 103 ‘Slippery road (due to weather)’ can be considered a ‘Lack of road sense’ as a competent motor vehicle driver should have recognised the hazards and taken action accordingly as advised in the Highway Code (Department for Transport, 2015h). The next two codes, code 401 ‘Junction overshoot’ and code 402 ‘Junction restart (moving off at junction)’ can be considered as irregular driving. Failing to judge another person speed or direction, code 406 shows a lack of road sense. Swerving, being specifically covered by code 409 and code 410, a loss of control can be considered under the same context. The set of codes 601-604 may constitute offences under the standard of driving offences within the *Road Traffic Act 1988* as this would show a standard of driving below that of a competent and careful motor vehicle driver. The next two codes, code 605, used if inexperience contributed, not just mere presence and code 606, relating to foreign motor vehicle drivers, usually related to motor vehicle drivers unfamiliar with driving on the left, could fit with a lack of road sense, albeit for different reasons. The remaining 700 series codes, code 702 ‘Vegetation’, code 704 ‘Building, road signs, street furniture’, code 705 ‘Dazzling headlights’, 706 ‘Dazzling sun’, code 708 ‘Spray from other vehicles’, code 709 ‘Visor or windscreen dirty scratched or frosted etc.’ and code 710 ‘Vehicle blind spot’ relate to an obstruction to vision, as contributory and should have been taken into account by the motor vehicle driver, where this has not occurred it could constitute a ‘Lack of road sense’, further, failing to take account of these factors adequately may also constitute offences under the standards of driving offences within the *Road Traffic Act 1988*.

The 800 series codes, codes 801-810, relate directly to pedestrians and do not relate to motor vehicle drivers. However, if present they may indicate that a motor vehicle driver was not to blame for the collision or may represent some mitigation and can be dealt with accordingly.

The relationship of STATS19 variables, contributory factors and collision description to the scoring criteria for this section of the scoring tool are presented in table 5.25 below.

Table 5.25 Applied STATS19 data and considerations for each Robertson and Drummer (1994) witness observation criteria

5. Witness Observations	**STATS19 data**			**Applied STATS19 data, considerations and assumptions**
	Variable	**Contributory factor**	**Narrative**	
No apparent reason	No	No	No	A collision occurring for no reason cannot be supported by STATS19 variables or contributory factors
Reckless				
Swerving	No	Yes	No	Contributory factor 'swerved' (409)
Irregular driving	No	No	No	STATS19 data cannot be directly mapped to the construct of irregular driving
Negligent				
Witnessed road infringement				See section six
Lack of road sense	No	Yes	No	Failing to take account of factors presented in the contributory factors presented in table 5.24
Vehicle fault	No	Yes	No	See section two or contributory factor codes 201-206 and 999
Driver not to blame	No	No	No	No variables, contributory factors or material in the description indicating the driver was at fault for the collision

Presented in table 5.26 below are how the considerations and application described in this section produced results for the four motor vehicle drivers in the two case studies.

Table 5.26 Robertson and Drummer (1994) witness observation case study examples

Case Study	**Driver**	**Variables and contributory factors present**	**Robertson and Drummer (1994) criteria**	**Score**
One	One	Nothing		No score recorded
	Two	Nothing		No score recorded
Two	One	Contributory factors Poor turn or manoeuvre (403), Failed to look properly (405), Illegal turn or direction of travel (305) all indicating a standard of driving far below that of a competent and careful driver	Reckless or road infringement are both applicable	1
	Two	No variables, contributory factors or detail in the description to indicate any fault on the part of this driver	Driver not to blame	4

Section 6. Road Law Obedience

Section six relates to any failure to comply with road law. This was interpreted within the UK context encompassing the broad spectrum of offences which can be committed. The criteria for section six of the Robertson and Drummer (1994) scoring tool are set out in table 5.27 below.

Table 5.27 Robertson and Drummer (1994) road law obedience criteria (Section 6)

6. Road Law Obedience
Was driver obeying road laws?
Yes
No

Some of the circumstances which constitute offences may also have been assessed in section five as many of the matters which may be considered a lack of road sense may also fall within the scope of a standards of driving offence. However, there are also specific codes which relate to specific offences.

In the original application of the scoring tool the influence of drugs on the culpability of motor vehicle drivers was assessed by scoring culpability without reference to alcohol, the alcohol was then overlaid on the culpability results to assess impact, in this study, all factors including drugs and alcohol are explored during the culpability scoring process.

The appropriate factors can be ascertained from a combination of variable codes and the contributing factors. With a variable specifically for the ‘Breath Test’, clearly a code of one (Positive) would indicate a breach of the law.

There are specific contributory factors which indicate a failure to comply with the law and these are found in the contributory factor variables. The STATS19 contributory factor codes are presented in table 5.28 below.

Table 5.28 Robertson and Drummer (1994) section 6 related poor driving STATS19 contributory factor codes

301.	Disobeyed automatic traffic signal
302.	Disobeyed "Give Way" or "Stop" sign or markings
303.	Disobeyed double white lines
304.	Disobeyed pedestrian crossing facility
305.	Illegal turn or direction of travel
306.	Exceeding speed limit
307.	Travelling too fast for conditions
308.	Following too close
309.	Vehicle travelling along pavement
403.	Poor turn or manoeuvre
404.	Failed to signal or misleading signal
405.	Failed to look properly
407.	Too close to cyclist, horse rider or pedestrian
408.	Sudden braking
501.	Impaired by alcohol
502.	Impaired by drugs
504.	Uncorrected, defective eyesight
506.	Not displaying lights at night or in poor visibility
508.	Driver using mobile phone
509.	Distraction in vehicle
510.	Distraction outside vehicle
904.	Vehicle door opened or closed negligently

The 300 series codes, codes 301-306 are specific offences with codes 307-309 as well as codes 403-408 describing actions which would be regarded as ‘driving without due care and attention’ or ‘driving without due consideration for other road users’. These matters would fall under the standards of driving offences under the *Road Traffic Act 1988*; the specific offence would be dictated by the circumstance.

The 600 series codes, codes 601-604, were described in the explanation of section five of the tool and are not be repeated, these could also constitute offences under the standard of driving matters within the *Road Traffic Act 1988*.

Code 904 relates to a specific offence.

Also note that the vehicle defect codes (201-206 and 999) described in the explanation of section two of the tool constitute offences contrary to *The Road Vehicles (Construction and Use) Regulations 1986*.

The relationship of STATS19 variables, contributory factors and collision description to the scoring criteria for this section of the scoring tool are presented in table 5.29 below.

Table 5.29 Applied STATS19 data and considerations for each Robertson and Drummer (1994) road law obedience criteria

6. Road Law Obedience	**STATS19 data**			**Applied STATS19 data, considerations and assumptions**
	Variable	**Contributory factor**	**Narrative**	
Was driver obeying road laws?				
Yes	No	Yes	No	No offences indicated by contributory factors or variable codes
No	No	Yes	No	Breath test variable code one (positive), any of the contributory factor codes indicated in table 5.28, any defects indicated in section two, any combination of factors indicated in section five which may combine to indicate a standards of driving offence

Presented in table 5.30 below are how the considerations and application described in this section produced results for the four motor vehicle drivers in the two case studies.

Table 5.30 Robertson and Drummer (1994) road law obedience case study examples

Case Study	**Driver**	**Variables and contributory factors present**	**Robertson and Drummer (1994) criteria**	**Score**
One	One	Failed to look properly (405), Poor turn or manoeuvre (403), Failed to observe keep clear (under a 999 code)	No	1
	Two	Failed to look properly (405)	No	1
Two	One	Poor turn or manoeuvre (403), Failed to look properly (405), Illegal turn or direction of travel (305)	No	1
	Two	No offences indicated by contributory factors or variable codes	Yes	3

Section 7. Difficulty of Task Involved

Section seven relates to the difficulty of the task the individual motor vehicle driver was involved in; the factors do not apply directly across from STATS19. The criteria for section seven of the Robertson and Drummer (1994) scoring tool are set out in table 5.31 below.

Table 5.31 Robertson and Drummer (1994) difficulty of task involved criteria (Section 7).

7. Difficulty of Task Involved
Straight road or sweeping bend
§Across lanes in
Heavy traffic
Light traffic
Winding road/sharp bend/U-turn
Overtaking
Avoiding unexpected traffic

This section combines a number of codes from STATS19, there may also be other factors mentioned in the narrative section which would fall within this section. The STATS19 contributory factor codes are presented in table 5.32 below.

Table 5.32 Robertson and Drummer (1994) section 7 related road layout STATS19 contributory factor codes

108.	Road layout (e.g. bend, hill, narrow carriageway)
703.	Road layout (e.g. Bend, winding road, hill crest)

Contributory factor codes 108 and 703 relate directly to the scoring tool criteria but would only be mentioned in the contributory factors section if they impacted on the circumstances of the collision. By inference if these codes were not present and there was no mention of a bend or curve in the narrative then the road would be straight or a bend which was not tight enough to be relevant.

Overtaking manoeuvres are considered in STATS19 as an option within the 'manoeuvres' variable codes 13-15. Code 13 relates to overtaking a moving vehicle on its offside, code 14 relates to overtaking a stationary vehicle on its offside and code 15 relates to overtaking on the nearside. The other criteria in this section would be contained within the narrative if present.

The relationship of STATS19 variables, contributory factors and collision description to the scoring criteria for this section of the scoring tool are presented in table 5.33 below.

Table 5.33 Applied STATS19 data and considerations for each Robertson and Drummer (1994) difficulty of task involved criteria

7. Difficulty of Task Involved	**STATS19 data**			**Applied STATS19 data, considerations and assumptions**
	Variable	**Contributory factor**	**Narrative**	
Straight road or sweeping bend	No	Yes	No	Contributory factors 108 or 703 not present
§Across lanes in	No	No	No	Not indicated directly by STATS19, see below
Heavy traffic	Yes	No	Yes	Manoeuvre variable, left (07) or right (09) turn combined with the description indicating heavy traffic
Light traffic	Yes	No	Yes	Manoeuvre variable, left (07) or right (09) turn combined with the description indicating light traffic
Winding road/sharp bend/U-turn	No	Yes	No	Contributory factors 108 or 703 present
Overtaking	Yes	No	No	Manoeuvre variable, overtaking (13-15)
Avoiding unexpected traffic	No	No	Yes	Not indicated directly by STATS19 but may be described in the description

Presented in table 5.34 below are how the considerations and application described in this section produced results for the four motor vehicle drivers in the two case studies.

Table 5.34 Robertson and Drummer (1994) difficulty of task involved case study examples

Case Study	**Driver**	**Variables and contributory factors present**	**Robertson and Drummer (1994) criteria**	**Score**
One	One	Nothing to indicate anything other than a straight road or sweeping bend, crossing heavy traffic	Straight road or sweeping bend, crossing heavy traffic	2
	Two	Nothing to indicate anything other than a straight road or sweeping bend, combined with a manoeuvre ‘overtaking stationary vehicle on the offside (13)	Straight road or sweeping bend, overtaking	2
Two	One	Nothing to indicate anything other than a straight road or sweeping bend, u-turn	Straight road or sweeping bend, u-turn	2
	Two	Nothing to indicate anything other than a straight road or sweeping bend	Straight road or sweeping bend	1

Section 8. Level of Fatigue

Section eight relates to fatigue in the motor vehicle driver. The criteria for section eight of the Robertson and Drummer (1994) scoring tool are set out in table 5.35 below.

Table 5.35 Robertson and Drummer (1994) level of fatigue criteria (Section 8)

8. Level of Fatigue
Only if mentioned in police reports

Fatigue has a specific contributory factor in STATS19. The code for Fatigue being 503 and relates to situations where the 'Driver/rider was so tired that they could not drive effectively or were unable to perceive hazards' which corresponds with the Robertson and Drummer (1994) criteria.

The relationship of STATS19 variables, contributory factors and collision description to the scoring criteria for this section of the scoring tool are presented in table 5.36 below.

Table 5.36 Applied STATS19 data and considerations for each Robertson and Drummer (1994) fatigue criteria

8. Level of Fatigue	**STATS19 data**			**Applied STATS19 data, considerations and assumptions**
	Variable	**Contributory factor**	**Narrative**	
Only if mentioned in police reports	No	Yes	No	Contributory factor 'fatigue' (503) present

Presented in table 5.37 below are how the considerations and application described in this section produced results for the four motor vehicle drivers in the two case studies.

Table 5.37 Robertson and Drummer (1994) fatigue case study examples

Case Study	**Driver**	**Variables and contributory factors present**	**Robertson and Drummer (1994) criteria**	**Score**
One	One	None	Not mentioned	No score recorded
	Two	None	Not mentioned	No score recorded
Two	One	None	Not mentioned	No score recorded
	Two	None	Not mentioned	No score recorded

Unused STATS19 contributory factors

There are a number of contributory factor codes from STATS19 which do not appear to fit within any of the Robertson and Drummer (1994) categories in any straightforward manner, however, they may depending on the circumstances. The STATS19 contributory factor codes are presented in table 5.38 below.

Table 5.38 Robertson and Drummer (1994) non-applicable STATS19 contributory factor codes

104.	Inadequate or masked signs or road markings
105.	Defective traffic lights
106.	Traffic calming (e.g. Speed cushions, road humps, chicanes)
107.	Temporary road layout (e.g. Contraflow)
109.	Animal or object in carriageway
110.	Slippery inspection cover or road marking
310.	Cyclist entering road from pavement
505.	Illness or disability, mental or physical
507.	Driver wearing dark clothing at night
607.	Unfamiliar with model of vehicle
901.	Stolen vehicle
902.	Vehicle in course of crime
903.	Emergency vehicle on a call

Codes 105/106/107/109/110 could be a lack of road sense under section 5 if the motor vehicle driver did not take them into account and caused a collision as a result or they could also mean the motor vehicle driver was not culpable for the collision and need to be judged from the narrative. Code 505 could be an offence under the standards of driving offences if it was pre-existing, or the symptoms that impaired driving ability were obvious, again this would need to be guided by the narrative. Code 507 relates to a motorcyclist and may constitute a lack of conspicuity and be mitigation for another party.

Case study results Robertson and Drummer (1994)

The case study results for the Robertson and Drummer (1994) scoring tool are presented in table 5.39 below.

Table 5.39 Robertson and Drummer (1994) case study results

Criteria	**Criteria scores**			
	Case study one	**Case study one**	**Case study two**	**Case study two**
	Driver one	**Driver two**	**Driver one**	**Driver two**
Condition of road	1	1	1	1
Condition of vehicle	1	1	1	1
Driving conditions	1	1	3	3
Type of accident	1	1	1	2
Witness observations	No score recorded	No score recorded	1	4
Road law obedience	1	1	1	3
Difficulty of task involved	2	2	2	1
Level of fatigue	No score recorded	No score recorded	No score recorded	No score recorded
Number of categories	6	6	7	7
Overall score	9.3	9.3	11.4	17.1
Culpable (yes/no)	Yes	Yes	Yes	No

Bringing the applied components together allows for the construction of two composite tables which append the STATS19 material to the specific scoring sections within the Robertson and Drummer (1994) scoring tool, the first table presents what data was available for each scoring tool section, see appendix six, the second table contains the detailed application of data to each scoring criteria and the related score, see appendix seven.

5.4.2 Applying STATS19 onto the Brubacher, Chan and Asbridge (2012) Scoring Tool

This section of the chapter sets out the process for applying the STATS19 data onto the Brubacher, Chan and Asbridge (2012) scoring tool and follows the same format as the previous section relating to the Robertson and Drummer (1994) tool. As with that exercise the objective was to overlay the data held on STATS19 with the mitigation categories used within the Brubacher, Chan and Asbridge (2012) assessment framework. The same procedure of assessing what variables and contributory factors fit within each mitigation category was used, again the aim was to use as many variables or combinations of variables as required to gather the information and use, if possible, all of the contributory factors.

Many of the logistical complications experiences with the Robertson and Drummer (1994) are repeated. The Brubacher, Chan and Asbridge (2012) tool also contains a section related to witness observations which although not described as such in STATS19 are incorporated into data as part of the circumstantial description and the allocation of contributory factors to individual motor vehicle drivers involved in the collision.

The scoring system structure examines multiple factors similar to those used by Robertson and Drummer (1994) and when the scoring guidelines are examined the similarities in structure and criteria are clear. The process was tailored by the authors to fit a Canadian paradigm and also starts from a position of culpability for all motor vehicle drivers concerned and then scores mitigating factors which may negate that culpability if the scores are sufficiently high.

The scoring works in the following fashion:

This model looks at seven factors (mitigating categories) which were linked to the data available from the police reports. The mitigating factors are given a score of one to five, one being not mitigating through to five mitigating. Therefore, the scores range from lowest of seven to the highest at 35.

Therefore, motor vehicle drivers with a score of ≤13 are deemed responsible for the collision. Scores of ≥16 were not responsible with a score of 14 or 15 considered indeterminate/ contributory. Unlike Robertson and Drummer (1994) no minimum number of factors need to be scored in order to get the desired result, the results are purely based on the sum of the factors that are present. The mitigating factors are set out in table 5.40 below.

Table 5.40 Brubacher, Chan and Asbridge (2012) scoring guidelines used for responsibility analysis

APPENDIX A ***Culpability Scoring Tool***	
This simplified scoring tool shows how each factor is scored. Low scores indicate either driver error or the presence of external factors that contributed to the crash. Drivers with total scores ≥16 are considered nonculpable, those with scores ≤13 are culpable, and scores of 14 or 15 are indeterminate. Note that the full scoring tool is automated and assigns scores to all possible entries in the BC traffic accident system. This scoring tool cannot be applied directly to police crash reports from other jurisdictions because of differences in the content of police traffic crash reports. However, by following the methods in this article, similar culpability scoring tools using electronic crash data from other jurisdictions could be developed and validated.	
	Score
(1) Road type	
One-way traffic	
Road class = anything other than ramp	1
Road class = ramp	2
Two-way traffic	

Between intersection	2
At intersection	3
Ramp	3
Police list roadside hazard or poor design as contributory factor	5
(2) Driving condition = **road surface and visibility/weather conditions**	
Road surface	
Dry road/asphalt or concrete	1
Dry road/gravel, oiled gravel, brick, stone, earth, or wood	2
Wet road/asphalt or concrete	2
Wet road/gravel, oiled gravel, brick, stone, earth, or wood	3
Road muddy or covered with snow or slush or ice	4
Road surface listed as contributory factor	5
Visibility and weather	
Weather = clear or cloudy	1
If lighting condition = dark with partial or no illumination	2
Weather = raining, smog or smoke, or strong wind	2
If lighting condition = dark with partial or no illumination	3
Weather = snow, sleet, hail, fog	3
If lighting condition = dark with partial or no illumination	4
Police list visibility or weather as a contributory factor	5
(3) Vehicle condition	
Vehicle condition not listed as contributory factor in crash	1
Police list vehicle condition as contributory factor in crash	5
(4) Unsafe driving actions	
Driver not obeying road laws or driving in unsafe manner	1
Driver obeying road laws and driving safely	5
(5) Contribution from other parties	
No contribution from other parties	1
Contribution from other parties	5
(6) Type of collision	
Unsafe driving (factor 4)	1
No unsafe driving	
Single vehicle without pedestrian	1
Single motor vehicle crash involving pedestrian	
Pedestrian action	
Standing/walking on a sidewalk	1
Crossing with signal	1
Crossing, no signal, marked crosswalk	1
Crossing, no signal, no crosswalk	3
Crossing against signal	4
Child getting on/off bus	2
Adult getting on/off vehicle	2
Emerging from in front of or behind a parked vehicle	3
Pushing or working on a vehicle	1
Walking along highway with or against traffic	1
Working in roadway	1
Playing in roadway	2
Multivehicle crash	
“Innocent third party”	5
Stopped/parked	
Lead vehicle in rear-end collision	
Third or subsequent vehicle in crash (entity # ≥3–this only applies to crashes with more than 2 vehicles)	
Loss of control prior to crash	
Precollision action = swerving, spinning, yaw, jackknifing, skidding	1
Maneuvering vehicle: precollision action = left turn, right turn, U-turn, overtaking, etc.	
Striking vehicle (determined from damage location)	1
Indeterminate vehicle (determined from damage location)	1
Struck vehicle (determined from damage location)	2
If right turn rear ended	3
Precollision action = traveling straight, crash configuration∗ = rear end	
Striking vehicle (determined from damage location)	1

Indeterminate vehicle (determined from damage location)	3
Struck vehicle (determined from damage location)	5
Precollision action = traveling straight, crash configuration = intersection, off road	
Striking vehicle (determined from damage location)	1
Indeterminate vehicle (determined from damage location)	1
Struck vehicle (determined from damage location)	3
Precollision action = traveling straight, crash configuration = any turn, overtaking—that is, other vehicle maneuvering	
Striking vehicle (determined from damage location)	3
Indeterminate vehicle (determined from damage location)	3
Struck vehicle (determined from damage location)	4
Precollision action = traveling straight, crash configuration = head on, sideswipe)	
Striking vehicle (determined from damage location)	3
Indeterminate vehicle (determined from damage location)	3
Struck vehicle (determined from damage location)	3
Precollision action = traveling straight, crash configuration = unknown	
Striking vehicle (determined from damage location)	2
Indeterminate vehicle (determined from damage location)	
Struck vehicle (determined from damage location)	4
(7) Task involved	
Unsafe driving (Factor 4)	1
No unsafe driving	
Avoiding object on road	5
Parked, stopped in traffic *a*	5
Changing lanes, merging	3
Turning and backing	2
All other precollision actions	1
a These vehicles could not have caused the crash so the driver is given a high score even though the task is simple	

Each section of the tool was examined in turn to explore the STATS19 data available to assist with the mitigation assessment.

Section 1. Road Type

The first section of the tool examines the road where the collisions occurred. The criteria for section one of the Brubacher, Chan and Asbridge (2012) scoring tool are set out in table 5.41 below.

Table 5.41 Brubacher, Chan and Asbridge (2012) road type criteria (Section 1)

(1) Road type
One-way traffic
Road class = anything other than ramp
Road class = ramp
Two-way traffic
Between intersection
At intersection
Ramp
Police list roadside hazard or poor design as contributory factor

STATS19 does not deal with the scoring tool descriptions specifically, but these can be deduced from three variables and the possible use of two contributory factors.

The number of lanes in, or configuration of the primary road are contained in the 'Road Type' variable. The STATS19 codes are presented in table 5.42 below.

Table 5.42 STATS19 road type codes

1.	Roundabout
2.	One way street
3.	Dual carriageway
6.	Single carriageway
7.	Slip Road
9.	Unknown

The North-American term 'ramp' translates to 'Slip Road'. Whether or not there was an 'intersection', junction in translation, can be determined by examining the 'Junction Location of Vehicle' variable. The STATS19 codes are presented in table 5.43 below.

Table 5.43 STATS19 junction location of vehicle codes

0.	Not at, or within 20 metres of, junction
1.	Approaching junction or waiting/parked at junction approach
2.	Cleared junction or waiting/parked at junction exit
3.	Leaving roundabout
4.	Entering roundabout
5.	Leaving main road
6.	Entering main road
7.	Entering from slip road
8.	Mid junction - on roundabout or on main road

Code zero denotes between junctions; all other codes indicate at a junction. For roundabouts (one) the option of 'Two-way traffic – At intersection' was used.

The 'Special Conditions at Site' variable, code five, relates to 'Road surface defective'. This needed to be examined if it was likely to be required.

There are two contributory factors which may indicate poor design as a contributory factor. The STATS19 contributory factor codes are presented in table 5.44 below.

Table 5.44 Brubacher, Chan and Asbridge (2012) section 1 related STATS19 contributory factors

106.	Traffic calming (e.g. Speed cushions, road humps, chicanes)
107.	Temporary road layout (e.g. Contraflow)

The relationship of STATS19 variables, contributory factors and collision description to the scoring criteria for this section of the scoring tool are presented in table 5.45 below.

Table 5.45 Applied STATS19 data and considerations for each Brubacher, Chan and Asbridge (2012) road type criteria

(1) Road type	STATS19 data			Applied STATS19 data, considerations and assumptions
	Variable	Contributory factor	Narrative	
One-way traffic	Yes	No	No	Road type variable ‘one way street’ (2)
Road class = anything other than ramp	Yes	No	No	Road type variable ‘one way street’ (2)
Road class = ramp	Yes	No	No	Road type variable ‘slip road’ (7)
Two-way traffic	Yes	No	No	Road type variable ‘roundabout’ (1), ‘duel carriageway’ (3), ‘single carriageway’ (6)
Between intersection	Yes	No	No	Junction location of vehicle variable ‘not at, or within 20 metres of a junction’ (0)
At intersection	Yes	No	No	Junction location of vehicle variable, all codes except ‘not at, or within 20 metres of a junction’ (0)
Ramp	Yes	No	No	Road type variable ‘slip road’ (7)
Police list roadside hazard or poor design as contributory factor	Yes	Yes	No	Contributory factor codes ‘traffic calming’ (106), or Temporary road layout’ (107) or special conditions at site variable ‘road surface defective’ (5)

Presented in table 5.46 below are how the considerations and application described in this section produced results for the four motor vehicle drivers in the two case studies.

Table 5.46 Brubacher, Chan and Asbridge (2012) road type case study examples

Case Study	Driver	Variables and contributory factors present	Brubacher, Chan and Asbridge (2012) criteria	Score
One	One	Single Carriageway (6) Leaving Roundabout (3)	Two-way traffic - At intersection	3
	Two	Single Carriageway (6) Leaving Roundabout (3)	Two-way traffic - At intersection	3
Two	One	Dual Carriageway (3) Leaving main road (5)	Two-way traffic - At intersection	3
	Two	Dual Carriageway (3) Leaving main road (5)	Two-way traffic - At intersection	3

Section 2. Driving Conditions

Section two of the Brubacher, Chan and Asbridge (2012) scoring tool relates to the prevailing driving conditions at the time of the collisions. The criteria for section two of the Brubacher, Chan and Asbridge (2012) scoring tool are set out in table 5.47 below.

Table 5.47 Brubacher, Chan and Asbridge (2012) driving conditions criteria (Section 2).

(2) Driving condition = **road surface and visibility/weather conditions**
Road surface
Dry road/asphalt or concrete
Dry road/gravel, oiled gravel, brick, stone, earth, or wood
Wet road/asphalt or concrete
Wet road/gravel, oiled gravel, brick, stone, earth, or wood
Road muddy or covered with snow or slush or ice
Road surface listed as contributory factor
Visibility and weather
Weather = clear or cloudy
If lighting condition = dark with partial or no illumination
Weather = raining, smog or smoke, or strong wind
If lighting condition = dark with partial or no illumination
Weather = snow, sleet, hail, fog
If lighting condition = dark with partial or no illumination
Police list visibility or weather as a contributory factor

This section needed a combination of STATS19 factors to be examined. In STATS19 there appears to be an assumption that roads are sealed, i.e. that it has a conventional hard road surface such as tarmacadam or concrete. Deviation from this assumption may be recorded using contributory factors.

There are codes in the STATS19 contributory factors which relate to the road environment and these may contribute to this section if present. The codes are presented in table 5.48 below.

Table 5.48 Brubacher, Chan and Asbridge (2012) section 2 related STATS19 contributory factor codes

101.	Poor of defective road surface
102.	Deposit on road (e.g. oil, mud, chippings)
103.	Slippery road (due to weather)
104.	Inadequate or masked signs or road markings
110.	Slippery inspection cover or road marking

The ‘Special Conditions at Site’ variable, code five, which relates to ‘Road surface defective’, may be considered in this section if present. Any reference to unmade roads may require the examination of the narrative in the report.

STATS19 considers daylight and darkness within the entry for ‘Light Conditions’ variable. The codes are presented in table 5.49 below.

Table 5.49 STATS19 light condition codes

1.	Daylight
4.	Darkness: street lights present and lit
5.	Darkness: street lights present but unlit
6.	Darkness: no street lighting
7.	Darkness: street lighting unknown

The weather conditions are considered separately in the ‘Weather’ variable. The STATS19 codes are presented in table 5.50 below.

Table 5.50 STATS19 weather conditions codes

1.	Fine without high winds
2.	Raining without high winds
3.	Snowing without high winds
4.	Fine with high winds
5.	Raining with high winds
6.	Snowing with high winds
7.	Fog or mist – if hazard
8.	Other
9.	Unknown

The contributory factor code 707 for ‘Rain, sleet, snow or fog’ can contribute to building this picture if present.

There are descriptive codes for the ‘Road Surface Condition’ variable. The STATS19 codes are presented in table 5.51 below.

Table 5.51 STATS19 surface conditions codes

1.	Dry
2.	Wet/damp
3.	Snow
4.	Frost/ice
5.	Flood (surface water over 3cm deep)

The relationship of STATS19 variables, contributory factors and collision description to the scoring criteria for this section of the scoring tool are presented in table 5.52 below.

Table 5.52 Applied STATS19 data and considerations for each Brubacher, Chan and Asbridge (2012) driving conditions criteria

(2) Driving condition = road surface and visibility/weather conditions	**STATS19 data**			**Applied STATS19 data, considerations and assumptions**
	Variable	**Contributory factor**	**Narrative**	
Road surface				
Dry road/asphalt or concrete	Yes	No	No	Surface conditions variable ‘dry’ (1) the road surface can be assumed to be asphalt or concrete unless otherwise stated
Dry road/gravel, oiled gravel, brick, stone, earth, or wood	Yes	No	Yes	Surface conditions variable ‘dry’ (1) alternative road surfaces are not dealt with directly in STATS19 although this may be mentioned in the description if it was a factor in the collision
Wet road/asphalt or concrete	Yes	No	No	Surface conditions variable ‘wet’ (2) the road surface can be assumed to be asphalt or concrete unless otherwise stated
Wet road/gravel, oiled gravel, brick, stone, earth, or wood	Yes	No	Yes	Surface conditions variable ‘wet’ (2) alternative road surfaces are not dealt with directly in STATS19 although this may be mentioned in the description if it was a factor in the collision
Road muddy or covered with snow or slush or ice	Yes	Yes	No	Surface conditions variable ‘snow’ (3) of Surface conditions ‘frost/ice’ (4). Contributory factors ‘deposit on road (e.g. oil, mud, chippings)’ (102) or ‘slippery road (due to weather)’ (103)
Road surface listed as contributory factor	Yes	Yes	No	Contributory factor ‘poor or defective road surface’ (101) or Special conditions at site variable ‘road surface defective’ (5)
Visibility and weather				
Weather = clear or cloudy	Yes	No	No	Weather conditions variable ‘fine without high winds’ (1)
If lighting condition = dark with partial or no illumination	Yes	No	No	Light conditions variable ‘darkness: street lights present but unlit’ (5) or ‘darkness: no street lighting’ (6)
Weather = raining, smog or smoke, or strong wind	Yes	No	No	Weather conditions variable ‘raining without high winds’ (2) or ‘fine with high winds’ (4) or ‘raining with high winds’ (5) or ‘fog or mist – if hazard’ (7)
If lighting condition = dark with partial or no illumination	Yes	No	No	Light conditions variable ‘darkness: street lights present but unlit’ (5) or ‘darkness: no street lighting’ (6)
Weather = snow, sleet, hail, fog	Yes	No	No	Weather conditions variable ‘snowing without high winds’ (3) or ‘snowing with high winds’ (6) or ‘fog or mist – if hazard’ (7)
If lighting condition = dark with partial or no illumination	Yes	No	No	Light conditions variable ‘darkness: street lights present but unlit’ (5) or ‘darkness: no street lighting’ (6)
Police list visibility or weather as a contributory factor	No	Yes	No	Contributory factor ‘slippery road (due to weather)’ (103), there may also be reference to the weather in the description

Presented in table 5.53 below are how the considerations and application described in this section produced results for the four motor vehicle drivers in the two case studies.

Table 5.53 Brubacher, Chan and Asbridge (2012) driving conditions case study examples

Case Study	Driver	Variables and contributory factors present	Brubacher, Chan and Asbridge (2012) criteria	Score
One	One	Wet/damp (2), Fine without high wind (1), Darkness: street lights present and lit (4)	Wet asphalt, raining, illuminated	2
	Two	Wet/damp (2), Fine without high wind (1), Darkness: street lights present and lit (4)	Wet asphalt, raining, illuminated	2
Two	One	Wet/damp (2), Raining without high winds (2), Darkness: No street lighting (6)	Wet asphalt, raining, no illumination	3
	Two	Wet/damp (2), Raining without high winds (2), Darkness: No street lighting (6)	Wet asphalt, raining, no illumination	3

Section 3. Vehicle Condition

The third section of the Brubacher, Chan and Asbridge (2012) scoring tool relates to the condition of the vehicle. This has a different approach to the Robertson and Drummer (1994) tool, where only defects which contribute to the collision are considered. The criteria for section three of the Brubacher, Chan and Asbridge (2012) scoring tool are set out in table 5.54 below.

Table 5.54 Brubacher, Chan and Asbridge (2012) vehicle condition criteria (Section 3)

(3) Vehicle condition
Vehicle condition not listed as contributory factor in crash
Police list vehicle condition as contributory factor in crash

Note that 'vehicle condition' matters are likely to be within the scope of defect offences unless there has been a sudden component failure not linked to a pre-existing defect or poor maintenance.

With no reference to vehicle condition in the vehicle section of the collision report, vehicle defects are dealt with in the contributory factors section of the report (see previous explanation of variable names). These vehicle defects are listed as contributory factors only if they contribute to the collision. Any non-contributory defects may be part of the narrative of the report or may result in officers reporting the individuals. The STATS19 contributory factor codes are presented in table 5.55 below.

Table 5.55 STATS19 vehicle defect contributory factor codes

201.	Tyre illegal, defective or under-inflated
202.	Defective lights and indicators
203.	Defective brakes
204.	Defective steering or suspension
205.	Defective or missing mirrors
206.	Overloaded or poorly loaded vehicle or trailer
999.	Other contributory defect not listed above

Clearly, if there are no vehicle defect codes in the contributory factors and there are no defect offences reported which were not contributory then the vehicle can be deemed to be roadworthy for scoring purposes.

The relationship of STATS19 variables, contributory factors and collision description to the scoring criteria for this section of the scoring tool are presented in table 5.56 below.

Table 5.56 Applied STATS19 data and considerations for each Brubacher, Chan and Asbridge (2012) vehicle condition criteria

(3) Vehicle condition	**STATS19 data**			**Applied STATS19 data, considerations and assumptions**
	Variable	**Contributory factor**	**Narrative**	
Vehicle condition not listed as contributory factor in crash	No	Yes	No	Contributory factors 201-206 or 999 not present
Police list vehicle condition as contributory factor in crash	No	Yes	No	Contributory factors 201-206 or 999 present

Presented in table 5.57 below are how the considerations and application described in this section produced results for the four motor vehicle drivers in the two case studies.

Table 5.57 Brubacher, Chan and Asbridge (2012) vehicle condition case study examples

Case Study	Driver	Variables and contributory factors present	Brubacher, Chan and Asbridge (2012) criteria	Score
One	One	Contributory factors 201-206 or 999 not present	Vehicle condition not listed as contributory factor in crash	1
	Two	Contributory factors 201-206 or 999 not present	Vehicle condition not listed as contributory factor in crash	1
Two	One	Contributory factors 201-206 or 999 not present	Vehicle condition not listed as contributory factor in crash	1
	Two	Contributory factors 201-206 or 999 not present	Vehicle condition not listed as contributory factor in crash	1

Section 4. Unsafe Driving Actions

Section four of the scoring tool relates to the actions of the motor vehicle driver. The criteria for section four of the Brubacher, Chan and Asbridge (2012) scoring tool are set out in table 5.58 below.

Table 5.58 Brubacher, Chan and Asbridge (2012) unsafe driving actions criteria (Section 4)

(4) Unsafe driving actions
Driver not obeying road laws or driving in unsafe manner
Driver obeying road laws and driving safely

For the purposes of this exercise road laws were considered to encompass all UK road traffic legislation. The 'Breath Test' variable, where a code of one (Positive) was indicated, would clearly indicate a breach of the law.

There are specific contributory factors which indicate a failure to comply with the law and are found in the contributory factor variables as described earlier. The STATS19 contributory factor codes are presented in table 5.59 below.

Table 5.59 STATS19 driving offence related contributory factor codes

301.	Disobeyed automatic traffic signal
302.	Disobeyed "Give Way" or "Stop" sign or markings
303.	Disobeyed double white lines
304.	Disobeyed pedestrian crossing facility
305.	Illegal turn or direction of travel
306.	Exceeding speed limit
307.	Travelling too fast for conditions
308.	Following too close
309.	Vehicle travelling along pavement

Codes 307-309 would be regarded as 'driving without due care and attention' or 'driving without due consideration for other road users'.

There are further contributory factor codes which relate to poor driving. The first set of these STATS19 contributory factor codes relate to manoeuvring. The STATS19 contributory factor codes are presented in table 5.60 below.

Table 5.60 STATS19 standard of driving related contributory factor codes

403.	Poor turn or manoeuvre
404.	Failed to signal or misleading signal
405.	Failed to look properly
407.	Too close to cyclist, horse rider or pedestrian
408.	Sudden braking

These matters would fall within scope of the standards of driving offences under the *Road Traffic Act 1988*; the specific offence would be dictated by the circumstance.

The next set relate to impaired and distracted driving. The STATS19 contributory factor codes are presented in table 5.61 below.

Table 5.61 STATS19 impaired and distracted driving related contributory factor codes

501.	Impaired by alcohol
502.	Impaired by drugs
504.	Uncorrected, defective eyesight
506.	Not displaying lights at night or in poor visibility
508.	Driver using mobile phone
509.	Distraction in vehicle
510.	Distraction outside vehicle

Codes 601-604 listed under the previous section could also constitute offences under the standard of driving matters within the *Road Traffic Act 1988*.

The specific offence of opening a vehicle door to danger (*regulation 105, The Road Vehicles (Construction and Use) Regulations 1986*) has a related STATS19 contributory factor code, presented in table 5.62 below.

Table 5.62 STATS19 vehicle door opening to danger contributory factor code

904.	Vehicle door opened or closed negligently

Unsafe driving may occur in a number of circumstances, including the circumstances described by the previously explained contributory factor codes within this section. These may be due to direct actions of the motor vehicle driver or may involve the failure to deal with an obvious hazard present in the driving environment these are covered within a further set of STATS19 contributory factors. The STATS19 contributory factor codes are presented in table 5.63 below.

Table 5.63 Brubacher, Chan and Asbridge (2012) section 4 related STATS19 contributory factor codes

105.	Defective traffic lights
108.	Road layout (e.g. bend, hill, narrow carriageway)
401.	Junction overshoot
402.	Junction restart (moving off at junction)
406.	Failing to judge other person's path or speed
601.	Aggressive driving
602.	Careless, reckless or in a hurry
603.	Nervous, uncertain or panic
604.	Driving too slow for conditions, or slow vehicle (e.g. Tractor)
605.	Learner or inexperienced driver/rider
606.	Inexperience of driving on the left
702.	Vegetation
703.	Road layout (e.g. Bend, winding road, hill crest)
704.	Buildings, road signs, street furniture
705.	Dazzling headlights
706.	Dazzling sun
708.	Spray from other vehicles
709.	Visor or windscreen dirty, scratched or frosted etc.
710.	Vehicle blind spot

A number of these codes could also constitute offences contrary to traffic law and fit within section six. For example, code 401 'Junction overshoot' and code 402 'Junction restart (moving off at junction)' can be considered under the irregular driving category. Codes 601-604 may also constitute offences under the standard of driving offences within the *Road Traffic Act 1988*. Code 605 can be used if inexperience contributed not just mere presence. Code 606 relates to foreign motor vehicle drivers. Code 702 'Vegetation', code 704 'Building, road signs, street furniture', code 705 'Dazzling headlights', code 706 'Dazzling sun', code 708 'Spray from other vehicles', code 709 'Visor or windscreen dirty scratched or frosted etc.' and code 710 'Vehicle blind spot' are where this was contributory and would fall under a 'Unsafe driving' as the obstruction to vision should be apparent and motor vehicle drivers should take action accordingly, failing to take account of these factors adequately may also constitute offences under the standards of driving offences within the *Road Traffic Act 1988*.

The relationship of STATS19 variables, contributory factors and collision description to the scoring criteria for this section of the scoring tool are presented in table 5.64 below.

Table 5.64 Applied STATS19 data and considerations for each Brubacher, Chan and Asbridge (2012) unsafe driving actions criteria

(4) Unsafe driving actions	**STATS19 data**			Applied STATS19 data, considerations and assumptions
	Variable	**Contributory factor**	**Narrative**	
Driver not obeying road laws or driving in unsafe manner	Yes	Yes	No	Breath test variable 'positive' (1) or Contributory factors 'disobeyed automatic traffic signal' (301), 'disobeyed "Give Way" or "Stop" sign or markings' (302), 'disobeyed double white lines' (303), 'disobeyed pedestrian crossing facility' (304), 'illegal turn or direction of travel' (305), 'exceeding speed limit' (306), 'travelling too fast for conditions' (307), 'following too close' (309), 'vehicle travelling along pavement' (309), 'poor turn or manoeuvre' (403), 'failed to signal or misleading signal' (404), 'failed to look properly' (405), 'too close to cyclist, horse rider or pedestrian' (407), 'sudden braking' (408), 'impaired by alcohol' (501), 'impaired by drugs' (502), 'uncorrected, defective eyesight' (504), 'not displaying lights at night or in poor visibility' (506), 'driver using mobile phone' (508), 'distraction in vehicle' (509), 'distraction outside vehicle' (510), 'vehicle door opened or closed negligently' (904), also failing to deal with the following contributory factors adequately to avoid a collision or driving in the manner described in the contributory factor are likely to constitute offences under the standards of driving matters, 'defective traffic lights' (105), 'road layout (e.g. bend, hill, narrow carriageway)' (108), 'junction overshoot' (401), 'junction restart (moving off at junction)' (402), 'failing to judge other person's path or speed' (406), 'aggressive driving' (601), 'careless, reckless or in a hurry' (602), 'nervous, uncertain or panic' (603), 'driving too slow for conditions, or slow vehicle (e.g. Tractor)' (604), 'learner or inexperienced driver/rider' (605), 'inexperience of driving on the left' (606), 'vegetation' (702), 'road layout (e.g. Bend, winding road, hill crest)' (703), 'buildings, road signs, street furniture' (704), 'dazzling headlights' (705), 'dazzling sun' (706), 'spray from other vehicles' (708), 'visor or windscreen dirty, scratched or frosted etc' (709), 'vehicle blind spot' (710)
Driver obeying road laws and driving safely	Yes	Yes	No	None of the variables or contributory factor present

Presented in table 5.65 below are how the considerations and application described in this section produced results for the four motor vehicle drivers in the two case studies.

Table 5.65 Brubacher, Chan and Asbridge (2012) unsafe driving actions case study examples

Case Study	Driver	Variables and contributory factors present	Brubacher, Chan and Asbridge (2012) criteria	Score
One	One	Failed to look properly (405), Poor turn or manoeuvre (403), Failed to observe keep clear (under a 999 code)	Driver not obeying road laws or driving in unsafe manner	1
	Two	Failed to look properly (405)	Driver not obeying road laws or driving in unsafe manner	1
Two	One	Poor turn or manoeuvre (403), Failed to look properly (405), Illegal turn or direction of travel (305)	Driver not obeying road laws or driving in unsafe manner	1
	Two	No related contributory factors present	Driver obeying road laws and driving safely	5

Section 5. Contribution from other parties

This section of the scoring tool examines the impact or influence of other vehicles on the motor vehicle driver subject to scoring. The criteria for section five of the Brubacher, Chan and Asbridge (2012) scoring tool are set out in table 5.66 below.

Table 5.66 Brubacher, Chan and Asbridge (2012) contribution of other parties' criteria (Section 5)

(5) Contribution from other parties
No contribution from other parties
Contribution from other parties

This factor can be determined by examining the 'number of vehicles' involved in the collision variable where a single vehicle incident clearly has no other parties involved, however, some multi vehicle collisions recorded on STATS19 include non-motor vehicles, such as pedal cycles as a second vehicle. These need to be included in the 'no other parties' category. The relative contributions need to be determined from the narrative in the absence of other information.

The relationship of STATS19 variables, contributory factors and collision description to the scoring criteria for this section of the scoring tool are presented in table 5.67 below.

Table 5.67 Applied STATS19 data and considerations for each Brubacher, Chan and Asbridge (2012) contribution of other parties' criteria

(5) Contribution from other parties	**STATS19 data**			**Applied STATS19 data, considerations and assumptions**
	Variable	**Contributory factor**	**Narrative**	
No contribution from other parties	Yes	No	No	Number of vehicles variable indicates one vehicle or if the number of vehicles variable indicates more than one vehicle but in examining the vehicle type variable only one of the vehicles can be considered a motor vehicle or Multi-vehicle collisions determined by the number of vehicles variable indicates more than one and examining the vehicle type variable indicates (see table 5.17) more than one motor vehicle, combined with the driver of the vehicle having a determination of 'Driver not obeying road laws or driving in unsafe manner' in section four
Contribution from other parties	Yes	No	No	Multi-vehicle collisions determined by the number of vehicles variable indicates more than one and examining the vehicle type variable indicates (see table 5.17) more than one motor vehicle, combined with the driver of the vehicle having a determination of 'Driver obeying road laws and driving safely' in section four with one of the drivers of another vehicle having a determination of 'Driver not obeying road laws or driving in unsafe manner' in section four

Presented in table 5.68 below are how the considerations and application described in this section produced results for the four motor vehicle drivers in the two case studies.

Table 5.68 Brubacher, Chan and Asbridge (2012) contribution from other parties' case study examples

Case Study	**Driver**	**Variables and contributory factors present**	**Brubacher, Chan and Asbridge (2012) criteria**	**Score**
One	One	A section four determination of 'Driver not obeying road laws or driving in unsafe manner'	No other party contribution	1
	Two	A section four determination of 'Driver not obeying road laws or driving in unsafe manner'	No other party contribution	1
Two	One	A section four determination of 'Driver not obeying road laws or driving in unsafe manner'	No other party contribution	1
	Two	No contributory factors present combined with a section four determination of 'Driver obeying road laws and driving safely' combined with a determination of 'Driver not obeying road laws or driving in unsafe manner' for the other party in the collision	Other party contribution	5

Section 6. Type of collision

This section of the tool examines the construction of the collision in relation to the constituent vehicles and actions of the parties involved. This factor must be split into three sections, although this may not be obvious from the original table 5.40 provided.

The initial criteria specify that if there are unsafe driving actions defined by section four then the motor vehicle driver scores one, if there are no unsafe driving under section four then the no unsafe driving option should be used. There then follows two sets of scoring options where there are no unsafe driving actions under section four. Section six has been split into the three sections to assist in understanding. The first criteria for section six of the Brubacher, Chan and Asbridge (2012) scoring tool are set out in table 5.69 below.

Table 5.69 Brubacher, Chan and Asbridge (2012) type of collision criteria (Section 6) first criteria

(6) Type of collision
Unsafe driving (factor 4)
No unsafe driving

If no unsafe driving was present, then there are two further sets of criteria options. The first set relates to single vehicle collisions with pedestrians and examines the pedestrian actions, presented in table 5.70 below.

Table 5.70 Brubacher, Chan and Asbridge (2012) type of collision criteria (Section 6) single vehicle vs pedestrian criteria

Single vehicle without pedestrian
Single motor vehicle crash involving pedestrian
Pedestrian action
Standing/walking on a sidewalk
Crossing with signal
Crossing, no signal, marked crosswalk
Crossing, no signal, no crosswalk
Crossing against signal
Child getting on/off bus
Adult getting on/off vehicle
Emerging from in front of or behind a parked vehicle
Pushing or working on a vehicle
Walking along highway with or against traffic
Working in roadway
Playing in roadway

The second set of options relates to a section for multi-vehicle collisions and the pre-collisions actions for motor vehicle drivers involved in collisions where there are more than two vehicles involved, these are presented in table 5.71 below.

Table 5.71 Brubacher, Chan and Asbridge (2012) type of collision criteria (Section 6) multi-vehicle criteria

Multivehicle crash
“Innocent third party”
Stopped/parked
Lead vehicle in rear-end collision
Third or subsequent vehicle in crash (entity # ≥3–this only applies to crashes with more than 2 vehicles)
Loss of control prior to crash
Precollision action = swerving, spinning, yaw, jackknifing, skidding
Maneuvering vehicle: precollision action = left turn, right turn, U-turn, overtaking, etc.
Striking vehicle (determined from damage location)
Indeterminate vehicle (determined from damage location)
Struck vehicle (determined from damage location)
If right turn rear ended
Precollision action = traveling straight, crash configuration∗ = rear end
Striking vehicle (determined from damage location)
Indeterminate vehicle (determined from damage location)
Struck vehicle (determined from damage location)
Precollision action = traveling straight, crash configuration = intersection, off road
Striking vehicle (determined from damage location)
Indeterminate vehicle (determined from damage location)
Struck vehicle (determined from damage location)
Precollision action = traveling straight, crash configuration = any turn, overtaking—that is, other vehicle maneuvering
Striking vehicle (determined from damage location)
Indeterminate vehicle (determined from damage location)
Struck vehicle (determined from damage location)
Precollision action = traveling straight, crash configuration = head on, sideswipe)
Striking vehicle (determined from damage location)
Indeterminate vehicle (determined from damage location)
Struck vehicle (determined from damage location)
Precollision action = traveling straight, crash configuration = unknown
Striking vehicle (determined from damage location)
Indeterminate vehicle (determined from damage location)
Struck vehicle (determined from damage location)

In the second section the constructs of striking and struck are introduced and the scoring tool suggests this can be determined purely from the damage location. The STATS19 data does not contain specifics of damage locations and patterns but merely the first point of contact variable. The first point of contact variable may be insufficient to determine if a vehicle was the striking or struck vehicle. The constructs are also binary in nature, for example in a head-on collision where both vehicles are moving towards each other and the impact was frontal for both it could be considered that both vehicles are simultaneously striking and struck.

The initial analysis of whether the collision was a single-vehicle of multi-vehicle can be seen as straightforward enough and has been previously examined in relation to section five of this scoring tool, in that STATS19 contains a variable for the ‘number of vehicles’, this purely being the number of vehicles involved, however, some multi vehicle collisions recorded on STATS19 include non-motor vehicles such as pedal cycles as a second vehicle. These need to be included in the ‘single vehicle without pedestrian’ category.

The multi vehicle categories need a combination of factors considered. It should be noted that the above reference to ‘Single-vehicle: Influence of other vehicles’ would not be represented within STATS19 as a single-vehicle collision as if a collision occurred ‘owing to the presence’ of another vehicle that would be in the report and it would therefore be multi-vehicle. The involvement of other vehicles that did not impact a damaged vehicle could be ascertained from the ‘First Point of Impact’ variable which contains the option of code zero, ‘Did not impact’. Therefor if there was a multi-vehicle collision where only one of the vehicles has a point of impact code and all the rest have a zero then this would fit this criterion. Equally, the ‘Hit and Run’ variable has an option of code two for a ‘Non-stop vehicle, not hit’ indicating involvement in the collision but no impact.

The STATS19 contributing factors code of 701 ‘Stationary or parked vehicle’ can be used where this vehicle although not hit contributed to the circumstance of the collision and may be present in conjunction with a ‘did not impact’ variable code.

The category ‘Loss of control prior to crash’ can be ascertained from a combination of codes and contributing factors. The STATS19 contributory factor codes are presented in table 5.72 below.

Table 5.72 Brubacher, Chan and Asbridge (2012) section 6 related STATS19 contributory factor codes

409.	Swerved
410.	Loss of control

STATS19 has a specific descriptive ‘Skidding and Overturning’ variable, skidding being a loss of control. The STATS19 ‘Skidding and Overturning’ variable codes are presented in table 5.73 below.

Table 5.73 STATS19 skidding or overturning codes

0.	No skidding, jack-knifing or overturning
1.	Skidded
2.	Skidded and overturned
3.	Jack-knifed
4.	Jack-knifed and overturned
5.	Overturned

For the second section regarding the movements of the vehicles prior to the collision STATS19 does contain this data in a combination of descriptive sections. STATS19 contains descriptive codes within the ‘First point of impact’ variable, these may be useful in determining ‘striking’ category. The STATS19 ‘First point of impact’ variable codes are presented in table 5.74 below.

Table 5.74 STATS19 first point of impact codes

0.	Did not impact
1.	Front
2.	Back
3.	Offside
4.	Nearside

What the vehicle was doing prior to the collision can be contained within the descriptive variable ‘Manoeuvres’. The STATS19 ‘Manoeuvres’ variable codes are presented in table 5.75 below.

Table 5.75 STATS19 vehicle manoeuvre codes

01.	Reversing
02.	Parked
03.	Waiting to go ahead but held up
04.	Slowing or stopping
05.	Moving off
06.	U turn
07.	Turning left
08.	Waiting to turn left
09.	Turning right
10.	Waiting to turn right
11.	Changing lane to left
12.	Changing lane to right
13.	Overtaking moving vehicle on its offside
14.	Overtaking stationary vehicle on its offside

15.	Overtaking on nearside
16.	Going ahead left hand bend
17.	Going ahead right hand bend
18.	Going ahead other

A number of the criteria set out in this section require information regarding the location, movement and actions of any pedestrians involved in the collision. The location options for a pedestrian prior to the collision are coded in the STATS19 pedestrian location variable. The coding options for the location of the pedestrian are set out in table 5.76 below.

Table 5.76 STATS19 pedestrian location codes

01.	In carriageway, crossing on pedestrian crossing facility
02.	In carriageway, crossing within zig-zag lines at crossing approach
03.	In carriageway, crossing within zig-zag lines at crossing exit
04.	In carriageway, crossing elsewhere within 50 metres of pedestrian crossing
05.	In carriageway, crossing elsewhere
06.	On footway or verge
07.	On refuge, central island or central reservation
08.	In centre of carriageway, not on refuge, central island or central reservation
09.	In carriageway, not crossing
10.	Unknown or other

The movement options for a pedestrian are coded in the STATS19 pedestrian movement variable. The coding options for the location of the pedestrian are set out in table 5.77 below.

Table 5.77 STATS19 pedestrian movement codes

1.	Crossing from driver's nearside
2.	Crossing from driver's nearside - masked by parked or stationary vehicle
3.	Crossing from driver's offside
4.	Crossing from driver's offside - masked by parked or stationary vehicle
5.	In carriageway, stationary - not crossing (standing or playing)
6.	In carriageway, stationary - not crossing (standing or playing), masked by parked or stationary vehicle
7.	Walking along in carriageway - facing traffic
8.	Walking along in carriageway - back to traffic
9.	Unknown or other

The STATS19 contributory factor codes in the series 801-810 related directly to pedestrian actions for single vehicle matters. The STATS19 contributory factor codes are presented in table 5.78 below.

Table 5.78 STATS19 pedestrian related contributory factor codes

801.	Crossing road masked by stationary or parked vehicle
802.	Failed to look properly
803.	Failed to judge vehicle's path or speed
804.	Wrong use of pedestrian crossing facility
805.	Dangerous action in carriageway (e.g. playing)
806.	Impaired by alcohol
807.	Impaired by drugs (illicit or medicinal)
808.	Careless, reckless or in a hurry
809.	Pedestrian wearing dark clothing at night
810.	Disability or illness, mental or physical

The relationship of STATS19 variables, contributory factors and collision description to the scoring criteria for this section of the scoring tool are presented in table 5.79 below.

Table 5.79 Applied STATS19 data and considerations for each Brubacher, Chan and Asbridge (2012) type of collision criteria

(6) Type of collision	**STATS19 data**			**Applied STATS19 data, considerations and assumptions**
	Variable	**Contributory factor**	**Narrative**	
Unsafe driving (factor 4)				See section four
No unsafe driving				This being the position regarding the result of section four, does not score individually, the below factors are then taken into account for the driver and scored accordingly
Single vehicle without pedestrian				See result of section 5 for the driver
Single motor vehicle crash involving pedestrian				This being the heading for the single vehicle vs pedestrian circumstances, does not score individually, the below factors relating to the pedestrian are then taken into account for the driver and scored accordingly, see the result for section 5 for the driver
Pedestrian action				This being the heading for the pedestrian actions listed below, does not score individually, the below factors are then taken into account for the driver and scored accordingly
Standing/walking on a sidewalk	Yes	No	No	Pedestrian location variable ‘on footway or verge’ (06) and Pedestrian movement variable ‘unknown or other’ (9)
Crossing with signal	Yes	No	No	Pedestrian location variable ‘in carriageway, crossing on pedestrian crossing facility’ (01) and Pedestrian movement variable ‘crossing from driver's nearside’ (1), ‘crossing from driver's offside’ (3)
Crossing, no signal, marked crosswalk	Yes	Yes	No	Pedestrian location variable ‘in carriageway, crossing on pedestrian crossing facility’ (01) and Pedestrian movement variable ‘crossing from driver's nearside’ (1), ‘crossing from driver's offside’ (3) and Contributory factor ‘wrong use of pedestrian crossing facility’ (804)
Crossing, no signal, no crosswalk	Yes	No	No	Pedestrian location variable ‘in carriageway, crossing elsewhere within 50 metres of pedestrian crossing’ (04) or ‘in carriageway, crossing elsewhere (05) and Pedestrian movement variable ‘crossing from driver's nearside’ (1), ‘crossing from driver's offside’ (3)
Crossing against signal	Yes	Yes	No	Pedestrian location variable ‘in carriageway, crossing on pedestrian crossing facility’ (01) and Pedestrian movement variable ‘crossing from driver's nearside’ (1), ‘crossing from driver's offside’ (3) and Contributory factor ‘wrong use of pedestrian crossing facility’ (804)

Child getting on/off bus	No	No	Yes	STATS19 does not have variables or contributory factors which constitute these circumstances although it may be indicated in the description
Adult getting on/off vehicle	No	No	Yes	STATS19 does not have variables or contributory factors which constitute these circumstances although it may be indicated in the description
Emerging from in front of or behind a parked vehicle	Yes	No	No	Pedestrian location variable 'in carriageway, crossing elsewhere within 50 metres of pedestrian crossing' (04) or 'in carriageway, crossing elsewhere (05) and Pedestrian movement variables 'crossing from driver's nearside - masked by parked or stationary vehicle' (2) or 'crossing from driver's offside - masked by parked or stationary vehicle' (4) or 'in carriageway, stationary - not crossing (standing or playing), masked by parked or stationary vehicle' (6)
Pushing or working on a vehicle	No	No	Yes	STATS19 does not have variables or contributory factors which constitute these circumstances although it may be indicated in the description
Walking along highway with or against traffic	Yes	No	No	Pedestrian location variable 'in carriageway, not crossing' (09) or 'unknown or other (10) and Pedestrian movement variables 'walking along in carriageway - facing traffic' (7) or 'walking along in carriageway - back to traffic' (8)
Working in roadway	Yes	No	No	Pedestrian location variable 'in carriageway, not crossing' (09) or 'unknown or other (10) and Pedestrian movement variables 'In carriageway, stationary - not crossing (standing or playing)' (5) or 'in carriageway, stationary - not crossing (standing or playing), masked by parked or stationary vehicle' (6) or 'walking along in carriageway - facing traffic' (7) or 'walking along in carriageway - back to traffic' (8) or 'unknown or other' (9) with reference to working in the carriageway in the description
Playing in roadway	Yes	Yes	No	Pedestrian location variable 'in carriageway, not crossing' (09) and Pedestrian movement variable 'in carriageway, stationary - not crossing (standing or playing) (5) or 'in carriageway, stationary - not crossing (standing or playing), masked by parked or stationary vehicle' (6) and Contributory factor 'dangerous action in carriageway (e.g. playing)' (805)
Multivehicle crash				See the result of section five for the driver
"Innocent third party"				See the result of section four for the driver
Stopped/parked	Yes	No	No	Manoeuvres variable 'parked' (02) then one of the following indicating the vehicle was stopped at the time of impact 'waiting to go ahead but held up' (03) or 'waiting to turn left' (08) or 'waiting to turn right' (10)
Lead vehicle in rear-end collision	Yes	No	No	Manoeuvres variable 'slowing or stopping' (04) or one of the following indicating the vehicle was stopped at the time of impact 'waiting to go ahead but held up' (03) or 'waiting to turn left' (08) or 'waiting to turn right' (10) combined with First point of impact variable 'back' (2)
Third or subsequent vehicle in crash (entity # ≥3–this only applies to crashes with more than 2 vehicles)				
Loss of control prior to crash	No	Yes	No	Contributory factor 'loss of control' (410)
Precollision action = swerving, spinning, yaw, jackknifing, skidding	Yes	Yes	No	Skidding and overturning variable 'Skidded' (1) or 'skidded and overturned' (2) or 'jack-knifed' (3) or 'jack-knifed and overturned' (4) or Contributory factor 'swerved' (409) or 'loss of control' (410) (for spinning)
Maneuvering vehicle: precollision action = left turn, right turn, U-turn, overtaking, etc.	Yes	No	No	Manoeuvres variable 'u turn' (06) or 'turning left' (07) or 'turning right' (09) or 'overtaking moving vehicle on its offside' (13) or 'overtaking stationary vehicle on its offside' (14) or 'overtaking on nearside' (15)

Striking vehicle (determined from damage location)	Yes	No	Yes	The striking construct may be determined by combining First point of contact variable, the Movement to variable, the Movement from variable, the Manoeuvres variable and the information held in the collision description.
Indeterminate vehicle (determined from damage location)	Yes	No	Yes	The indeterminate construct may be determined by combining First point of contact variable, the Movement to variable, the Movement from variable, the Manoeuvres variable and the information held in the collision description.
Struck vehicle (determined from damage location)	Yes	No	Yes	The struck construct may be determined by combining First point of contact variable, the Movement to variable, the Movement from variable, the Manoeuvres variable and the information held in the collision description.
If right turn rear ended	Yes	No	No	First point of contact variable 'back' (2) and Manoeuvres variable 'turning right' (09), however, this scoring tool was designed for vehicles driving on the right. For a UK context with vehicles driving on the left this criterion should be vehicles turning left, this being represented by the Manoeuvres variable 'turning left' (07)
Precollision action = traveling straight, crash configuration∗ = rear end	Yes	No	No	First point of impact variable 'back' (2) and Manoeuvres variable 'going ahead left hand bend' (16) or 'going ahead right hand bend' (17) or 'going ahead other' (18)
Striking vehicle (determined from damage location)	Yes	No	Yes	The striking construct may be determined by combining First point of contact variable, the Movement to variable, the Movement from variable, the Manoeuvres variable and the information held in the collision description.
Indeterminate vehicle (determined from damage location)	Yes	No	Yes	The indeterminate construct may be determined by combining First point of contact variable, the Movement to variable, the Movement from variable, the Manoeuvres variable and the information held in the collision description.
Struck vehicle (determined from damage location)	Yes	No	Yes	The struck construct may be determined by combining First point of contact variable, the Movement to variable, the Movement from variable, the Manoeuvres variable and the information held in the collision description.
Precollision action = traveling straight, crash configuration = intersection, off road	Yes	No	No	Manoeuvres variable 'going ahead left hand bend' (16) or 'going ahead right hand bend' (17) or 'going ahead other' (18) combined with a Junction location variable (see table 5.43 of 'mid junction - on roundabout or on main road' (8)
Striking vehicle (determined from damage location)	Yes	No	Yes	The striking construct may be determined by combining First point of contact variable, the Movement to variable, the Movement from variable, the Manoeuvres variable and the information held in the collision description.
Indeterminate vehicle (determined from damage location)	Yes	No	Yes	The indeterminate construct may be determined by combining First point of contact variable, the Movement to variable, the Movement from variable, the Manoeuvres variable and the information held in the collision description.
Struck vehicle (determined from damage location)	Yes	No	Yes	The struck construct may be determined by combining First point of contact variable, the Movement to variable, the Movement from variable, the Manoeuvres variable and the information held in the collision description.
Precollision action = traveling straight, crash configuration = any turn, overtaking—that is, other vehicle maneuvering	Yes	No	No	Manoeuvres variable 'going ahead left hand bend' (16) or 'going ahead right hand bend' (17) or 'going ahead other' combined with the Manoeuvre variable for the other vehicle involved in the collision being (18) 'turning left' (07) or 'turning right' (09) or 'changing lane to left' (11) or 'changing lane to right' (12) or 'overtaking moving vehicle on its offside' (13) or 'overtaking stationary vehicle on its offside' (14) or 'overtaking on nearside' (14)
Striking vehicle (determined from damage location)	Yes	No	Yes	The striking construct may be determined by combining First point of contact variable, the Movement to variable, the Movement from variable, the Manoeuvres variable and the information held in the collision description.
Indeterminate vehicle	Yes	No	Yes	The indeterminate construct may be determined by combining First point of contact variable, the Movement to variable, the Movement

(determined from damage location)				from variable, the Manoeuvres variable and the information held in the collision description.
Struck vehicle (determined from damage location)	Yes	No	Yes	The struck construct may be determined by combining First point of contact variable, the Movement to variable, the Movement from variable, the Manoeuvres variable and the information held in the collision description.
Precollision action = traveling straight, crash configuration = head on, sideswipe)	Yes	No	No	Manoeuvres variable ‘going ahead left hand bend’ (16) or ‘going ahead right hand bend’ (17) or ‘going ahead other’ (18) combined with First point of impact variable ‘front’ (1) or ‘offside’ (3) or ‘nearside’ (4)
Striking vehicle (determined from damage location)	Yes	No	Yes	The striking construct may be determined by combining First point of contact variable, the Movement to variable, the Movement from variable, the Manoeuvres variable and the information held in the collision description.
Indeterminate vehicle (determined from damage location)	Yes	No	Yes	The indeterminate construct may be determined by combining First point of contact variable, the Movement to variable, the Movement from variable, the Manoeuvres variable and the information held in the collision description.
Struck vehicle (determined from damage location)	Yes	No	Yes	The struck construct may be determined by combining First point of contact variable, the Movement to variable, the Movement from variable, the Manoeuvres variable and the information held in the collision description.
Precollision action = traveling straight, crash configuration = unknown	Yes	No	Yes	Manoeuvres variable ‘going ahead left hand bend’ (16) or ‘going ahead right hand bend’ (17) or ‘going ahead other’ (18) with no other details
Striking vehicle (determined from damage location)	Yes	No	Yes	The striking construct may be determined by combining First point of contact variable, the Movement to variable, the Movement from variable, the Manoeuvres variable and the information held in the collision description.
Indeterminate vehicle (determined from damage location)	Yes	No	Yes	The indeterminate construct may be determined by combining First point of contact variable, the Movement to variable, the Movement from variable, the Manoeuvres variable and the information held in the collision description.
Struck vehicle (determined from damage location)	Yes	No	Yes	The struck construct may be determined by combining First point of contact variable, the Movement to variable, the Movement from variable, the Manoeuvres variable and the information held in the collision description.

Presented in table 5.80 below are how the considerations and application described in this section produced results for the four motor vehicle drivers in the two case studies.

Table 5.80 Brubacher, Chan and Asbridge (2012) type of collision case study examples

Case Study	**Driver**	**Variables and contributory factors present**	**Brubacher, Chan and Asbridge (2012) criteria**	**Score**
One	One	See section four	Unsafe driving action (section 4)	1
	Two	See section four	Unsafe driving action (section 4)	1
Two	One	See section four	Unsafe driving action (section 4)	1
	Two	None present	Innocent third party	5

Section 7. Task involved

Section seven of the Brubacher, Chan and Asbridge (2012) scoring tool relates to the task the motor vehicle driver was undertaking at the time of the collision. The criteria for section seven of the Brubacher, Chan and Asbridge (2012) scoring tool are set out in table 5.81 below.

Table 5.81 Brubacher, Chan and Asbridge (2012) task involved criteria (Section 7)

(7) Task involved
Unsafe driving (Factor 4)
No unsafe driving
Avoiding object on road
Parked, stopped in traffic *a*
Changing lanes, merging
Turning and backing
All other precollision actions

The scoring for this section relies on the determination from section four. The first of the criteria transfers the unsafe driving determination in section four to this section. If there was a determination of no unsafe driving in section four then the remaining criteria in this section are then examined. There are four specific circumstances described with the final criteria encompasses all the other collisions circumstances.

There are a number of variables and contributory factors which can assist in determining if the circumstances fit within one of the four specific circumstances, if none of these are present then the default falls to ‘all other pre-collision actions.’

The STATS19 descriptive variable ’Carriageway Hazards’ can be applied to this factor. The STATS19 codes are presented in table 5.82 below.

Table 5.82 STATS19 carriageway hazard codes

0.	None
1.	Dislodged vehicle load in carriageway
2.	Other object in carriageway
3.	Involvement with previous incident
6.	Pedestrian in carriageway – not injured
7.	Any animal in carriageway (except ridden horse)

There are a number of contributory factors which may be included in determining this factor. The STATS19 contributory factor codes are presented in table 5.83 below.

Table 5.83 Brubacher, Chan and Asbridge (2012) section 7 related STATS19 contributory factor codes

109.	Animal or object in carriageway
310.	Cyclist entering road from pavement

Under the ‘All other precollision actions’ category consideration can be given to the descriptive variable ‘Hit object in carriageway’. The STATS19 ‘Hit object in carriageway’ variable codes are presented in table 5.84 below.

Table 5.84 STATS19 hit object in carriageway codes

00.	None
01.	Previous accident
02.	Roadworks
04.	Parked vehicle
05.	Bridge - roof
06.	Bridge - side
07.	Bollard/Refuge
08.	Open door of vehicle
09.	Central island of roundabout
10.	Kerb
11.	Other object
12.	Any animal (except ridden horse)

The STATS19 contributing factors code of 701 ‘Stationary or parked vehicle’ can be used when a motor vehicle driver was not moving and was hit by a third party. The STATS19 vehicle manoeuvre variable codes are presented in table 5.85 below.

Table 5.85 Brubacher, Chan and Asbridge, section 7 related STATS19 manoeuvre variable codes

01.	Reversing
02.	Parked
03.	Waiting to go ahead but held up
06.	U turn
07.	Turning left
08.	Waiting to turn left
09.	Turning right
10.	Waiting to turn right
11.	Changing lane to left
12.	Changing lane to right
13.	Overtaking moving vehicle on its offside
14.	Overtaking stationary vehicle on its offside
15.	Overtaking on nearside

The relationship of STATS19 variables, contributory factors and collision description to the scoring criteria for this section of the scoring tool are presented in table 5.86 below.

Table 5.86 Applied STATS19 data and considerations for each Brubacher, Chan and Asbridge (2012) task involved criteria

(7) Task involved	STATS19 data			Applied STATS19 data, considerations and assumptions
	Variable	**Contributory factor**	**Narrative**	
Unsafe driving (Factor 4)				See section four
No unsafe driving				This being the position regarding the result of section four, does not score individually, the below factors are then taken into account for the driver and scored accordingly
Avoiding object on road	Yes	Yes	No	Carriageway hazard variable 'dislodged vehicle load in carriageway' (1), 'other object in carriageway' (2), 'involvement with previous incident' (3), 'pedestrian in carriageway – not injured, (6), 'any animal in carriageway (except ridden horse)' (7), contributory factors 'animal or object in carriageway' (109), 'cyclist entering road from pavement' (310), although the criteria of avoiding object in carriageway does not preclude that the driver did hit the object so consideration must be given to the 'Hit object in carriageway' variable, 'previous accident' (01), 'roadworks' (02), 'parked vehicle' (04), 'bridge – roof' (05), 'bridge – side' (06), 'bollard/refuge' (07), 'open door of vehicle' (08), 'central island of roundabout' (09), 'kerb' (10), 'other object ' (11), 'any animal (except ridden horse)' (12)
Parked, stopped in traffic *a*	Yes	Yes	No	Manoeuvres variable 'parked' (02) or 'waiting to go ahead but held up' (03), 'waiting to turn left' (08), 'waiting to turn right' (10) or Contributing factor 'Stationary or parked vehicle' (701)
Changing lanes, merging	Yes	No	No	Manoeuvres variable 'changing lane to left' (11), 'changing lane to right' (12), 'overtaking moving vehicle on its offside' (13), 'overtaking stationary vehicle on its offside' (14), 'overtaking on nearside', (15). STATS19 does not use the term or construct of Merging
Turning and backing	Yes	No	No	Manoeuvres variable 'reversing' (01), 'U-turn' (06), 'turning left' (07), 'turning right' (09)
All other precollision actions				No unsafe driving under section four and none of the four above criteria apply

Presented in table 5.87 below are how the considerations and application described in this section produced results for the four motor vehicle drivers in the two case studies.

Table 5.87 Brubacher, Chan and Asbridge (2012) task involved case study examples

Case Study	Driver	Variables and contributory factors present or considerations	Brubacher, Chan and Asbridge (2012) criteria	Score
One	One	A section four determination of 'Driver not obeying road laws or driving in unsafe manner'	Unsafe driving (Factor 4)	1
	Two	A section four determination of 'Driver not obeying road laws or driving in unsafe manner'	Unsafe driving (Factor 4)	1
Two	One	A section four determination of 'Driver not obeying road laws or driving in unsafe manner'	Unsafe driving (Factor 4)	1

	Two	No unsafe driving under section four and none of the other four factors present	All other pre-collision actions	1

There are a number of contributory factor codes which at this time do not appear to fit within any of the Brubacher, Chan and Asbridge factors. The contributory factor codes are presented in table 5.88 below.

Table 5.88 Brubacher, Chan and Asbridge (2012) non-applicable STATS19 contributory factor codes

505.	Illness or disability, mental or physical
507.	Driver wearing dark clothing at night
607.	Unfamiliar with model of vehicle
901.	Stolen vehicle
902.	Vehicle in course of crime
903.	Emergency vehicle on a call

Brubacher, Chan and Asbridge specifically negate illness as a mitigating factor in their original piece.

Case study results Brubacher, Chan and Asbridge (2012)

The case study results for the Brubacher, Chan and Asbridge (2012) scoring tool are presented in table 5.89 below.

Table 5.89 Brubacher, Chan and Asbridge case study results

Criteria	**Criteria scores**			
	Case study one	**Case study one**	**Case study two**	**Case study two**
	Driver one	**Driver two**	**Driver one**	**Driver two**
Road type	3	3	3	3
Driving conditions	2	2	3	3
Vehicle conditions	1	1	1	1
Unsafe driving actions	1	1	1	5
Contribution of other parties	1	1	1	5
Type of collision	1	1	1	5
Task involved	1	1	1	1
Overall score	9	10	11	23
Culpable (yes/no)	Yes	Yes	Yes	No

Appendix eight contains a composite table bringing together all the Brubacher, Chan and Asbridge (2012) scoring criteria, Applied data and related scores.

5.5. Phase 2: Culpability Scoring Comparison Sample

The comparison between two scoring tools for consistency of results can give confidence in the categorisation designated to each motor vehicle driver. A sample were scored using both tools, there was no guidance on such a sample from the literature, however as the data can be conveniently split into years a single year was selected. The sample was of the motor vehicle drivers from the 2012-2013, i.e. one of the five years in the data, MAIS3+ deterministically linked motor vehicle drivers drawn from study one. This sample comprised n=83 motor vehicle drivers of the n=399 from the five years of data, however, the sample contained n=4 motor vehicle drivers where there was insufficient data to undertake culpability scoring so these individuals were excluded from the process. The remaining n=79 motor vehicle drivers being involved in n=51 collisions. The results from the two scoring tools analysis of the sample are presented in table 5.90 below.

Table 5.90 Scoring tool comparison results

Scoring tool	**Sample (n=)**	**Culpable (n=/ % of sample)**	**Contributory (n=/ % of sample)**	**Non-culpable (n=/ % of sample)**
Robertson and Drummer (1994)	n=79	n=55/ 69.6	n=6/ 7.6	n=18/ 22.8
Brubacher, Chan and Asbridge (2012)	n=79	n=56/ 70.9	n=0/ 0.0	n=23/ 29.1

It was found that both tools worked with the data available although in some cases there was a requirement to interpret the information given in the collision description within STATS19 to fit with the scoring tool categories. These results are in line with what would be expected from the literature (af Wåhlberg, 2009).

5.5.1 Culpability Scoring Comparison Examination

From the comparison it was clear that both scoring tools used produced similar results. There were, however, a number of collisions which differed. In simple terms all the motor vehicle drivers deemed culpable using the Robertson and Drummer (1994) tool were also deemed culpable using the Brubacher, Chan and Asbridge (2012) tool, this was equally the same for the Robertson and Drummer (1994) tool non-culpable motor vehicle drivers. In using the Robertson and Drummer (1994) tool the results included 6 motor vehicle drivers whose involvement was deemed contributory. When considering the same motor vehicle drivers results using the Brubacher, Chan and Asbridge (2012) of the 6 contributory motor vehicle drivers produced by the Robertson and Drummer (1994) tool one was deemed culpable under the Brubacher, Chan and Asbridge (2012) system and five were deemed non-culpable, four of the non-culpable judgements related to single vehicle vs pedestrian collisions (in fact all these type of collisions present in this dataset). The Brubacher, Chan and Asbridge (2012) system clearly shifted responsibility in these collisions to the pedestrian and not the motor vehicle driver.

The difference in the scoring tool weighting was particularly pronounced when it came to the actions of pedestrians overcoming the culpability of motor vehicle drivers. The circumstances of the collisions were such that the impact of the pedestrian factors, such as alcohol or not looking, did have a bearing on the collision occurring. However, suggesting that all collisions involving pedestrians where the pedestrian may have been drinking, did not look properly or ran out are not the fault of the motor vehicle driver does not reflect these complex situations. There are many circumstances where due to the speed, reaction, anticipation or caution of the motor vehicle driver no collision occurs and the fact remains that the pedestrians were present, in the carriageway, to be seen and that the motor vehicle drivers were unable to stop in the distance they could see to be clear or had not taken account of the possibility that pedestrians may be present at the location and driven accordingly. With the Robertson and Drummer (1994) tool this was taken into account by categorising the motor vehicle driver's actions as contributory.

The Robertson and Drummer (1994) and the Brubacher, Chan and Asbridge (2012) produced consistent results for the majority of cases examined mainly with the exception of certain collision circumstances, which have been explored and this may reflect the differing criteria selected and factor weighting. However, overall, the culpable and not culpable findings matched for both tools.

5.6. Phase 3: Robertson and Drummer (1994) Culpability Scoring Inter-rater Reliability Examination of the Application and Results

Having determined that the Robertson and Drummer (1994) scoring tool produced results which were consistent when compared with the Brubacher, Chan and Asbridge (2012) tool, the next stage was for external scrutiny of the application process and results for inter-rater reliability.

5.6.1 Robertson and Drummer (1994) Culpability Scoring Application and Results Inter-rater Agreement Method

The process was divided into two exercises, the first examining the inter-rater reliability of the application of the STATS19 data to the Robertson and Drummer (1994) scoring tool with the second examining the inter-rater reliability of the results obtained when the scoring tool was applied to a sample of data. During the first exercise the expert was provided with a copy of the scoring categories and criteria along with the

STATS20 data dictionary for STATS19. There were options to append any combination of variables, contributory factors or the collision narrative to each category. The second exercise used the applied scoring tool to culpability score a 10 percent (n=40) sample of the population. The sample was drawn chronologically from the start of the data and collisions were selected to give a combination of single and multi-vehicle incidents. For the repeat of the application and results inter-rater reliability exercise the same 10 percent sample was used to allow direct comparison with the first part.

The scrutiny by the three external experts was undertaken in two separate events, for the expert profiles see appendix nine. The first event was also used as a pilot and proof of concept to examine the application and results inter-rater reliability process as well as produce results, this process was undertaken by an expert in collision reconstruction and collision analysis who was proposed by the thesis supervision team, from within the Loughborough University Design School but independent of the research. The second event was undertaken by two experts, working independently, who were formerly expert police collision investigators, though now private consultants, who are independent of both the university and the research. The process was divided into two exercises. The briefing document setting out the process can be found in appendix ten

There was examination of each event. For the first exercise there was an explanation of any differences between the application process administered by the author and that of the independent experts. The analysis of the second exercise consisted of determining the proportion of motor vehicle drivers who were allocated the same score by the independent experts as the author, the mean variance, standard deviation and standard error in all scores followed by the mean variance, standard deviation and standard error in the scores that showed variance, low means, standard deviations and standard errors showed low variation and consistent scores. There was also a narrative explanation of the difference causation.

5.6.2 Robertson and Drummer (1994) Culpability Scoring Application and Results Inter-rater Agreement Sample

The same sample was examined by all three external experts. The sample selected was drawn from the 2012-2013, i.e. one of the five years in the data, MAIS3+ deterministically linked motor vehicle drivers drawn from study one and accounted for 10 percent of the motor vehicle drivers identified in the MAIS3+ injury collision dataset produced by the data linkage exercise in study one, see chapter four, n=40 motor vehicle drivers from the n=399 identified. The collisions represented were also present in the sample which was examined using the two scoring tools in section 5.4.

The sample was selected chronologically from the dataset starting with the oldest collisions recorded. However, it was not the straightforward first n=40 as this included a number of motor vehicle drivers that could not be culpability scored. The selection also needed to encompass a selection of collisions types including single vehicle, multivehicle and collisions involving non-motor vehicle-based parties. The stages of the process for the sample selection are presented in figure 5.12 below. This was done to ensure that the tool worked on all combinations of circumstances presented in the data.

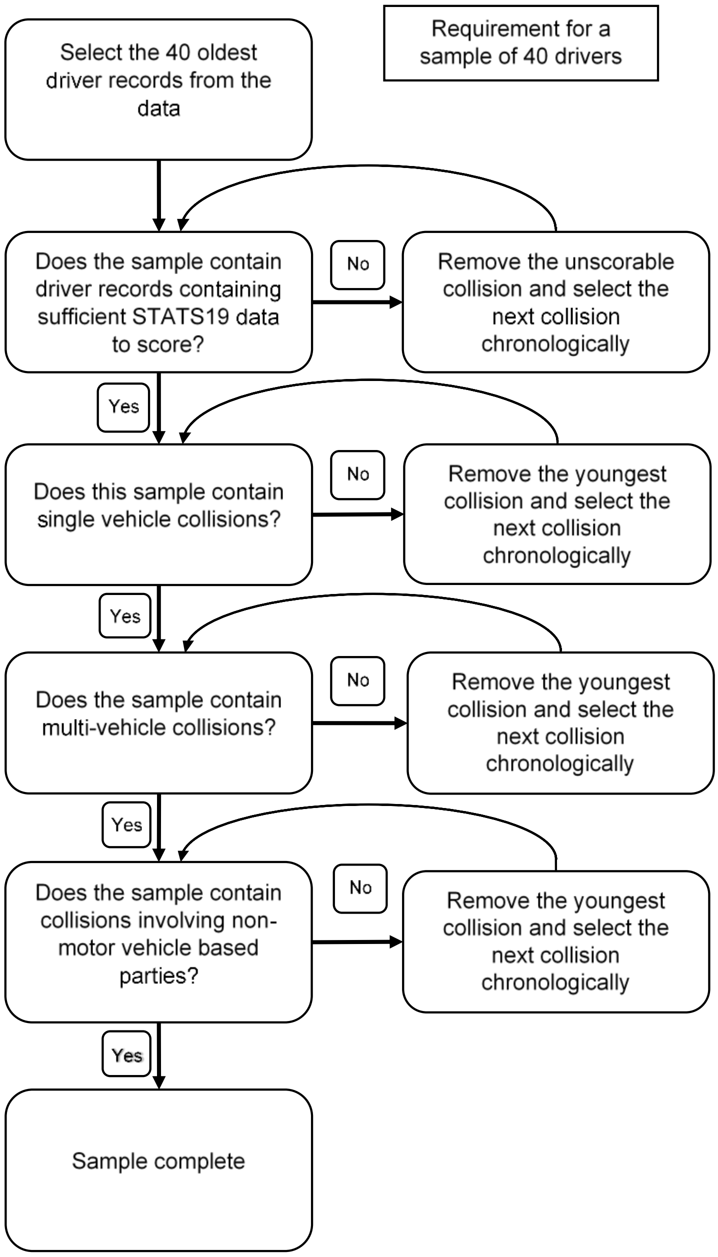

Figure 5.12 Inter-rater comparison sample selection process

5.6.3 Robertson and Drummer (1994) Culpability Scoring Tool Application and Results Inter-rater Reliability Results

The application and results inter-rater reliability exercises were undertaken with the first event conducted by the independent expert from within the Loughborough Design School showing that the processes were adequately explained in the briefing document and the processes produced results. The first exercise of event one was the examination of the application of STATS19 data to the Robertson and Drummer (1994) scoring tool criteria for inter-rater reliability. In examining the same STATS19 data available to the author and allocating the data to the scoring criteria the independent expert used the same combination of STATS19 variables, contributory factors and narrative content as the author with no variation for each mitigating factor. The second exercise of the first event, involved the scoring of the sample of n=40 motor vehicle s to examine the results for inter-rater reliability, this process produced the same scores for 40 percent of the motor vehicle drivers, the variation in scores of the remaining 60 percent, n=24. Analysis of these results shows for all score, n=40, mean variance was 0.79 (95% CI 0.55-1.04, SD 0.79), difference in score with a standard error of 0.13, (95% CI 0.54-1.04) and for the scores with variance, n=24, mean variance was 1.27 (95% CI 1.05-1.49, SD 0.55), difference in score with standard error of 0.26, (95% CI 0.76-1.78). In examining the variance 75 percent was as a result of the retrospective application of the additional factor identified in the second phase of application inter-rater reliability assessment, the remaining variation was as a result of difference in interpretation of the data in relation to the constructs of ‘type of accident’, lack of road sense’ and ‘witness observations’. However, these variations were within the category scoring boundaries of the tool resulting in 100 percent of the motor vehicle drivers with matching culpability categories.

The second event, undertaken by the two external independent experts, highlighted one matter relating to the application and did produce some different variation in the scores for some motor vehicle drivers from that produced by the independent expert during the first phase.

During exercise one of event two, the application results inter-rater reliability exercise one additional factor was identified, this involved the consideration of the STATS19 contributory factor code 103 'Wet road' within the driving conditions section but only when the lighting conditions were daylight, code one. The Robertson and Drummer (1994) scoring tool guidelines are set out in table 5.1, at the bottom of the table there are a number of footnotes which can have an impact on specific scoring criteria under specific circumstances and this factor relates to the single Asterix footnote on scoring guidance table. This additional matter was incorporated into application and retrospectively applied to the authors application and scoring process. It did not affect the results of this scoring process or the application and results inter-rater reliability exercise as this contributory factor did not feature.

The second event second exercise scoring did produce a variation in score in 22.5 percent (n=9) of the motor vehicle s, and these were the same motor vehicle drivers for both the individuals undertaking the exercise, although the score that varied did not all vary by the same amount. The first of the two individuals, examining all the scores, n=40, the mean difference was 0.50 (95% CI 0.06-0.94, SD = 1.43), with standard error of 0.23 (95% CI 0.06-0.94) for just scores with variance, n=9, the mean was 2.20 (95% CI 0.63-3.77, SD 2.41), and Standard error of 0.80 (95% CI 0.63-3.77) and the second individuals a mean difference for all score, n=40, of 0.55 (95% CI 0.08-1.02, SD = 1.53) and standard error of 0.24 (95% CI 0.08-1.02) for just scores with variance, n=9, the mean was 2.46 (95% CI 0.80-4.12, SD 2.54) and standard error 0.85 (95% CI 0.80-3.02). In examining the records that did show a variation in score the factors which influences the variation were interpretation of the constructs of 'witness observations', 'road law obedience' and difficulty of task. For the first individual this resulted in n=2 (5 percent) of the culpability categories to change, one from non-culpable to culpable and the other a contributory to non-culpable for the second individual this resulted in n=3 (7.5 percent) of the culpability categories to change, one from non-culpable to culpable, one from culpable to contributory and the other a contributory to non-culpable.

The variation in assessment was as a result of the subjective interpretation of constructs. All the interpretations were valid, and this was acknowledged during the process, however, they came about due to individual variation in the weight given to individual items of data. The situation where expert subjectivity results in alternative interpretations of the data, within constructs, in a small number of cases can be seen as a limitation of this process.

5.7. Phase 4: Robertson and Drummer (1994) Culpability Scoring Full Dataset

The culpability scoring using the Robertson and Drummer (1994) scoring tool, based on the application confirmed during the application and results inter-rater reliability process, was undertaken on the motor vehicle driver dataset, this included the deterministic linked collisions motor vehicle drivers (n=347) and the validated match motor vehicle drivers from the probabilistic linked collisions (n=13). Culpability scoring was also undertaken on the motor vehicle drivers involved in the collisions within the STATS19 dataset designated as resulting in a fatality (n=300). This dataset contained the collision circumstances pertaining to n=660 motor vehicle drivers. The scoring was undertaken incorporating the results of the application and results inter-rater reliability exercise.

5.8. Culpability Scoring Results

The results of the culpability scoring process are grouped by the section of the population from which they derived, namely the fatal collisions, the MAIS3+ injury severity collisions determined by the deterministic linkage process and the MAIS3+ injury severity collisions derived from the probabilistic linkage process. This allows the proportion in each of the categories to be presented as well as the distribution in the combined data. The results are presented in table 5.91 below.

Table 5.91 Robertson and Drummer (1994) culpability scoring results

Injury Severity	Number of Collisions (n=)	Motor Vehicle Drivers	Culpable (n=/ %)	Contributory (n=/ %)	Non/Culpable (n=/ %)
Mais3+ Deterministic linkage process	n=202	n=347 (343 could be scored)	n= 222/ 64.7	n=26/ 7.6	n=95/ 27.7
Mais3+ Probabilistic linkage process	n=8	n=13	n=9/ 69.2	n=1/ 7.7	n=3/ 23.1
Fatal	n=158	n=300	n=159/ 53.0	n=18/ 6.0	n=123/ 41.0
Total	n=368	n=660 (656 could be scored)	n=390/ 59.4	n=45/ 6.9	n=221/ 33.7

The results allow a dataset of n=660 motor vehicle drivers to be taken forward to study three, although only n=656 of these motor vehicle drivers have been subject to culpability scoring, the remaining four motor vehicle driver records, all from a single collision, did not contain any contributory factors or narrative which meant insufficient mitigation categories could be completed for successful culpability scoring. It has been suggested that culpability processes which produce around 70 percent culpable motor vehicle drivers (to any degree) have suitably stringent criteria to produce valid results (af Wåhlberg, 2009), the results give a combined culpable and contributory group comprising n=435 (66.3 percent) of the population.

5.9. Summary of Findings

The research presented in this chapter answers the research question which asks what alternatives are available to culpability score motor vehicle drivers in the UK context. Culpability scoring using the established tools devised by Robertson and Drummer (1994) and Brubacher, Chan and Asbridge (2012) was a complex process which requires the extraction of multiple combinations of data from that available within STATS19. However, the results obtained are consistent between tools and produce inter-rater reliable results. The complexity can be observed in the composite tables presented in appendices six to eight.

What can be observed, in examining the application of the Brubacher, Chan and Asbridge (2012) scoring tool, was that there was more utilisation of the descriptive material contained within STATS19 to build the constructs in section six (Type of collision) than are required for the constructs within the Robertson and Drummer (1994) tool. Brubacher, Chan and Asbridge made more use of multiple variables, including manoeuvres, pedestrian movement, pedestrian location, skidding and overturning, movement, junction location and first point of contact as well as contributory factor ‘swerved’ (409) or ‘loss of control’ (410) and the collision narrative (see table 5.79). This makes the use of the Brubacher, Chan and Asbridge (2012) more time consuming and inserts a further element of subjectivity.

Chapter Six: Motor Vehicle Driver Geodemographic Profiling (study three)

6.1. Introduction

The research presented in this chapter examines the geodemographic profiles of the motor vehicle drivers and forms the third study.

Geodemographics entail the segmentation of society into smaller groups based on combinations of data available in the public domain, such as census data, with commercial data, such as financial activity, purchasing history or survey responses (Burns *et al.*, 2018) and has developed over time from a course census based classification (Harris, Sleight and Webber, 2005). Geodemographic profiles are used in many contexts, both commercial and governmental, and the product can be tailored to the user by the provider. The population can be segmented in different ways from course segmentation of around six segments to fine segmentation at around sixty depending on the system, these different segmentations, including any intermediate levels are described as the granularity of the system (Webber and Burrows, 2018).

The use of geodemographic profiles can often be more accurate at predicting behaviour and attitudes than other conventional demographic information such as gender, age or occupation. Webber and Burrows (2018) give examples relating to attitudes towards human rights, political views and voting habits as well as social matters such as low educational attainment amongst others in addition to consumer behaviour. Members of the population are far more like the people who reside around them than people of their age and gender living in other areas (Webber and Burrows, 2018).

Geodemographics has been used in collisions research but has been limited to looking at the injured parties and the identification of vulnerable groups distinguished by their socio-economic status and lifestyle based on where they reside (Anderson, 2005; 2010; Loo and Anderson, 2016). Geodemographics can also be applied to public service delivery (CACI Limited, 2019b), including for example, policing (Singleton, 2004; Ashby and Longley, 2005; Longley, 2005; Farr, Wardlaw and Jones, 2008), health (Abbas, Ojo and Orange, 2009; Pasquali *et al.*, 2010) and education (Singleton and Spielman, 2014) and can be used to target communications at specific populations (Longley, 2005; Pasquali *et al.*, 2010). Ashby and Longley (2005) in particular used geodemographic profiling to examine the disproportionate impact of crime on some communities as part of a wider intelligence led approach to the policing of local needs.

Geodemographics have been used in the private sector since their launch in the late 1970s and are now well established and embedded within the operational and analytical systems of large corporations such as Tesco, John Lewis and many more (Leventhal, 2016; Data Analysts User Group, 2017). These organisations make business decisions based on geodemographic data, with the data seen as an essential discriminator (Leventhal, 2016). The direct marketing methods which are successful in business can be applied to alternative sectors but only if analysis of geodemographic data evidences that there are differences in geodemographic profiles which can be utilised.

Geodemographic profiles are created by organisations for different purposes, the nature of the profiling system created reflects those differences (CACI Limited, 2014; 2019a; Experian, 2019). For example, the segmentation of population for a marketing purpose may be more focussed on financial data and purchasing with segment titles reflecting the nature of this data, this could be different from segmentation focussing on political affiliation or voting habits, again, the profile titles would reflect this data.

The two main commercial geodemographic databases available in the UK are Mosaic (Experian, 2017) and Acorn (CACI Limited, 2014) although there are others with more specialist applications. The Office for National Statistics has its own geodemographic profile system called the ‘output area classification’ (Office for National Statistics, 2011) an ‘output area’ being based on a cluster of adjacent postcodes, but these are not generated until after the census data was processed, where the criteria was designed so each has a similar population size and be socially homogenous. Output areas are designed to follow local authority boundaries and a minimum size of 40 households and 100 residents, generally postcodes contain around 15 households. Therefore, the ‘output area classification’ are based on the aggregate of a cluster of postcodes, although homogeneous, as intended in the process, rather than individual postcodes (CACI Limited, 2014; 2019b; Office for National Statistics, 2018a; 2020b).

6.1.1 Acorn Geodemographic Profiles

For this research the Acorn consumer classification (CACI Limited, 2014; 2019b) geodemographic profiles were selected. These data were selected for two reasons, the first was economic, in that the Acorn data was provided free of charge via the UK data service (CACI Limited, 2017) and the second that Cambridgeshire County Council use the Acorn data, for example, in a report relating to community safety issues in Littleport (Cambridgeshire County Council, 2019a) where the use of Acorn geodemographic profiles allowed direct comparison with other areas within the county and target audiences for local delivery of the Think Communities initiative. Cambridgeshire County Council were also one of the partners organisations involved in this research. The Acorn data provided by the UK data service was the 2017 profile (CACI Limited, 2017).

6.1.2 Granularity

The Acorn system allocates a geodemographic profile to individual postcodes (CACI Limited, 2014; 2019b; Webber and Burrows, 2018), although it has been possible to create sophisticated systems which can go to an individual person level (Burns *et al.*, 2018). These profiles are based on a combination of social factors, behaviours and interactions (CACI Limited, 2014; 2019b). The profiles are called the Acorn 'type' within their system of classification and represent the finest level of granularity available allocated to individual postcodes, there are 62 Acorn types available. For the benefit of organisations which use Acorn but may not require the finest level of granularity, CACI have created broader collections of types which are more similar creating 18 Acorn 'group' classifications, forming a medium level of granularity. A further level, which forms the coarsest level of granularity, brings together more similar groups into one of six broad Acorn 'category' sets. An example of how one of the Acorn types fits within the three granularity levels being presented below in figure 6.1.

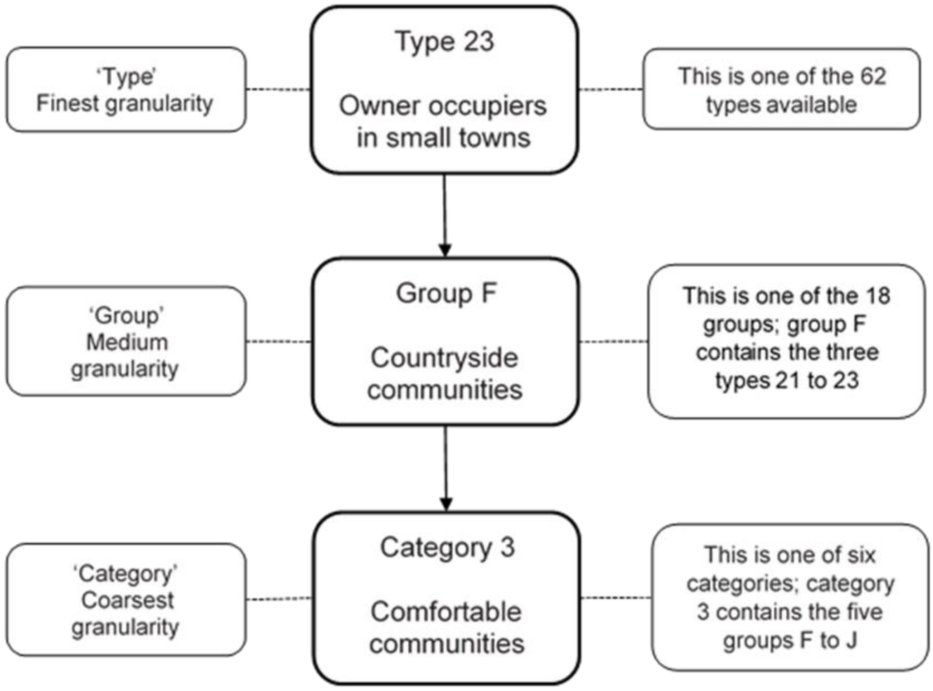

Figure 6.1 Acorn type, group, category relationship example

The Acorn types are not evenly distributed within the Acorn groups, the collections of more similar types do not contain the same number of types under the broader group umbrellas. Likewise the allocation of the Acorn groups into the collections which form the Acorn categories do not have an even distribution for the same reason (CACI Limited, 2014), the distributions are set out in appendix 11. Each of the Acorn types has a title and behind the title a full description of that segment of society (CACI Limited, 2014).

6.2. Aims and Objectives

The aim of this study was to undertake the geodemographic profiling of the motor vehicle drivers brought forward from the second study and complete thesis objective set out below.

- Determine the geodemographic profile of motor vehicle drivers involved in fatal and serious (MAIS3+) injury collisions.

6.3. Methodology

This study involves four stages. The study involves the use of the sample of motor vehicle drivers which was produced by the linkage of STATS19 police collision data and TARN hospital trauma patient data undertaken in study one, (see chapter four). This sample contains the motor vehicle drivers involved in fatal and MAIS3+ collisions which occurred in Cambridgeshire during the period April 2012 to March 2017. This sample contains a postcode variable for each of the motor vehicle drivers.

To facilitate the process the postcodes from the study sample were extracted into a separate worksheet with the related collision reference. This worksheet was used as the working version where the validation and census data were appended before the data was then appended to the study sample dataset. The validation process, undertaken by the author, manually compares each postcode with data available from the 2011 census. Where the postcode was determined to be valid, the census data for the postcode including the county of local authority in which it sits was appended to the record. The county or local authority data for each postcode allows differentiation of the motor vehicle drivers in the sample by residence, hence, the motor vehicle drivers who were resident within Cambridgeshire at the time of the collisions could be determined. The valid postcodes in the sample were then linked to the Acorn geodemographic dataset to determine if an Acorn geodemographic profile was available for the valid postcode; where an Acorn geodemographic profile was present for the postcode, the Acorn profile data was appended to each motor vehicle driver record. Motor vehicle drivers that did not present a valid postcode could not have an Acorn profile appended to the record and could, therefore, not be subject to further analysis using the geodemographic profiles. For the process chart for this study see figure 6.2 below.

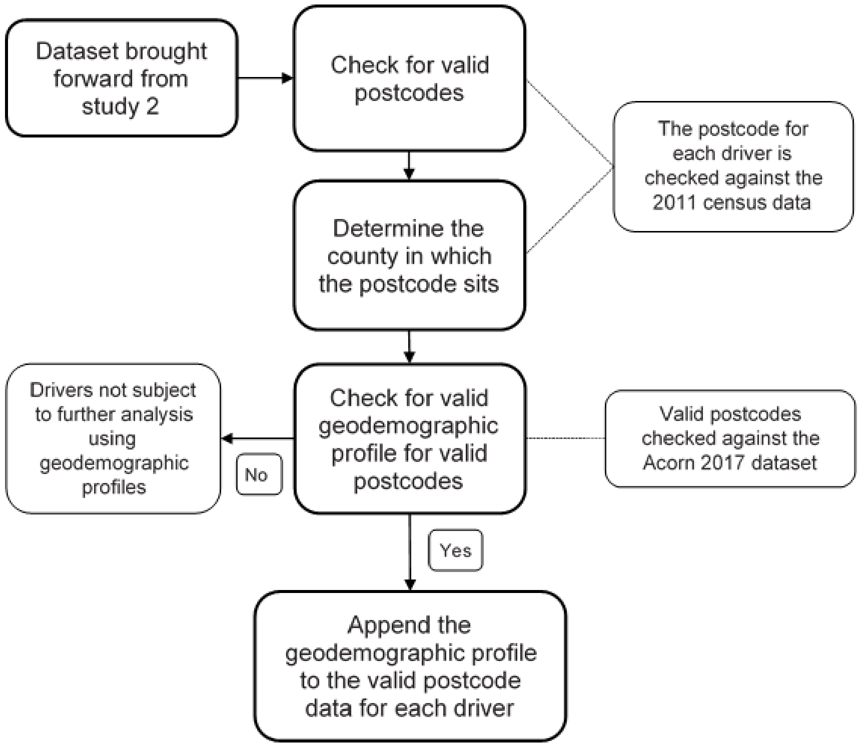

Figure 6.2 Study 3 geodemographic profiling process chart

6.3.1 Study Sample

This study utilised the sample created during the first two studies presented in chapters four and five. For the process involved in producing the sample dataset to this stage see figure 6.3 below.

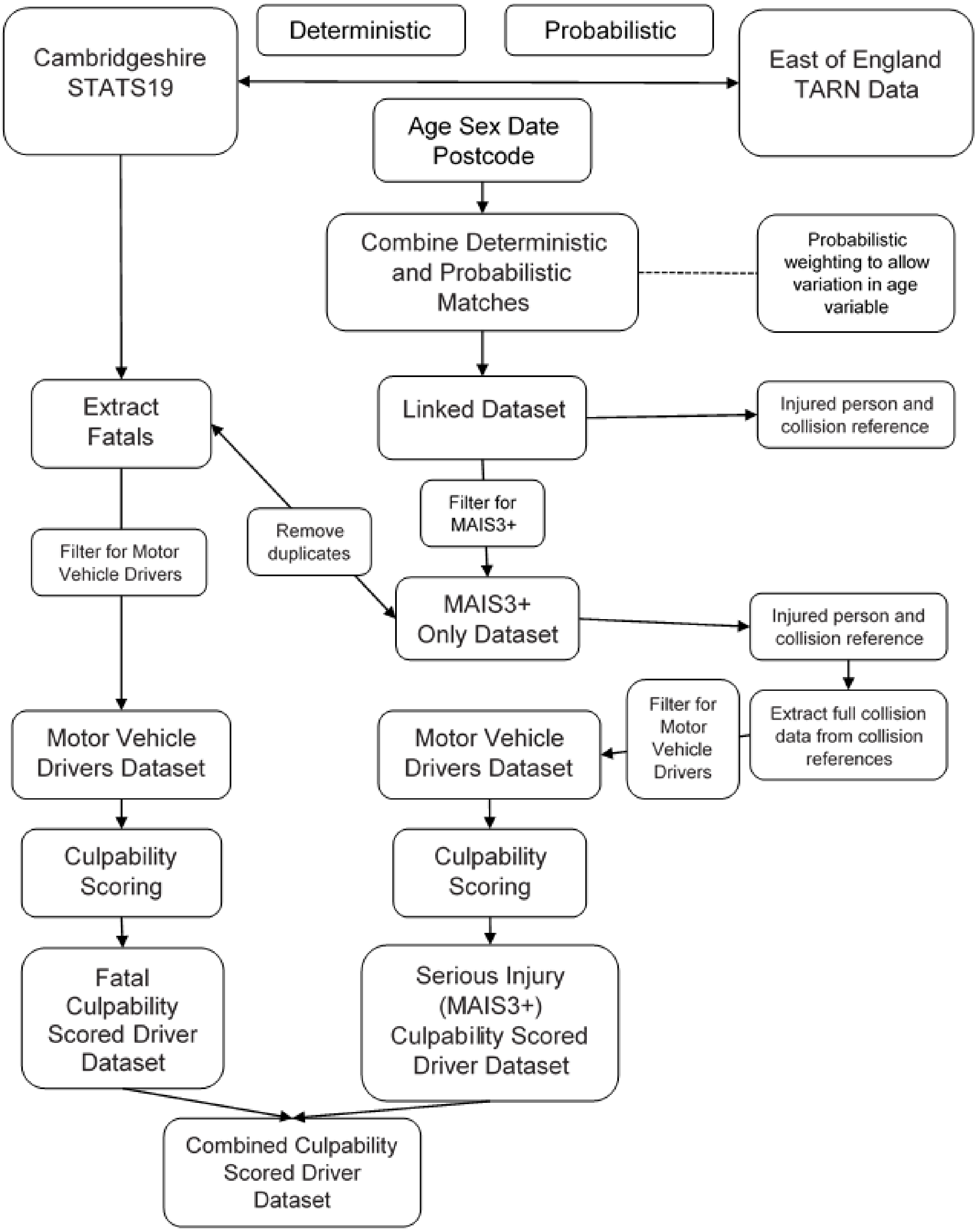

Figure 6.3 Dataset source diagram, summarising studies one and two

The dataset includes all the drivers of motor vehicles involved in collisions in Cambridgeshire between April 2012 and the end of March 2017 which resulted in a fatality or a casualty with an injury which reached the AIS score of three or above to any of the AIS designated body regions, see section 2.2.2.2, and who also fulfilled the entry criteria to the TARN database.

6.3.2 Sample Size

The first study, see chapter four, produced a sample of n=660 motor vehicle drivers involved in 368 fatal and MAIS3+ collisions. The second study, see chapter five, applied culpability scoring to the motor vehicle drivers from study one, however four of the motor vehicle driver records had insufficient data for culpability scoring to be undertaken, this produced a sample of n=656 culpability scored motor vehicle drivers. These motor vehicle drivers were differentiated by the collision injury severity, and motor vehicle driver culpability category. The groups and their relationship to each other and the whole population are presented in table 6.1 below.

Table 6.1 Study three sample population and within population group relationships

Motor vehicle driver sample			
	Fatal Collisions	MAIS3+ Collisions	Total
Number of Collisions represented in the sample (n=368) (n, % of total collisions)	n=158 (42.9)	n=210 (57.1)	n=368
Motor Vehicle Driver sample from study one (n=660) (n, % of total motor vehicle drivers)	n=300 (45.5)	n=360 (54.5)	n=660
Motor Vehicle Drivers Culpability Scored sample from study two (n, % of culpability scored motor vehicle drivers)	n=300 (45.7)	n=356 (54.3)	n=656
Culpability scored motor vehicle drivers			
	Fatal Collisions	MAIS3+ Collisions	Total (% of culpability scored motor vehicle drivers
Culpable Drivers (n, % of culpable drivers)	n=159 (40.8)	n=231 (59.2)	n=390 (59.5)
Contributory Drivers (n, % of contributory drivers)	n=18 (40.0)	n=27 (60.0)	n=45 (6.9)
Non-culpable Drivers (n, % of non-culpable drivers)	n=123 (55.7)	n=98 (44.3)	n=221 (33.7)

6.3.3 Inclusion and Exclusion Criteria

There are no additional inclusion and exclusion criteria over those used for the first and second study samples, these can be found in section 4.3.2. All the motor vehicle drivers identified in the first study and then culpability scored in the second study have been included in this study sample, however, during the first stage of this study the validity of the motor vehicle driver's postcode was assessed. Only motor vehicle drivers with a valid home postcode were assigned a geodemographic profile in the final stage, therefore, motor vehicle drivers without a valid postcode were excluded from the final stage of this study.

6.3.4 Postcode Validity

The sample includes a variable which contains the home postcode of each of the motor vehicle drivers represented in the data, should it have been recorded. The contents of this variable were manually compared to postcodes held in the 2011 census data (UK Data Service, 2017). The comparison resulted on one of four findings; the field contains a valid postcode, the field does not contain postcode data, the field contains partial or incorrectly formatted postcode data and finally the field contains data which appears to be correctly formatted to be a postcode, see section 2.10 and figure 2.4, however, does not correspond to a valid postcode. Data which produced the first of these findings, i.e. was a valid postcode, was the subject to the next stage in the process.

6.3.5 County Designation

The census data used to validate the postcodes also contains other data including data regarding local authorities and output area classification (Office for National Statistics, 2011). Where a valid postcode was identified in the first stage of this study the local authority information, from the census data, was appended to the record creating a new variable. The county or local authority variable allows for the differentiation of the motor vehicle drivers by county of resident. In the case of motor vehicle drivers resident in the county of Cambridgeshire this involved the combination of motor vehicle drivers residing in Cambridgeshire and the unitary authority of Peterborough. The variable also allows assessment of the proportion of motor vehicle drivers who were resident in the counties that surround Cambridgeshire at the time of the collisions, this ‘surrounding counties’ construct can give further understanding of the localism of those involved in fatal and MAIS3+ collisions being examined.

6.3.6 Postcode to Acorn Geodemographic Profile Comparison

The valid postcodes identified in the first stage of this study, in section 6.3.4, were then manually compared to the available Acorn geodemographic profiles dataset (CACI Limited, 2017).

6.3.7 Mapping the Geodemographic Profiles onto the Dataset

Where a valid postcode from the first stage of this study was found to correspond to an Acorn geodemographic profile on the third stage the Acorn geodemographic profile was manually appended to the record by the author.

The Acorn dataset contains 19706 valid postcode-to-geodemographic profiles for Cambridgeshire alone, there are just over 2.5 million for the whole of the UK. This stage was accomplished by manually appending the geodemographic material from the Acorn dataset (CACI Limited, 2017) to all the valid postcodes in the valid postcode dataset. The process involved a stage to assure reliability. The Acorn profile was appended with its related postcode adjacent to the valid postcode. This allowed a visual check that the postcode was an exact match. A new variable was appended for each participant with a valid postcode for Acorn category, Acorn group, Acorn type and the type description.

6.4. Result

This section presents the results of the four stages of study three. The process was applied to all the motor vehicle s and presented with differentiation by collision injury severity only, differentiation by motor vehicle driver culpability was dealt with during the analysis presented in chapter seven.

6.4.1 Postcode Validity

The results of the postcode validity exercise for the full motor vehicle dataset are presented below in table 6.2.

Table 6.2 Postcode validity results all motor vehicle drivers

	Fatal Collisions (% of total valid postcodes)	**MAIS3+ Collisions (% of total valid postcodes)**	**Total**
Valid Postcodes	n=234 (41.2)	n=334 (58.8)	n=568

The n=568 of the motor vehicle drivers with a valid postcode accounts for 86.1 percent of the motor vehicle drivers represented in the sample (n=660) brought forward from study one and 86.6 percent of the motor vehicle drivers subject to culpability scoring in study two (n=656). There were a number of reasons the n=92 (13.9 percent of the motor vehicle driver sample from study one) of the postcode variable entries did not have a valid postcode and hence were excluded from further analysis in this study. The reasons are presented in table 6.3 below and are an indication of the limitations created by data quality in the STATS19 dataset.

Table 6.3 Reasons for no valid postcode

Reason	Fatal collisions (% of total drivers in group)	MAIS3+ collisions (% of total drivers in group)	n= (% of total drivers)
No postcode	n=36 (12.0)	n=14 (3.9)	n=50 (7.6)
Partial postcode or incorrect data	n=15 (5.0)	n=2 (0.6)	n=17 (2.6)
Invalid postcode (structured correctly)	n=15 (5.0)	n=10 (2.8)	n=25 (3.8)

6.4.2 County Designation

The application of the county or local authority data for each valid postcode allowed for the differentiation of motor vehicle drivers who were resident in Cambridgeshire at the time of the collisions. The motor vehicle drivers that were resident in Cambridgeshire at the time of the collisions are represented in the table 6.4 below.

Table 6.4 Motor vehicle driver's resident in Cambridgeshire at the time of the collision

	Fatal Collisions (% of total valid Cambridgeshire postcodes)	MAIS3+ Collisions (% of total valid Cambridgeshire postcodes)	Total
Valid Cambridgeshire Postcodes	n=137 (36.9)	n=234 (63.1)	n=371

The ability to allocate counties or local authorities to individual postcodes allowed for the examination of the proportion of motor vehicle drivers involved in collisions within Cambridgeshire who were resident in Cambridgeshire at the time of the collision and those who were resident in the surrounding counties. The distributions are set out in the table 6.5 below.

Table 6.5 Motor vehicle driver residence distribution, Cambridgeshire and surrounding counties

County	Number of drivers (% of total valid postcodes)
Cambridgeshire	n= 371 (65.3)
Suffolk	n=35 (6.2)
Norfolk	n=32 (5.6)
Lincolnshire	n=23 (4.0)
Essex	n=17 (3.0)
Hertfordshire	n=15 (2.6)
Northamptonshire	n=8 (1.4)
Bedfordshire	n=7 (1.2)
Other UK counties	n=60 (10.6)

This data showed that 65.3 percent of the motor vehicle drivers come from within Cambridgeshire and a further 24.1 percent come from the surrounding counties.

6.4.3 Postcode to Acorn Geodemographic Profile Comparison

The comparison of the valid postcodes with the available Acorn geodemographic profiles showed that of the n=568 postcodes all but two, n=566, had an available Acorn geodemographic profile. The distributions of the profiles are presented in the next section.

6.4.4 Mapping the Geodemographic Profiles onto the Dataset

All three levels of granularity available in the Acorn profile system were represented in profiles of all the motor vehicle drivers with valid postcodes within the sample. The number of Acorn categories, groups and types represented in the dataset containing all the motor vehicle drivers are presented below in table 6.6.

Table 6.6 Acorn categories, groups and types for all motor vehicle drivers irrespective of county of residence

	Fatal Collisions	**MAIS3+ Collisions**	**Total from both injury severity groups**
Acorn Categories Represented (of the 6 available)	6	6	6
Acorn Groups Represented (or the 18 available)	17	17	18
Acorn Types Represented (of the 62 available)	51	47	54

Neither collision injury severity category contained all the Acorn groups or Acorn types, and the Acorn groups and Acorn types within each collision injury severity category varied, there were Acorn groups and Acorn types which appear in one and not the other, hence the total number for both Acorn groups and Acorn types present in the whole sample was higher than each of the individual collision injury severity categories.

The distribution of the Acorn types across the collision injury severity categories, presented in table 6.7 below, also presents the relationship between the categories, groups and types. The far right hand column presents whether the Acorn types either feature in the collision injury severity groups or do not feature in either of the collision injury severity categories.

Table 6.7 Acorn type presence in the injury severity categories for all motor vehicle drivers

Acorn category	Acorn group	Acorn type	Frequency in fatal collisions	Frequency in MAIS3+ collisions	Frequency in all drivers	Present in one or both of the injury severity categories
1. Affluent Achievers	A. Lavish Lifestyles	1. Exclusive enclaves	0	0	0	No
		2. Metropolitan money	0	0	0	No
		3. Large house luxury	1	0	1	Yes
	B. Executive Wealth	4. Asset rich families	2	9	11	Yes
		5. Wealthy countryside commuters	7	8	15	Yes
		6. Financially comfortable families	7	16	23	Yes
		7. Affluent professionals	2	1	3	Yes
		8. Prosperous suburban families	0	0	0	No
		9. Well-off edge of towners	2	10	12	Yes
	C. Mature Money	10. Better-off villagers	9	27	36	Yes
		11. Settled suburbia, older people	5	3	8	Yes
		12. Retired and empty nesters	10	8	18	Yes
		13. Upmarket downsizers	1	3	4	Yes
2. Rising Prosperity	D. City Sophisticates	14. Townhouse cosmopolitans	1	0	1	Yes
		15. Younger professionals in smaller flats	0	0	0	No
		16. Metropolitan professionals	0	0	0	No
		17. Socialising young renters	0	1	1	Yes
	E. Career Climbers	18. Career driven young families	10	13	23	Yes
		19. First time buyers in small, modern homes	2	3	5	Yes
		20. Mixed metropolitan areas	1	0	1	Yes
3. Comfortable Communities	F. Countryside Communities	21. Farms and cottages	6	9	15	Yes
		22. Larger families in rural areas	17	20	37	Yes
		23. Owner occupiers in small towns and villages	19	26	45	Yes
	G. Successful Suburbs	24. Comfortably-off families in modern housing	9	14	23	Yes
		25. Larger family homes, multi-ethnic areas	1	4	5	Yes
		26. Semi-professional families, owner occupied neighbourhoods	6	9	15	Yes
	H. Steady Neighbourhoods	27. Suburban semis, conventional attitudes	3	10	13	Yes
		28. Owner occupied terraces, average income	0	0	0	No
		29. Established suburbs, older families	10	10	20	Yes
	I. Comfortable Seniors	30. Older people, neat and tidy neighbourhoods	4	6	10	Yes
		31. Elderly singles in purpose-built accommodation	1	0	1	Yes
	J. Starting Out	32. Educated families in terraces, young children	1	6	7	Yes
		33. Smaller houses and starter homes	6	3	9	Yes
4. Financially Stretched	K. Student Life	34. Student flats and halls of residence	0	0	0	No
		35. Term-time terraces	0	0	0	No
		36. Educated young people in flats and tenements	0	4	4	Yes
	L. Modest Means	37. Low cost flats in suburban areas	1	3	4	Yes
		38. Semi-skilled workers in traditional neighbourhoods	12	12	24	Yes
		39. Fading owner occupied terraces	7	3	10	Yes
		40. High occupancy terraces, many Asian families	2	4	6	Yes
	M. Striving Families	41. Labouring semi-rural estates	14	16	30	Yes
		42. Struggling young families in post-war terraces	8	16	24	Yes
		43. Families in right-to-buy estates	9	10	19	Yes
		44. Post-war estates, limited means	4	2	6	Yes
	N. Poorer Pensioners	45. Pensioners in social housing, semis and terraces	1	2	3	Yes
		46. Elderly people in social rented flats	1	1	2	Yes
		47. Low income older people in smaller semis	6	6	12	Yes
		48. Pensioners and singles in social rented flats	2	3	5	Yes
5. Urban Adversity	O. Young Hardship	49. Young families in low cost private flats	1	3	4	Yes
		50. Struggling younger people in mixed tenure	3	7	10	Yes
		51. Young people in small, low cost terraces	2	2	4	Yes
	P. Struggling Estates	52. Poorer families, many children, terraced housing	3	4	7	Yes
		53. Low income terraces	0	2	2	Yes
		54. Multi-ethnic, purpose-built estates	1	1	2	Yes
		55. Deprived and ethnically diverse in flats	2	0	2	Yes
		56. Low income large families in social rented semis	2	4	6	Yes
		57. Social rented flats, families and single parents	3	3	6	Yes

	Q. Difficult Circumstances	58. Singles and young families, some receiving benefits	1	2	3	Yes
		59. Deprived areas and high-rise flats	2	1	3	Yes
6. Not Private Households	R. Not Private Households	60. Active communal population	1	0	1	Yes
		61. Inactive communal population	1	0	1	Yes
		62. Business addresses without resident population	2	2	4	Yes
		Total	234	332*	566*	54

*Two of the valid postcodes did not have an Acorn profile.

Of the n=568 valid postcodes available in the sample two of the postcodes were not represented in the Acorn geodemographic profile data. The n=566 motor vehicle driver home postcodes to which geodemographic profiles have been append represents 85.8 percent of the sample brought forward from study one.

6.4.5 Cambridgeshire Resident Motor Vehicle Drivers

With the appending of the county of residence to the data it was possible to determine how many of the available Acorn profiles at the three levels of granularity were present within the motor vehicle drivers residing in Cambridgeshire at the time of the collision. The distribution across the three levels of Acorn granularity are presented in table 6.8 below.

Table 6.8 Acorn categories, groups and types Cambridgeshire resident motor vehicle drivers

	Fatal Collisions	**MAIS3+ Collisions**	**Total from both injury severity groups**
Acorn Categories Represented (of the 6 available)	6	6	6
Acorn Groups Represented (or the 18 available)	16	16	17
Acorn Types Represented (of the 62 available)	39	42	47

Again, both of the injury severity groups do not contain all the Acorn types and that between the groups there are types which appear in one and not the other, hence the total number of groups used in the Cambridgeshire motor vehicle driver portion of the dataset was higher than each of the groups.

The distribution of the Acorn types across the collision injury severity categories for Cambridgeshire resident motor vehicle drivers, presented in table 6.9 below, also presents the relationship between the categories, groups and types along. The far right hand column presents whether the Acorn types either feature in the collision injury severity groups or do not feature in either of the collision injury severity categories.

Table 6.9 Acorn type presence in the injury severity categories for Cambridgeshire resident motor vehicle drivers

Acorn category	Acorn group	Acorn type	Frequency in fatal collisions	Frequency in MAIS3+ collisions	Frequency in all drivers	Present in one or both of the injury severity categories
1. Affluent Achievers	A. Lavish Lifestyles	1. Exclusive enclaves	0	0	0	No
		2. Metropolitan money	0	0	0	No
		3. Large house luxury	0	0	0	No
	B. Executive Wealth	4. Asset rich families	1	3	4	Yes
		5. Wealthy countryside commuters	4	7	11	Yes
		6. Financially comfortable families	3	13	16	Yes
		7. Affluent professionals	1	0	1	Yes
		8. Prosperous suburban families	0	0	0	No
		9. Well-off edge of towners	0	8	8	Yes
	C. Mature Money	10. Better-off villagers	5	24	29	Yes
		11. Settled suburbia, older people	1	1	2	Yes
		12. Retired and empty nesters	5	6	11	Yes
		13. Upmarket downsizers	0	2	2	Yes
2. Rising Prosperity	D. City Sophisticates	14. Townhouse cosmopolitans	1	0	1	Yes
		15. Younger professionals in smaller flats	0	0	0	No
		16. Metropolitan professionals	0	0	0	No
		17. Socialising young renters	0	0	0	No
	E. Career Climbers	18. Career driven young families	5	11	16	Yes
		19. First time buyers in small, modern homes	2	3	5	Yes
		20. Mixed metropolitan areas	0	0	0	No
3. Comfortable Communities	F. Countryside Communities	21. Farms and cottages	3	6	9	Yes
		22. Larger families in rural areas	10	14	24	Yes
		23. Owner occupiers in small towns and villages	12	18	30	Yes
	G. Successful Suburbs	24. Comfortably-off families in modern housing	4	11	15	Yes
		25. Larger family homes, multi-ethnic areas	0	3	3	Yes
		26. Semi-professional families, owner occupied neighbourhoods	6	6	12	Yes
	H. Steady Neighbourhoods	27. Suburban semis, conventional attitudes	2	8	10	Yes
		28. Owner occupied terraces, average income	0	5	0	No
		29. Established suburbs, older families	8	5	13	Yes
	I. Comfortable Seniors	30. Older people, neat and tidy neighbourhoods	2	0	7	Yes
		31. Elderly singles in purpose-built accommodation	1	5	1	Yes
	J. Starting Out	32. Educated families in terraces, young children	0	2	5	Yes
		33. Smaller houses and starter homes	4	0	6	Yes
4. Financially Stretched	K. Student Life	34. Student flats and halls of residence	0	0	0	No
		35. Term-time terraces	0	0	0	No
		36. Educated young people in flats and tenements	0	2	2	Yes
	L. Modest Means	37. Low cost flats in suburban areas	0	3	3	Yes
		38. Semi-skilled workers in traditional neighbourhoods	6	8	14	Yes
		39. Fading owner occupied terraces	3	3	6	Yes
		40. High occupancy terraces, many Asian families	2	4	6	Yes
	M. Striving Families	41. Labouring semi-rural estates	12	10	22	Yes
		42. Struggling young families in post-war terraces	5	8	13	Yes
		43. Families in right-to-buy estates	4	7	11	Yes
		44. Post-war estates, limited means	2	1	3	Yes
		45. Pensioners in social housing, semis and terraces	1	2	3	Yes

	N. Poorer Pensioners	46. Elderly people in social rented flats	0	0	0	No
		47. Low income older people in smaller semis	5	6	11	Yes
		48. Pensioners and singles in social rented flats	2	2	4	Yes
5. Urban Adversity	O. Young Hardship	49. Young families in low cost private flats	0	1	1	Yes
		50. Struggling younger people in mixed tenure	2	3	5	Yes
		51. Young people in small, low cost terraces	2	1	3	Yes
	P. Struggling Estates	52. Poorer families, many children, terraced housing	3	3	6	Yes
		53. Low income terraces	0	1	1	Yes
		54. Multi-ethnic, purpose-built estates	0	0	0	No
		55. Deprived and ethnically diverse in flats	0	0	0	No
		56. Low income large families in social rented semis	1	2	3	Yes
	Q. Difficult Circumstances	57. Social rented flats, families and single parents	1	2	3	Yes
		58. Singles and young families, some receiving benefits	1	1	2	Yes
		59. Deprived areas and high-rise flats	2	0	2	Yes
6. Not Private Households	R. Not Private Households	60. Active communal population	0	0	0	No
		61. Inactive communal population	1	0	1	Yes
		62. Business addresses without resident population	2	2	4	Yes
		Total	137	234*	370*	47

*One of the valid Cambridgeshire postcodes did not have an Acorn profile.

Of the n=371 Cambridgeshire resident motor vehicle drivers with a valid postcode available in the sample one postcode was not represented in the Acorn geodemographic profile data. The n=370 Cambridgeshire resident motor vehicle driver home postcodes to which geodemographic profiles have been append represents 56.1 percent of the sample brought forward from study one.

Once a dataset containing the valid postcodes and related geodemographic material was completed this data was then appended to the motor vehicle driver dataset brought forward from study two and described in section 6.3.1. Analysis of the Acorn geodemographic profile distribution differentiated by motor vehicle driver culpability is undertaken in chapter seven.

6.5. Summary of Findings

The first stage in the process was the validating of the postcodes presented in the sample produced by study one, see chapter four. STATS19 data quality has been a recurring issue for researchers and analysts (Transport Scotland, 2015; Imprialou and Quddus, 2017; Department for Transport, 2019d) and STATS19 data quality may account for the 13.9 percent (n=92) of the motor vehicle drivers in the dataset with no valid postcode. There was insufficient data to determine why there was the difference in proportion of collisions without a valid postcode between the collision injury severity groups with 22.0 percent of the fatal collisions (66 of the 300 motor vehicle drivers) not having a valid postcode compared to just 7.2 percent (26 of the 360 motor vehicle drivers) for the MAIS3+ collisions. However, the missing postcode data and resulting motor vehicle driver records in the data without a corresponding geodemographic profile does mean that the study has not captured all the possible data and any analysis must be considered in light of the missing data when conclusions are drawn.

The second stage in the process, where the county in which the postcode sits was determined from the census data, allowed identification of motor vehicle drivers resident within Cambridgeshire, at the time of the collisions, or whether from 'surrounding counties' or other areas in the UK. This showed that 65.3 percent of the motor vehicle drivers involved in the fatal and MAIS3+ collisions that occurred within Cambridgeshire county were residents of Cambridgeshire at the time of the collisions, with a further 24.1 percent resident within the surrounding counties. Only 10.6 percent of the motor vehicle drivers were resident in other parts of the UK. These data do support other research which suggests the local nature of collisions. In this study there has been examination of motor vehicle drivers involved in collisions, yet Steinbach, Edwards and Grundy (2013) in examining various casualty groups as well as motor vehicle drivers found similar patterns of localism in pedestrians, cyclists and the riders of powered two wheelers.

The third stage of this study involved comparison of the validated motor vehicle driver postcodes with the data held on the Acorn geodemographic data to confirm a profile was available for the postcode. Where an Acorn geodemographic profile was available the final stage was the appending of the geodemographic profiles to the valid postcodes. Of the n=568 motor vehicle drivers with a valid postcode available in the dataset there were Acorn geodemographic profiles available for n=566 (99.6 percent). Of the motor vehicle drivers with a valid postcode who were resident in Cambridgeshire, n=371, all but one had an available Acorn geodemographic profile available resulting in n=370 (99.7 percent) geodemographically profiled Cambridgeshire resident motor vehicle drivers available for analysis.

Chapter Seven: Analysis

7.1. Introduction

There has been a long history of targeting road safety interventions at higher risk profile segments of the population, such as young motor vehicle drivers (*Road Traffic (New Drivers) Act 1995*; Transport Research Laboratory, 2010; Department for Transport, 2018a; 2019c; 2019a; Transport Select Committee, 2019). The analysis presented in this chapter explores demographics and the geodemographics of the motor vehicle driver population identified during the three preceding studies as being involved in fatal and MAIS3+ injury collisions in Cambridgeshire between 2012 and 2017, see chapters four to six.

The use of the collision injury severity categories within STATS19 to differentiate groups within the data, be it casualties or motor vehicle drivers, relies on the non-clinical injury assessment of the reporting police officer. This process has a number of limitations, including ambiguity in the severity of outcome within the 'STATS19 'serious' category, which were previously explored in section 2.2.1.

However, where a death occurs there would be no ambiguity with the collision injury severity, albeit that the death must occur within 30 days of the collision, resulting in previous research using the data from fatal collisions, for example, Steinbach, Edwards and Grundy (2013) and Department for Transport (2014), with road safety strategy based around the 'fatal four' (Transport Research Laboratory, 2015).

The limitation of examining fatal collisions as an outcome can be that collisions resulting in fatalities are a small proportion of the injury collisions reported. For example, in the STATS19 data used in this research, encompassing all the injury collisions which occurred in Cambridgeshire over a five-year period, fatal collisions only accounted for 158 collisions (1.5 percent) of the 10498 collisions in the dataset. The inclusion of the MAIS3+ injury severity collisions increased the number of collisions being examined in this research to 368 of the 10498 taking the proportion being examined up to 3.5 percent.

Prior to the analysis presented in this thesis, there has been no research found that compared motor vehicle drivers differentiated by the clinical injury severity categories of fatal and MAIS3+, which may be as a result of the difficulty in precisely identifying other injury severity categories other than those resulting in a fatality.

The research in this chapter investigates the motor vehicle drivers identified in the three studies conducted. The three studies reported in chapters four to six have produced a dataset of motor vehicle drivers which can be grouped by collision injury severity, motor vehicle driver culpability and motor vehicle driver residence. The collisions occurred in Cambridgeshire involving motor vehicle drivers from across the UK. However, those that were resident in Cambridgeshire at the time of the collisions can be identified, allowing focus on local motor vehicle drivers involved in local collisions, and hence allowing for future interventions to be targeted towards the local motor vehicle drivers. Similarly, there would only be value in differentiating the Cambridgeshire motor vehicle drivers by motor vehicle driver culpability and collision injury severity if there are differences between the groups which can be identified and used to allow the targeting of interventions.

The analysis in this chapter explores all the motor vehicle drivers in the sample and the subset of motor vehicle drivers who were resident in Cambridgeshire at the time of the collision and variation in the geodemographic profile distribution from the overall population in Cambridgeshire.

The research in this chapter tests two hypotheses, set out in the aims and objectives below, regarding the motor vehicle driver groups identified by collision injury severity, motor vehicle driver culpability and motor vehicle driver residence, see section 7.3.1.

If there are differences in demographic and geodemographic factors between the groups of motor vehicle drivers stratified by motor vehicle driver culpability and collision injury severity then it may be possible to deal with the stratified groups by either using different road safety or casualty reduction intervention tactics or focussing the road safety or casualty reduction intervention on specific stratified groups. If there are no differences, then the process of differentiation would be unnecessary and road safety and casualty reduction interventions can be applied to the whole motor vehicle driver population.

The aim of the research presented in this thesis was to determine if a more sophisticated targeting based on the analysis of geodemographic distributions, a well-established method in marketing, can be applied to the data relating to the culpable motor vehicle drivers involved in injury collisions.

7.2. Aim and Objectives

The chapter explores both aims of the thesis,

i. investigate if geodemographic profiles can be used to differentiate motor vehicle drivers involved in fatal and serious injury (MAIS3+) collisions by their culpability.
ii. To investigate if the analysis of motor vehicle driver geodemographic profiles could allow direct marketing methods to be applied to road safety interventions.

The related objectives, set out below, entailed the investigation of geodemographic profile variation by culpability of the motor vehicle drivers involved in fatal and serious injury (MAIS3+) collisions resident in Cambridgeshire at the time of the collision. There was also examination of the other demographic factors, age and gender, to explore if these differ between the motor vehicle driver groups.

Objectives:

- Determine if there are differences in demographic distributions between culpable and non-culpable motor vehicle drivers.
- Evaluate the potential for using geodemographic profiling to deliver targeted road safety interventions.

The analysis in this chapter was undertaken to test the two hypotheses set out below.

Hypothesis one: There are differences between motor vehicle driver groups identified by collision injury severity, motor vehicle driver culpability and motor vehicle driver residence within the county of Cambridgeshire relating to the demographic and geodemographic data of the motor vehicle drivers within the groups. The null hypotheses being that there was no difference between the motor vehicle driver groups identified by collision injury severity, motor vehicle driver culpability and motor vehicle driver residence in Cambridgeshire in relation to the motor vehicle driver's demographic and geodemographic factors examined.

Hypothesis two: There are differences in geodemographic profile distribution within and between the motor vehicle driver groups identified by collision injury severity, motor vehicle driver culpability and motor vehicle driver residence within the county of Cambridgeshire when compared to the distribution within the population of the county of Cambridgeshire. The null hypothesis being that there are no differences in geodemographic profile distribution within or between the motor vehicle driver groups identified by collision injury severity, motor vehicle driver culpability and motor vehicle driver residence within the county of Cambridgeshire when compared to the distribution within the population of the county of Cambridgeshire.

7.3. Methodology

7.3.1 Sample Groups

This section explores the process followed to produce the dataset used in the analysis in this chapter. The three preceding chapters set out the methodology employed to build a dataset containing the details of collisions, and related motor vehicle drivers involved in fatal and serious MAIS3+ injury collisions in Cambridgeshire, for the five-year period from April 2012 to March 2017. This dataset also included information relating to the culpability of each motor vehicle driver involved in the collisions and related geodemographic data.

The process started in chapter four with the linking of the police collision data, STATS19, to hospital trauma patient data, TARN, in study one using a two-stage process of a deterministic linkage followed by a probabilistic linkage. This was undertaken to identify MAIS3+ injury causing collisions within the Cambridgeshire STATS19 dataset and the related motor vehicle drivers.

In chapter five the STATS19 data relating to the motor vehicle drivers involved in MAIS3+ collisions identified in study one, and the motor vehicle drivers identified in the STATS19 data as being involved in a collision resulting in a fatality was extracted to facilitate culpability scoring. Culpability scoring using the Robertson and Drummer (1994) tool was then calculated for all motor vehicle drivers involved in these collisions.

The two sets of motor vehicle driver data were combined into a single dataset with a variable allowing them to be categorised as involved in either a fatal or MAIS3+ collision. The culpability scoring process categorised the motor vehicle drivers as either culpable, contributory or non-culpable in 99.4 percent of all the motor vehicle drivers identified.

In chapter six, each motor vehicle driver with a valid home postcode present in the STATS19 data had their Acorn geodemographic profile appended. This further categorised the motor vehicle drivers into three levels of geodemographic profile granularity. The process stages, from chapters 4 to 6 set out above, through which the data passed to produce the dataset for this analysis and the number of individuals identified at each stage can be brought together and presented in the form of a process chart, presented in figure 7.1 below.

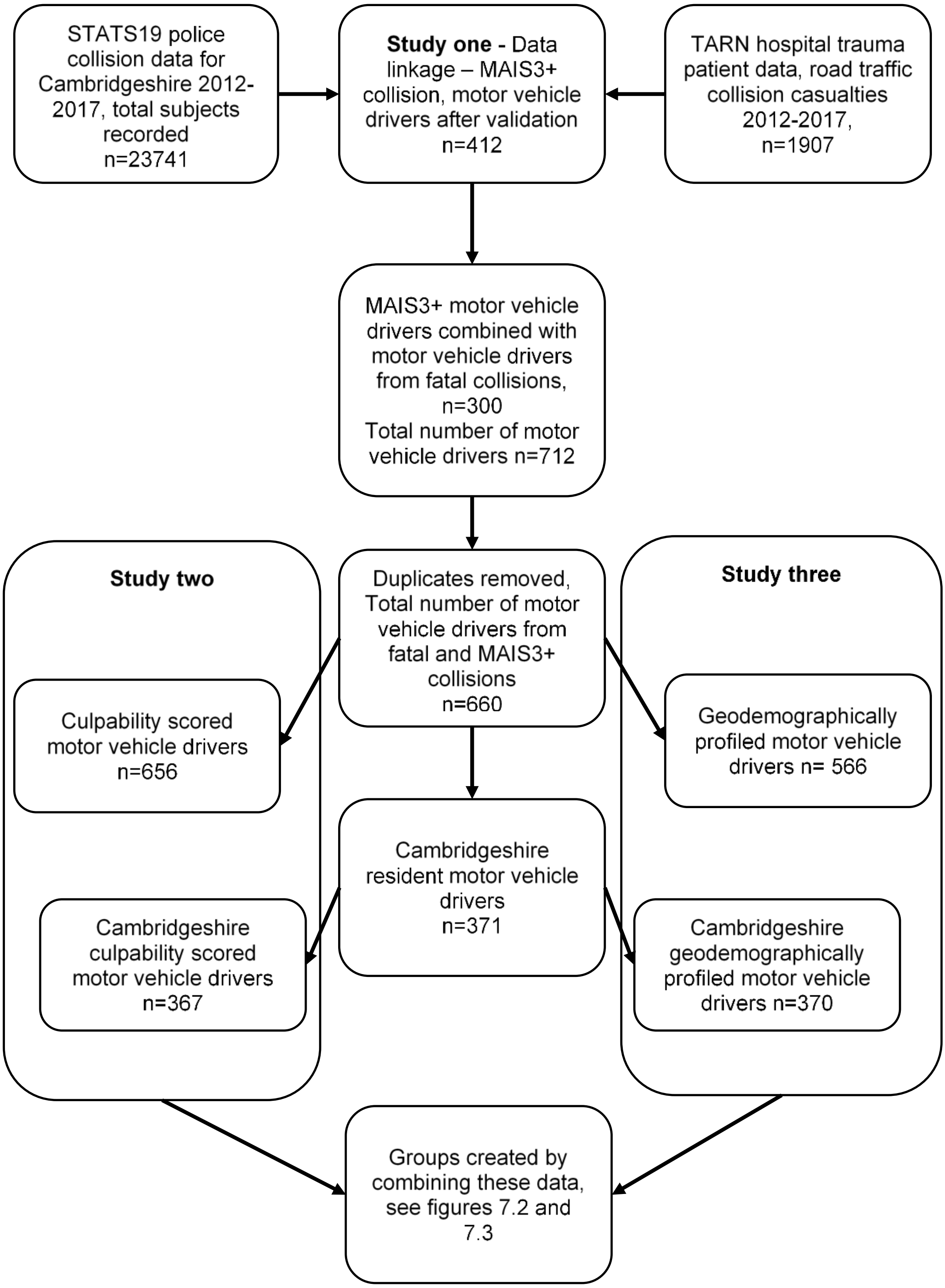

Figure 7.1 Dataset development process

During the three studies new variables were created to record results for each motor vehicle driver at each stage, these variables allow for the differentiation of the motor vehicle drivers by collision injury severity, motor vehicle driver culpability and motor vehicle driver residence and facilitate the creation of the motor vehicle driver groups presented in table 7.1 below where the variables are presented in study order.

Table 7.1 Motor vehicle driver related study generated variables

Study	**Variable**	**Description**
Study one - linkage of STATS19 police collision data to TARN hospital trauma patient data	fatal_or_serious	Categorical numeric variable with three options indication if the entry originated in the fatal collision data direct from STATS19 or either the deterministic MAIS3+ linkage process or the probabilistic MAIS3+ linkage process.
	fatal_or_mais3plus	Categorical numeric variable with two options indication if the entry originated in the fatal collision data direct from STATS19 or from a MAIS3+ linkage process
Study two - driver culpability assessment	_culp_res	Categorical numeric variable with three options indicating the result of the culpability scoring process in study two.
	culp_and_cont_combined	Categorical numeric variable with two options indication the culpability of the driver as one option being that the driver was either culpable or contributory and the second that they were non-culpable.
Study three - driver geodemographic profiling	acorn_category	Categorical numeric variable indicating one of six course granularity Acorn geodemographic profiles.
	acorn_group	Categorical alphabetic variable indicating one of eighteen medium granularity Acorn geodemographic profiles.
	acorn_type	Categorical numeric variable indicating one of sixty-two fine granularity Acorn geodemographic profiles.
	acorn_description	Text explanation of the Acorn type geodemographic profile.
	county_or_local_authority	Categorical numeric variable indicating either the county or unitary authority in which the home postcode of the driver sits.
	sex_proportion_testing	Categorical numeric variable derived from the sex variable with the unknown category removed to allow proportion between male and female to be assessed.

A summary of the frequency of motor vehicle drivers in the dataset and motor vehicle driver groups differentiated by collision injury severity, motor vehicle driver culpability and motor vehicle driver residence, bringing together results from studies one to three, are presented in tables 7.2 and 7.3 below.

Table 7.2 All Motor vehicle driver dataset summary

All Motor Vehicle Driver Dataset			
	Fatal Collisions	MAIS3+ Collisions	Total (% of total motor vehicle drivers as appropriate)
Collisions Represented (% of total collisions in the dataset)	n=158 (42.9)	n=210 (57.1)	n=368

Motor Vehicle Drivers Represented (% of total motor vehicle drivers)	n=300 (45.5)	n=360 (54.5)	n=660
Total Motor Vehicle Drivers Culpability Scored (% of motor vehicle drivers in collision injury severity category)	n=300 (100.0)	n=356 (98.9)	n=656 (99.4)
Culpable Motor Vehicle Drivers (% of total culpable motor vehicle drivers)	n=159 (40.8)	n=231 (59.2)	n=390 (59.0)
Contributory Motor Vehicle Drivers (% of total contributory motor vehicle drivers)	n=18 (40.0)	n=27 (60.0)	n=45 (6.8)
Culpable and Contributory Motor Vehicle Drivers Combined (% of total combined culpable and contributory motor vehicle drivers)	n=177 (40.7)	n=258 (59.3)	n=435 (66.3)
Non-culpable Motor Vehicle Drivers (% of total non-culpable motor vehicle drivers)	n=123 (55.7)	n=98 (44.3)	n=221 (33.7)
Valid Postcodes	n=234 (41.3)	n=334 (58.8)	n=568 (86.1)
Valid Postcodes with Acorn profile	n=234 (41.3)	n=332 (58.7)	n=566 (85.7)
Acorn Categories Represented (of the 6 available)	6	6	
Acorn Groups Represented (of the 18 available)	17	17	
Acorn Types Represented (of the 62 available)	51	47	

Extracting the Cambridgeshire resident motor vehicle drivers with a valid postcode and corresponding geodemographic profile n=370. The Cambridgeshire subset being represented in table 7.3 below.

Table 7.3 Cambridgeshire motor vehicle drivers summary

Cambridgeshire Motor Vehicle Drivers			
	Fatal Collisions	MAIS3+ Collisions	Total (% of total motor vehicle drivers as appropriate)
Motor Vehicle Drivers Represented (% of total motor vehicle drivers)	n=137 (36.9)	n=234 (63.1)	n=371
Total Motor Vehicle Drivers Culpability Scored (% of motor vehicle drivers in collision injury severity category)	n=137 (100.0)	n=230 (98.3)	n=367 (98.9)
Culpable Motor Vehicle Drivers (% of total culpable motor vehicle drivers)	n=74 (31.8)	n=159 (68.2)	n=233 (62.8)
Contributory Motor Vehicle Drivers (% of total contributory motor vehicle drivers)	n=9 (40.9)	n=13 (59.1)	n=22 (5.9)
Culpable and Contributory Motor Vehicle Drivers Combined (% of total combined culpable and contributory motor vehicle drivers)	n=83 (32.6)	n=172 (67.4)	n=255 (68.7)
Non-culpable Motor Vehicle Drivers (% of total non-culpable motor vehicle drivers)	n=54 (48.2)	n=58 (51.8)	n=112 (30.2)
Valid Postcodes (all had Acorn profiles)	n=137 (37.0)	n=233 (63.0)	n=370 (99.7)
Acorn Categories Represented (of the 6 available)	6	6	
Acorn Groups Represented (or the 18 available)	16	16	
Acorn Types Represented (of the 62 available)	39	42	

The combinations of collision injury severity categories, motor vehicle driver culpability categories and motor vehicle driver residence create sub-population motor vehicle driver groups, see the matrices presented in figures 7.2 and 7.3 below, which facilitate between and within motor vehicle driver group analysis. The motor vehicle driver groups available are explored in the next section.

7.3.1.1 Sample groups

The sample used in this chapter was the linked data set produced in study one, described in chapter 4 containing all motor vehicle drivers involved in collisions which resulted in either a fatality or a MAIS3+ category of injury. These motor vehicle drivers were culpability scored, see section 5.4 to 5.8, resulting in three categories of culpable, contributory and non-culpable motor vehicle drivers. The motor vehicle drivers identified in study one were also examined in study three, see chapter six, where their postcodes were validated, where a valid postcode was present the motor vehicle drivers also had their county or local authority of residence and a geodemographic profile identified. Individual analyses were also subject to additional exclusion criteria, for example, the gender distribution analysis excluded motor vehicle drivers who had the gender categorisation of ‘unknown’, these are explored in the related methodological explanation.

The categorisation of the motor vehicle drivers by culpability category as a result of the culpability scoring undertaken in study two, reproduced later in this chapter in tables 7.2 and 7.3, produced a contributory category which only contains a small proportion of the motor vehicle drivers represented in the data, 6.8 percent (45 of 656) of all the motor vehicle drivers and 5.9 percent (22 of 367) of the motor vehicle drivers resident in Cambridgeshire at the time of the collision. Due to small frequencies and to create a binary outcome the culpable and contributory motor vehicle drivers were grouped together and presented in tables 7.2 and 7.3 below.

In combining the motor vehicle driver culpability scoring with the collision injury severity categories creates two groups containing both injury severity categories and four independent groups, where the injury severity categories are differentiated, six groups in total, within the data, see the matrix in figure 7.2 below.

	Culpable and contributory motor vehicle drivers	Non-culpable motor vehicle drivers
Fatal and MAIS3+ collisions	All culpable and contributory motor vehicle drivers within the dataset	All non-culpable motor vehicle drivers within the dataset
Fatal collisions	Culpable and contributory motor vehicle drivers involved in fatal collisions	Non-culpable motor vehicle drivers involved in fatal collisions
MAIS3+ collisions	Culpable and contributory motor vehicle drivers involved in MAIS3+ injury collisions	Non-culpable motor vehicle drivers involved in MAIS3+ injury collisions

Figure 7.2 Motor vehicle driver groups matrix identified by collision injury severity and motor vehicle driver culpability category

These six groups, containing all the motor vehicle drivers, created by combining the motor vehicle driver culpability scoring with the collision injury severity categories can be further differentiated by consideration of the motor vehicle drivers who were resident in Cambridgeshire at the time of the collision from study three in chapter six, this creates a further six groups, see the matrix in figure 7.3 below. It should be noted that not all of these groups are independent, for example, where both injury severity categories are considered in the same group and in other groups they are separated. This was done to allow comparison of the independent groups with the results that would be obtained had the differentiation had not been undertaken. This allowed for testing of both hypotheses where differences between both the independent groups and the combined groups, i.e. without the differentiation, were explored.

These groups, created by the differentiation of the motor vehicle drivers by collision injury severity, motor vehicle driver culpability and motor vehicle driver residence, undertaken in the three preceding studies presented in chapters four to six, allow for within and between group analysis. There was comparison of the groups in the rows, for example, between the results for all motor vehicle drivers and the results for Cambridgeshire motor vehicle drivers, as well as the groups in the columns, for example, between Cambridgeshire resident culpable motor vehicle driver from fatal collisions and the Cambridgeshire resident culpable motor vehicle drivers from MAIS3+ collisions.

Motor vehicle drive sample	Motor vehicle drivers regardless of residence	Cambridgeshire resident motor vehicle drivers
All motor vehicle drivers	All motor vehicle drivers within the dataset	Cambridgeshire resident motor vehicle drivers within the dataset
All motor vehicle drivers, fatal collisions	All motor vehicle drivers within the dataset involved in fatal collisions	Cambridgeshire resident motor vehicle drivers within the dataset involved in fatal collisions
All motor vehicle drivers, MAIS3+ collisions	All motor vehicle drivers within the dataset involved in MAIS3+ collisions	Cambridgeshire resident motor vehicle drivers within the dataset involved in MAIS3+ collisions
All culpable and contributory motor vehicle drivers	All culpable and contributory motor vehicle drivers within the dataset	Cambridgeshire resident culpable and contributory motor vehicle drivers within the dataset
All non-culpable motor vehicle drivers	All non-culpable motor vehicle drivers within the dataset	Cambridgeshire resident non-culpable motor vehicle drivers within the dataset
Culpable and contributory motor vehicle drivers involved in fatal collisions	All culpable and contributory motor vehicle drivers involved in fatal collisions	Cambridgeshire resident culpable and contributory motor vehicle drivers involved in fatal collisions
Culpable and contributory motor vehicle drivers involved in MAIS3+ injury collisions	All culpable and contributory motor vehicle drivers involved in MAIS3+ collisions	Cambridgeshire resident culpable and contributory motor vehicle drivers involved in MAIS3+ collisions
Non-culpable motor vehicle drivers involved in fatal collisions	All non-culpable motor vehicle drivers involved in fatal collisions	Non-culpable motor vehicle drivers involved in fatal collisions

Non-culpable motor vehicle drivers involved in MAIS3+ injury collisions	All non-culpable motor vehicle drivers involved in MAIS3+ injury collisions	Non-culpable motor vehicle drivers involved in MAIS3+ injury collisions

Figure 7.3 Motor vehicle driver groups matrix identified by collision injury severity, motor vehicle driver culpability and motor vehicle driver residence

If differences between combined or independent groups were evident there could be value in targeting the groups using the differentiation.

The groups created by the differentiation of the motor vehicle drivers by collision injury severity, motor vehicle driver culpability and motor vehicle driver residence was further explored by the analysis of the geodemographic profiles of the motor vehicle drivers. For a full explanation of the application of the Acorn geodemographic profiles to the motor vehicle drivers see chapter six.

7.3.2 Descriptive Statistics Methodology

Descriptive statistics were used to present the age and gender distributions of the motor vehicle drivers. All the motor vehicle drivers involved in the collisions were explored, followed by a focus on the motor vehicle drivers who were resident in Cambridgeshire at the time of the collision. The descriptive statistics explored if there are differences in the distribution of attributes between the groups of motor vehicle drivers stratified by collision injury severity, and motor vehicle driver culpability to explore hypothesis one, the distributions are presented in either graphical or tabular form as appropriate. There are two demographic variables for each of the motor vehicle drivers in the data,

The age distribution of the motor vehicle drivers, as recorded in STATS19 are presented in summary form with median and inter quartile range. Histograms of the age distribution, as well as five and ten year age groups, are presented appendix 12.

The gender distribution for all motor vehicle drivers and Cambridgeshire resident motor vehicle drivers differentiated by collision injury severity and motor vehicle driver culpability are presented as frequencies and percentages.

The distribution of the IMD decile, see section 2.9.1, in which the home address of the motor vehicle driver falls for all motor vehicle drivers and Cambridgeshire resident motor vehicle drivers differentiated by collision injury severity and motor vehicle driver culpability are presented as frequencies and percentages.

7.3.2.1 Geodemographic analysis

The geodemographic profile distribution within the Cambridgeshire resident motor vehicle driver subset was explored. Geodemographics were introduced in section 2.10 with an examination of the Acorn geodemographic profiling in section 6.1. Three layers of granularity were previously explored, see section 6.1. However, in this section only the two coarser layers, Acorn Category and Acorn Group as Acorn type was dealt with using the risk index, described in section 7.3.6.1. The groups were examined, and distributions presented as histograms of frequency within the two layers represented by Acorn categories and Acorn groups as well as differentiated by collision injury severity, motor vehicle driver culpability and motor vehicle driver residence.

7.3.3 Statistical Testing Methodology

The age, gender and geodemographic characteristics of study participants in the different groups outlined in figure two and three were compared. Additionally, these groups were stratified and analysed separately for the Cambridgeshire resident motor vehicle drivers.

7.3.3.1 Motor vehicle driver age distribution analysis

Hypothesis one: comparison of the age distributions between motor vehicle driver groups were explored using, analysis of variance (ANOVA) (Fisher, 1925; Levy, 1978) and effect size analysis (Kolmogorov, 1933; Wilcoxon, 1945; Mann and Whitney, 1947; Smirnov, 1948; Cohen, 1962; Lehmann and D'Abrera, 1975; Peacock, 1983; Fasano and Franceschini, 1987; Wilcox, 1995).

The assumptions to use ANOVA are that the distribution was normal and that there was equality of variance (heteroskedasticity) between groups (Wilcox, Charlin and Thompson, 1986). If there were assumption breaches these were overcome by the use of Welch's ANOVA or the W test (Wilcox, Charlin and Thompson, 1986; Mitchell, 2014; 2019) which takes account of unequal variance and unequal means across motor vehicle driver groups and minimises type one error (Levy, 1978).

The motor vehicle driver age distributions were examined for normality. Normality was tested using the Shapiro-Wilk (S-W) test (Yap and Sim, 2011). The test was assessed using the $p < .05$ threshold for rejection of the null hypothesis for this test, that the test sample came from a normally distributed population.

The second ANOVA assumption that was tested was equal variance across samples. If this assumption was violated this can increase the instance of type one error. If equal variances are not found Levene's test was conducted (Levene, 1960; Brown and Forsythe, 1974), the test with alternative estimators (Brown and Forsythe, 1974) was also conducted to determine heteroskedasticity (Baum, 2006; Stata.com, 2014; 2019). The Levene test statistic has the hypothesis that variance between the samples was not equal. Levene's robust test statistic was reported as (W_0) with the Brown and Forsythe (1974) alternatives of median replacing mean reported as (W_50) and the 10 percent trimmed mean reported as (W_10). Result values of $p < .05$ allow for rejection of the null hypothesis that the variances are equal.

The use of Cohen's *d* to measure the effect size (ES) between group means (Cohen, 1962) can indicate differences between groups by considering the difference in the group means standardised to units of standard deviation (SD). Unfortunately, both mean and SD are affected by non-normal distributions, this includes distributions with a skew or heavy tail and also the presence of outliers. The normality of the motor vehicle driver group age distribution data was examined, and Cohen's *d* could therefore be used to compare ES between some motor vehicle driver groups where both have a normal distribution. However, as it cannot be used for all the combinations more robust tests were used. Alternative, more robust, tests are available which can be used for combinations including groups with a multi-modal distributions or non-normal distribution, the Kolmogorov-Smirnov (K-S) test and the Mann-Whitney (M-W) (also called the Wilcoxon test) rank sum test were used to test all such combinations. The K-S test has more power to detect changes in shape of distributions but less power than the M-W test in relation to shifts in median (Lehmann and D'Abrera, 1975).

The K-S test, being independent of the shape of distribution and not limited to central tendency was used to test the similarity of the distributions between the motor vehicle driver groups stratified by motor vehicle driver culpability and collision injury severity (Kolmogorov, 1933; Smirnov, 1948; Peacock, 1983; Fasano and Franceschini, 1987). The K-S test null hypothesis being that the two samples have identical distributions and tests for violations such as different medians, different variances and different distributions and produces the *D* statistic. A low *p* value of <.05 indicates that the populations are different.

The M-W rank sum test, a non-parametric test, examines the means of the ranks of the two samples. The M-W test null hypothesis being that the distributions of both groups are identical, and the test produces a *z* statistic. A low *p* value of <.05 indicates that the populations are distinct (Wilcoxon, 1945; Mann and Whitney, 1947; Lehmann and D'Abrera, 1975; Wilcox, 1995).

7.3.3.2 Motor vehicle driver gender distribution analysis

The second variable tested for hypothesis one was gender. The distribution of the gender in STATS19 allowed for three options, as set out at the beginning of the chapter the unknown category represent n=8 or 1.2 percent of the population.

The comparison between gender in groups was undertaken using Pearson's Chi Squared test or χ^2 , where the assumptions for this test were met (Pearson, 1900; Fisher, 1922).

For Pearson's χ^2 there was an assumption of independent errors, with the statistic based on the assumption that the categories are independent. This means that each entity only presents in one of the cells in any associated contingency table. Also, for any given two by two contingency table any particular expected frequency should not be below five. For larger tables all expected frequencies should be greater than one with no more than 20 percent having an expected frequency less than five. If the expected frequencies are below these thresholds, then the test statistic has poor power to detect relationships (Howell, 2010). If these assumptions are not met, the Fisher's exact test (Fisher, 1922) was used instead.

To examine the motor vehicle driver gender two by two, two-way tables of association were created. The tables present expected frequencies and χ^2 results (Acock, 2016).

The χ^2 test hypothesis being that there was a relationship between the data tested with results of $p > .05$ indicate that the null hypothesis that there was no relationship cannot be rejected.

7.3.4 Logistic Regression

Logistic regression was used to evaluate the impact of independent variables within the sample on the two binary outcomes,

i) the culpability of the motor vehicle driver, being culpable or contributory compared to be non-culpable, see section 7.3.1,

ii) being involved in a fatal injury collision compared to being involved in a MAIS3+ injury collision, and hence identify any differences in impact to evaluate hypotheses one.

The variables examined are those that relate directly to the motor vehicle driver, rather than to the circumstances of the collision as these would have an impact all the motor vehicle drivers involved. These analyses were conducted using Cambridgeshire resident motor vehicle driver subset in addition to all the motor vehicle drivers in the sample.

The logistic regression requires a number of assumptions to be met, these being; the outcomes are independent, the requirement in relation to continuous independent variables of them having a linear relationship with their respective logit-transformed outcome; an absence of multicollinearity amongst independent variables; an absence of strongly influential outliers and finally a sample size requirement in relation to the variables examined. (Peng, Lee and Ingersoll, 2002; Stoltzfus, 2011).

The outcomes are independent with no duplicate responses, so the first assumption was met. The independent variables available for the motor vehicle driver were.

- gender.
- age (categorised as 10 year categories rather than individual year groups due to the low frequencies in the individual years groups).
- the vehicle they were driving (categorised as; motorcycles; cars; Passenger Carrying Vehicles (PCVs): agricultural vehicles; and goods vehicles rather than initial STATS19 categories).
- the purpose of the journey.
- the IMD decile from the 2011 Census (The Department for Communities and Local Government, 2015; UK Data Service, 2017; Ministry of Housing Communities and Local Government, 2019) of their home address (the lower the index the more deprived, i.e. index 1 are the most deprived 10 percent of households).
- the Acorn category (CACI Limited, 2014) of the home address were analysed, the Acorn category is used in preference to Acorn type due to the low frequencies exhibited in some of the individual types.

None of these independent variables are continuous, so the second assumption was met. There was multicollinearity or redundancy in the independent variables between the IMD variable and the Acorn category variable. This occurred as both variables are constructs which take into account socio-economic data, therefore in the analysis each of these variables is dealt with as part of the mutual adjustment separately. There were no strong outliers present, and six variables were examined giving an observation to predictor ratio, even for the variable with the lowest frequency in those examined in excess of the 10 to one recommended and hence the remaining assumptions were met (Peng, Lee and Ingersoll, 2002; Stoltzfus, 2011).

The regression took the form of univariable analysis and then mutually adjusted analysis with the remaining variables. In all cases the most frequent category within each variable was used as the reference category and results are presented as Odds Ratios (OR) with 95 percent confidence Interval (CI) values and exact *p* value.

However, the logistic regression only explores the relationships between the variables within the sample and not with the wider population of Cambridgeshire and is, therefore, not directly comparable with the geodemographic distribution analysis and risk evaluation described in sections 7.3.5 and 7.3.6.

7.3.5 Risk of Motor Vehicle Drivers Being Involved in a Fatal or MAIS3+ Collision

Consideration was given to how to analyse how the risk, as a motor vehicle driver, of being in the fatal and MAIS3+ collision sample relates to the general population of Cambridgeshire. The relationship in the risk of one group of subjects compared to another can be expressed using a risk ratio, odds ratio or risk index, however, the lack of population based data relating to motor vehicle drivers meant it was not possible to explore population-based risk ratio or odds ratio. The relationship between the sample groups and the general population of Cambridgeshire was explored using geodemographics and risk index, as the geodemographic profiles of the motor vehicle drivers was determined as was the distribution of the geodemographic profiles within the general population of Cambridgeshire.

7.3.5.1 Risk Index

The use of indexation to present data in a road safety context was explored in section 2.11. The method can be used in relation to a ratio and was a technique used within geodemographic analysis, in a number of contexts, to present the relationship between a particular sub-population and the whole population (Anderson, 2005; 2010; Ashby and Longley, 2005; Farr, Wardlaw and Jones, 2008; CACI Limited, 2014; Quddus, 2015; Loo and Anderson, 2016). It was also used in road safety research to represent relationships relative to a baseline or standard (Cerrelli, 1973; Warren *et al.*, 1981; Janke, 1991; Blatt and Furman, 1998; Anderson, 2005; University of Leicester, 2005; Biecheler *et al.*, 2008; Department for Transport, 2012b; 2018b; Quddus, 2015; International Transport Forum, 2017), although in one case were the ratio was reported unindexed it was still described as an index in the text (West and Hall, 1997). The method has also been used to report other societal based information, such as, annual numbers of arrests by age group (Home Office, 2018). The index can be represented with a central position either a one or 100.

The risk index used in this analysis uses a central position score of 100, as used in previous research relating to analysis of collisions and public service delivery (Anderson, 2005; Ashby and Longley, 2005). The motor vehicle driver groups, differentiated by collision injury severity, motor vehicle driver culpability and motor vehicle driver residence, presented during the chapter are maintained, however, in the explanation of how the index was calculated they are referred to as sub-populations for ease of use.

The risk index was calculated by first determining the proportion of the Acorn type being examined in the total of Acorn types within the geographically defined population, in this analysis this was the general population of Cambridgeshire, however, the equation was applicable to any population, see figure 7.4 below.

$$Acorn\ type\ population\ proportion\ = \frac{Acorn\ type\ frequency\ in\ the\ population}{Total\ Acorn\ types\ present\ in\ the\ population}$$

Figure 7.4 Acorn type population proportion equation

The expected frequency for each Acorn type within a sub-population can then be calculated by multiplying the population proportion by the size of the sub-population, see figure 7.5 below.

$$Expected\ frequency\ in\ the\ sub-population$$
$$= Acorn\ type\ population\ proportion\ \times Sub-population\ size$$

Figure 7.5 Expected frequency in sub-population equation

The risk index was produced by dividing the actual number of the particular Acorn type in the sub-population by the expected frequency in the sub-population and multiplying this by 100, see figure 7.6 below.

$$Risk\ index = \frac{Actual\ Acorn\ type\ frequency\ in\ the\ sub-population}{Expected\ Acorn\ type\ frequency\ in\ the\ sub-population} \times 100$$

Figure 7.6 Risk index equation

Scores over 100 show over-representation of the Acorn type in the sub-population compared to the whole population. The score works as a ratio so scores of 200 show there are twice as many in the sub-population as the distribution in the population would predict, 300 was three times and so on. Scores below 100 work in a similar way with scores of 50 indicating half the frequency in the sub-population that the distribution in the population would predict, scores of 25 indicate a quarter and so on. Therefore, the higher the risk index the more over-represented the Acorn type was in the motor vehicle driver data.

The analysis was presented as bar graphs to allow visual comparison. The index central position of 100 was represented on the y axis at the intersection with the x axis and this was the level at which the frequency in the sub-population matches that of the expected frequency, or, there are as many present in the sub-population as the distribution in the whole population would predict.

The graphs represent the Acorn type in the numerical form, for full Acorn type descriptions see appendix 11, and the top ten types by frequency are presented for each sub-population, the most frequent on the left of the x axis descending to the tenth most frequent on the right. For each motor vehicle driver group presented the total number of Acorn types within the motor vehicle driver group, the proportion of the sub-population presented by the top ten types by frequency and the Acorn type which represents the highest risk index, and hence be the most over-represented of the Acorn types in the top ten, was noted.

7.3.5.2 Acorn Type Contributory Factor Analysis

To facilitate the application of interventions to the Acorn types identified in the risk index analysis, the distribution of the contributory factors applicable to the motor vehicle drivers who reside within the Acorn types was explored. To give an indication of the manner of distribution the three most frequent Acorn types identified in the culpable and contributory drivers group for both fatal and MAIS3+ collisions were selected for analysis. The analysis shows the contributory factor distribution within each of the Acorn types and also the distribution across all three of the types.

7.4. Results

7.4.1 Motor Vehicle Driver Related Demographic Descriptive Statistics

7.4.1.1 Motor vehicle driver age descriptive statistics

The age distribution of the sample population was initially examined using histograms plotting the frequency of each age represented, the ages in five year groups and 10 year groups to visually assess the normality of the distribution, the histograms are presented in appendix 12.

The age distributions for the groups containing all motor vehicle drivers, Cambridgeshire resident motor vehicle drivers regardless of culpability, Cambridgeshire resident culpable and contributory motor vehicle drivers involved in fatal collisions and Cambridgeshire resident culpable and contributory motor vehicle drivers involved in MAIS3+ collisions all followed a similar non-normal positively skewed bi- or multi- modal distribution. The non-culpable motor vehicle driver age distribution was different, the distribution does not display any bi or multi-modal tendency or skew and for the 10-year age groups appears unimodal. It did not present as a classic bell shape which would clearly indicate a normal distribution but equally does not present clearly as a non-normal distribution, the normality of this distribution was confirmed in section 7.4.3.

For each of the groups the median and interquartile range (IQR) are presented below in table 7.4.

Table 7.4 Age distribution median and Interquartile range

Motor vehicle driver group	**Age (median/ IQR)**

All motor vehicle drivers present within the dataset	42/ 28.5-54
All motor vehicle drivers, fatal collisions	42/ 29-54
All motor vehicle drivers, MAIS3+ collisions	43/ 28-54
Culpable and contributory motor vehicle drivers within the dataset	40/ 27-52
Culpable and contributory motor vehicle drivers, fatal collisions	39/ 27-51
Culpable and contributory motor vehicle drivers MAIS3+ collisions	42/ 27-53
Non-culpable motor vehicle drivers within the dataset	45/ 33-55
Non-culpable motor vehicle drivers, fatal collisions	44/ 33-56
Non-culpable motor vehicle drivers, MAIS3+ collisions	46.5/ 34-54
Cambridge resident motor vehicle drivers within the dataset	41/ 28-54
Cambridge resident motor vehicle drivers within the dataset involved in fatal collisions	38/ 28-52
Cambridge resident motor vehicle drivers within the dataset involved in MAIS3+ collisions	42/ 28-55
Cambridge resident culpable and contributory motor vehicle drivers within the dataset	41/ 27.5-54.5
Cambridge resident culpable and contributory motor vehicle drivers, fatal collisions	35.5/ 27-50
Cambridge resident culpable and contributory motor vehicle drivers, MAIS3+ collisions	42/ 28-55
Cambridge resident non-culpable motor vehicle drivers within the dataset	42/ 30-53
Cambridge resident non-culpable motor vehicle drivers, fatal collisions	40/ 31-52
Cambridge resident non-culpable motor vehicle drivers, MAIS3+ collisions	42/ 30-53

The normality of all the group combinations was tested, see section 7.3.3.1 for methodology and 7.4.3.1 for results.

7.4.1.2 Motor vehicle driver gender descriptive statistics

The gender distribution within all motor vehicle driver groups are presented in table 7.5 below.

Table 7.5 Gender distribution proportions

Population	Male	Female
All motor vehicle drivers, n (%)	506 (77.6)	146 (22.4)
All Cambridgeshire resident motor vehicle drivers, n (%)	280 (75.5)	91 (24.5)
Cambridgeshire resident culpable and contributory motor vehicle drivers, fatal and MAIS3+ collisions, n (%)	192 (75.3)	63 (24.7)
Cambridgeshire resident culpable and contributory motor vehicle drivers, fatal collisions, n (%)	62 (74.7)	21 (25.3)
Cambridgeshire resident culpable and contributory motor vehicle drivers, MAIS3+ collisions, n (%)	130 (75.6)	42 (24.4)
Cambridgeshire resident non-culpable motor vehicle drivers, fatal and MAIS3+ collisions, n (%)	84 (75.0)	28 (25.0)
Cambridgeshire resident non-culpable motor vehicle drivers, fatal collisions, n (%)	44 (81.5)	10 (18.5)
Cambridgeshire resident non-culpable motor vehicle drivers, MAIS3+ collisions, n (%)	40 (69.0)	18 (31.0)

The distribution was similar within all groups presented with male motor vehicle drivers three times as likely to be involved than female motor vehicle drivers.

7.4.1.3 Motor vehicle driver IMD descriptive statistics

The IMD distribution within all motor vehicle driver groups are presented in table 7.6 below.

Table 7.6 IMD distribution proportions

Population	IMD decile									
	1 (Most deprived)	2	3	4	5	6	7	8	9	10 (least deprived)
Cambridgeshire resident population %	3.1	8.3	5.6	6.6	10.4	13.8	13.6	14.4	12.5	11.8
All motor vehicle drivers, n (%)	23 (4.0)	48 (8.4)	44 (7.7)	48 (8.4)	81 (14.1)	77 (13.4)	63 (11.0)	64 (11.1)	72 (12.5)	55 (9.6)
All Cambridgeshire resident motor vehicle drivers, n (%)	13 (3.5)	30 (8.1)	16 (4.3)	29 (7.8)	55 (14.8)	51 (13.8)	42 (11.3)	49 (13.2)	48 (13.0)	38 (10.2)
Cambridgeshire resident culpable and contributory motor vehicle drivers, fatal and MAIS3+ collisions, n (%)	12 (4.7)	15 (5.9)	9 (3.5)	20 (7.8)	35 (13.7)	41 (16.1)	29 (11.4)	36 (14.1)	31 (12.2)	27 (10.6)
Cambridgeshire resident culpable and contributory motor vehicle drivers, fatal collisions, n (%)	3 (3.6)	5 (6.0)	5 (6.0)	10 (12.1)	15 (18.1)	15 (18.1)	8 (9.6)	10 (12.1)	7 (8.4)	5 (6.0)
Cambridgeshire resident culpable and contributory motor vehicle drivers, MAIS3+ collisions, n (%)	9 (5.2)	10 (5.8)	4 (2.3)	10 (5.8)	20 (11.6)	26 (15.1)	21 (12.2)	26 (15.1)	24 (14.0)	22 (12.8)
Cambridgeshire resident non-culpable motor vehicle drivers, fatal and MAIS3+ collisions, n (%)	1 (0.9)	12 (10.7)	7 (6.3)	9 (8.0)	19 (17.0)	10 (8.9)	13 (11.6)	13 (11.6)	17 (15.8)	11 (9.8)
Cambridgeshire resident non-culpable motor vehicle drivers, fatal collisions, n (%)	1 (1.9)	6 (11.1)	2 (3.7)	5 (9.3)	9 (16.7)	4 (7.4)	7 (13.0)	9 (16.7)	8 (14.8)	3 (5.6)
Cambridgeshire resident non-culpable motor	0 (0.0)	6 (10.3)	5 (8.6)	4 (6.9)	10 (17.2)	6 (10.3)	6 (10.3)	4 (6.9)	9 (15.5)	8 (13.8)

vehicle drivers, MAIS3+ collisions, n (%)										

These distributions show that the motor vehicle drivers involved in the collisions in Cambridgeshire were not evenly distributed across the IMD deciles with more motor vehicle drivers coming from the less deprived end of the scale, although this was less pronounced for the culpable and contributory Cambridgeshire resident motor vehicle drivers involved in fatal collisions.

7.4.1.4 Geodemographic analysis

For the geodemographic profile analysis, the motor vehicle drivers who were resident in Cambridgeshire at the time of the collision were explored as these were the motor vehicle driver which could be subject to local targeted application of interventions.

This section presented the results of the methods described in section 7.3.2. Each of the motor vehicle drivers represented in the data for which a valid home postcode was available also had the corresponding Acorn geodemographic profile appended to their record, see sections 6.4.1 for the postcode validation and 6.4.3 and 6.4.4 for the mapping of the Acorn geodemographic profiles to the valid postcodes. Of the motor vehicle drivers in the sample 86.1 percent had a valid postcode and all but two of the valid postcodes had a corresponding Acorn geodemographic profile (n=566). The profile contained all three layers of granularity and the profile type description, section 2.10, 6.1 and see appendix 11.

The three Acorn levels of granularity available relating to motor vehicle drivers in the sample with a valid postcode are recorded in the following variables presented in table 7.7 below.

Table 7.7 Categorical variables relating to the motor vehicle driver and descriptions

Variable name	Contents description
acorn_category	Acorn geodemographic category, this being the coarsest level of granularity with 6 categories.
acorn_group	Acorn geodemographic group, this being the mid-level of granularity with 18 groups.
acorn_type	Acorn geodemographic type, this being the finest level of granularity with 62 types.

The distribution of the coarsest level of granulation among the motor vehicle drivers who were resident in Cambridgeshire at the time of the collisions, where the population was segmented into the six Acorn categories, are presented below in figure 7.7.

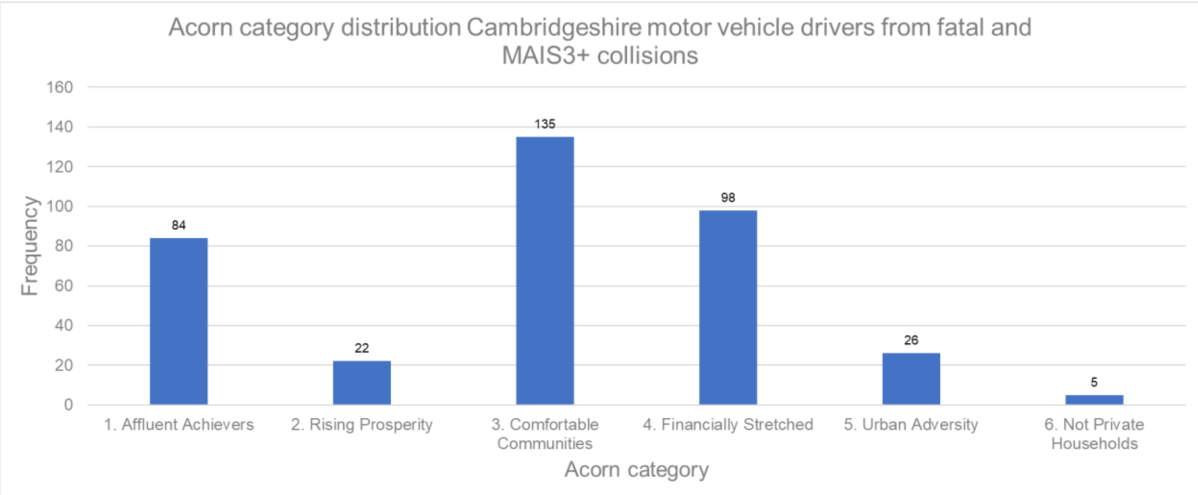

Figure 7.7 Acorn category distribution of Cambridgeshire motor vehicle drivers involved in fatal and MAIS3+ collisions

The same analysis can be undertaken within motor vehicle driver groups. For each of the six Acorn categories the relative distributions within the motor vehicle driver groups differentiated by collision injury severity, motor vehicle driver culpability and residence show the same pattern of distribution as that displayed in the whole sample above. In that for each motor vehicle driver group the order of most frequent to least remains the same, i.e. Comfortable communities being the most frequent, followed by Frequently Stretched, Affluent Achievers, Urban Adversity, Rising Prosperity and finally Not Private Households (with the one exception for Cambridgeshire MAIS3+ culpable and contributory motor vehicle drivers, Frequently Stretched and Affluent Achievers are transposed), see figure 7.8 below.

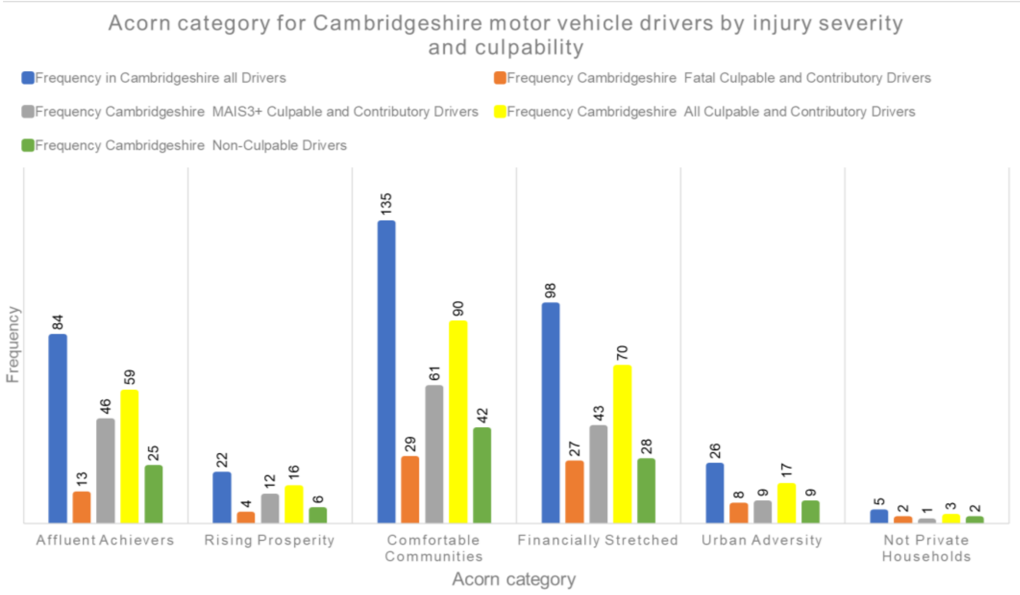

Figure 7.8 Acorn category for Cambridgeshire motor vehicle drivers by collision injury severity and motor vehicle driver culpability

The distribution of the middle granularity of segmentation, Acorn groups, within the population where the population are divided into 18 categories are presented below. It should be noted that the count of Acorn groups are not evenly distributed between categories. The frequency distribution of Acorn groups within all the motor vehicle drivers involved in both injury severity category collisions are presented in figure 7.9 below.

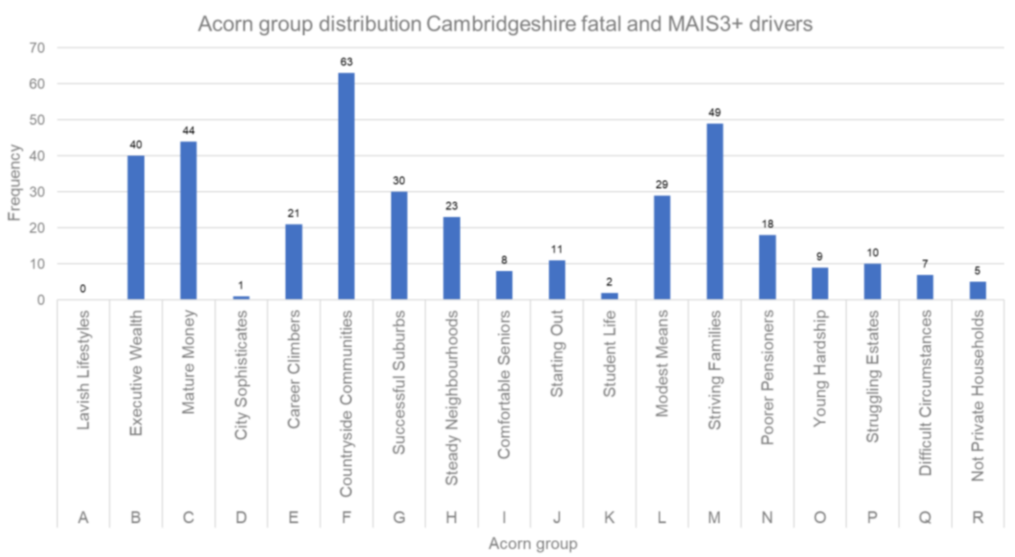

Figure 7.9 Acorn group distribution of Cambridgeshire motor vehicle drivers involved in fatal and MAIS3+ collisions

The distribution of the finest level of granularity, Acorn type, of which there are 62 being dealt with in the section 7.3.9. In this section the geodemographic profiles relating to the motor vehicle drivers who were resident in Cambridgeshire at the time of the collisions being combined with the profile distribution within the general population of Cambridgeshire to produce a risk index.

7.4.2 Motor Vehicle Driver Demographic Data Distribution Statistical Testing

In this section the age distributions and gender distributions are subject to statistical testing.

7.4.2.1 Motor vehicle drive age distribution statistical testing

This section presented the results of the methods described in section 7.3.3.1. The S-W normality test was applied to the age distribution of the motor vehicle drivers differed by collision injury severity, motor vehicle driver culpability and motor vehicle driver residence. This showed that the distributions for 'all driver' motor vehicle driver groups and the culpable and contributory motor vehicle driver groups as well as the non-culpable motor vehicle drivers within the whole dataset produce results with values of $p < .05$ allowing for the rejection of the null hypothesis that the distribution was normal. However, the non-culpable motor vehicle divers within the two collision injury classification groups and all the non-culpable motor vehicle driver groups residing within Cambridgeshire produced results $p > .05$ and can be considered to have a normal distribution as the null hypothesis that the distribution was normal cannot be rejected. See appendix 12, table one for the tabulated results.

In the first stage of testing the heteroskedasticity between groups differentiated by motor vehicle driver culpability category the Levene's tests including the alternative parameters. This test produced results of $p < .05$ for 13 of the 18 tests allowing for the null hypothesis to be rejected and the variance was not equal. The remaining five tests produced results $p > .05$ with the null hypothesis not rejected and equality of variance was evident. The groups represented in these five tests were the comparison of the culpable and contributory against non-culpable motor vehicle drivers in the Cambridgeshire MAIS3+ motor vehicle drivers for all three tests and the two alternative tests for the comparison of culpable and contributory motor vehicle drivers against non-culpable motor vehicle drivers in the motor vehicle drivers involved in fatal collisions. See appendix 12, table two for the tabulated results.

In the second stage the heteroskedasticity was tested between groups differentiated by collision injury severity category. All combinations of motor vehicle driver groups tested produced results $p > .05$ therefore, the null hypothesis was not rejected. See appendix 12, table three for the tabulated results.

The results for normality and heteroskedasticity allow for the use of Fisher's ANOVA for some motor vehicle driver group combinations but not for others. Where the assumptions were shown to have been breached Welch's ANOVA or the W test was used. The Fisher's ANOVA assumptions were breached in 13 of the 18 motor vehicle driver groups combinations requiring the use of the W test. The five motor vehicle driver groups combinations where Fisher's ANOVA could still be applied were the non-culpable motor vehicle drivers differentiated by collision injury severity category from the sample and the Cambridgeshire resident non-culpable motor vehicle drivers in their entirety or differentiated by collision injury severity. See appendix 12, table four for the tabulated results.

The appropriate test for each motor vehicle driver groups categorical combination was undertaken, either Fisher's ANOVA or the W test, in all cases the result of $p > .05$ indicated that there was no significant difference in variance within age distributions across all the combinations of motor vehicle driver groups available within the data. See appendix 12, table five for the tabulated results.

The results of applying the K-S test and M-W test to the motor vehicle driver categories show the results for both tests are consistent and that there are significant differences, $p < .05$, between the age distributions of motor vehicle drivers by culpability category in support of hypotheses one, however, with a $p > .05$ between the collision injury severity categories hypotheses one was not supported. See appendix 12, table six for the tabulated results.

7.4.2.2 Motor vehicle drive gender distribution statistical testing

This section presented the results of the methods described in section 7.3.3.2. The data complies with the assumptions required for χ^2 testing (McHugh, 2012). In this analysis of the gender distributions between and within motor vehicle driver groups all expected frequencies were above five. The results of the testing using two-way table of association comparing motor vehicle driver groups differentiated by collision injury severity, motor vehicle driver culpability and motor vehicle driver residence were that the χ^2 result gave $p > .05$ in all cases and therefore the null hypothesis that there was no relationship was not rejected in this case and the gender distributions are not significantly different and hypotheses one was not supported. See appendix 12, table seven for the tabulated results.

7.4.3 Logistic Regression

This section presents the results of the logistic regression. Culpability in all motor vehicle drivers, culpable and contributory compared to non-culpable within the sample, are presented in tables 7.8 and 7.9 below. Note that the univariable results for gender, age, vehicle type and journey purpose are the same in both tables but are reproduced.

Table 7.8 presents the logistic regression results exploring the culpability of the motor vehicle drivers incorporating the IMD variable.

Table 7.8 Logistic regression result for culpability, culpable or contributory compared to non-culpable, within all the motor vehicle drivers in the sample, mutually adjusted including IMD

Variable	**Univariable**		**Mutually adjusted n=557**	
	OR (95% CI)	*p* value	OR (95% CI)	*p* value
Gender (univariable n=648)				
Male	1		1	
Female	0.86 (0.58 - 1.26)	.440	0.75 (0.47 - 1.22)	.250
Age (univariable n=640)				
<26	2.37 (1.35 - 4.16)	.003	2.05 (1.07 - 3.92)	.030
26-35	1.44 (0.87 - 2.39)	.155	1.22 (0.68 - 2.18)	.501
36-45	1.03 (0.62 - 1.71)	.912	1.08 (0.59 - 1.98)	.799
46-55	1		1	
56-65	0.85 (0.48 - 1.50)	.574	0.81 (0.42 - 1.57)	.540
66-75	0.82 (0.40 - 1.68)	.583	0.72 (0.31 - 1.67)	.448
76-85	6.01 (1.35 - 26.80)	.019	10.40 (1.31 - 82.57)	.027
>85	4.43 (0.53 - 36.95)	.008	Empty	
Vehicle type (univariable n=653)				
Motorcycles	2.99 (1.64 - 5.45)	.000	3.39 (1.72 - 6.64)	.000
Cars	1		1	
PCVs	1.74 (0.36 - 8.50)	.491	1.90 (0.39 - 10.67)	.466
Agricultural Vehicles	0.20 (0.04 - 1.04)	.056	0.10 (0.01 - 1.04)	.054
Goods vehicles	0.43 (0.28 - 0.67)	.000	0.53 (0.28 - 1.00)	.052
Purpose of the journey (univariable n=656)				
Journey as part of work	0.48 (0.32 - 0.71)	.000	0.71 (0.39 - 1.27)	.244
Commuting to/from work	0.73 (0.44 - 1.22)	.234	0.92 (0.52 - 1.63)	.769
Taking pupil to/from school	0.76 (0.07 - 8.48)	.824	0.55 (0.03 - 10.08)	.684
Other	1		1	
Not known	0.48 (0.26 - 0.87)	.015	0.48 (0.19 - 1.19)	.113

Index of Multiple Deprivation (decile) (univariable n=571)				
1 (most deprived)	3.21 (0.87 - 11.78)	.079	4.86 (1.24 - 19.03)	.023
2	0.60 (0.28 - 1.28)	.185	0.61 (0.27 - 1.38)	.238
3	0.76 (0.36 - 1.65)	.493	0.88 (0.39 - 2.03)	.773
4	0.96 (0.45 - 2.06)	.923	0.97 (0.43 - 2.20)	.947
5	1		1	
6	1.37 (0.69 - 2.74)	.370	1.49 (0.70 - 4.88)	.297
7	1.04 (0.51 - 2.10)	.924	1.16 (0.53 - 3.18)	.716
8	1.44 (0.69 - 3.01)	.326	1.25 (0.57 - 2.73)	.579
9	0.76 (0.39 - 1.47)	.412	0.69 (0.33 - 1.41)	.305
10 (least deprived)	0.84 (0.41 - 1.73)	.642	0.92 (0.42 - 2.03)	.843

The analysis presented in Table 7.8 indicates a number of significant results. Motor vehicle drivers under 26 years of age within the sample are 2.06 (p = .030) times more likely to be culpable or contributory than non-culpable for the collision they are involved in compared to the most frequent age group (46-55 years old). Motor vehicle drivers in the 76-85 year age group within the sample are 10.40 (p = .027) times more likely to be culpable or contributory than non-culpable for the collision they are involved in compared to the most frequent age group (46-55 years old). Motor vehicle drivers of motorcycles within the sample are 3.39 (p = .000) times more likely to be culpable or contributory than non-culpable for the collision they are involved in compared to the most frequent vehicle category (cars). The drivers of both agricultural vehicles and goods vehicles are less likely to be culpable or contributory than non-culpable at a probability close to significance, 0.10 (p = .054) and 0.53 (p = .052) respectively. Motor vehicle drivers who reside at an address designated as within IMD category one (most deprived) within the sample are 4.86 (p = .023) times more likely to be culpable or contributory than non-culpable for the collision they are involved in compared to the most frequent vehicle category (IMD category five).

Table 7.9 presents the logistic regression results exploring the culpability of the motor vehicle drivers incorporating the Acorn category variable.

Table 7.9 Logistic Regression result for culpability, culpable or contributory compared to non-culpable, within all the motor vehicle drivers in the sample, mutually adjusted including Acorn Category

Variable	**Univariable**		**Mutually adjusted n=549**	
	OR (95% CI)	*p* value	OR (95% CI)	*p* value
Gender (univariable n=648)				
Male	1		1	
Female	0.86 (0.58 - 1.26)	.440	0.71 (0.44 - 1.13)	.149
Age (univariable n=640)				
<26	2.37 (1.35 - 4.16)	.003	2.23 (1.16 - 4.26)	.016
26-35	1.44 (0.87 - 2.39)	.155	1.23 (0.69 - 2.19)	.474
36-45	1.03 (0.62 - 1.71)	.912	1.20 (0.66 - 2.20)	.548
46-55	1		1	
56-65	0.85 (0.48 - 1.50)	.574	0.91 (0.47 - 1.76)	.783
66-75	0.82 (0.40 - 1.68)	.583	0.87 (0.38 - 1.97)	.731
76-85	6.01 (1.35 - 26.80)	.019	12.54 (1.58 - 99.38)	.017
>85	4.43 (0.53 - 36.95)	.008	Empty	
Vehicle type (univariable n=653)				
Motorcycles	2.99 (1.64 - 5.45)	.000	3.36 (1.71 - 6.62)	.000
Cars	1		1	
PCVs	1.74 (0.36 - 8.50)	.491	2.04 (0.36 - 11.41)	.419
Agricultural Vehicles	0.20 (0.04 - 1.04)	.056	0.10 (0.01 - 0.93)	.043
Goods vehicles	0.43 (0.28 - 0.67)	.000	0.54 (0.29 - 1.03)	.063
Purpose of the journey (univariable n=656)				
Journey as part of work	0.48 (0.32 - 0.71)	.000	0.82 (0.46 - 1.47)	.506
Commuting to/from work	0.73 (0.44 - 1.22)	.234	0.87 (0.49 - 1.54)	.641
Taking pupil to/from school	0.76 (0.07 - 8.48)	.824	0.46 (0.03 - 8.42)	.604
Other	1		1	
Not known	0.48 (0.26 - 0.87)	.015	0.42 (0.17 - 1.08)	.074
Acorn Category (univariable n=563)				
1	1.01 (0.63 - 1.61)	.974	0.80 (0.48 - 1.33)	.381
2	1.20 (0.52 - 2.76)	.662	1.11 (0.46 - 2.69)	.821
3	1		1	
4	1.17 (0.74 - 1.86)	.492	1.13 (0.68 - 1.86)	.637
5	0.93 (0.48 - 1.79)	.821	0.94 (0.46 - 1.90)	.856
6	0.98 (0.18 - 5.52)	.986	0.59 (0.09 - 4.13)	.599

The analysis presented in Table 7.9 indicates a number of significant results. Motor vehicle drivers under 26 years of age within the sample are 2.23 (p = .016) times more likely to be culpable or contributory than non-culpable for the collision they are involved in compared to the most frequent age group (46-55 years old). Therefore, the results for this age group are consistent regardless of the socio-economic/geodemographic variable explored. Motor vehicle drivers in the 76-85 year age group within the sample are 12.54 (p = .017) times more likely to be culpable or contributory than non-culpable for the collision they are involved in compared to the most frequent age group (46-55 years old). Therefore, the results for this age group are consistent regardless of the socio-economic/geodemographic variable explored. Drivers of motorcycles within the sample are 3.36 (*p* = .000) times more likely to be culpable or contributory than non-culpable for the collision they are involved in compared to the most frequent vehicle category (cars). Therefore, the results for motorcycles are consistent regardless of the socio-economic/geodemographic variable explored. Drivers of agricultural vehicles within the sample are 0.10 (*p* = .043) times more likely to be culpable or contributory than non-culpable for the collision they are involved in compared to the most frequent vehicle category (cars). Therefore, the results for agricultural vehicles are consistent regardless of the socio-economic/geodemographic variable explored. The drivers of goods vehicles are less likely to be culpable or contributory than non-culpable at a probability close to significance, 0.54 (*p* = .063). Therefore, the results for goods vehicles are consistent regardless of the socio-economic/geodemographic variable explored.

Culpability in the Cambridgeshire resident motor vehicle drivers in the sample, including the IMD variable are presented in table 7.10 below.

Table 7.10 Logistic Regression results for culpability, culpable or contributory compared to non-culpable, within the Cambridgeshire resident motor vehicle drivers in the sample, mutually adjusted including IMD

Variable	**Univariable**		**Mutually adjusted (n=349)**	
	OR (95% CI)	*p* value	OR (95% CI)	*p* value
Gender (univariable n=367)				
Male	1		1	
Female	0.98 (0.59 - 1.65)	.952	1.04 (0.57 - 1.90)	.904
Age (univariable n=355)				
<26	2.34 (1.09 - 5.04)	.030	1.54 (0.64 - 3.68)	.330
26-35	1.21 (0.61 - 2.42)	.580	1.05 (0.49 - 2.27)	.899
36-45	1.02 (0.50 - 2.06)	.963	0.78 (0.35 - 1.75)	.549
46-55	1		1	
56-65	1.29 (0.55 - 3.00)	.555	1.37 (0.51 - 3.65)	.535

66-75	1.06 (0.41 - 2.75)	.908	0.84 (0.29 - 2.40)	.739
76-85	8.33 (1.03 - 67.26)	.047	6.17 (0.72 - 52.69)	.096
Vehicle type (univariable n=361)				
Motorcycles	3.74 (1.63 - 8.56)	.002	4.15 (1.72 - 9.99)	.001
Cars	1		1	
PCVs	0.68 (0.11 - 4.13)	.673	0.99 (0.12 - 7.87)	.993
Goods vehicles	0.34 (0.17 - 0.69)	.003	0.47 (0.19 - 1.16)	.103
Purpose of the journey (univariable n=366)				
Journey as part of work	0.39 (0.22 - 0.69)	.001	0.55 (0.25 - 1.19)	.129
Commuting to/from work	0.60 (0.32 - 1.11)	.103	0.71 (0.36 - 1.42)	.336
Taking pupil to/from school	0.31 (0.02 - 5.10)	.415	0.49 (0.27 - 8.97)	.630
Other	1		1	
Not known	0.49 (0.18 - 1.33)	.164	0.28 (0.09 - 0.88)	.029
Index of Multiple Depravation (decile) (univariable n=367)				
1 (most deprived)	6.51 (0.79 - 54.00)	.082	8.49 (0.96 - 74.66)	.054
2	0.69 (0.26 - 1.74)	.420	0.68 (0.24 - 1.94)	.471
3	0.70 (0.22 - 2.17)	.535	1.01 (0.29 - 3.59)	.983
4	1.21 (0.46 - 3.17)	.703	1.13 (0.40 - 3.23)	.809
5	1		1	
6	2.23 (0.92 - 5.41)	.078	3.08 (1.11 - 8.53)	.030
7	1.21 (0.51 - 2.86)	.663	1.15 (0.43 - 3.11)	.778
8	1.50 (0.65 - 3.50)	.344	1.20 (0.48 - 3.01)	.694
9	0.99 (0.44 - 2.23)	.981	0.90 (0.37 - 2.21)	.822
10 (least deprived)	1.33 (0.54 - 3.27)	.530	1.43 (0.53 - 3.81)	.480

When the analysis was undertaken within the motor vehicle drivers who were resident in Cambridgeshire at the time of the collision and incorporating the IMD variable there were a number of significant results. However, in comparison with all the motor vehicle drivers in the sample none of the age categories provided significant results. Drivers of motorcycles within the sample are 4.15 (p = .001) times more likely to be culpable or contributory than non-culpable for the collision they are involved in compared to the most frequent vehicle category (cars). Therefore, the results for motorcycles ridden by Cambridgeshire residents are consistent with the results when all motor vehicle drivers in the sample are considered. Motor vehicle drivers who reside at an address designated as within IMD category six within the sample are 3.08 (p = .030) times more likely to be culpable or contributory than non-culpable for the collision they are involved in compared to the most frequent vehicle category (IMD category five). There was also a result close to significance with motor vehicle s who reside at an address designated as within IMD category one (most deprived) within the sample are 8.49 (*p* = .054) times more likely to be culpable or contributory than non-culpable for the collision they are involved in compared to the most frequent vehicle category (IMD category five).

Culpability in the Cambridgeshire resident motor vehicle drivers in the sample, including the Acorn category variable are presented in table 7.11 below.

Table 7.11 Logistic Regression results for culpability, culpable or contributory compared to non-culpable, within the Cambridgeshire resident motor vehicle drivers in the sample, mutually adjusted including Acorn Category

Variable	**Univariable**		**Mutually adjusted (n=313)**	
	OR (95% CI)	*p* value	OR (95% CI)	*p* value
Gender (univariable n=367)				
Male	1		1	
Female	0.98 (0.59 - 1.65)	.952	1.06 (0.58 - 1.90)	.868
Age (univariable n=355)				
<26	2.34 (1.09 - 5.04)	.030	1.60 (0.69 - 3.71)	.227
26-35	1.21 (0.61 - 2.42)	.580	1.12 (0.53 - 2.36)	.759
36-45	1.02 (0.50 - 2.06)	.963	0.84 (0.38 - 1.83)	.658
46-55	1		1	
56-65	1.29 (0.55 - 3.00)	.555	1.43 (0.55 - 3.75)	.463
66-75	1.06 (0.41 - 2.75)	.908	0.91 (0.32 - 2.56)	.854
76-85	8.33 (1.03 - 67.26)	.047	7.48 (0.88 - 63.35)	.065
Vehicle type (univariable n=361)				
Motorcycles	3.74 (1.63 - 8.56)	.002	4.06 (1.70 - 9.69)	.002
Cars	1		1	
PCVs	0.68 (0.11 - 4.13)	.673	1.18 (0.16 - 8.85)	.874
Goods vehicles	0.34 (0.17 - 0.69)	.003	0.46 (0.19 - 1.11)	.086
Purpose of the journey (univariable n=366)				
Journey as part of work	0.39 (0.22 - 0.69)	.001	0.64 (0.30 - 1.35)	.236
Commuting to/from work	0.60 (0.32 - 1.11)	.103	0.70 (0.35 - 1.37)	.296
Taking pupil to/from school	0.31 (0.02 - 5.10)	.415	0.38 (0.02 - 7.10)	.517
Other	1		1	
Not known	0.49 (0.18 - 1.33)	.164	0.33 (0.11 - 0.99)	.048
Acorn Category (univariable n=367)				
1	1.10 (0.61 - 1.99)	.684	0.86 (0.44 - 1.65)	.645
2	1.24 (0.45 - 3.41)	.549	1.25 (0.42 - 3.76)	.691
3	1		1	
4	1.16 (0.66 - 2.07)	.592	1.20 (0.63 - 2.27)	.579
5	0.88 (0.36 - 2.14)	.123	1.07 (0.40 - 2.87)	.891
6	0.70 (0.11 - 4.35)	.282	0.69 (0.08 - 5.66)	.727

When the analysis was undertaken within the motor vehicle drivers who were resident in Cambridgeshire at the time of the collision and incorporating the Acorn category variable there were a number of significant results. However, in comparison with all the motor vehicle drivers in the sample, with the same variables, none of the age categories provided significant results. Drivers of motorcycles within the sample are 4.06 (p = .002) times more likely to be culpable or contributory than non-culpable for the collision they are involved in compared to the most frequent vehicle category (cars). Therefore, the results for motorcycles ridden by Cambridgeshire residents are consistent with the results when all motor vehicle drivers in the sample are considered with these variables.

Collision injury severity category in all the motor vehicle drivers in the sample including the IMD variable are presented in table 7.12 below.

Table 7.12 Logistic regression results for collision injury severity category, being involved in a fatal collision compared to being involved in a MAIS3+ collision, within all the motor vehicle drivers in the sample, mutually adjusted including IMD

Variable	**Univariable**		**Mutually adjusted n=538**	
	OR (95% CI)	*p* value	OR (95% CI)	*p* value
Gender (univariable n=652)				
Male	1		1	
Female	0.81 (0.56 - 1.17)	.262	0.80 (0.51 - 1.25)	.326
Age (univariable n=644)				
<26	0.97 (0.59 - 1.60)	.913	1.04 (0.58 - 1.86)	.895
26-35	1.44 (0.89 - 2.32)	.137	1.73 (1.00 - 3.01)	.052
36-45	1.04 (0.64 - 1.72)	.863	1.23 (0.69 - 2.21)	.478
46-55	1		1	
56-65	0.92 (0.52 - 1.61)	.764	1.01 (0.53 - 1.93)	.966
66-75	1.11 (0.54 - 2.25)	.781	1.14 (0.50 - 2.60)	.755
76-85	0.97 (0.38 - 2.44)	.945	0.98 (0.36 - 2.72)	.975
>85	3.87 (0.76 - 19.84)	.105	3.62 (0.59 - 22.08)	.163
Vehicle type (univariable n=657)				
Motorcycles	0.53 (0.33 - 0.85)	.008	0.56 (0.33 - 0.95)	.031
Cars	1		1	
PCVs	1.50 (0.40 - 5.66)	.550	3.34 (0.70 - 15.88)	.130
Agricultural Vehicles	7.20 (0.86 - 60.30)	.069	7.91 (0.81 - 76.47)	.074
Goods vehicles	1.55 (1.00 - 2.38)	.048	2.48 (1.31 - 4.68)	.005

Purpose of the journey (univariable n=658)				
Journey as part of work	1.14 (0.78 - 1.66)	.508	0.59 (0.33 - 1.04)	.031
Commuting to/from work	0.64 (0.38 - 1.05)	.078	0.55 (0.31 - 0.96)	.130
Taking pupil to/from school	0 .65 (0.06 - 7.20)	.723	1.61 (0.10 - 27.12)	.074
Other	1		1	
Not known	3.51 (1.84 - 6.70)	.000	1.91 (0.82 - 4.41)	.005
Index of Multiple Depravation (decile) (univariable n=575)				
1 (most deprived)	0.70 (0.27 - 1.84)	.470	0.64 (0.24 - 1.74)	.384
2	0.86 (0.42 - 1.78)	.687	0.80 (0.37 - 1.72)	.570
3	1.10 (0.52 - 2.29)	.809	1.00 (0.46 - 2.21)	.984
4	1.55 (0.76 - 3.18)	.229	1.47 (0.69 - 3.11)	.315
5	1		1	
6	0.89 (0.47 - 1.67)	.707	0.84 (0.44 - 1.63)	.615
7	1.05 (0.54 - 2.04)	.882	1.03 (0.51 - 2.10)	.930
8	1.09 (0.56 - 2.11)	.800	1.22 (0.61 - 2.44)	.572
9	0.94 (0.49 - 1.78)	.847	0.89 (0.45 - 1.74)	.729
10 (least deprived)	0.54 (0.26 - 1.12)	.097	0.62 (0.29 - 1.33)	.216

The analysis presented in Table 7.12 indicates a number of significant results. None of the results for age groups within the motor vehicle driver sample were significant, however, the result for motor vehicle drivers in the 26-35 year old age group was close to significance showing they were 1.73 (p = .052) times more likely to be involved in a fatal collision compared to being involved in a MAIS3+ collision compared to the most frequent age group (46-55 years old). Drivers of motorcycles within the sample are 0.56 (p = .031) times more likely to be involved in a fatal collision compared to being involved in a MAIS3+ collision compared to the most frequent vehicle category (cars). The motor vehicle drivers who were undertaking a journey as part of their work were 0.59 (p = .031) times as likely to be involved in a fatal collision compared to being involved in a MAIS3+ collision compared to the most frequent journey type (other).

Collision injury severity category in all the motor vehicle drivers in the sample including the Acorn category variable are presented in table 7.13 below.

Table 7.13 Logistic regression results for collision injury severity category, being involved in a fatal collision compared to being involved in a MAIS3+ collision, within all the motor vehicle drivers in the sample, mutually adjusted including Acorn category

Variable	**Univariable**		**Mutually adjusted n=556**	
	OR (95% CI)	*p* value	OR (95% CI)	*p* value
Gender (univariable n=652)				
Male	1		1	
Female	0.81 (0.56 - 1.17)	.262	0.81 (0.52 - 1.28)	.365
Age (univariable n=644)				
<26	0.97 (0.59 - 1.60)	.913	1.11 (0.62 - 1.98)	.727
26-35	1.44 (0.89 - 2.32)	.137	1.89 (1.09 - 3.28)	.024
36-45	1.04 (0.64 - 1.72)	.863	1.20 (0.67 - 2.16)	.542
46-55	1		1	
56-65	0.92 (0.52 - 1.61)	.764	1.08 (0.57 - 2.07)	.811
66-75	1.11 (0.54 - 2.25)	.781	1.05 (0.46 - 2.39)	.911
76-85	0.97 (0.38 - 2.44)	.945	1.13 (0.41 - 3.12)	.812
>85	3.87 (0.76 - 19.84)	.105	3.97 (0.65 - 24.19)	.134
Vehicle type (univariable n=657)				
Motorcycles	0.53 (0.33 - 0.85)	.008	0.54 (0.32 - 0.92)	.023
Cars	1		1	
PCVs	1.50 (0.40 - 5.66)	.550	3.19 (0.66 - 15.38)	.149
Agricultural Vehicles	7.20 (0.86 - 60.30)	.069	7.31 (0.76 - 70.07)	.084
Goods vehicles	1.55 (1.00 - 2.38)	.048	2.23 (1.16 - 4.26)	.015
Purpose of the journey (univariable n=658)				
Journey as part of work	1.14 (0.78 - 1.66)	.508	0.59 (0.33 - 1.04)	.069
Commuting to/from work	0.64 (0.38 - 1.05)	.078	0.46 (0.26 - 0.82)	.008
Taking pupil to/from school	0 .65 (0.06 - 7.20)	.723	1.66 (0.10 - 28.13)	.725
Other	1		1	
Not known	3.51 (1.84 - 6.70)	.000	1.69 (0.73 - 3.93)	.221
Acorn Category (univariable n=566)				
1	0.76 (0.48 - 1.20)	.245	0.74 (0.45 - 1.20)	.216
2	1.16 (0.54 - 2.49)	.701	1.22 (0.55 - 2.72)	.624
3	1		1	
4	1.15 (0.75 - 1.77)	.518	1.20 (0.77 - 1.90)	.421
5	0.97 (0.52 - 1.84)	.931	0.86 (0.44 - 1.68)	.657
6	2.82 (0.50 - 15.75)	.238	4.16 (0.66 - 26.18)	.128

The analysis presented in Table 7.13 indicates a number of significant results. Motor vehicle drivers in the 26-35 year old age group were 1.89 (p = .024) times more likely to be involved in a fatal collision compared to being involved in a MAIS3+ collision compared to the most frequent age group (46-55 years old). Drivers of motorcycles within the sample are 0.54 (p = .023) times more likely to be involved in a fatal collision compared to being involved in a MAIS3+ collision compared to the most frequent vehicle category (cars). Drivers of good vehicles within the sample are 2.23 (p = .015) times more likely to be involved in a fatal collision compared to being involved in a MAIS3+ collision compared to the most frequent vehicle category (cars). The motor vehicle drivers who were undertaking a journey commuting to or from work were 0.46 (p = .008) times as likely to be involved in a fatal collision compared to being involved in a MAIS3+ collision compared to the most frequent journey type (other).

Collision injury severity category in the Cambridgeshire resident motor vehicle drivers in the sample including the IMD variable are presented in table 7.14 below.

Table 7.14 Logistic regression results for collision injury severity category, being involved in a fatal collision compared to being involved in a MAIS3+ collision, within the Cambridgeshire resident motor vehicle drivers in the sample, mutually adjusted including IMD

Variable	**Univariable**		**Mutually adjusted n=359**	
	OR (95% CI)	*p* value	OR (95% CI)	*p* value
Gender (univariable n=371)				
Male	1		1	
Female	0.85 (0.52 - 1.40)	.515	0.81 (0.46 - 1.45)	.484
Age (univariable n=366)				
<26	1.24 (0.61 - 2.54)	.547	1.44 (0.64 - 3.23)	.377
26-35	2.13 (1.08 - 4.22)	.030	2.51 (1.18 - 5.32)	.017
36-45	0.95 (0.46 - 1.99)	.897	1.23 (0.55 - 2.77)	.614
46-55	1		1	
56-65	1.05 (0.46 - 2.44)	.901	1.17 (0.43 - 2.90)	.821
66-75	1.03 (0.38 - 2.76)	.952	1.39 (0.47 - 4.07)	.549
76-85	1.10 (0.33 - 3.60)	.881	1.07 (0.30 - 3.88)	.915
>85	5.48 (0.98 - 30.56)	.053	6.29 (0.94 - 42.30)	.059
Vehicle type (univariable n=365)				
Motorcycles	0.60 (0.33 - 1.10)	.097	0.55 (0.28 - 1.08)	.084
Cars	1		1	
PCVs	2.53 (0.42 - 15.42)	.314	6.11 (0.77 - 48.51)	.087
Goods vehicles	1.43 (0.72 - 2.87)	.308	2.53 (1.00 - 6.41)	.050
Purpose of the journey (univariable n=370)				
Journey as part of work	0.84 (0.48 - 1.48)	.546	0.41 (0.18 - 0.93)	.032
Commuting to/from work	0.67 (0.36 - 1.25)	.208	0.59 (0.30 - 1.16)	.126
Taking pupil to/from school	1.61 (0.10 - 26.11)	.737	1.91 (0.10 - 35.15)	.663
Other	1		1	
Not known	1.61 (0.62 - 4.22)	.331	1.64 (0.59 - 4.57)	.347
Index of Multiple Depravation (decile) (univariable n=371)				
1 (most deprived)	0.57 (0.16 - 2.09)	.400	0.58 (0.15 - 2.29)	.439

2	0.75 (0.30 - 1.87)	.533	0.68 (0.25 - 1.82)	.442
3	1.00 (0.33 - 3.09)	.994	0.89 (0.26 - 3.09)	.854
4	1.38 (0.56 - 3.41)	.480	1.18 (0.47 - 3.07)	.729
5	1		1	
6	0.77 (0.35 - 1.67)	.504	0.65 (0.28 - 1.50)	.311
7	0.72 (0.31 - 1.64)	.431	0.72 (0.29 - 1.79)	.484
8	0.82 (0.37 - 1.79)	.616	0.85 (0.37 - 1.95)	.697
9	0.59 (0.26 - 1.32)	.198	0.50 (0.21 - 1.20)	.121
10 (least deprived)	0.34 (0.13 - 0.89)	.027	0.36 (0.13 - 0.99)	.047

The analysis presented in Table 7.14 indicates a number of significant results. Motor vehicle drivers in the 26-35 year old age group were 2.51 (p = .017) times more likely to be involved in a fatal collision compared to being involved in a MAIS3+ collision compared to the most frequent age group (46-55 years old). Drivers of good vehicles within the sample are 2.53 (p = .050) times more likely to be involved in a fatal collision compared to being involved in a MAIS3+ collision compared to the most frequent vehicle category (cars). The motor vehicle drivers who were undertaking a journey as part of their work were 0.41 (p = .032) times as likely to be involved in a fatal collision compared to being involved in a MAIS3+ collision compared to the most frequent journey type (other). Motor vehicle drivers who were resident at an address designated within IMD ten (least deprived) were 0.36 (p = .047) times as likely to be involved in a fatal collision compared to being involved in a MAIS3+ collision compared to the most frequent journey type (other).

Collision injury severity category in the Cambridgeshire resident motor vehicle drivers in the sample including the Acorn category variable are presented in table 7.15 below.

Table 7.15 Logistic regression results for collision injury severity category, being involved in a fatal collision compared to being involved in a MAIS3+ collision, within the Cambridgeshire resident motor vehicle drivers in the sample, mutually adjusted including Acorn Category

Variable	**Univariable**		**Mutually adjusted n=326**	
	OR (95% CI)	*p* value	OR (95% CI)	*p* value
Gender (univariable n=371)				
Male	1			
Female	0.85 (0.52 - 1.40)	.515	0.77 (0.43 - 1.38)	.381
Age (univariable n=366)				
<26	1.24 (0.61 - 2.54)	.547	1.77 (0.79 - 3.96)	.162
26-35	2.13 (1.08 - 4.22)	.030	2.68 (1.27 - 5.66)	.010
36-45	0.95 (0.46 - 1.99)	.897	1.40 (0.62 - 3.16)	.416
46-55	1			
56-65	1.05 (0.46 - 2.44)	.901	1.27 (0.49 - 3.25)	.623
66-75	1.03 (0.38 - 2.76)	.952	1.30 (0.44 - 3.78)	.636
76-85	1.10 (0.33 - 3.60)	.881	1.32 (0.37 - 4.74)	.671
>85	5.48 (0.98 - 30.56)	.053	8.73 (1.23 - 61.79)	.030
Vehicle type (univariable n=365)				
Motorcycles	0.60 (0.33 - 1.10)	.097	0.50 (0.25 - 0.99)	.047
Cars	1			
PCVs	2.53 (0.42 - 15.42)	.314	6.26 (0.75 - 52.06)	.090
Goods vehicles	1.43 (0.72 - 2.87)	.308	2.45 (0.96 - 6.29)	.062
Purpose of the journey (univariable n=370)				
Journey as part of work	0.84 (0.48 - 1.48)	.546	0.37 (0.16 - 0.83)	.017
Commuting to/from work	0.67 (0.36 - 1.25)	.208	0.52 (0.26 - 1.03)	.062
Taking pupil to/from school	1.61 (0.10 - 26.11)	.737	2.10 (0.11 - 41.78)	.625
Other	1			
Not known	1.61 (0.62 - 4.22)	.331	1.40 (0.51 - 3.83)	.512
Acorn Category (univariable n=370)				
1	0.50 (0.27 - 0.92)	.025	0.45 (0.23 - 0.88)	.020
2	0.91 (0.36 - 2.32)	.847	0.95 (0.35 - 2.59)	.916
3	1		1	
4	1.20 (0.71 - 2.03)	.505	1.33 (0.74 - 2.37)	.336
5	1.37 (0.59 - 3.19)	.467	1.35 (0.53 - 3.46)	.528
6	2.39 (0.39 - 14.81)	.348	3.62 (0.48 - 27.45)	.214

The analysis presented in Table 7.15 indicates a number of significant results. Motor vehicle drivers in the 26-35 year old age group were 2.68 (p = .010) times more likely to be involved in a fatal collision compared to being involved in a MAIS3+ collision compared to the most frequent age group (46-55 years old). This significance is consistent through the collision culpability logistic regression exploration. Motor vehicle drivers in the over 85 year old age group were 8.73 (p = .030) times more likely to be involved in a fatal collision compared to being involved in a MAIS3+ collision compared to the most frequent age group (46-55 years old). Drivers of motorcycles within the sample are 0.50 (*p* = .047) times more likely to be involved in a fatal collision compared to being involved in a MAIS3+ collision compared to the most frequent vehicle category (cars). That motorcyclist are more likely to be involved in MAIS3+ collisions is consistent through the collision injury severity analysis. Drivers of good vehicles within the sample are 2.53 (*p* = .050) times more likely to be involved in a fatal collision compared to being involved in a MAIS3+ collision compared to the most frequent vehicle category (cars). The motor vehicle drivers who were undertaking a journey as part of their work were 0.37 (*p* = .017) times as likely to be involved in a fatal collision compared to being involved in a MAIS3+ collision compared to the most frequent journey type (other), again this result is consistent across the analysis. Motor vehicle drivers who were resident at an address designated within Acorn category one (most affluent) were 0.45 (*p* = .020) times as likely to be involved in a fatal collision compared to being involved in a MAIS3+ collision compared to the most frequent journey type (other).

7.4.4 Risk Index

This section presents the results of the risk index method described in section 7.3.3.4. exploring the relationship between the distribution in Cambridgeshire residents motor vehicle drivers in the sample with the distribution in the general population of Cambridgeshire.

An indexation process generated score of 100 means that the proportion of motor vehicle drivers living at an address in any given Acorn type in the sample or group was the same proportion as the segment of the residential population living within the same

Acorn type in Cambridgeshire. Scores in excess of 100, with bars which extend above the 100 line, indicate over-representation within the sample or group to the whole and these have bars which are red in colour. Scores of less than 100 indicate under-representation in the sub-population to the whole with bars below the 100 line indicate and these bars are green in colour. In the presentations the Acorn types are identified numerically due to space restrictions within the histogram, for the related Acorn type description see appendix 11.

When considering all the Cambridgeshire motor vehicle drivers in the dataset the population included 47 Acorn types, the top ten Acorn codes by frequency accounted for 51.9 percent of the sub-population. The top ten Acorn types by frequency for all the Cambridgeshire motor vehicle drivers are presented in figure 7.10 below.

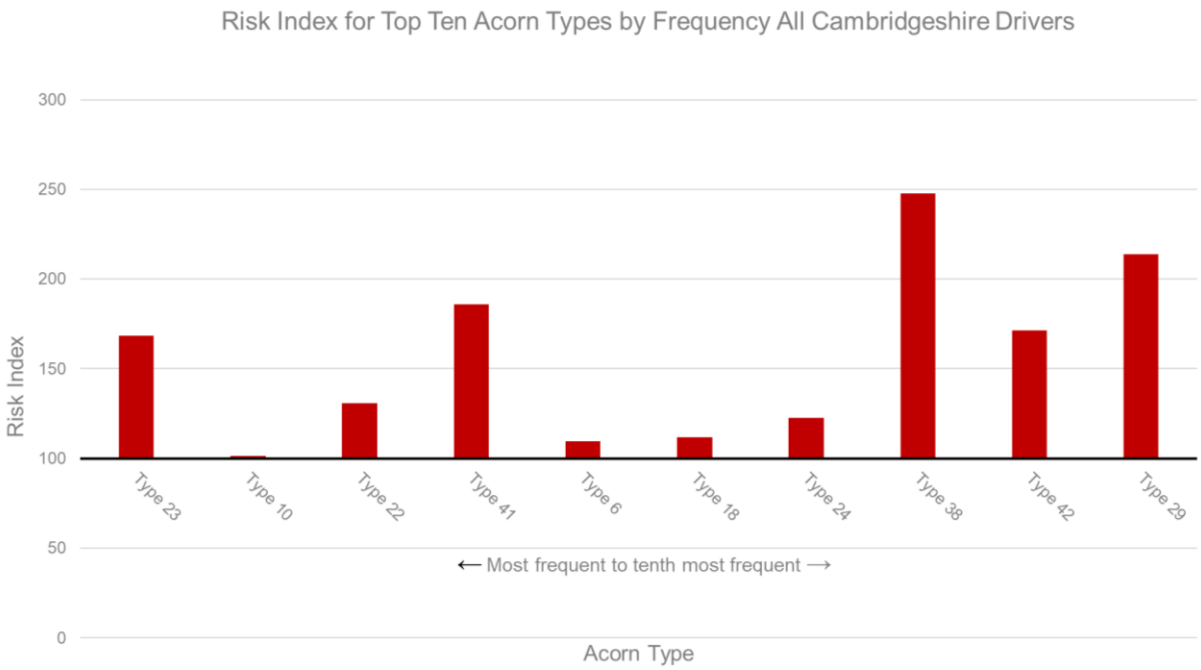

Figure 7.10 Risk index for the top ten Acorn types by frequency for all Cambridgeshire motor vehicle drivers in the sample

Figure 7.10 indicates that within the top ten by frequency all the Acorn types present are also over-represented compared to the expected frequency predicted by the distribution in the whole population of Cambridgeshire. The most frequent type presented was type 23 (owner occupiers in small towns and villages). The risk index for the type 23 profile was 168, this show that Acorn type 23 was represented 1.68 times more frequently than the proportion in the general population would suggest and was therefore over-represented in the group. The frequency accounts for 8.1 percent of the population. The Acorn type in the Cambridgeshire motor vehicle drivers with the highest risk index, and hence the most over-represented, was the eight most frequent, type 38 (semi-skilled workers in traditional neighbourhoods). The risk index for the type 38 was 248 and the frequency accounts for 3.8 percent of the population.

The first of the sub-population groups examined was the culpable and contributory Cambridgeshire motor vehicle drivers involved in collisions resulting in a fatality in the dataset. The sub-population included 33 Acorn types, the top ten Acorn codes by frequency accounted for 57.8 percent of the sub-population. The top ten Acorn types by frequency for the culpable and contributory Cambridgeshire motor vehicle drivers involved in collisions, which result in a fatality, are presented in figure 7.11 below.

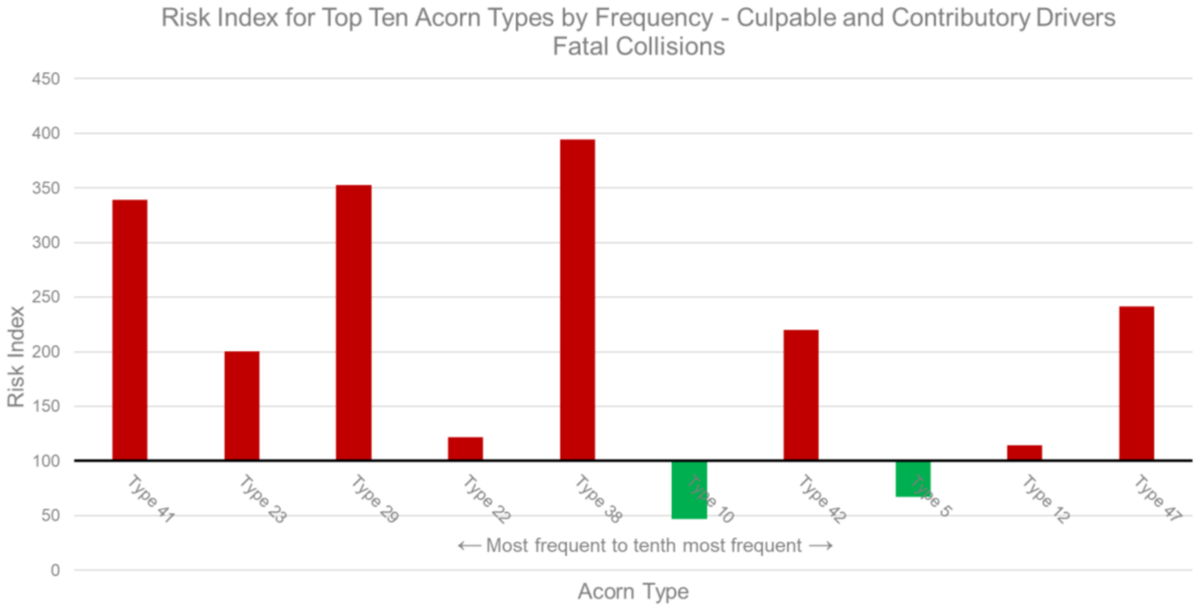

Figure 7.11 Risk index for top ten Acorn types by frequency for the culpable and contributory Cambridgeshire motor vehicle drivers in the sample involved in fatal collisions

Figure 7.11 indicates that within the top ten by frequency eight of the Acorn types present are over-represented and two under-represented compared to the expected frequency predicted by the distribution in the whole population of Cambridgeshire. The most frequent type presented was type 41, the description of this type was ‘labouring semi-rural estates.’ The risk index for the type 41 profile was 339 and the frequency accounts for 10.8 percent of the population. The most over-represented Acorn type in the Cambridgeshire motor vehicle drivers was the fifth most frequent and was again, type 38, the description of this type was ‘semi-skilled workers in traditional neighbourhoods.’ The risk index for the type 38 was 394 and the frequency accounts for 6.0 percent of the population. Of the two types under-represented type 10, the description of this type was ‘better-off villagers’, was the one with the lowest risk index of 47 and was the sixth most frequent type in the group representing 3.6 percent of the sub-population.

The next sub-population examined was the culpable and contributory Cambridgeshire motor vehicle drivers involved in collisions resulting in a MAIS3+ injury in the dataset. The sub-population included 38 Acorn types, the top ten Acorn codes by frequency accounted for 56.4 percent of the sub-population. The top ten Acorn types by frequency for the culpable and contributory Cambridgeshire motor vehicle drivers involved in collisions, which result in a MAIS3+ injury, are presented in figure 7.12 below.

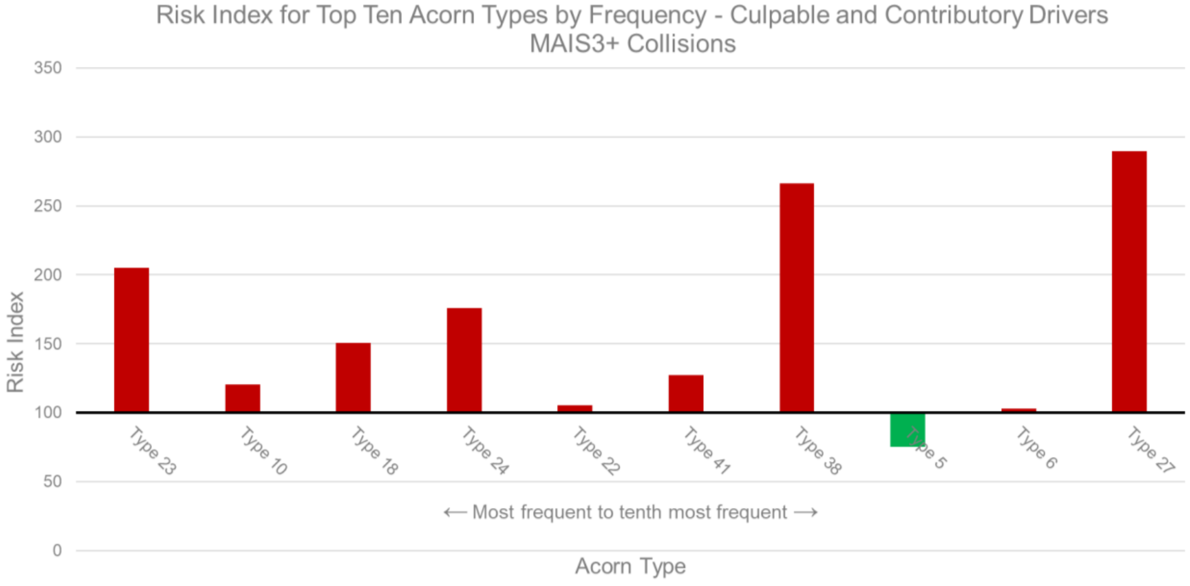

Figure 7.12 Risk index for top ten Acorn types by frequency for the culpable and contributory Cambridgeshire motor vehicle drivers in the sample involved in MAIS3+ collisions

Figure 7.12 indicates that within the top ten by frequency nine of the Acorn types present are over-represented and one under-represented compared to the expected frequency predicted by the distribution in the whole population of Cambridgeshire. The most frequent type presented was type 23, the description of this type was 'owner occupiers in small towns and villages.' The risk index for the type 23 profile was 205 and the frequency accounts for 9.9 percent of the population. The highest risk index attributable within the ten most frequent Acorn types in the Cambridgeshire motor vehicle drivers, and hence the most over-represented, was the tenth most frequent, type 27. The description of type 27 was 'suburban semis, conventional attitudes.' The risk index for the type 27 was 290 and the frequency accounts for 4.1percent of the population. The only type under-represented was type 5, the description of this type was 'wealthy countryside commuters', with a risk index of 75 and was the eighth most frequent type in the group representing 4.1 percent of the sub-population.

Next the culpable and contributory Cambridgeshire motor vehicle drivers involved in collisions resulting in either a fatality or a MAIS3+ injury was examined. The sub-population included 42 Acorn types, the top ten Acorn codes by frequency accounted for 53.3 percent of the sub-population. The top ten Acorn types by frequency for the culpable and contributory Cambridgeshire motor vehicle drivers involved in collisions, which resulted in either a fatality or a MAIS3+ injury, are presented in figure 7.13 below.

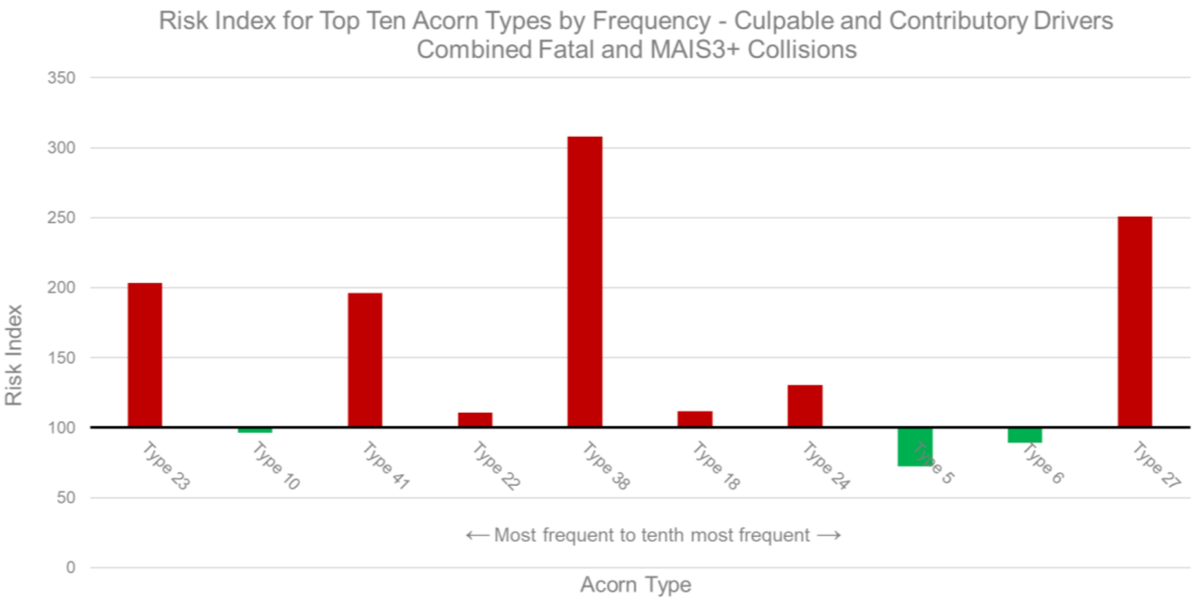

Figure 7.13 Risk index for top ten Acorn types by frequency for the culpable and contributory Cambridgeshire motor vehicle drivers in the sample involved in combined fatal and MAIS3+ collisions

Figure 7.13 indicates that within the top ten by frequency, eight of the Acorn types presents are over-represented and two under-represented compared to the expected frequency predicted by the distribution in the whole population of Cambridgeshire. The most frequent type presented was type 23, the description of this type was ‘owner occupiers in small towns and villages.’ The risk index for the type 23 profile was 204 and the frequency accounts for 9.8 percent of the population. The most over-represented Acorn type in the Cambridgeshire motor vehicle drivers was the fifth most frequent and was again, type 38, the description of this type was ‘semi-skilled workers in traditional neighbourhoods.’ The risk index for the type 38 was 308 and the frequency accounts for 4.7 percent of the population. Of the two types under-represented type 5, the description of this type was ‘wealthy countryside commuters’, was the one with the lowest risk index of 73 and was the sixth most frequent type in the group representing 3.9 percent of the sub-population.

The final group to be examined was the non-culpable Cambridgeshire motor vehicle drivers involved in collisions resulting in either a fatality or a MAIS3+ injury in the dataset. The sub-population included 38 Acorn types, the top ten Acorn codes by frequency accounted for 56.3 percent of the sub-population. The top ten Acorn types by frequency for the non-culpable Cambridgeshire motor vehicle drivers involved in collisions, which result in either a fatality or a MAIS3+ injury, are presented in figure 7.14 below.

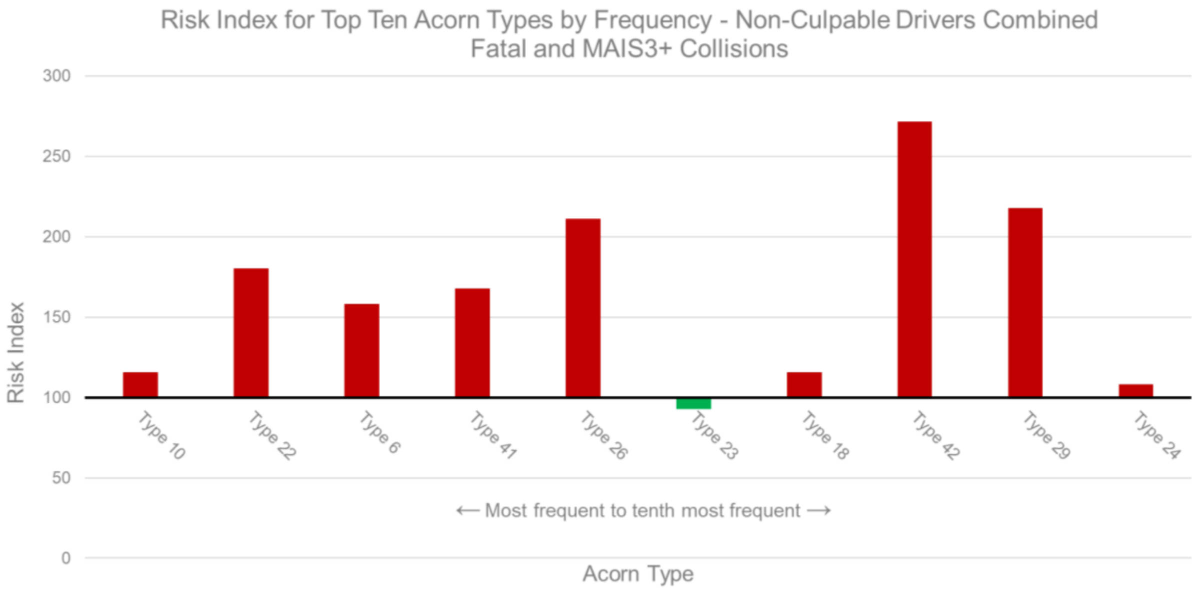

Figure 7.14 Risk index for top ten Acorn types by frequency for the non-culpable Cambridgeshire motor vehicle drivers in the sample involved in combined fatal and MAIS3+ collisions

Figure 7.14 indicates that within the top ten by frequency nine of the Acorn types present are over-represented and one under-represented compared to the expected frequency predicted by the distribution in the whole population of Cambridgeshire. The most frequent type presented was type 10, the description of this type was ‘better-off villagers.’ The risk index for the type 10 profile was 116 and the frequency accounts for 8.9 percent of the population. The most over-represented Acorn type in the non-culpable Cambridgeshire motor vehicle drivers was the eighth most frequent and was, type 42, the description of this type was ‘struggling young families in post-war terraces.’ The risk index for the type 42 was 272 and the frequency accounts for 4.5 percent of the population. The only type under-represented was type 23, the description of this type was ‘owner occupiers in small towns and villages’, with a risk index of 93 and was the sixth most frequent type in the group representing 4.5 percent of the sub-population.

The results show that for each motor vehicle driver group the Acorn type distributions are different. Some Acorn types feature in the top ten Acorn types by frequency for all the groups, such as type 23, some Acorn types feature only in one group, such as type 12, with others featuring in more than one, such as type 24. Not only are different Acorn types featured in the top ten of each motor vehicle driver group but also the risk index scores, even for Acorn types which feature in multiple motor vehicle driver groups, are different between motor vehicle driver groups. To assist with visualising these differences all four histograms are reproduced above one another in appendix 12.

7.4.4.1 Acorn Type Contributory Factor Analysis

To allow the application of interventions to the most frequent Acorn types that present within the Risk Index analysis it is essential to explore the contributory factors which gave rise to the culpability of the motor drivers involved.

The results of the analysis of the three most frequent Acorn types presenting in the culpable and contributory motor vehicle drivers in fatal and MAIS3+ collisions is presented in table 7.16 below.

Table 7.16 Acorn type contributory factor analysis results

Type 23		Type 10		Type 41	
cf code	Freq. n=	cf code	Freq. n=	cf code	Freq. n=
102	1	103	1	103	1
103	3	108	1	302	1
203	1	302	1	306	1
307	1	305	1	307	1
310	1	401	1	308	1
403	6	404	1	401	1
405	6	405	14	403	4
410	5	406	2	404	1
502	2	410	4	405	4
505	1	509	1	408	1
508	1	602	1	410	3
602	4	802	1	501	1
707	1	806	2	502	1
806	1	999	2	602	3
				605	1
				802	1

All cf codes present		
cf code and occurrence	Code description	Freq. n=
405 (3)	Failing to look properly	24
410 (3)	Loss of control	12
403 (2)	Poor turn or manoeuvre	10
602 (3)	Careless, reckless or in a hurry	8
103 (3)	Slippery road (due to weather)	5
806 (2)	Ped impaired by alcohol	3
302 (2)	Disobeyed “Give Way” or “Stop” sign	2
307 (2)	Travelling too fast for conditions	2
401 (2)	Junction overshoot	2
404 (2)	Failed to signal or misleading signal	2
406 (1)	Fail to judge other person’s path or speed	2
802 (2)	Ped failing to look properly	2
999 (1)	Other	2
102 (1)	Deposit on road (e.g., oil, mud, chippings)	1
108 (1)	Road layout (e.g., bend, hill, etc.)	1
203 (1)	Defective brakes	1
305 (1)	Illegal turn or direction of travel	1
306 (1)	Exceeding speed limit	1
308 (1)	Following too close	1
310 (1)	Cyclist enters road from pavement	1
408 (1)	Sudden braking	1
501 (1)	Impaired by alcohol	1
502 (2)	Impaired by drugs	3
505 (1)	Illness or disability, mental or physical	1
508 (1)	Driver using mobile phone	1
509 (1)	Distraction in vehicle	1
605 (1)	Learner or inexperienced driver	1
707 (1)	Rain, sleet, snow or fog	1

7.5. Summary of Findings

The analysis was divided into four sections, the first explored the motor vehicle related variables descriptively, this was followed by statistical testing of the age and gender distributions. Logistic regression of motor vehicle driver related variables within the sample was then undertaken finishing with exploration of a risk index based on the geodemographic profile distribution within the sample and the general population of Cambridgeshire.

The analysis of the age distribution showed that the median and IQR were consistent across the motor vehicle driver groups explored with the median range of 35 to 46.5, with 13 of the 18 groups examined withing a 38 to 42 range. All the IQR ranges fell within a range of 27 to 56.

The gender distribution proportions again showed consistency with the male proportion ranging from 69 percent to 81.5 percent, however, six of the eight groups examined had a male proportion within the 74.7 to 77.6 percent range. With men being represented around three times as often as women in the data.

The distribution of IMD categories designated to the home addresses of the motor vehicle drivers in the sample showed that the motor vehicle drivers who were resident in Cambridgeshire at the time of the collision all tended, regardless of culpability, to come from the less deprived end of the IMD scale. However, this is consistent with the distribution across Cambridgeshire in the resident population. It can be observed that for the culpable and contributory groups the proportions at the lower end of the scale, i.e. more deprived, tended to be higher than those in the resident population distribution. The opposite being the case for the non-culpable groups, where the proportion of motor vehicle drivers at the lower end of the scale, i.e. more deprived, tended to be lower than in the resident Cambridgeshire population distribution.

The Acorn geodemographic segmentation of society is structured, in a simplistic interpretation of the complex analysis, from the most affluent to least at all three granularity levels. In the Acorn category the middle two categories were most frequent in all motor vehicle driver groups examine followed by the most affluent category, this does reflect the population of Cambridgeshire and corresponds to the results obtained from IMD. In exploring the mid granularity of Acorn, the group, but taking into account the highest frequencies within the middle two Acorn categories, it was observed that the of the groups which make up the Comfortable Communities (third most affluent) category it was the Acorn group Countryside Communities that was the most frequent. In the Financially Stretched category (Fourth most affluent) it was the Striving Families group that was most frequent.

The statistical testing of the age distributions within the motor vehicle driver groups required a number of stages to determine compliance with assumptions for either Fisher's or Welch's ANOVA testing. Normality testing using the S-W test showed that groups which contained all the motor vehicle drivers, or the culpable and contributory motor vehicle drivers did not have normal distributions. However, the non-culpable motor vehicle driver age distributions for both injury severity categories and the non-culpable motor vehicle drivers, resident in Cambridgeshire at the time of the collisions were normal. Testing of equal variance using Levene's test showed that 13 of the 18 motor vehicle driver groups differentiated by culpability category, did not have equal variance, the remaining did. When the Levene's test was applied to the motor vehicle driver groups differentiated by injury severity category the null hypothesis was not rejected in any of the groups and therefore they all display equal variance. The appropriate ANOVA test was applied, depending on the normality and equality of variance testing, but whichever Anova test was applied all motor vehicle driver group comparisons showed no significant differences in variance between the age distributions.

The testing of the motor vehicle driver age distributions using the K-S and M-W tests gave consistent results with both tests, producing significant results when motor vehicle driver groups are differentiated by culpability but not significant when differentiated by injury severity categorisation.

The χ^2 testing of the gender distributions showed that the gender distributions between motor vehicle driver groups are not significantly different.

The logistic regression explored the relationship of seven variables (two with collinearity so only six were tested together) on the two binary outcome of being culpable/contributory or non-culpable and being involved in a fatal or MAIS3+ collisions within the sample. There were a number of significant results for each motor vehicle driver group explored, in both the univariable and mutually adjusted results. However, these were not consistent enough to summarise to generalisations and the results of the individual analysis set out in section 7.3.8 should be referred to.

The analysis of risk index showed that for any given motor vehicle driver group there were Acorn types which were more frequent than others and that the top ten of the Acorn types, by frequency, for any given motor vehicle driver groups explored always accounted for in excess of 50 percent of all the motor vehicle drivers within the group. The majority of the top ten most frequent Acorn types were also over-represented in the sample compared to the general population of Cambridgeshire.

Analysis was undertaken on the contributory factor distribution related to the culpability of the motor vehicle drivers that were resident in the three most frequent Acorn types for the combined injury severity analysis of the culpable and contributory motor vehicle drivers. This analysis showed that four contributory factors dominated the distribution, these being failing to look properly (405), loss of control (410), poor turn or manoeuvre (403) and careless, reckless or in a hurry (602), see table 7.16 above.

Chapter Eight: Discussion

8.1. Introduction

In the UK, the longstanding decline in the number of road related fatalities and serious injuries stopped in 2010 (Department for Transport, 2020d). These reductions come from a combination of multiple road safety measures, with Elvik *et al.* (2009) identifying 128, however, it can be difficult to attribute specific reductions to specific measures (Elvik *et al.*, 2009) and the cumulative combination contributes to the overall effect.

The flattening of the decline and plateauing of the number of casualties coincided with the period of austerity imposed by the UK government, as well as other governments across Europe, after the financial crisis and this has undoubtably had an impact on road safety, along with other health matters (Karanikolos *et al.*, 2013; RAC Foundation, 2015; Leyendecker, 2019). Her Majesty's Inspectorate of Constabulary and Fire and Rescue Services (2020) identified a correlation between reductions in roads policing and collisions.

The analysis of socio-economic and geodemographic data regarding road incident casualties has been used to target safety interventions at the most vulnerable groups (Anderson, 2005; 2010; Loo and Anderson, 2016; Road Safety Analysis, 2020), however, this has not been applied to the motor vehicle drivers involved in collisions, in times where resources are restricted, focussing those resources where they are most impactful can be considered essential.

This research reported in this thesis was a proof of concept and set out to explore methods of segmenting the population of motor vehicle drivers involved in collisions to allow the targeting of interventions. The method uses parameters which had not previously been combined before to undertake this task, resulting in an alternative method of segmentation which would allow the targeting of interventions.

Therefore, the overall aim of the thesis was to

iii. investigate if geodemographic profiles can be used to differentiate motor vehicle drivers involved in fatal and serious injury (MAIS3+) collisions by their culpability.

iv. To investigate if the analysis of motor vehicle driver geodemographic profiles could allow direct marketing methods to be applied to road safety interventions.

The preceding chapters of this thesis have explored, described and discussed the findings from the literature review, methodologies and the three studies. The discussion for chapters four to seven are in this chapter.

This chapter moves on to consider the main findings of the thesis, what contribution this research has made to the body of knowledge in the field, the strengths and weaknesses of the research, considerations of the generalisability of the research, the implications and finishes with consideration of any unanswered questions and opportunities for future research.

8.2. Main Findings

The literature review undertaken demonstrated that collisions are complex events, this complexity was reflected in the diversity of research undertaken. This diversity of approach has led to the diversity of measures available as options for efforts to reduce road casualties (Elvik *et al.*, 2009). There are also clear issues within the research when injury severity was considered, with the use of non-clinical injury severity categorisation causing problems.

A non-clinical assessment process, such as that presented in the STATS19 data was evaluated by non-clinically trained police reporting agents and does not allow direct international comparison or deeper understanding of which collisions cause which injuries, yet the construct of KSI, based on the non-clinical assessment, can be considered in most cases the basis for performance management relating to road safety. Although there are other clinical injury severity categorisation frameworks available, AIS was selected as the international standard. In the UK AIS has been used to categorise injury severity within the NHS on the TARN database, however, other NHS data uses ICD, the option to map ICD to AIS can be considered, however, this can be problematic and would add another stage to an already multi-stage process.

The research reported in this thesis produced a sample of collisions which could be differentiated by two main factors, these being the collision injury severity categorisation, i.e., fatal or MAIS3+, and the culpability of the motor vehicle drivers involved in the collisions. When comparing these two factors culpability was a much stronger factor in differentiating the motor vehicle drivers compared to the injury severity level of the collision. This was especially noticeable in the age distributions of the motor vehicle drivers within the groups with both the injury severity categories having similar distributions, yet the difference between the culpable and non-culpable motor vehicle drivers age distributions are striking with the culpable motor vehicle drivers age distribution being multi-modal and skewed whereas the non-culpable motor vehicle driver age distribution was normal and can be considered a proxy for the general driving population. This finding would suggested that if motor vehicle driver populations are to be explored within road safety research there would be greater utility in examining the motor vehicle drivers differentiated for culpability and this reinforces that position in other literature (af Wåhlberg, 2009).

8.2.1 Study One Discussion

This study set out to explore the most serious of injuries, those which resulted in fatalities or injuries classified as MAIS3+. The limitations of the injury severity categorisation in STATS19 was overcome in this research by linking the STATS19 data to TARN trauma patient data which gave direct access to the AIS injury severity classification of the casualties, see chapter four.

The data linking was successful. The four variables chosen did produce a high level of true matches. The additional requirements for a manual validation of the probabilistic stage of the process, only providing a small number of additional matches would probably not be worth the effort if automation was a future study aim. Clearly, if there was a common variable between the two dataset this would facilitate a simpler linkage process. For applications based on KSI measures the identification of MAIS3+ injury collisions would not be required.

In line with research (Bull and Roberts, 1973; Transport and Road Research Laboratory, 1980; James, 1991; Transport Research Laboratory, 1993b; 1996; 2002; Cryer *et al.*, 2001; Roberts *et al.*, 2008; Broughton *et al.*, 2010; International Transport Forum, 2011; 2018; Yannis *et al.*, 2014; World Health Organization, 2018) it seems likely that almost all of the MAIS3+ collisions in the geographic area were captured in the combination of collision data and casualty data. The number of linked casualties accounted for around one sixth of the casualties represented in the TARN sample provided, which in turn was for the six counties which make up the East of England region, although the TARN data did not contain the location the injury was sustained and therefore it was not possible to quantify this assertion. The methodology employed to link the two available datasets in this research could be replicated across any geographic areas where STATS19 and TARN are available. The selection of the collisions withing the STATS19 sample used could allow for exploration of any chosen geographic construct, in the case of this research a county boundary was chosen, but it would be possible to undertake the same process on a small construct, such as a town, or wider, at regional level for example.

The linkage exposed a number of factors requiring consideration should the process be repeated. Both the deterministic and probabilistic stages produced valid results, although the latter produced a high error rate. The validation sample from the deterministic process produced a high degree of true matches, at 95.8 percent and low error rate of 4.2 percent, with the use of four common variables of incident date, age, sex and first string of the home postcode. The probabilistic stage managed to capture additional true-matches, n=12 after validation, but the criteria and parameters of the process, specifically which variables should be allowed to vary and by what degree as well as how this variation could be distinguished using weighting did require exploration to reduce the level of false-matches.

The collision sample, once it only represented fatal and MAIS3+ collisions, was subject to descriptive analysis. The descriptive analysis allowed for the comparison of the sample with other available collision data, looking at chronological and driver age distributions, for example (Sullivan and Flannagan, 2003; Michalaki, Quddus and Huetson, 2016; RAC Foundation, 2018; Department for Transport, 2019c) as well as traffic flow, journey, vehicle, volume, and junction type data and other incident detail (Cambridgeshire County Council (unpublished), no date; Department for Transport, 2004; 2015c; 2019f; 2019g; 2019h; 2019d; Crundall, Humphrey and Clarke, 2008; Crundall *et al.*, 2012; Cambridgeshire County Council, 2019b) and previous research (Elvik, 2001; Hirst, Mountain and Maher, 2005; Mountain, Hirst and Maher, 2005; Grundy *et al.*, 2009; Transport Research Laboratory, 2010; Cairns *et al.*, 2014; 20's Plenty For Us, 2020). It was found that in all cases the data in the sample followed similar distributions to that presented in the alternative data from other sources, clearly suggesting that the data presented in the sample is not unusual and can be considered a proxy for UK collision data more widely.

As the majority of road safety interventions worldwide are based on collision statistics analysis (af Wåhlberg, 2009; Department for Transport, 2012b; Imprialou and Quddus, 2017), having a more specific dataset allows the assessment of interventions based on whole collision datasets to be reassessed for their suitability to reduce these most serious of injury collisions. The use of the combined Killed and Seriously Injured (KSI), seriously injured from a STATS19 categorisation, may not give the richness required to target specific levels of injury or, in the case of the serious category, reflect actual medically assessed trauma, although it has been deemed to give a good reflection of collision injury trends (Department for Transport, 2012b). Albeit that the STATS19 has a number of issues and more specifically the STATS19 serious injury category has limitations, described above. This study has been able to categorically identify a subset of STATS19 data where a MAIS3+ injury has resulted from the collision.

The resultant linked dataset focussed on MAIS3+ injuries using AIS as the classification. The use of AIS also allows international comparisons of population based casualty comparators, such as number of injured individuals per one hundred thousand population (Stevenson *et al.*, 2001; International Transport Forum, 2011; Aarts *et al.*, 2016).

Access to both datasets, in the form used in this research, was restricted and was subject to specific information sharing protocols put in place for this research, this would not have been possible without the cooperation of partner agencies and their involvement in the research from incept.

The descriptive analysis of the sample, to test the hypothesis that the sample was not unusual, allows for comparison with other known factors associated with collisions in the UK. The chronological analysis consistently showed, at month, day and hour level the distribution of the fatal collisions and the MAIS3+ collisions were broadly similar. However, the fatal collisions were more evenly distributed with the MAIS3+ collisions displaying more variation and higher peaks. The analysis of monthly distribution showed a spike in MAIS3+ collisions which was consistent with research which indicates a spike in injury collisions corresponding to the change from daylight saving time (usually referred to as British Summer Time in the UK) to Greenwich Mean Time (GMT) thus creating darker evenings (Sullivan and Flannagan, 2003; RAC Foundation, 2018). Conversely, this increase in MAIS3+ collisions was not reflected in the fatal collisions. In fact, for the three months October, November and December the frequencies of the MAIS3+ and fatal collisions move in the opposite direction, MAIS3+ collisions reducing and fatal collisions increasing. Additionally, the MAIS3+ monthly frequency also shows spikes during May and June as well as August and September which are again not reflected in the fatal collision frequencies.

The variation exhibited in the Cambridgeshire data analysed may not however, be unusual, in the annual collision statistics for Great Britain for 2018 (Department for Transport, 2019d, p. 34) the monthly casualty frequency for four police force areas, Metropolitan, Thames Valley, Hampshire and Derbyshire, were presented as part of the analysis of the impact of online reporting. However, this presentation, albeit that the serious injuries presented are the non-clinical police assessments does allow examination of the month on month frequency variation for fatal collisions and the non-clinical serious injury category.

The visual comparison does show the same difference in variation between the two injury severity groups displayed in the Cambridgeshire data, with fatal collisions showing less fluctuation. There are also autumnal peaks similar to the October MAIS3+ peak in the Cambridgeshire sample, although, there was no consistency in the movement of the peak through November and December.

There was consistency in all four other force areas with the Cambridgeshire data in that they displayed a peak in May and June although again there was variation in where the peak starts, and which month has the highest frequency. What was different in the Cambridgeshire data to all four of the other force areas presented was the peak in frequency in August in the Cambridgeshire data as in all the other four there was a trough in August, however, in analysis of UK motorway collisions over a 26 year period Michalaki *et al.* (2016, p. 11) did observe a peak in August as well as the October-December peak but the May-June peak was absent.

In examining the distribution of collisions across the road classes it was observed that 53.5 percent, of the all collisions occurred on an A-class road, this was consistent across the two collision injury severity categories at 55.1 percent of fatal and 52.4

percent of the MAIS3+ collisions. This was despite A class roads only accounting for 9.5 percent of the total Cambridgeshire road network (Cambridgeshire County Council, 2019b).

However, this may be explained by the fact that more vehicle miles are travelled on A roads in the East of England, unfortunately the same analysis was not available for Cambridgeshire alone, than any other road class at an estimated 18.4 billion vehicle miles in 2018 (47.4 percent of the journeys), this compares to 11.0 billion on c class and unclassified roads (28.4 percent), 6.3 billion on Motorways (16.2 percent) and 3.1 billion on b class roads (0.8 percent) (Department for Transport, 2019f). The analysis of the dataset gives the respective distribution across the road classes as 53.5 percent, 26.6 percent, 2.2 percent and 17.7 percent. Although this comparison was comparing estimated total vehicle miles to the actual collision distribution within the dataset and therefore has limitations, the A class roads and C or unclassified roads groups which account for 80.1 percent of the collisions have striking similar proportions to the estimated total vehicle miles with the proportions being a reflection of exposure, by miles travelled on those routes.

The proportion of collisions in the data which occur on dual carriageways was high in comparison to the length of dual carriageway in the county, with 17.9 percent on a dual carriageway, that being a road where the lanes in each direction are separated by some form of barrier or reservation, but the bulk, 76.4 percent, of the collisions occurred on single carriageway roads, that being a road without a central divide between oncoming traffic. The road network of Cambridgeshire can be described as predominantly single carriageway with only 2.2 percent dual carriageway (Cambridgeshire County Council (unpublished)).

However, as described previously the bulk of the vehicle miles are undertaken on A class roads with a further significant proportion on motorways, 63.6 percent of all the vehicle miles in the county in 2018, and all the dual carriageways are represented within these two road classes (Department for Transport, 2019g; 2019h). Therefore, as with the road class distribution, the proportion of the collisions which occur on dual carriageways may be a reflection of the vehicle miles travelled on these types of road.

The findings previously discussed regarding A-class roads and the dual/single carriageway distribution follow into the examination of the speed limit of the road where the collisions occurred. The analysis show that 49.7 percent of the collisions occurred where the limit was 60mph. In addition, a further 15.0 percent were on 70mph limit roads. The distribution between the collision injury severity categories was consistently less than 2 percent difference for each speed limit with the exception of 30 mph where the MAIS3+ collisions represented 13.6 percent more than the fatal collisions, with a frequency four times higher.

It was also worth noting that although the number of collisions occurring in 20mph speed limit roads was very low, this total did not include any fatalities. The difference between the two lower speed limits, 20mph and 30mph, compared to the 40mph and above was consistent with the findings of research relating to speed and severity of injury. The findings show that at 30mph and below fatalities are significantly reduced, these findings have led to the spread of 20mph zones and campaigning (Elvik, 2001; Hirst, Mountain and Maher, 2005; Mountain, Hirst and Maher, 2005; Grundy *et al.*, 2009; Transport Research Laboratory, 2010; Cairns *et al.*, 2014; 20’s Plenty For Us, 2020).

Only dual carriageway roads, including motorways, can be subject to a 70mph speed limit, although the limit can be lower and in some urban locations dual carriageways can be subject to a 30mph limit. Therefore, the 15.0 percent of collisions occurring on 70mph speed limit roads must have occurred on dual carriageways and account for that proportion of the 17.9 percent of collisions which occurred on dual carriageways in the carriageway type distribution presented earlier. The remaining 2.9 percent of collisions on dual carriageways are distributed between 60mph roads (1.1 percent), 40mph roads (0.7 percent) and 30 mph roads (1.1 percent).

In Cambridgeshire dual carriageways with 30 and 40 mph speed limits only account for 0.5 percent of the road network with faster dual carriageways accounting for 1.7 percent (Cambridgeshire County Council (unpublished)), so dual carriageways are over-represented in the collision statistics if length alone was the criteria, however, the examination of vehicle miles applied to A class roads and the 60 and 70mph speed limits was also applicable to dual carriageways.

In considering the how road class and speed limit may combine it can be observed that 70.5 percent of all collisions that occur on A class roads are in 60 and 70mph speed limits, this accounts for 37.7 percent of all the collisions. This distribution was consistent for both the collision injury severity categories with fatal collisions the proportions are 79.3 percent and 43.7 percent respectively and for MAIS3+ collisions 63.6 percent and 33.3 percent respectively. This gives more insight into the distribution of the 64.7 percent of all collisions occurring of 60 and 70mph roads occurring on A class roads.

The 22.8 percent of all collisions which occurred on roads subject to a 30mph speed limit were spread across the four road classes where this speed limit can be applied with the highest proportion being A class roads at 11.0 percent to the lowest on B class roads at 4.8 percent. As the class of road drops in status the proportion of the collisions within each road class which occur in 30 mph limits increases, the proportions are A class 20.9 percent, B class 31.2 percent, C class 35.9 percent and Unclassified roads 80.0 percent. For fatal collisions, 60mph roads in all road classes produced the highest proportion of collisions, but for MAIS3+ collisions this was not the case, with unclassified 30mph limit roads having more collisions than on 60mph roads and accounting for much of the high number of all collision. The differences between fatal and MAIS3+ collisions on roads with 30mph speed limits and lower have previously been discussed (Elvik, 2001; Hirst, Mountain and Maher, 2005; Mountain, Hirst and Maher, 2005; Grundy *et al.*, 2009; Transport Research Laboratory, 2010; Cairns *et al.*, 2014; 20's Plenty For Us, 2020).

The distribution of junction type categories within the collisions in the dataset show that 63.0 percent of the collisions occurred at a location without a junction, with the distribution was consistent across the two collision injury severity categories. Where the collision did occur at a junction, 37.0 percent of the collisions, there are consistently more MAIS3+ collisions than fatal collisions and the junction types which are most prevalent are the T or staggered junctions category accounting for 20.4 percent of all the collisions (55.1 percent of all junction related collisions). Previous research into motorcycle collisions examined right of way violations at junctions by all parties and found that such violations were three times more likely at T junctions than roundabouts or crossroads, T junctions are also particularly problematic as a result of look but fail to see errors by the motor vehicle drivers pulling out of the side road, note case study one in chapter five, which would suggest the high proportion of the collisions in the dataset when a junction was involved being at T or staggered junctions would be appropriate (Department for Transport, 2004, p. 21; Crundall, Humphrey and Clarke, 2008; Crundall *et al.*, 2012).

Exploring the category of motor vehicle involved in the collisions represented in the data shows that the car represented 68.2 percent of all the vehicles involved in the collisions, this was consistent across the two collision injury severity categories with the fatal collision category at 67.7 percent and MAIS3+ injury category at 68.8 percent. Powered two wheelers are separated in STATS19 by engine capacity, however, when combined they account for 15.3 percent of all the motor vehicles involved in the collisions in the dataset, for the collision injury severity categories this represents 12.0 percent of the vehicle in fatal collisions and 17.7 percent of vehicles in the MAIS3+ collisions.

In the same manner as powered two wheelers, goods vehicles are separated in STATS19 according to weight. When the categories are combined goods vehicles account for 13 percent of all motor vehicles involved in collisions represented in the dataset and corresponds to 14.5 percent of the motor vehicles involved in fatal collisions and 12.0 percent of the vehicles involved in MAIS3+ collisions.

Again unfortunately there was no available data for Cambridgeshire although the East of England data for vehicle type estimated vehicle miles was available, these data show that in 2018 (the proportions have remained similar year on year since the 1993 data presented in the reference), in descending order, cars accounted for 76.7 percent of the vehicle miles, light commercial vehicle account for 16.3 percent, heavy goods vehicle 5.7 percent (all good vehicles 22.0 percent), motorcycles 0.8 percent and buses and coaches 0.5 percent (Department for Transport, 2019d). The over-representation of powered two wheelers in the collisions was consistent with the interpretation in the annual casualty report for Great Britain for 2019 (and preceding yearly reports) and other reports (Department for Transport, 2004; 2015c; 2019d; 2020d).

Bringing together all the circumstantial analysis above it may be possible to propose what might be described as a typical collision resulting in a fatality or MAIS3+ collisions in Cambridgeshire. This collision was during the day, probably during the afternoon peak period, in fine weather without high winds, on a stretch of A class road single carriageway without a junction subject to a 60mph speed limit and involve cars. However, due to the heterogenous nature of collisions, such as the peak in distribution of MAIS3+ collisions on 30mph roads, this construct must be considered with caution.

All of the comparisons undertaken showed that the distributions of the examined factors in the research sample were not unusual when compared to available data detailing other collision samples or research. The fact that the sample was not unusual gives confidence that any findings resulting from the analysis of the sample are also not likely to be unusual.

8.2.2 Study Two Discussion

This study explored the culpability scoring of the motor vehicle drivers identified in study one. An exercise was undertaken to apply the variables and contributory factors available in the STATS19 data across to the Robertson and Drummer (1994) culpability scoring tool. This exercise showed that it was possible to construct the Robertson and Drummer (1994) scoring criteria from the available variables and contributory factors. The same process was also undertaken for the Brubacher, Chan and Asbridge (2012) tool.

A trial sample of the motor vehicle driver population was subjected to culpability scoring using the Robertson and Drummer (1994) scoring tool utilising the application process devised to meet the objective. This sample comprised the motor vehicle drivers involved in MAIS3+ injury severity collisions during the 2012-13 financial year.

The application of the STATS19 variables and contributory factors onto the Robertson and Drummer (1994) was subject to an external inter-rater reliability process and found to be appropriate.

The trial produced results which were in line with those that would be expected from the literature (af Wåhlberg, 2009). The same sample was then examined using the Brubacher, Chan and Asbridge (2012) tool which produced comparable results for the motor vehicle drivers deemed culpable and non-culpable using the Robertson and Drummer (1994) but some variance occurred regarding culpability of the motor vehicle drivers deemed contributory. This small set of six motor vehicle drivers contained four which were involved in single vehicle versus pedestrian collisions. The Robertson and Drummer (1994) allocated some blame to the motor vehicle driver whereas the alternate weighting of the Brubacher, Chan and Asbridge (2012) allowed all the blame to be placed on the pedestrian.

The general consensus between the results obtained from the two tools despite the differences in criteria examined and weighting applied gives confidence in the tools ability to determine culpability from the available data.

The results produced by the Robertson and Drummer (1994) was subject to an external inter-rater reliability exercise and found to produce reliable and consistent results in 92.5 percent, 95 percent and 100 percent of the sample used by the three external experts.

The culpability of the motor vehicle drivers involved in the MAIS3+ collisions was assessed using the Robertson and Drummer (1994) tool. Four motor vehicle drivers did not have sufficient data available to be scored. The remaining n=356 motor vehicle drivers were categorised as 64.9 percent (n=231) culpable, 7.6 percent (n=27) contributory and 27.5 percent (n=98) as non-culpable.

The culpability of the motor vehicle drivers involved in the fatal collisions was assessed using the Robertson and Drummer (1994) tool. All n=300 motor vehicle drivers were scored. The motor vehicle drivers were categorised as 53.0 percent (n=159) culpable, 6.0 percent (n=18) contributory and 41.0 percent (n=123) as non-culpable.

With the Robertson and Drummer (1994) the proportion of culpable motor vehicle drivers in the fatal and MAIS3+ groups varied. In examining a possible cause, it appears the distribution of single and multi-vehicle collisions within the data had an influence, for example, one of the collisions in the fatal collision sample was a collision involving five vehicles, only one of the motor vehicle drivers was categorised as culpable. In relatively small datasets multi-vehicle collisions such as this with only a single culpable motor vehicle driver can influence the overall distribution. A higher proportion of single vehicle collisions in a dataset are likely to shift the proportion of culpable motor vehicle drivers higher. This factor does not appear to have been considered by af Wåhlberg (2009) in their assertion that a scoring tool should produce levels of culpable motor vehicle drivers of 70 to 80 percent in any given dataset.

With the Robertson and Drummer (1994) tool there remained a subjective nature to some of the scoring decisions, this also holds for the Brubacher, Chan and Asbridge (2012). It would not be possible to use either tool in their current format without interpretation of the collision narrative available in this dataset as the description variable. It must be acknowledged that this descriptive variable may not always be available to researchers who may wish to undertake culpability scoring and this was a limitation of the application of the process used in this study.

It was the interpretation of the collision narrative represented in the description variable which accounted for the variation in the scores produced by the Robertson and Drummer (1994) tool during the result inter-rater reliability exercise.

In summary, the culpability scoring undertaken on the dataset of n=660 motor vehicle drivers brought forward from the data linkage study has been successful in categorising the motor vehicle drivers into culpability categories and the objectives relating to the culpability scoring study have been achieved.

The complex nature of collisions was reflected in the complexity of the available culpability scoring tools and it was understandable that those designing such tools wished to reflect that complex nature. The tools have been used to research the impact of factors on motor vehicle driver culpability, such as drink or drugs. However, in this research culpability has been used as a differentiator to separate the culpable motor vehicle drivers from the non-culpable motor vehicle drivers allowing further research into each of the groups. It was clearly shown in study two, see chapter five, that the scoring tools devised by Robertson and Drummer (1994) and Brubacher, Chan and Asbridge (2014) could be applied to the data available in STATS19, albeit that the process was complex and requires the subjective assessment of STATS19 to fit constructs within the scoring tools.

However, in reflecting on the factors taken into account in relation to the individual motor vehicle drivers in the Robertson and Drummer (1994) and Brubacher, Chan and Asbridge (2012) scoring tools it is questionable that a factor which is present for all the motor vehicle drivers, in multi-vehicle collisions, should be a factor in determining individual culpability of the motor vehicle drivers involved. For example, the weather, if the weather was poor for two motor vehicle drivers on the same stretch of road and one crashes and the other does, not it cannot be the weather that was the factor. It was the individual actions in dealing with the prevailing conditions which was the factor. Therefore, the weather cannot be mitigation for the motor vehicle driver having a collision, it should be a factor the motor vehicle driver takes into account and drives accordingly, i.e., still safely and not causing a collision. This can be seen to be the basis and thrust of both the legislative tools, legal precedent and official advice to motor vehicle drivers in the UK (*Road Traffic Act 1988*; 'DPP V Smith' (2002) *EWHC* 1151 (Admin); 'McCrone v Riding' (1938) *1 All ER* 157; 'Taylor' (2004) *EWCA Crim* 213; Department for Transport, 2015).

Therefore, the available scoring tools, for a UK context and for purely determining culpability as a differentiator, are overly complex and involve the manipulation and interpretations of significantly more data than was actually required to achieve the goal. This allows for a simpler scoring tool to be devised and applied to STATS19 data. This scoring tool takes into account the factors which directly impact on the individuals motor vehicle drivers. The suggested alternative tool has the advantage that it does not rely on any subjective interpretation of material within the STATS19 data and would lend itself to automation should this be required.

Study two answered the research question which asks what alternatives are available to culpability score motor vehicle drivers in the UK context. Culpability scoring using the established tools devised by Robertson and Drummer (1994) and Brubacher, Chan and Asbridge (2012) was a complex process which requires the extraction of multiple combinations of data from that available within STATS19. However, the results obtained are consistent between tools and produce inter-rater reliable results. The complexity can be observed in the composite tables presented in appendices six to eight.

What can be observed, in examining the application of the Brubacher, Chan and Asbridge (2012) scoring tool, was that there was more utilisation of the descriptive material contained within STATS19, this includes multiple variables, including manoeuvres, pedestrian movement, pedestrian location, skidding and overturning, movement, junction location and first point of contact as well as contributory factor 'swerved' (409) or 'loss of control' (410) and the collision narrative, see table 5.79, to build the constructs in section six (Type of collision) than are required for the constructs within the Robertson and Drummer (1994) tool, this makes the use of the Brubacher, Chan and Asbridge (2012) more time consuming.

Both of the established tools utilised in this study were built for specific purposes and framed within jurisdictional paradigms and data availability. The experience of applying the tools to STATS19 data leads to consideration of whether a tool could be produced which would be a more suitable fit to the prevailing circumstances in the UK.

8.2.2.1 Formulating an Alternative Scoring Tool for STATS19

Both the Robertson and Drummer (1994) and Brubacher, Chan and Asbridge (2012) can be used to culpability score with the STATS19 data, however, in practice there were still elements of subjectivity and interpretation of the collision narrative in determining what data may be used to determine the score apportioned to the constructs used in the tools. This subjectivity and interpretation could create difficulty if culpability scoring was to be applied to bulk STATS19 data and possibly unnecessary if the scoring was purely for the function of determining culpability, rather than the impact of an additional factor, it may be appropriate to explore the formulation of an alternative tool to simplify the process and hence reduce the time and resources required. Collisions are complex events with multiple factors leading to their occurrence. The two culpability scoring tools examined and applied in this chapter are also complex mechanisms which reflect the complex nature of collisions. The two scoring tools examined were both written to deal with the data available to the authors, to examine an additional factor (an intoxicant) and built within the jurisdictional context where the researchers were based.

It was clear from the examination of the results produced by the application and results inter-rater reliability process that variation of the scores produced by different individuals utilising the tool resulted from the subjective interpretation of a number of constructs within the scoring tool. Such as the lack of road sense construct in the witness observation section of the Robertson and Drummer (1994) tool, discussed in section 5.6.2, which led to variation in the culpability allocated to a small number of motor vehicle drivers. The avoidance of using constructs, such as ‘lack of road sense’ or ‘striking’ and ‘struck’ which do not appear in the data in that form and require a subjective and/or interpretative construction, in any scoring tool, should produce a tool that produces more consistent results across different users.

The function of the culpability scoring tools was to differentiate culpability from the actions or lack of them by individual motor vehicle drivers, therefore, the applying of the same factors to all motor vehicle drivers in a collision, such as the weather or road layout, if taken on a simplistic level does not have the power to assist with this differentiation. Hence a tool which only concentrates on the individual motor vehicle driver's actions, be they positive, negative or inaction could dispense with consideration of the circumstantial material as these factors affect all motor vehicle drivers in the collision.

This section examines the criteria used in the scoring tools from a UK jurisdictional, legal and STATS19 data perspective which may allow for a simplification of the process within a UK context.

For the Robertson and Drummer (1994) scoring tool the criteria in sections one to three (Condition of road; Condition of vehicle and Driving conditions) and sections seven (Difficulty of task) and eight (Fatigue) were examined as well as observation on the content of section four (Type of accident). For the Brubacher, Chan and Asbridge (2012) The examination explores the factors set out in sections one to three (Road type; Driving conditions and Vehicle condition) as well as sections six (Type of collision) and seven (Task involved).

In a UK legal context, motor vehicle drivers are responsible for their actions and responsible for the vehicle they are driving. The *Road Traffic Act 1988* contains the offences related to standards of driving, two sections have been specifically enacted setting out the meanings of the two levels of driving defined by the act. The two levels of unsatisfactory driving described in the legislation are 'dangerous' driving , the most serious under *section 2, Road Traffic Act 1988*, and 'careless and inconsiderate' driving under *section 3, Road Traffic Act 1988*. The meaning of 'dangerous driving', presented in *section 2A, Road Traffic Act 1988*, entails a standard of driving which falls far below that of a 'competent and careful driver' (*section 2A(1)(a)*).

The meaning of 'careless or inconsiderate driving' being presented in *section 3ZA, Road Traffic Act 1988*, giving 'careless' driving as a standard of driving which falls below of a ‘competent and careful driver’ (*section 3ZA(2)*). The difference between the severity being whether the driving fell ‘below’ or ‘far below’ that of a ‘competent and careful driver’, this being an objective test to be considered by the court ('Loukes' (1996) *1 Cr. App.* R.444). With no definition of what a ‘competent and careful’ driver looks like it falls to the court to decide on the facts presented.

However, *section 3ZA(3)* does give guidance that in any determination of a ‘competent and careful’ driver the court should consider not only the circumstances that the motor vehicle driver should have been aware of but also what should have been within their knowledge to be aware of. There are also a considerable number of offences which relate to specific behaviour which are beyond the scope of this text to explore, irrespective of the behaviour described it can always be considered the responsibility of the motor vehicle driver.

The condition of a vehicle has an impact on safety, and this has led to a considerable body of legislation which has been specifically written to deal with situations where a vehicle may not be in a satisfactory condition. The primary source being the *The Road Vehicles (Construction and Use) Regulations 1986* with other provisions within the *Road Traffic Act 1988* and there are also specific regulations, such as *The Road Vehicles Lighting Regulations 1989*.

These requirements regarding standards of driving and vehicle condition are put into context by the advice and guidance set out in the Highway Code (Department for Transport, 2015h) which forms the basis for safe driving principles. A separate Highway Code exists for Northern Ireland with a single document for the remaining three UK countries. The Highway Code has a wide scope, being designed for all road users, so contains advice for pedestrians, equestrians, cyclists and more, as well as the drivers of motor vehicles. If a motor vehicle driver complies with the requirements set out in the Highway Code, they should not commit any road traffic offences and in most cases avoid being involved in collisions as a culpable party.

The Highway Code sets out the requirements in the form of rules with an expectation that motor vehicle drivers will follow them, these are used to build the construct of a ‘competent and careful driver’. The construct of the ‘competent and careful driver’ was then taken into the legal context of the offences which relate to standards of driving under the *Road Traffic Act 1988*.

The Highway Code rules themselves are not law and motor vehicle drivers are not prosecuted for failing to follow their direction, however, *section 38, Road Traffic Act 1988* which deals with the Highway Code does make specific provision, under *subsection (7)* for them to taken into account in proceeding, *subsection (7)* being reproduced below.

> (7) A failure on the part of a person to observe a provision of the Highway Code shall not of itself render that person liable to criminal proceedings of any kind but any such failure may in any proceedings (whether civil or criminal, and including proceedings for an offence under the Traffic Acts, the Public Passenger Vehicles Act 1981 or sections 18 to 23 of the Transport Act 1985) be relied upon by any party to the proceedings as tending to establish or negative any liability which is in question in those proceedings. (*section 38 (7), Road Traffic Act 1988*)

This subsection forms part of the Crown Presecution Service (2019) guidance on charging practice for road traffic offences relating to dangerous driving or driving without due care and attention, reproduced below.

> Prosecutors should also consider whether a driver has failed to observe a provision of the Highway Code. This does not itself render that person liable to criminal proceedings, but a failure, particularly a serious one, may constitute evidence of careless or even dangerous driving; see s.38(7) RTA 1988 (Crown Prosecution Service, 2019).

The Highway Code rules contain a mixture of legal requirements and advice. If the rule relates to a legal requirement then the Highway Code always contains the modal verbs ‘must’ and ‘must not’. The other rules contained in the Highway Code are advisory, many, but not all, of these also contain a modal verb, in these circumstances, ‘should’, these rules relate to best practice or best advice. Examples of the rules relevant to this discussion are presented in appendix 13.

A critical examination of many of the criteria applied by the Robertson and Drummer (1994) and Brubacher, Chan and Asbridge (2012) scoring tools within a UK data and legal context could provide a less complex scoring paradigm which would allow wider use of culpability scoring in the UK.

Both scoring tools examine the type of road and road layout in various combinations and across sections of the scoring tools, for the Robertson and Drummer (1994) this was section one (Condition of road) and for the Brubacher, Chan and Asbridge (2012) sections one (Road type) and two (Driving conditions). In both cases there are some combinations which attract a mitigating score. In the UK context the more complex the road situation the higher the expectation of extra driver care; therefore, the likelihood of a collision should be no greater in any given road circumstance. Failure to deal adequately with these complex situations would be likely to constitute a standards of driving offence. Therefore, complex road situation should not be mitigation for a motor vehicle driver, and these sections of the scoring tools are not required to determine motor vehicle driver culpability. Clearly, this data in STATS19 still has important implication in understanding other aspects of the collision, such as from an engineering or education perspective but not motor vehicle driver culpability.

Similarly, both tools examine combinations of weather, lighting and road surface conditions in various scoring criteria, for the Robertson and Drummer (1994) this was section three (Driving conditions) and for the Brubacher, Chan and Asbridge (2012) section two (Driving conditions). Again, there are some combinations, which could be considered more complex, that are scored as mitigating to the motor vehicle driver. In the UK context these more hazardous circumstances require, and there was an expectation of, more care by the motor vehicle driver. The extra care taken countering the extra hazard posed should result in there being no more likelihood of a collision. Failure to deal adequately with these adverse conditions were likely to constitute a standards of driving offence. Therefore, adverse conditions should not be mitigation for a motor vehicle driver, and these sections of the scoring tools are not required to determine motor vehicle driver culpability. Again, clearly the collection of this data in STATS19 still has important implications in understanding other aspects of the collision, such as from an engineering or education perspective.

Both scoring tools mitigate for a defective vehicle for the Robertson and Drummer (1994) this was section two (Condition of vehicle) and for the Brubacher, Chan and Asbridge (2012) sections three (Vehicle condition). In the UK responsibility for the roadworthiness of a vehicle sits with the motor vehicle driver (if others also have responsibility for the vehicle, such as employers or fleet managers they are independently liable, but this does not abdicate the motor vehicle driver's responsibility). Therefore, a defect places responsibility directly on the motor vehicle driver and compounds their culpability and should not be a mitigating factor, therefore, these sections of the scoring tools are not required to determine motor vehicle driver culpability. Again, clearly the collection of this data in STATS19 still has important implications in understanding other aspects of the collision, such as from an enforcement, engineering or education perspective.

Both scoring tools examine to some degree the complexity of the task involved, for the Robertson and Drummer (1994) this was section seven (Difficulty of task involved) and for the Brubacher, Chan and Asbridge (2012) sections seven (Task involved), in these cases the critique presented in the last three paragraphs would be equally applicable. Failure to deal adequately with these more difficult of situations would be likely to constitute a standards of driving offence. Therefore, adverse or more complicated conditions should not be mitigation for a motor vehicle driver, therefore, these sections of the scoring tools are not required to determine motor vehicle driver culpability. Again, clearly the collection of this data in STATS19 still has important implications in understanding other aspects of the collision, such as from an engineering or education perspective.

The Robertson and Drummer (1994) scoring tool has a separate criteria for motor vehicle drivers suffering from fatigue (section eight), a motor vehicle driver suffering from fatigue has a mitigating score added. In a UK context driving whilst tired has a specific Highway Code rule, rule 91, and breaches of the advice given would likely render the motor vehicle driver liable to have committed a standards of driving offence. Therefore, fatigue should not be a mitigating factor, therefore, this section of the scoring tool would not be required to determine motor vehicle driver culpability. Again, the collection of this data in STATS19 still has important implications in understanding other aspects of the collision, such as from an enforcement or education perspective.

In formulating an alternative scoring tool consideration must be given to the factors which influenced the results produced by the validated scoring tools from the literature.

With the Robertson and Drummer (1994) tool all the motor vehicle drivers involved in single motor vehicle collisions were deemed culpable, there was some divergence of culpability result with the Brubacher, Chan and Asbridge (2012) but only for single vehicle versus pedestrian collisions, all other single motor vehicle collisions resulted in the motor vehicle driver be categorised as culpable. It follows that when a collision occurs and there was only one motor vehicle involved there can only be one motor vehicle driver culpable in those circumstances.

This leaves the remaining factors and criteria from the two scoring tools examined, these can be summarised as those which Robertson and Drummer (1994) term as witness observations and road law obedience and Brubacher, Chan and Asbridge (2012) term as unsafe driving actions and contribution from other parties. Within STATS19 the data that was applied for these criteria was primarily contained in the contributory factors and it was the contributory factors which add detail and individual criteria to specific motor vehicle drivers, interpreting their actions.

There are collisions recorded in STATS19 where there are no contributory factors listed. In such cases and with no additional information the default position must rest with the responsibility put on motor vehicle drivers by the legal position and the advice given in the highway code (rules 159-203). In these cases, only, reference must be made to the manoeuvres variable where the onus was on the motor vehicle driver undertaking a manoeuvre, i.e. where the vehicle was moving, to take extra care and undertake the manoeuvre in such a way as to not cause danger.

Therefore, motor vehicle drivers undertaking a manoeuvre other than one where the vehicle was stationary, or the vehicle was going straight ahead, and a collision occurred can be deemed to have failed in that duty and are therefore culpable.

However, the manoeuvre of slowing or stopping (04) needs to be examined in the context of the first point of impact variable. If a vehicle was slowing and was hit from behind the motor vehicle driver would not be culpable, alternatively if a slowing motor vehicle driver hits a vehicle in front of them or puts the vehicle in such a position as to be hit from the side then they would be culpable.

The factors which only assess the motor vehicle driver's culpability can be combined into a scoring tool, this tool being set out as an alternative in appendix 13. All of the data are available in STATS19 directly form variables or contributory factors, it does not require subjective interpretation of constructs or the collision narrative.

These criteria can be applied to the motor vehicle drivers involved in the two case studies the results are presented in table 8.1 below.

Table 8.1 Alternative scoring tool case study results

Criteria	**Criteria scores**			
	Case study one	**Case study one**	**Case study two**	**Case study two**
	Driver one	**Driver two**	**Driver one**	**Driver two**
Single motor vehicle collisions	No	No	No	No
Contributory factors present in the collision data	Yes	Yes	Yes	Yes
Contributory factors allocated to the driver	Yes	Yes	Yes	No
Culpable (yes/no)	Yes	Yes	Yes	No

The alternative scoring tool produced the same results in the case studies as the two scoring tools from the literature.

8.2.2.2 Alternative scoring tool validation

A validation process was undertaken applying the alternative scoring tool to the sample used in the validation process for the Robertson and Drummer (1994) scoring tool. This allowed the results produced by the alternative tool to the results produced by the Robertson and Drummer (1994) scoring tool. The alternative scoring tool is designed to remove the subjectivity and expert understanding of collisions required by the Robertson and Drummer (1994) scoring tool. Therefore, the validation process was designed for such individuals and undertaken by two academic colleagues who are not experts in road traffic collision related matters. The two non-experts were members of the policing teaching staff at Canterbury Christ Church University with no specific roads policing or collision reconstruction experience, training or expertise. A briefing document was created to guide the participants through the process, this is reproduced in appendix 14. The sample contained the details of 40 motor vehicle drivers.

In comparing the results from the alternative tool and the Robertson and Drummer (1994) it must be considered that the alternative tool only produces two results, that being that the driver is culpable or non-culpable. Whereas the Robertson and Drummer (1994) produces the additional result of contributory. As considered previously, the contributory result from the Robertson and Drummer (1994) tool only account for a small proportion of the results and can be combined with the culpable driver category as the drivers involved did in fact contribute to the collision occurring.

Of the 40 motor vehicle drivers scored with the alternative tool the resultant culpability classification, be is culpable or non-culpable, matched the results from the Robertson and Drummer (1994) in 85 percent (n=34) of the cases. A further 10 percent (n=4) of the cases which were classified as contributory using the Robertson and Drummer (1994) scoring tool were classified as culpable using the alternative tool. Therefore, 95% of the results obtained with the alternative tool produced the results in line with those produced by the Robertson and Drummer (1994) for the purpose of differentiating the motor vehicle drivers by culpability.

The remaining 5% (n=2) were motor vehicle drivers, which using the subjective examination of the descriptive material in STATS19 had been categorised as one being culpable and one being contributory, were categorised as non-culpable by the alternative tool. Further, these two motor vehicle drivers were two of the motor vehicle driver’s scoring where there was discrepancy during the inter-rater validation, as these assessments were purely based on the subjective interpretation of the descriptive material within STATS19. The use of the alternative scoring tool removes this subjective interpretation and errs in favour of the motor vehicle driver, so for these drivers, designated culpable and contributory by the Robertson and Drummer (1994) scoring categorisation, the alternative tool categorised them as non-culpable.

The validation process demonstrates that the alternative scoring tool does indeed remove the subjectivity evident in the Robertson and Drummer (1994) scoring tool. Where there is clear data to demonstrate culpability of a motor vehicle driver they are categorised as such, equally the absence of data suggesting culpability results in a motor vehicle driver being categorised as non-culpable. The results will be consistent regardless of the dataset the alternative tool is applied to.

8.2.3 Study Three Discussion

Geodemographics, the segmentation of the population into profiles based on multiple factors, including socioeconomic activity, are used by multi-million pound companies to set strategy, it has been shown over time to be the best way for them to determine where they can access the target audience for their products, be it physically or virtually (Tapp, Whitten and Housden, 2014; Webber and Burrows, 2018), the application being determined by the individual situation. Yet this option has not been explored within the road safety field in relation to motor vehicle drivers, even though it has been used to explore casualties (Anderson, 2005; 2010; Loo and Anderson, 2016; Road Safety Analysis, 2020), there was nothing in the literature to indicate why this may be the case, although the utility of doing so without determining culpability may be of limited use and as previously discussed, such a determination was complex using the existing tools and does not lend itself to automation.

Geodemographic analysis did show that culpable motor vehicle drivers were drawn from certain geodemographic types and some of these types were over-represented compared to the distribution within the general population of Cambridgeshire. These differences would allow the application of direct marketing techniques to the driver sample, however, the exact techniques to be applied would depend on the intervention they were being applied to. For example, if a road safety message banner was to be displayed on a webpage, as much current advertising tends to be, the use of geodemographics would allow for that message to only appear to users fitting the pre-determined geodemographic types in the geographic area required. Hence the message would only go to groups from which the culpable motor vehicle drivers were drawn with the resultant reduction in the cost of the campaign.

For organisations wishing to utilise such a segmentation there would be options available within the process. For organisations which intended to target fatal and clinically serious injury collisions all three stages of the process, the data-linkage, culpability scoring and geodemographic profiling, would be required, as the non-clinical STATS19 serious injury category would be insufficient. For those organisations intent on targeting all injury collisions or the more traditional KSI basis for interventions only the culpability scoring, and geodemographic profiling would be required.

Study three involved the straightforward processing of the data in the sample. The processing started with the examination of the postcode data within the sample. The postcode data was collected as part of the collision reporting process and was contained within STATS19. The postcodes were compared to those held in the 2011 census data. This was the most recent set of census data available. What the comparison showed was that 86.1 percent of the motor vehicle drivers in the sample had a valid postcode appended to their record. There were a number of reasons identified why the data in the postcode variable were not correct, missing data, incomplete data and data which appeared to be correctly formatted but did not correspond to the census data. The issue of missing or incorrect data in STATS19 is well established and acknowledged by the Department for Transport (2020d) and others (Transport Scotland, 2015; Imprialou and Quddus, 2017).

In addition to the postcode data the census data also holds data relating to which county or local authority the postcode sits. This data, for the valid postcodes, was also appended to the motor vehicle drivers record as an additional variable. This allowed for differentiation of the motor vehicle drivers who were resident in Cambridgeshire at the time of the collision, with 65.3 percent of the motor vehicle drivers in the sample being from within the county where the collision occurred and a further 24.1 percent from the six surrounding counties, supporting views that collisions occur close to individuals homes (Steinbach, Edwards and Grundy, 2013). The Cambridgeshire resident motor vehicle driver construct was incorporated into later analysis.

The final stage of this study appended the Acorn geodemographic data to the motor vehicle driver records with a valid postcode. Only two of the valid postcodes did not have a corresponding Acorn geodemographic profile resulting in n=566 (99.6 percent) of all the motor vehicle drivers records with a valid postcode also having an Acorn type profile. For motor vehicle drivers who were resident in Cambridgeshire only one of the postcodes did not have and Acorn type profile resulting in n=370 (99.7 percent) of the motor vehicle drivers being profiled.

The two final stages demonstrated that where a valid postcode was available only a very small number of the valid postcodes did not have a corresponding Acorn geodemographic profile. The objective was completed, all the motor vehicle drivers presented in the data, where there was a valid postcode and corresponding geodemographic profile, had the geodemographic data appended to the record. As well as the geodemographic categorisation additional information was added to records with valid postcodes which allows differentiation of the county or local authority area in which that motor vehicle driver was residing at the time of the collision.

8.2.4 Analysis Discussion

The age distributions within the sample and motor vehicle driver groups was explored, the medians and interquartile range were within relatively tight ranges, the examination which did show results which have further implications was the testing of normality. When examining the age distribution histograms, see appendix 12, it was apparent that groups, be it all motor vehicle drivers or just those containing culpable and contributory motor vehicle drivers, did not appear from the shape of the histogram to have normal distributions. This was supported and reinforced by the S-W testing which confirmed that these groups did indeed not display a normal distribution. The shape of the age distribution histograms for the non-culpable motor vehicle driver groups did not display a classic bell shape of a normal distribution, yet they also did not display the bi or multi modal shape of the groups containing the culpable and contributory motor vehicle drivers. The Shapiro-Wilks (S-W) testing did indeed show the non-culpable motor vehicle drivers had a normal distribution. The non-culpable motor vehicle driver age distribution has a similar distribution to that of the age distribution of all driving licence holders. This supports the suggestion that the non-culpable motor vehicle drivers within the sample could be used as a proxy for the general driving population and supports the need to undertake culpability scoring.

The logistic regression did find that within some of the variable combinations explored the age of the motor vehicle driver did have a significant impact on the culpability of the motor vehicle driver, however, the significant results, where they arose, were always an increased risk in the odds of being culpable and only affected motor vehicle drivers under 26 years of age or over 76 years of age. Likewise, when the logistic regression explored age in relation the likelihood of being involved in a fatal collision compared to MAIS3+ collision, where significant results were evident, they only ever related to two age groups, 26-35 years old or over 85 years old, and these always related to in increased odd of being involved in a fatal collision.

The age distribution of the motor vehicle drivers in the sample and the logistic regression support conclusions in other studies. Depending on the studies these conclusions may be in relation to all collisions, but also applicable to the more or most serious collisions, this was also reflected in government reports (West, 1997; Department for Transport, 2004; 2015i; 2018a; Anderson, 2005; Clarke *et al.*, 2010a;

Transport Research Laboratory, 2010; Jones, Begg and Palmer, 2013; Regev, Rolison and Moutari, 2018).

Gender distribution was consistent, the χ^2 results showing no significant differences, across the motor vehicle driver groups with three times as many men involved in the collisions as women, the logistic regression showed that gender was not significant in either culpability of the motor vehicle driver or the injury severity of the collision.

The Index of Multiple Deprivation (IMD) category of the motor vehicle drivers home address at the time of the collision was explored descriptively and within the logistic regression. When examining the proportions of each IMD category within each motor vehicle driver group what is apparent is that when considering the groups containing culpable and contributory motor vehicle drivers compared to non-culpable drivers there was an increase in the proportion in the most deprived IMD category, this observation was supported by the mutually adjusted results from the logistic regression within all the motor vehicle drivers within the sample. This analysis produced a significantly higher odds of being culpable or contributory if the motor vehicle driver's residence was within the IMD first decile. For the corresponding analysis for Cambridgeshire resident motor vehicle drivers there was also increased odds of being culpable or contributory for the IMD first decile, but the result did not reach the significance threshold, also there was an increased odds ratio of being culpable or contributory in the 6th decile compared to the most frequent. When the injury severity of the collisions was explored in the logistic regression, IMD decile only produced one significant result, that being a lowered odds ratio of being involved in a fatal collision if the Cambridgeshire resident motor vehicle driver had a home address designated as being in IMD 10th decile, i.e., the least deprived.

Acorn geodemographic profiles were explored at the two coarsest granularities, Acorn category and Acorn group descriptively and Acorn category was explored within the logistic regression. The Acorn category was found to be distributed in similar proportions regardless of the motor vehicle driver group. Exploration of the Acorn groups did show that within the Acorn categories the distribution of the groups was not even. This was to be expected as the Acorn categories and groups are not evenly distributed within the population of Cambridgeshire. The inclusion of Acorn category within the logistic regression model showed that Acorn category had no significant impact on either of the binary outcomes, be it motor vehicle driver culpability or the injury severity of the collision.

The analysis of motor vehicles classes within the logistic regression model produced some significant results for both outcomes. For culpability, in the all the modelling, being the rider of a motorcycle put the individual at higher odds of being culpable or contributory for the collision. Within the modelling exploring all the motor vehicle drivers in the sample regardless of residence being the motor vehicle driver of an agricultural vehicle or goods vehicle produced lower odds of being culpable at a significant level or close to the significance threshold, this was not reflected in the modelling for Cambridgeshire resident motor vehicle drivers. The logistic regression modelling exploring collision injury severity category identified that motorcycle riders were at reduced odds of being involved in a fatal collision compared to a MAIS3+ collision at a significant level or close to significance in all models explored. Conversely, the drivers of goods vehicle were at increased odds of being involved in a fatal collision at a significant or close to significant level, this may reflect the impact the weight of a goods vehicle has on the amount of energy within a collision.

Journey purpose was included in the logistic regression modelling. It should be noted that STATS19 only records a limited number of journey types and the majority of journeys are recorded as other journeys and not one of the defined types. None of the specified journey types was significant factor in the culpability of motor vehicle drivers in the sample. However, within all the motor vehicle drivers in the sample, incorporating IMD in the model, there was significantly lower odds of being involved in a fatal collision compared to being involved in a MAIS3+ collision for motor vehicle drivers involved in a journey as part of work. However, when Acorn category was incorporated in the model it was motor vehicle drivers involved in a to/from work journey category which had significantly lower odds of being involved in a fatal collision. For Cambridgeshire resident motor vehicle drivers, in both modelling options, motor vehicle drivers involved in a journey as part of work had significantly lower odds of being involved in a fatal collision compared to being involved in a MAIS3+ collision.

The descriptive analysis of the geodemographic profiles of the motor vehicle drivers presented in the data does show that there are differences in both the Acorn types distributions represented in the motor vehicle driver groups differentiated by motor vehicle driver culpability and collision injury severity category for the motor vehicle drivers who were resident in Cambridgeshire at the time of the collisions supporting hypothesis of difference.

The use of geodemographic profiles to segment populations takes into account multiple demographic material relating to individuals, which researchers would not be able to explore individually, as Quddus (2015, p. 2) observes 'A geodemographic profile of a motor vehicle driver therefore contains factors such as age, gender, residence of motor vehicle driver, social deprivation, and the distance from home to crash locations (at the motor vehicle driver-level); land-use patterns of crash location, casualties per crash and vehicles involved in the crash (at the crash- level); and vehicles per 1,000 population and population density (at the area-level)' and this was reinforced by CACI the developers of the Acorn segmentation (CACI Limited, 2014; 2019b; Webber and Burrows, 2018).

The risk index allows comparison of the distribution of geodemographic profiles, in the case of this research the Acorn segmentation (CACI Limited, 2014), within the sample to the distribution in the general population. This can indicate the risk to individuals within the Acorn type profiles in the general population of being involved in the matters being examined, in this research being a motor vehicle driver who was culpable or contributory in causing a fatal or MAIS3+ injury collision.

Anderson (2005; 2010) and Loo and Anderson (2016) explored the distribution of the casualties by analysis of spatial variation in the geodemographic distributions, using a risk index, which show that certain geodemographic segments, generally at the lower end of the socio-economic spectrum are at greater risk of being the casualties of collisions. These studies also found that different segments of the population are more likely to become casualties and were overrepresented in the casualty sample compared to the general population. By the application of the same methods, albeit with an alternative geodemographic profiling source, Acorn compared to Mosaic in the earlier studies, there have been similar findings in this research, with segments of the motor vehicle driving population in the sample overrepresented in the motor vehicle drivers culpable of causing the most serious of injury collisions. Although the dominance at the lower end of the socio-economic spectrum has not been found to be the case with the motor vehicle drivers explored within this research.

These finding should be considered within the constraints of the sample, namely the motor vehicle drivers involved in fatal and MAIS3+ collision in Cambridgeshire between 2012 and 2017. The finding that certain segments of the population contain the motor vehicle drivers that are culpable for causing the fatal and MAIS3+ collisions are identified in the analysis as the most frequent and are overrepresented compared to the general population would allow individuals tasked with delivering interventions, such as education campaigns, to the population of Cambridgeshire, to apply well established marketing methods based on population segmentation (Harris, Sleight and Webber, 2005; Webber and Burrows, 2018). The use of geodemographics allows exploration of multiple factors relating to residential locations, such as income, wealth, purchasing preferences and so on, by the analysis on a single variable, the geodemographic profile.

What the analysis has shown was that although there are differences in the distributions across the motor vehicle driver groups differentiated by motor vehicle driver culpability and collision injury severity category there were certain Acorn types which appear in the top ten types by frequency within each of the groups. Types 23 ‘owner occupiers in small towns and villages’, and type 10 ‘better-off villagers’ are the first and second most frequent in the all-Cambridgeshire motor vehicle driver group, the culpable and contributory motor vehicle drivers all the collisions and the culpable and contributory motor vehicle drivers in MAIS3+ collisions, type 23 was second most frequent in the culpable and contributory motor vehicle drivers in fatal collisions with type 10 in sixth. In the top ten Acorn types by frequency for the non-culpable motor vehicle driver in all collisions type 10 was the most frequent with type 23 in sixth. Type 41 ‘labouring semi-rural estates’ also appears in all the distributions and over-represented in the sample compared to the general population. What should be noted that although these types appear in all the motor vehicle driver groups there was variation between the risk index for these types across all the motor vehicle driver groups from a high level of over-representation compared to the population to under-representation, such as type 23 risk index varying between 205 and 93, type 10 risk index varying between 120 and 47 and type 41 risk index varying between 339 and 127, see appendix 12.

The risk index analysis of the Acorn type distribution within the Cambridgeshire resident motor vehicle drivers within the sample does show that there are segments of the population from which the culpable and contributory motor vehicle drivers involved in fatal and MAIS3+ collisions are drawn more than others. These segments, Acorn types, can be identified using the process set out in the thesis and are not only the most frequent represented but are also overrepresented compared to the distribution of the segments within the general population. The identification of these segments allows for the application of direct and social marketing methodology.

The analysis of the contributory factors related to the motor vehicle drivers in the three most frequent Acorn types in the culpable motor vehicle drivers involved in both injury classifications showed that there were four contributory factors which were most frequent, these being, in descending order, failing to look properly (405), loss of control (410), Poor turn or manoeuvre (403) and careless, reckless or in a hurry (602). Notable failing to look properly accounted for twice as many as the next most frequent. Comparison with the GB contributory factor statistics for 2017 (Department for Transport, 2020b), see Appendix 12 table 8, showed that these four contributory factors correspond to the four most frequent contributory factors in the fatal collisions for that year and four out of the top five for the STATS19 serious category. It is therefore clear that the factors leading to the culpability of motor vehicle drivers in the sample followed the same pattern of factors as those nationally.

This further reinforces the material suggesting that the sample is not unusual compared to other samples and that interventions designed nationally to attend to the poor standards of driving which create the circumstances of collisions would be applicable to the motor vehicle drivers residing in the Acorn types identified in study three. Undertaking this analysis also allows for the authority responsible for road safety interventions to confirm the interventions being used within their area of responsibility are appropriate to the culpable drivers being targeted.

8.3. Conclusions

Data linkage produces useful information not available from the original unlinked datasets (Abrahams and Davy, 2002; Department for Transport, 2012b; Dipnall *et al.*, 2014; Harron, 2016; Harron, Doidge, *et al.*, 2017; Gilbert *et al.*, 2018; Nunn *et al.*, 2018). In this case it was not possible to distinguish MAIS3+ collisions from the STATS19 dataset. This study has overcome this limitation of the STATS19 dataset by undertaking a linkage process with hospital trauma patient data. This linkage shows that in the data used in this study MAIS3+ injuries only represent some 14.7 percent of the STATS19 serious injury categorisation. Without carrying out similar processes for the alternate portions of the full UK STATS19 dataset it was not possible to say if this would be replicated nationally.

Study one produced a dataset which contains motor vehicle drivers from the road traffic collisions which occurred in Cambridgeshire during the period April 2012 to

March 2017 which resulted in a subject being injured to a level which reaches the MAIS3+ threshold, these being combined with material from the fatal collisions. This data contains the details of all the motor vehicle drivers involved in the collisions, which was the data required for study two (presented in chapter five), for culpability scoring.

The descriptive analysis of the collision circumstances in chapter one allowed comparison of the collisions represented in the sample with material available relating to other collision data and findings represented in the literature. The comparison of the circumstances of the collisions represented in the sample with findings from other analysis presented in the literature would not suggest that there was anything extraordinarily different, or unusual, about the collisions represented in the sample.

Within study two the use of the scoring tool devised by Robertson and Drummer (1994) was not without complication, this was primarily as a result of the origin of the tool and that it was not devised to use the data available within the STATS19 data. However, the culpability scoring process was successful in differentiating the motor vehicle drivers into the three available culpability categories. The results are in line with those proposed by the literature as ones which suggest the processes can be considered to be stringent enough to produce valid results.

The process was assessed for inter-rater reliability of the application process and inter-rater reliability of the results generated. The result of the assessment showed that the application of the STATS19 data was valid and that the results produced were reliable in inter-rater comparisons. There was also comparison with an alternative tool devised by Brubacher, Chan and Asbridge (2012) which showed that results were consistent across the tools.

There was an examination of culpability, and the scoring of it, within a UK context, this took account of the UK jurisdictional and legal framework combined with the data available within STATS19. This examination suggested that in a UK context and determining the culpability for the collision only rather than the impact of external factors a more simplified approach could allow the assessment of larger datasets.

This study has produced a dataset of culpability scored motor vehicle drivers involved in the fatal and MAIS3+ collisions in Cambridgeshire for the five-year period 2012-2017 which was then used for the following study.

Study three started with the assessment of the validity of the home postcodes represented in the data, this was straightforward. The process, which was linked together with the second stage of study three involved the appending of the county or local authority data, including the related postcode to each record, this allowed for a secondary visual check that both postcodes on each record matched. The process did highlight, as has been previously reported (see section 2.2.1) some of the data quality issues present in the STATS19 dataset, this resulted in a proportion of the motor vehicle drivers in the dataset (13.9 percent) not having a valid postcode. The postcode validation process gave access to the county and local authority data required for the second stage of this study as this was part of the material available in the census data. However, where a valid postcode was available very few did not have a corresponding Acorn geodemographic profile.

This additional data gave the opportunity to differentiate the motor vehicle drivers that were resident in Cambridgeshire at the time of the collision. The value of this ability to differentiate to the thesis was high as it allows the examination of the motor vehicle drivers who reside in Cambridgeshire rather than the whole sample population, with some motor vehicle drivers living a considerable distance away and beyond the scope of any local road safety activity. The understanding that a significant proportion of the non-Cambridgeshire motor vehicle drivers were residents from the surrounding counties give opportunity for joint or regional approaches.

This study has produced a dataset of culpability scored and geodemographically profiled motor vehicle drivers involved in the fatal and MAIS3+ collisions in Cambridgeshire for the five-year period 2012-2017. The dataset contains variables which allow the differentiation of the motor vehicle drivers into groups, the combination of groups available are presented in table 8.3 below.

Table 8.2 Dataset groups

Group option	Detail
Culpability	This option allows for the drivers to be differentiated by the culpability category allocated to them during the second study and also allows for the construct of a combined culpable and contributory category
Injury severity	The drivers involved in fatal collisions can be differentiated from the drivers involved in the serious injury (MAIS3+) collisions
Cambridgeshire residents	The drivers who were resident in the county of Cambridgeshire at the time of the collisions can be differentiated
County or local authority of residence	The county within which the home postcode of the driver sits can be differentiated, this also allows constructs such as the counties neighbouring Cambridgeshire to be examined
Acorn geodemographic profile	The drivers can be differentiated by all three levels of granularity available within the Acorn data
Invalid or missing postcode	When the driver did not have a valid postcode, the reason can be differentiated

The analysis undertaken in chapter seven had two objectives, to determine if there are differences in demographic distributions between culpable and non-culpable motor vehicle drivers involved in fatal and serious (MAIS3+) injury collisions and to evaluate the potential for using geodemographic profiling to deliver targeted road safety interventions.

There were a number of statistically significant differences between the motor vehicle driver groups defined by the culpability of the motor vehicle driver.

The logistic regression explored the impact of motor vehicle driver related variables on the culpability of the motor vehicle driver and the injury severity category of the collision within the sample. The consistently significant factors across the logistic regression modelling suggesting motor vehicle drivers were at higher odds of being culpable or contributory for the collision they were involved in was their age, less than 26 years old or over 76 years old and whether they were the driver of a motorcycle. The involvement of younger and older motor vehicle drivers in collisions where they are more likely to be culpable has already been reported (Transport and Road Research Laboratory, 1982; Department for Transport, 2001; 2018a; Transport Research Laboratory, 2010), the findings presented in this thesis support these conclusions and activity focussed towards these groups of road users.

The vulnerability of motorcyclist as casualties was commonly reported (Department for Transport, 2004; 2019c; 2020d), however, this analysis also links the riding of motorcycles with the rider's culpability for the collision, this may be linked to a propensity to be involved in single vehicle collisions. Therefore, activity focussed on motorcyclists can be seen as being further justified by the findings presented in this thesis. What this analysis does not explore was how both factors, their vulnerability as casualties and their culpability for the collision, relate to any other parties involved in those collisions. For example, the speed or movement of another vehicle, this relationship could be the subject of further study.

For all the motor vehicle drivers in the sample there were significant factors impacting on the odds of being involved in a fatal collision compared to a MAIS3+ collision, albeit less than those in the culpability distinction. Being the rider of a motorcycle showed higher odds. Being the driver of a goods vehicle showed lower odds as did being on a journey as part of work or commuting to/from work.

For Cambridgeshire resident motor vehicle drivers being in the >85 age group showed in increased odds of being involved in a fatal collision compared to being involved in a MAIS3+ collision. Being a motor vehicle driver on a journey as part of work showed significantly reduced odds. Being the driver of a goods vehicle showed increased odds, however, this did not reach the significance threshold (p = .058).

There were differences between the Acorn type distributions, highlighted by the risk index analysis, between both motor vehicle driver groups differentiated by collision injury severity, and motor vehicle driver culpability compared to the general population of Cambridgeshire, supporting the hypothesis of difference between the motor vehicle driver groups.

That in the risk index analysis the top ten Acorn types by frequency in each group represent over half of the motor vehicle drivers within each group could allow for the application of interventions to a narrow section of the population, segregated by Acorn type, and still engage with the target audience in a similar fashion to interventions targeting segments of the population based on age distributions.

The exploration of the contributory factors which determined the culpability of the motor vehicle drivers clearly indicated that within the segments explored the contributory factors were reflected those evident in the national statistics. Further indicating that the drivers represented in the sample are not an usual group and that interventions currently focussed on the standard of driving would be applicable to drivers within the identified Acorn types.

The identification of the Acorn types most frequently represented in the culpable motor vehicle drivers combined with the deep understanding of the people who reside within the Acorn types allows the application of established social marketing methods (Smith, 2006; Bird and Tapp, 2008; Tapp *et al.*, 2013) to the application of road safety interventions. Any resulting reduction in road traffic related injury will reduce the overall burden of injury (Lyons, 2008).

8.4. Contribution to Knowledge

This research has been undertaken using data from Cambridgeshire for a five-year period. The police collision data comes in the form of the STATS19 dataset, used across Great Britain. The hospital trauma patient data come in the form of the TARN dataset which continues to be collected in all the major trauma centres in England and Wales. This research has explored a new process to segment a motor vehicle driver population involved in specific clinically injury severity assessed collisions to allow the targeting of interventions and has been a successful proof of concept. With appropriate access to the data the process devised in this research can be applied to any county in England and Wales.

This has been the first research that shows that culpability scoring of motor vehicle drivers in the STATS19 dataset, given suitable data access, can be achieved using the culpability scoring tools devised by Robertson and Drummer (1994) and Brubacher, Chan and Asbridge (2012), however, it has also demonstrated an option to use an alternative culpability scoring tool specifically devised for STATS19 data in a UK context.

Analysis of the age distributions of the motor vehicle drivers differentiated by culpability showed statistically different distributions between the culpable, bi- or multi-modal non-normal, and the non-culpable, normal distribution. Gender showed no significant differences. For the collisions delineated by injury severity categorisation this was not the case. Therefore, it can be concluded that culpability, as a group delineator, differentiates the motor vehicle drivers on these two demographic factors, whereas injury severity, as a delineator, does not.

The use of geodemographic profiles as a delineator to examine the motor vehicle driver population has not been undertaken before and did show differences between groups for the groups differentiated by collision injury severity and motor vehicle driver culpability.

8.5. Study Strengths

The data provided by the partner organisations to this research was the only suitable data available. STATS19 data does have data quality issues and these are widely acknowledged (Department for Transport, 2011; 2019d; Transport Scotland, 2015; Imprialou and Quddus, 2017), however, the data quality only impacted at certain stages of the research. In study one where the two datasets were linked there was no missing data in the four variables used for the linkage. In the second study involving the culpability scoring of the motor vehicle drivers there were a very small number of records, four from 660, that did not contain sufficient material to allow for scoring to be undertaken. In the third study, where geodemographic profiles were appended to the motor vehicle driver records there was an issue with missing or incorrect postcodes which resulted in an inability to geodemographically profile 13.9 percent of the sample.

Improvements in data quality which may result from the current review of STATS19 (Department for Transport, 2020d) and an adoption of electronic reporting may result in an improvement of this situation in the future.

The TARN data was only used in the first study to identify the casualties which had suffered a MAIS3+ injury as a result of a collision and hence the collisions which had resulted in those injuries. This dataset did not have any missing data in the four variables used for the linkage process or in the injury data used to determine if the injury reached the MAIS3+ threshold.

This research concentrated on the county of Cambridgeshire as a distinct geographic area, this localism produced results which are specific to that county which may not be the case if the research had encompassed a larger geographical area.

The use of population segmentation to target road safety interventions has been a long standing tool, consider interventions targeted at young motor vehicle drivers, for example. However, the use of geodemographics to undertake this segmentation has not been, even though it has been a longstanding and fundamental segmentation tool for marketing and business (Tapp, Whitten and Housden, 2014; Leventhal, 2016), the strengths of geodemographics in taking into account multiple individual factors could also be applied to road safety interventions.

8.6. Limitations of the Study

There are a number of limitations associated with this study. Some variables in the data used, for example the descriptive narrative, were not in the public domain. The data was obtained after appropriate information sharing protocols were put in place with the data holders to allow access, therefore, it would not be possible to repeat the process described in the thesis without such access.

The STATS19 data provided for the research covered a five year period for one county, this included data relating to 10498 collisions. However, even with the addition of the MAIS3+ injury collisions to the fatal collisions from the original data, the sample, subject to analysis, still only represented 3.5 percent of the original collisions, albeit the collisions which caused the most severe of injuries. Although the results are applicable to the injury severities examined these only represent a small proportion of all collisions, therefore, any conclusions drawn may not be applicable to injury collisions which did not meet the entry criteria of resulting in a fatality or an injury at MAIS3+ level of severity.

The TARN dataset does have strict entry criteria. These strict criteria mean that not all patients with a MAIS3+ injury, those, for example, that are not admitted for the required period, were captured within this data. Therefore, the sample may not capture all the MAIS3+ injury severity collisions within the STATS19 data.

It was not possible to completely negate subjectivity in the culpability assessment process. Even if the culpability scoring process employed removes any subjective assessment by the researcher there remains the reliance on the material contained in the STATS19 data. The material relating to how the collision occurred, the interaction of the vehicles and motor vehicle driver actions including causation factors are the subjective assessment of the reporting officer. Not all police officers receive specialist training in the reconstruction of collisions, it remains a specialism generally restricted to roads policing officers. Often those dedicated to the investigation of collisions resulting fatal or life changing injuries which only account for around 3.9 percent of all injury collisions nationally (Department for Transport, 2020d). This dichotomy in the level of training received between the officers dealing with fatal and serious injury collisions and the remaining officers dealing with the remaining injury collisions means the material contained within STATS19 must be considered with caution. The process of reporting collisions using STATS19 as a base also fails to explore a number of possible causation factors, such as emotional state prior to the collisions, also, factors such as drug driving are likely to be underestimations, so the complete picture is not available.

This thesis presents research which focussed on one English county, where the localism had the advantage of producing results tailored to Cambridgeshire. However, conversely it has not been demonstrated how the process would work if larger geographic constructs, such as regions, were explored. The possible loss of the positives of localism, with variation in the population geodemographics between counties would need to be balanced with the advantages gained by the use of larger datasets.

8.7. Generalisability

The research presented in this thesis utilises data from one county. As previously stated, the process involved can be applied, given appropriate data access, to any county in England and Wales. However, the results obtained for Cambridgeshire are unlikely to be repeated in any other county. Each county, unitary authority or local authority are unique in their population distribution and geodemographic profile. It could be, in fact, this localism which can be on one hand a strength and in the other a limitation.

The analysis of the data, presented in chapter seven, did demonstrate that the sample of collisions and motor vehicle drivers, when compared to available data for other samples of collisions, was not unusual. The age and gender distributions are in line with what would be expected, as were the vehicles involved, road types and chronology of the collisions. That the sample used was not unusual would suggest that the results obtained are not likely to be unusual, albeit that local variation in populations distribution across geodemographic profiles was evident. Therefore, the process could have general applicability with available data.

The data used in this research was provided by partner organisations and was subject to a comprehensive information sharing protocol. The research has shown proof of concept in that the process devised during the research should be repeatable given suitable access.

8.8. Implications

There were benefits in being able to link collision and patient data, it allows a far greater understanding of the injuries which result from collisions and opens further opportunities for research. However, the process of linking the two types of data could be made much simpler if the processes both involved a common identifier. The most obvious common identifier would seem to be the casualties NHS number, and this may be something the hospital may be able to obtain in a relatively straightforward way from records.

However, it seems unlikely that individuals involved in collisions as casualties would be in a position to divulge this to the reporting officer and this would lead to officers being burdened with the responsibility to obtain the number from NHS staff and the undoubted raising of questions regarding data protection and the General Data Protection Regulations. An alternative could be a requirement on the hospital to record the police incident number, this would place the burden on NHS staff. In the absence of a simple solution involving a common identifier the improvement of STATS19 data quality in relation to the ages of casualties and home postcode data would mean any data linkage using the four common variables would be more comprehensive.

The Department for Transport are already undertaking a review of STATS19 (Department for Transport, 2019d) exploring possible improvements in the reporting process. The findings of this research, presented in this thesis, in relation to the processes involving the STATS19 data have already contributed to the information gathered by the team undertaking the review.

As there are statistically significant differences between the culpable and non-culpable motor vehicle driver in the sample, see chapter seven, the use of culpability scoring can give greater insight into the motor vehicle driver population allowing research to focus on the motor vehicle drivers which contributed to the circumstances of collisions rather than those motor vehicle drivers merely involved by their presence.

8.9. Unanswered Questions and Future Research

Although, as discussed in the generalisability section of this chapter, the analysis of the sample used in the research presented in this thesis would suggest that the process used could be applied to alternative geographic areas, this has not been tested. Certainly, for counties in England and Wales both the STATS19 and TARN data are available in the format used in the research, therefore the process devised would be applicable. Of less certainty are considerations of how the process would work if applied to larger geographic constructs, such as regions. Where although the dataset available would be considerably larger, depending on the number of counties in the region, in the case of the East of England this would be six, the local nature of the population distribution may be lost.

The analysis of data from Cambridgeshire was straightforward in that all seriously injured casualties from the county are treated at Addenbrookes Hospital in Cambridge, therefore, the trauma patient data would be as complete a record as possible. In other areas, notably London and the home counties there are multiple major trauma centres to which casualties could be taken, with four in London, so care would be needed to ensure that all the casualty data from geographically bounded collision data was captured, for example, casualties from Kent are regularly transported to Kings College Hospital in Denmark Hill, Southwark.

Application of direct marketing principles to the geodemographic profiles over-represented in the culpable motor vehicle driver groups to target interventions has not been tested in this research, further studies are required to ascertain if the ability to segment the motor vehicle driver population with geodemographic data, which has been accomplished with this research, can be applied in a practical scenario.

The alternative culpability scoring tool presented in this thesis, was based on the manual assessment of the material available in STATS19 against the devised criteria and was not an aim of the thesis, the tool arose out of the work undertaken during the second study and reflection on the processes involved. Hence, any automation of the alternative scoring tool was also not one of the aims of the thesis. However, the automation of the alternative culpability scoring tool would be desirable at some stage in the future should there be a requirement to apply it to bulk data. The application of the automated tool to bulk STATS19 data would allow analysis comparing the most serious collisions with the remaining injury collisions to assess if there are differences between the motor vehicle drivers involved. The automation would require complex commands to be written applicable to the software package to be applied, be it Stata, SPSS or R which was beyond the scope of the thesis and the capability of the author.

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Appendix 1: Other Clinical Injury Scales

There are other clinical injury scales, not related to AIS, which have been devised for specific purposes within specialist medical fields, which do not feature in collision related literature, although their use in relation to collision casualties may be applicable. A selection of examples being presented below.

The Organ Injury Scale (OIS) has been devised by The American Association for the Surgery of Trauma (AAST) and works in a very similar fashion to AIS, however, it has specific codes for individual organs. In comparing both ICD, AIS and OIS it was found that some OIS codes did not having equivalents within the other two tools. The AAST maintains and updates the OIS (The American Association for the Surgery of Trauma, 2019).

Amongst other specialist tools the Glasgow Coma Score was developed over 40 years to describe traumatic brain injury and the consciousness response to define stimuli (Royal College of Physicians and Surgeons of Glasgow, 2019). The Clinical Abdominal Scoring System was devised to score blunt force trauma to the abdomen (Afifi, 2008; Dave, Bansal and Astik, 2019), with a further classification system specifically devised for defining musculoskeletal fractures within the specialism of orthopaedics (AO Trauma and Orthopedic Trauma Association, 2018; Meinberg *et al.*, 2018). Ongoing development also includes a Scoring System for Inhalation Injury (U.S. National Library of Medicine, 2019).

Appendix 2: Literature review Tables and figures

The codes presented, from the AIS 2008 revision, do not necessarily represent injuries which would be sustained in a road traffic collision and are only to allow understanding of the structure. Note, trauma patients may have injury to more than one body regions and more than one injury to any given body region, so complex injury can be described. The important difference between AIS and ICD being the use of a severity element within the coding.

Appendix 2, table 1, AIS region, coding and severity (Association for the Advancement of Automotive Medicine, 2008)

Body Region, denoted by the chapters in the coding guidelines	**Injury Code examples for each body region (AIS 2008 coding)**	**Severity**
Head	All codes start with 1. Skull vault fracture 150406.4	AIS 1 – Minor AIS 2 – Moderate AIS 3 – Serious AIS 4 – Severe AIS 5 – Critical AIS 6 – Maximal (currently untreatable)
Face	All codes start with 2 Retrobulbar haemorrhage 240499.1	
Neck	All codes start with 3 Complete occlusion of the vertebral artery 321018.3	
Thorax	All codes start with 4 Trauma of the chest cavity with systemic aeroembolism 442212.5	
Abdomen	All codes start with 5 Duodenum "perforation, disruption < 50% circumference [OIS II]" 541021.2	
Spine	All codes start with 6 Intervertebral ligament injury 640484.1	
Upper Extremities	All codes start with 7 Glenohumeral Joint, NFS 771099.1	
Lower extremities	All codes start with 8 Knee joint dislocation 874030.2	
External and other	All codes start with 9 or 0 Burns 2nd or 3rd degree age < 5 years, 20 to 29% body surface 912020.4 Drowning 060006.5	

The codes identifying specific injuries and severity are constructed in a specific way. An example of allocation of information to the code digits being presented in table 2 below to allow deeper understanding.

Appendix 2, table 2, AIS code structure example (The Trauma Audit and Research Network, 2005)

Example				
Femoral shaft fracture (AIS 2005) = 851814.3				
8 = Body Region: Lower Extremity	5 =Type of Anatomic Structure: Skeletal	18 =Specific Anatomic Structure: Femur	14= Level of injury: Shaft	.3 = AIS: Severity score

The injury severity categorisation within AIS has six ordinal levels, one to six, and these are based on the relative risk of threat to life in an average person who sustains the coded injury as his or her only injury, ranging from zero probability of death for AIS1; AIS2 1-2 percent; AIS3 8-10 percent; AIS4 20-50 percent; AIS5 50-80 percent and AIS6 Close to 100 percent (The Trauma Audit and Research Network, 2005; Page *et al.*, 2012; Hendre, Mali and Kulkarni, 2020). An example of how the injury severity escalates, using chest injuries, are presented below in table 3.

Appendix 2, table 3, Example AIS codes for chest injuries with escalating severity (The Trauma Audit and Research Network, 2020, p. 7)

Injury	Numerical Identifier	AIS	Severity
Fracture 1 rid	450201	1	Minor
Fracture 2 ribs	450202	2	Moderate
Haemopneumothorax	442205	3	Serious
Bilateral lung lacerations	441450	4	Severe
Bilateral flail chest	450214	5	Critical
Massive chest crush	413000	6	Maximum

AIS also forms the basis for two constructs, MAIS and ISS which are dealt with in sections 2.3.4.3 and 2.3.4.4.

The body regions used to calculate ISS are set out below in table 4.

Appendix 2, table 4, Injury Severity Score body region explanation (Baker *et al.*, 1974; New South Wales Institute of Trauma and Injury Management, 2017)

ISS body region	Description of the body region contents
Head of neck	Head or neck injuries include injury to the brain or cervical spine, skull or cervical spine fractures and asphyxia/suffocation.
Face	Facial injuries include those involving mouth, ears, nose, and facial bones.
Chest	Chest injuries include all lesions to internal organs, drowning and inhalation injury. Chest injuries also include those to the diaphragm, rib cage, and thoracic spine.
Abdominal or pelvic contents	Abdominal or pelvic contents injuries include all lesions to internal organs. Lumbar spine lesions are included in the abdominal or pelvic region.
Extremities or pelvic girdle	Extremities or pelvic girdle injuries include sprains, fractures, dislocations, and amputations.

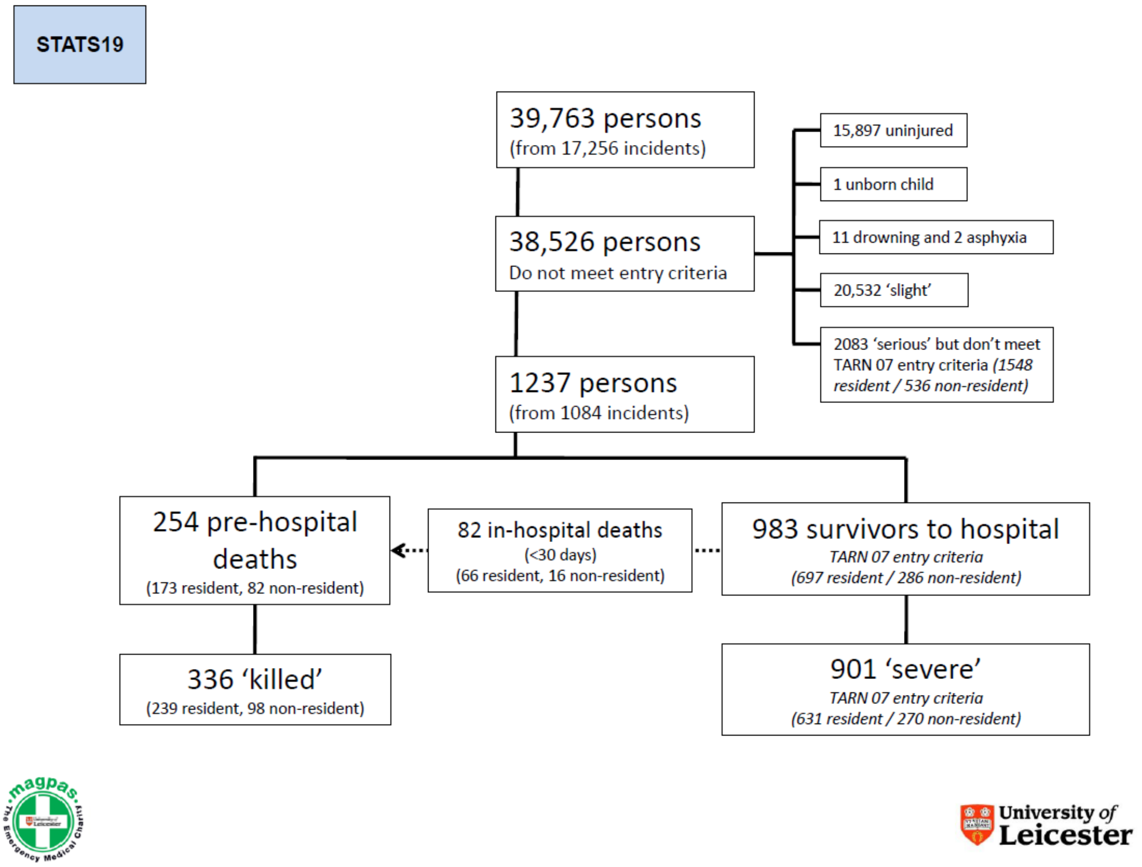
External	External and other trauma injuries include lacerations, contusions, abrasions, and burns, independent of their location on the body surface, except amputation burns that are assigned to the appropriate body region. Other traumatic events assigned to this ISS body region are: electrical injury, frostbite, hypothermia, and whole body (explosion-type) injury.

An example of how the ISS for a trauma patient may be calculated is presented in table 5 below.

Appendix 2, table 5, Injury Severity Score construct example

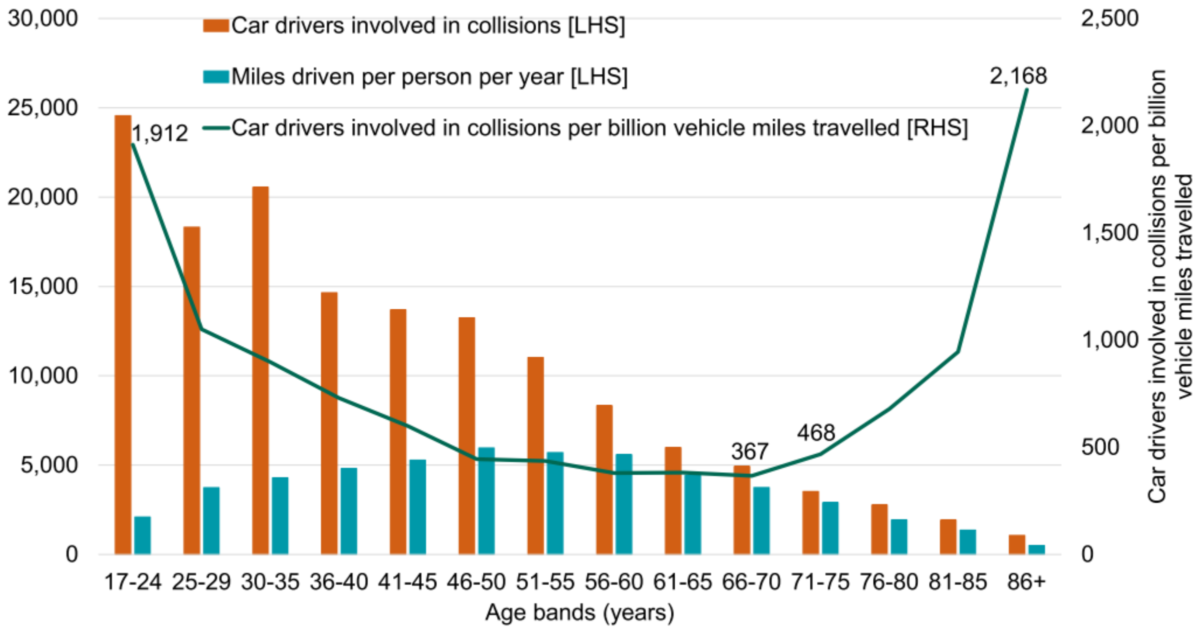
ISS body Region*	Injury	AIS Code	Highest AIS	AIS²
Head/ Neck	Skull vault fracture	150406.4	4	16
Face	Retrobulbar haemorrhage	240499.1	1	
Chest	Trauma of the chest cavity with systemic aeroembolism	442212.5	5	25
Abdomen	Duodenum "perforation, disruption < 50% circumference [OIS II]"	541021.2	2	
Extremities	Knee joint dislocation	874030.2	2	
External	Drowning	060006.5	5	25
				ISS = 66

The flow diagram of the CTARP project results is presented below in figure 1.



Appendix 2, figure 1, CTARP data flow (University of Leicester, 2005, p. 52)

The Department for Transport presentation of collision involvement with age is presented below in figure 2.



Appendix 2, figure 2, The relationship of age to miles driven per year for motor vehicle drivers in England in 2016 (Department for Transport, 2018a, p. 3)

The table below sets out the UK based research which links police collision data with hospital patient data.

Appendix 2, table 6, Summary of studies involving the linking of police and hospital data.

Research	**Data linked**	**Injury Coding/ Data range**	**Linkage method**	**Results**	**Observations**
(Bull and Roberts, 1973)	Local police records (STATS19 not specified) with Local Hospital A+E attendance	Not specified/ 1970 first 100 cases per month in Birmingham	Accident department records ‘traced’ in collision data, not details but appears to be manual deterministic using name, age, sex, place and time of incident, category of road user and type of injury	All fatalities reported, 1/6 of serious injuries unreported and 1/3 of slight injuries unreported	Single vehicle, incl. cycle, under-reported more
(Transport and Road Research Laboratory, 1980)	STATS19 with collision casualties in Hospital In-Patient Enquiry (HIPE) (this predates HES data)	ICD8/ 1972	Sequential automated deterministic process, with tolerances, which are scored. Using date of incident, local authority/ police force, age, sex, severity of injury, grid reference for incident,	50% of the HIPE records matched to STATS19 records	Under-reporting to police, less as injuries became more severe
(Transport and Road	STATS19 with collision	ICD9/ 1980	Automated deterministic process	24% of casualties	Variance in age allowed ± 2 years,

Research Laboratory, 1984b)	casualties in Scottish Hospital In-patient Statistics (SHIPS)		with tolerances, using location of incident, age, sex, class of road user.	not in police data, ICD serious injuries contained both fatal and slight police records	ICD converted to AIS, 20% of the casualties were MAIS3+
(Transport and Road Research Laboratory, 1987)	STATS19 with collision casualties in Scottish Hospital In-patient Statistics (SHIPS)	ICD9/ 1980-83	Automated deterministic process with tolerances, using location of incident, age, sex, class of road user. (As 1984 study)	70% of hospital patients represented in STATS19	ICD converted to AIS, 19.2% of the casualties were MAIS3+
(Austin, 1992)	STATS19 with Local Hospital A+E attendance	Not specified/ May-Dec 1991	Automated sequential deterministic, 6 variable options, date, surname, forename, address, age, gender. With a manual comparison undertaken.	Confidential information improved match rate to 97.3%	Better match rate provides better data for analysis
(Transport Research Laboratory, 1993b)	STATS19 with three Local Manchester Hospital A+E non-fatal attendances	AIS(1985)/ Jan-Jun 1990	Manual deterministic process, using age, gender, road user type, treatment, injury severity	63% of hospital patients represented in STATS19	21% of the police serious injury casualties were MAIS3+. Under-reporting to police, less as injuries became more severe
(Transport Research Laboratory, 1996)	STATS19 with Non-fatal A+E collision casualty admissions at 16 hospitals in the Accident Surveillance System	AIS(1990)/ 1993	Automated ‘statistical’ (deterministic with tolerances) method, using date of incident, age, sex, road user type, casualty severity	6% of the hospital sample were MAIS3+ with 8% in the police serious injury categorisation and 1% in the slight	The proportion of MAIS3+ casualties in this study being lower than similar studies. Under-reporting to police, less as injuries became more severe
(Transport Research Laboratory, 1999)	STATS19 with collision casualties in Scottish Hospital In-patient Statistics (SHIPS)	ICD9 and AIS(1990)/ 1980-1995	As the 1984 TRRL study with extended date range	Continuation of the 1984 and 1987 studies shows continuity of data analysis results with a reduction in in-patient timescales over the years	21.8% of the police serious injury casualties were MAIS3+. The proportions of linked records for fatal (13-16%), Serious (53-57%) and slight (4-6%) per year have been consistent for the study period
(Transport Research Laboratory, 2001)	STATS19 fatal and serious casualties with TARN collisions casualties	AIS(1990) and ISS / 1994-1996	As the 1984 TRRL study with extended date range and alternative geographic boundaries	61% of TARN records linked to STATS19 records	11% of STATS19 fatal or serious injury records linked to TARN records. Only unique matches accepted

(Cryer *et al.*, 2001)	Local police records (STATS19 not specified) with three Local East and West Sussex Hospitals A+E non-fatal attendances	ICD10/ Apr 1995 to Mar 1998	Manual process using name, date of incident, place of incident, then checked against age, sex, type of road user and date of crash/hospital admission	61% of the hospital records were linked to the police records	Only an estimated 50% of collision injury casualties were admitted to hospital, the proportion for serious injuries was higher
(Transport Research Laboratory, 2002b)	STATS19 with A+E records from three specific London Hospitals	Clinical injury assessment not examined/ 2001	Two stage, deterministic with n-1 option, 1st automated, 2nd manual (visual). Using, date of incident, age (banded), sex, road user class.	Between 70% and 87% of hospital casualties present in police data	The reporting rate, being only an estimate, should be treated with caution
(Department for Transport, 2012b)	STATS19 with HES for England only	ICD10/ 1999-2009	Deterministic and rule based (rather than formally probabilistic) process using sex, age date of incident region (of accident of hospital) for initial match , then postcode for most likely	Up to 20% of matches may have been missed. 32% of HES records were linked to STATS19 and 37% of STATS19 records linked to HES	The more severe the injury the more likely to be in STATS19

The four designs of road safety study are presented below in table

Appendix 2, table 7, Summary of road safety study designs (adapted from Kim and Mooney, 2016, p. 1673)

Design	**Cases**	**Comparison group**	**Assess risk of**	**Key risk of bias**	**Most suitable exposures**
Case-Control	Drivers involved in a collision	Independently sampled controls	Collision involvement	Sampling controls independent of exposure	Exposures unlikely to cause refusal to participate (e.g. sleep history, chronic medical conditions)
Case-crossover	Drivers involved in a collision	Cases themselves at another time point	Collision involvement	Recall bias, contextual contributions to the collision	Administratively assessable exposures (e.g. mobile telephone use, previous offending)
Culpability	Drivers responsible for a collision	Drivers involved but not responsible for a collision	Collision responsibility	Responsibility assessment, contextual contributions to collision risk	Exposures assessable from mandatory biological samples taken by first responders (e.g. drug or alcohol use)
Quasi-induced exposure	Drivers responsible for a 2+car collision	Drivers not responsible for the same 2+ car collision	Collision responsibility in 2+ car collisions	Responsibility assessment	Exposures assessable from mandatory biological samples taken by first responders (e.g. drug or alcohol use)

The literature employing culpability scoring during the methods are presented below in table 8.

Appendix 2, table 8, Literature considering culpability, the factor examined, and method described

Reason for examination of culpability	**Literature**	**Culpability assessment method use in the literature**
Impact of cannabis consumption	(Asbridge, Poulin and Donato, 2005) (Mann *et al.*, 2007) (Richer and Bergeron, 2009) (Mann, *et al.*, 2010)	Survey data, no collision data analysis Survey data, no collision data analysis Survey data, no collision data analysis Survey data, no collision data analysis
Impact of amphetamine, methamphetamine	(Logan, 1996) (Lemos, 2009)	No culpability method explained No culpability method explained
Impact of alcohol consumption	(Soderstrom *et al.*, 1993) (Robertson and Drummer, 1994) (Brubacher, Chan and Asbridge, 2012)	(Terhune, 1983) (Robertson and Drummer, 1994) (Brubacher, Chan and Asbridge, 2012)
Impact of benzodiazepine consumption	(Longo, Lokan and White, 2001) (Dubois, Bedard and Weaver, 2008) (Orriols *et al.*, 2016)…….	(Robertson and Drummer, 1994) Unsafe driving action as proxy for culpability (Robertson and Drummer, 1994)
Impact of opioid analgesic	(Reguly, Dubois and Bédard, 2014)	Unsafe driving action as proxy for culpability
Impact of more than one intoxicant (see section 2.55 regarding intoxicants)	(Terhune and Fell, 1981) (Terhune, 1983) (Terhune *et al.*, 1992) (Longo *et al.*, 2000b) (Lowenstein and Koziol-McLain, 2001) (Soderstrom *et al.*, 2001) (Mura *et al.*, 2003) (Drummer *et al.*, 2004) (Movig *et al.*, 2004) (Ogden *et al.*, 2010) (Gadegbeku, Amoros and Laumon, 2011) (Mørland *et al.*, 2011) (Corsenac *et al.*, 2012) (Poulsen, Moar and Pirie, 2014) (Dubois *et al.*, 2015) (Carvalho *et al.*, 2016) (Drummer and Yap, 2016) (Orriols *et al.*, 2017) (Orriols *et al.*, 2019) (Drummer *et al.*, 2020)	Single vehicle and rear end shunts (Terhune, 1983) (Terhune, 1983) (Robertson and Drummer, 1994) Trained crash reconstructionist – no method described Subject interview, no collision data analysis (Robertson and Drummer, 1994) (Robertson and Drummer, 1994) Subject interview, no collision data analysis (Terhune, 1983; Robertson and Drummer, 1994) (Robertson and Drummer, 1994) Single vehicle collisions (Robertson and Drummer, 1994) (Robertson and Drummer, 1994) Unsafe driving action as proxy for culpability (Terhune, 1983) (Robertson and Drummer, 1994) (Robertson and Drummer, 1994) (Robertson and Drummer, 1994) (Robertson and Drummer, 1994)
Unsafe driving actions, risky driving, personality, aggressive driving, reaction	(Underwood *et al.*, 1999) (Hendricks *et al.*, 2001)	Subject questionnaire, no collision data analysis No method described
Age and sex	(Dulisse, 1997a) (Lardelli-Claret, *et al.*, 2003a) (Maasalo *et al.*, 2016)	Offence citation No method described Finnish road accident investigation team determination, method not described
Comparison of driving convictions with collisions risk	(Banks *et al.*, 1977)	Legal culpability determined using local regulations, although not explicitly stated undertaken by the authors

Mobile telephone use	(Backer-Grøndahl and Sagberg, 2011) (Asbridge, Brubacher and Chan, 2013)	Subject questionnaire, no collision data analysis (Brubacher, Chan and Asbridge, 2012)
Driver dependent factors	(Lardelli-Claret, *et al.*, 2003b) (Lardelli-Claret *et al.*, 2005) (Hours *et al.*, 2008) (Moskal, Martin and Laumon, 2012) (Galéra *et al.*, 2012) (Bakiri *et al.*, 2013) (El Farouki *et al.*, 2014) (Orriols *et al.*, 2014) (Gil-Jardiné *et al.*, 2017) (Née *et al.*, 2019)	Reported infraction as proxy for culpability Reported infraction as proxy for culpability Subject questionnaire, no collision data analysis (Robertson and Drummer, 1994) (Robertson and Drummer, 1994) (Robertson and Drummer, 1994) (Robertson and Drummer, 1994) (Robertson and Drummer, 1994) (Robertson and Drummer, 1994) (Robertson and Drummer, 1994)
Impact of passengers	(Rueda-Domingo *et al.*, 2004) (Vollrath, Meilinger and Krüger, 2002)	Reported infraction as proxy for culpability (Terhune, 1983; Robertson and Drummer, 1994) application not described

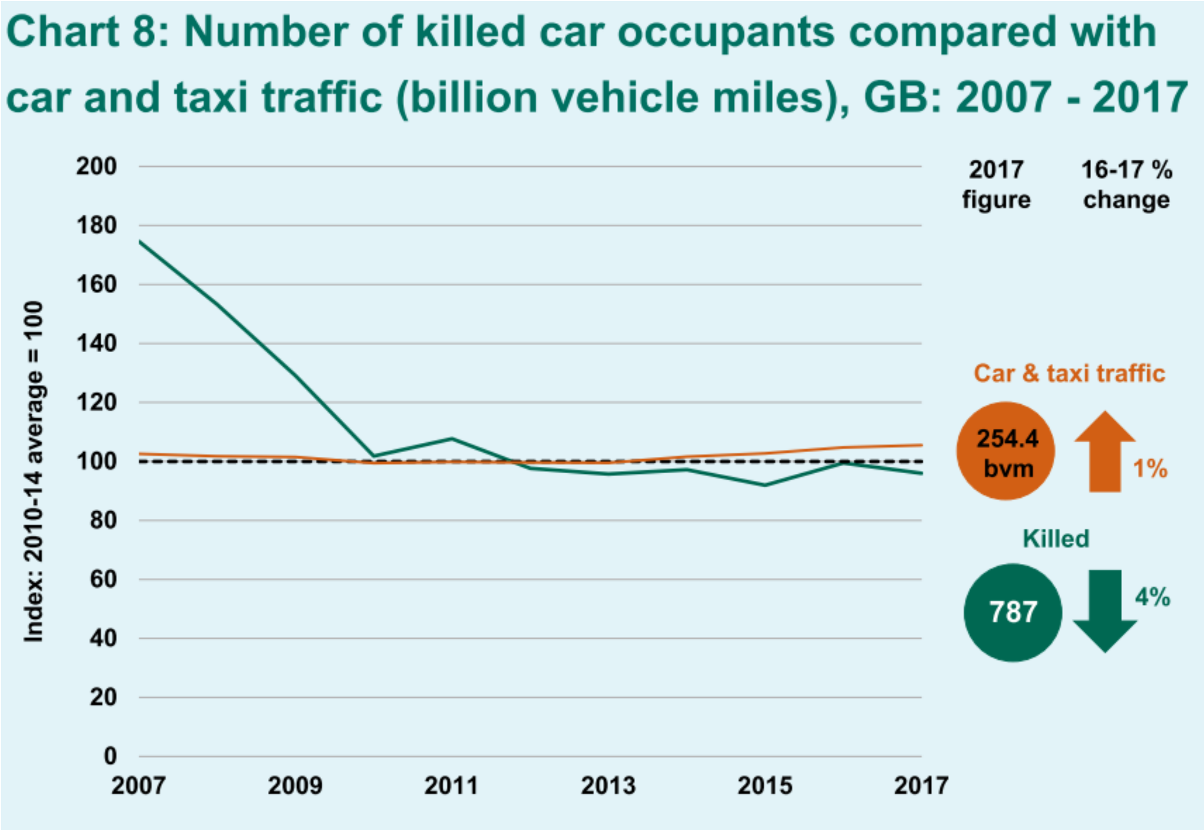
Figure 3 below presents a breakdown of the structure of a postcode and their UK distribution.

Postcode structure 2

Example	Geographic Unit	Number in UK
PO	Postcode Area	124
PO15	Postcode District	3,114
PO15 5	Postcode Sector	12,381
PO15 5RR	Unit Postcode	Approximately 1.75 million (Live)

Appendix 2, figure 3, UK postcode structure and distribution (Office for National Statistics, 2018a)

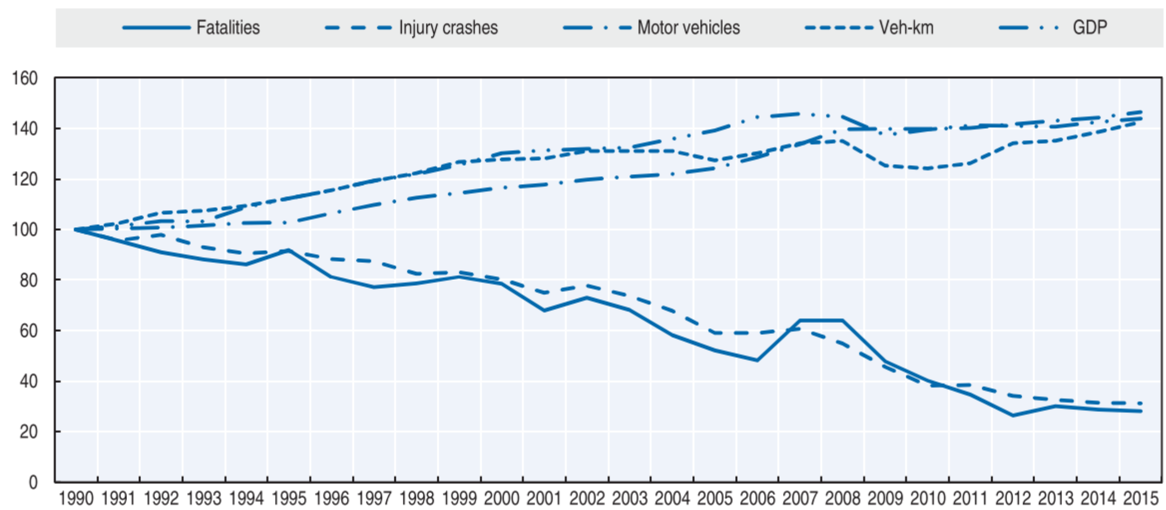
Presented below are figure demonstrating the application on indexation of data.



Appendix 2, figure 4, Presentation of indexed comparison of killed car occupants and miles driven by cars and taxis (Department for Transport, 2018b, p. 9)

All the International Transport Forum (2017) data presented have different scales and orders of magnitude, but the use of indexation allows for their comparison. The graph presented in the report being reproduced in figure 6 below.

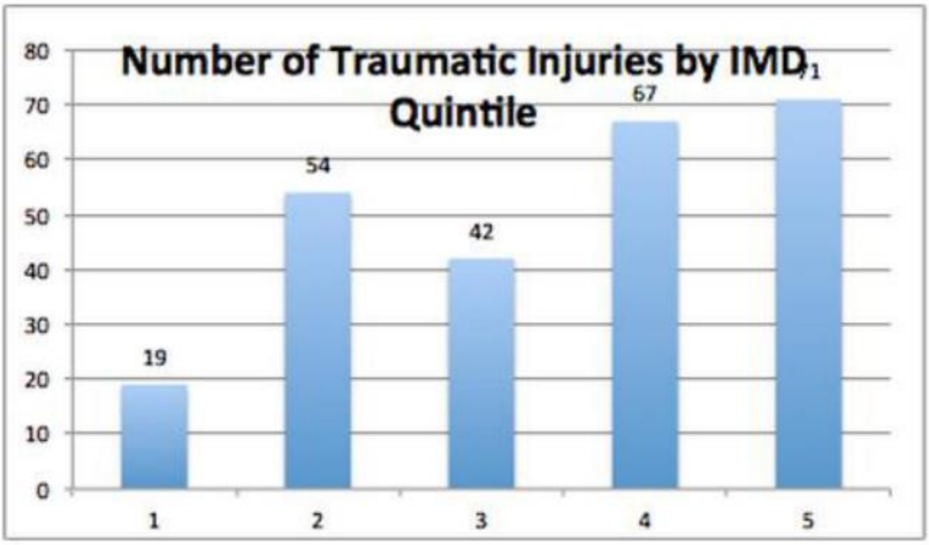
Figure 10.1. **Road safety, traffic and GDP trends index 1990 = 100**



Source: World Bank (2017) (GDP; constant prices).

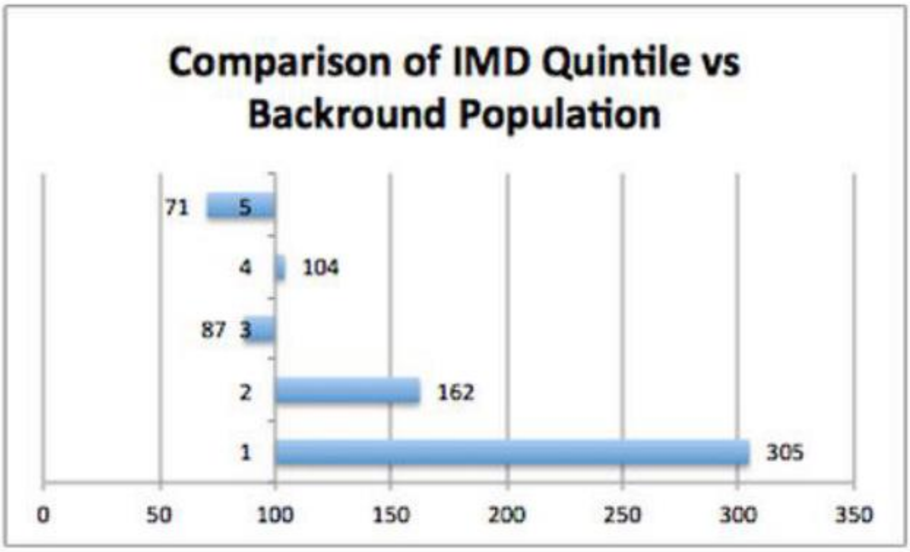
Appendix 2, figure 5, Presentation of indexed comparison of five variables (International Transport Forum, 2017, p. 146)

The CTARP report presented indexed raw IMD data, see figure 6 below.



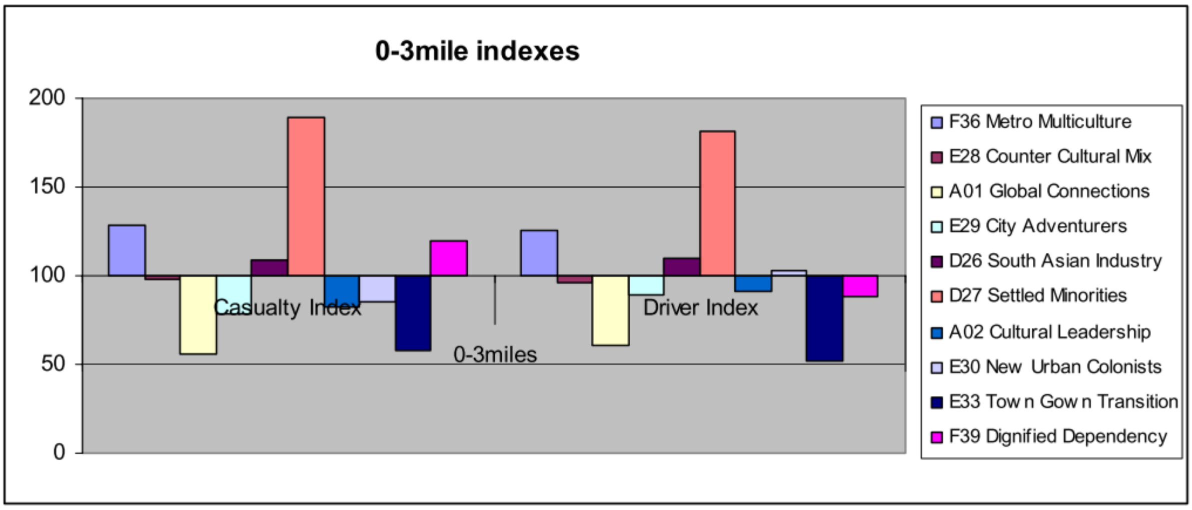
Appendix 2, figure 6, Frequency of casualties by Index of Multiple deprivation quintile group from the CTARP (University of Leicester, 2005, p. 42)

The CTARP report also compared the frequency to the resident population and presented this indexed, the figure is reproduced below in figure 7.



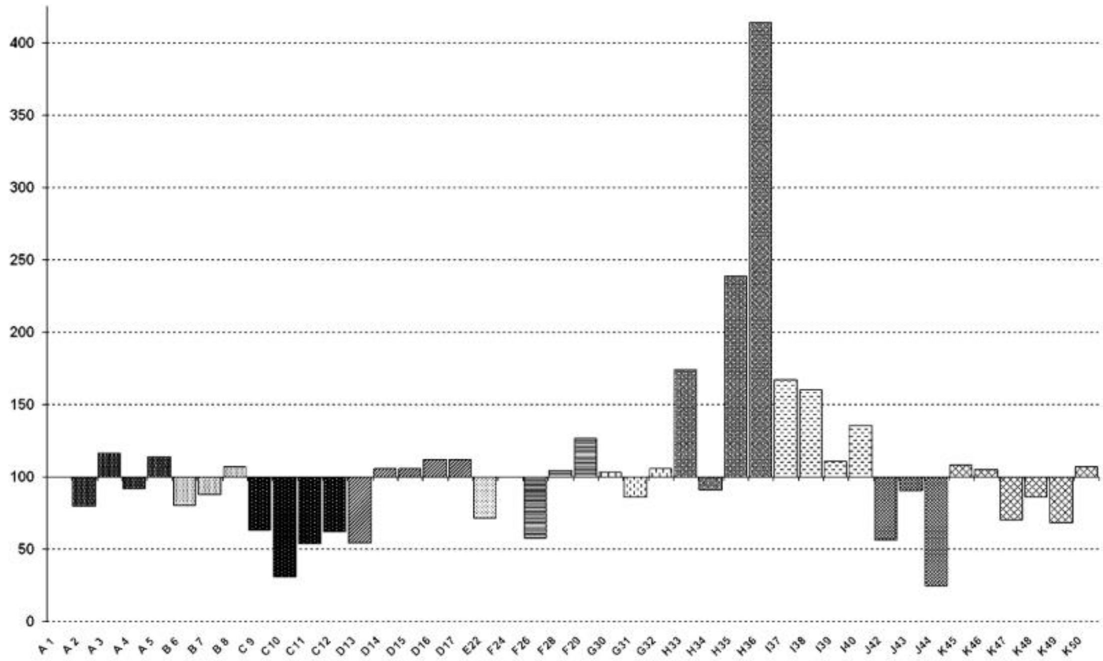
Appendix 2, figure 7, Presentation of indexed comparison of casualty frequencies compared to background population from the CTARP (University of Leicester, 2005, p. 42)

Anderson (2005) used indexation to present the relative risk of individual Mosaic geodemographic profiles, see figure 8 below.



Appendix 2, figure 8, Presentation of Mosaic Types by representation (Anderson, 2005, p. 19)

A further use of indexation to present Mosaic data related frequency was used by Ashby and Longley (2005) and is reproduced below in figure 9.



Appendix 2, figure 9, Presentation of indexed burglary propensity for Mosaic types (Ashby and Longley, 2005, p. 70)

Acorn geodemographic profiles contain information regarding the populations in indexed form, an example, the graph for type one, Exclusive enclaves (CACI Limited, 2014, p. 12) has been reproduced in figure 10 below.

Appendix 2, figure 10, Presentation of indexed comparison with national averages for an Acorn type (CACI Limited, 2014, p. 12)

Appendix 3: STATS19 Collision Reporting Form Suggested Format

Sept 2011

MG NSRF/A

ACCIDENT STATISTICS

*FATAL / SERIOUS / SLIGHT

Incident URN

Other ref.

1.3 ACCIDENT REFERENCE

1.9 TIME H H M M

DAY* Su M T W Th F S

1.7 DATE D D M M 2 0 Y Y

1st Road Class & No. or (Unclassified - UC) (Not Known - NK)

1st Road Name

Outside House No. or Name or Marker Post No.

at junction with / or metres N S E W * of

2nd Road Class & No. or (Unclassified - UC) (Not Known - NK)

2nd Road Name

Town

Sector /Beat No.

County or Borough

Parish No. or Name

1.10 Local Auth No. (if known)

1.11 Grid Reference E — N

REPORTING OFFICER Name

Number

BCU/Stn

1.2 Force

Tel Number

1.5 Number of vehicles

1.6 Number of casualties

1.14 ROAD TYPE		✗
Roundabout	1	
One way street	2	
Dual carriageway	3	
Single carriageway	6	
Slip road	7	
Unknown	9	

1.15 Speed Limit (Permanent)

1.16 JUNCTION DETAIL		✗
Not at or within 20 metres of junction	00	
Roundabout	01	
Mini roundabout	02	
T or staggered junction	03	
Slip road	05	
Crossroads	06	
Junction more than four arms (not RAB)	07	
Using private drive or entrance	08	
Other junction	09	

JUNCTION ACCIDENTS ONLY

1.17 JUNCTION CONTROL		✗
Authorised person	1	
Automatic traffic signal	2	
Stop sign	3	
Give way or uncontrolled	4	

1.20a PEDESTRIAN CROSSING - HUMAN CONTROL		✗
None within 50 metres	0	
Control by school crossing patrol	1	
Control by other authorised person	2	

1.20b PEDESTRIAN CROSSING - PHYSICAL FACILITIES		✗
No physical crossing facility within 50m	0	
Zebra crossing	1	
Pelican, puffin, toucan or similar non-junction pedestrian light crossing	4	
Pedestrian phase at traffic signal junction	5	
Footbridge or subway	7	
Central refuge — no other controls	8	

1.22 WEATHER		✗
Fine without high winds	1	
Raining without high winds	2	
Snowing without high winds	3	
Fine with high winds	4	
Raining with high winds	5	
Snowing with high winds	6	
Fog or mist — if hazard	7	
Other	8	
Unknown	9	

1.23 ROAD SURFACE CONDITION		✗
Dry	1	
Wet / Damp	2	
Snow	3	
Frost / Ice	4	
Flood (surface water over 3cm deep)	5	

1.21 LIGHT CONDITIONS		✗
Daylight	1	
Darkness: street lights present and lit	4	
Darkness: street lights present but unlit	5	
Darkness: no street lighting	6	
Darkness: street lighting unknown	7	

1.24 SPECIAL CONDITIONS AT SITE		✗
None	0	
Auto traffic signal out	1	
Auto traffic signal partially defective	2	
Permanent road signing or marking defective or obscured	3	
Roadworks	4	
Road surface defective	5	
Oil or diesel	6	
Mud	7	

1.25 CARRIAGEWAY HAZARDS		✗
None	0	
Dislodged vehicle load in carriageway	1	
Other object in carriageway	2	
Involvement with previous accident	3	
Pedestrian in carriageway - not injured	6	
Any animal in carriageway (except ridden horse)	7	

1.26 Did a police officer attend the scene and obtain the details for this report?		✗
Yes	1	
No	2	

Subject to local directions, boxes with a grey background need not be completed if already recorded

** Circle as appropriate*

UNCLASSIFIED

VEHICLE RECORD

2.26 VEHICLE REGISTRATION MARK

Vehicle 001	
Vehicle 002	
Vehicle 003	
Vehicle 004	

2.35 WAS THE VEHICLE LEFT HAND DRIVE ✗➡

	Code	Vehicle 1	2	3	4
No	1				
Yes	2				

2.5 / 2.5a TYPE OF VEHICLE ✗➡

	Code	Vehicle 1	2	3	4
Car	09				
Taxi / Private hire car	08				
Van - Goods vehicle 3.5 tonnes mgw and under	19				
Goods vehicle over 3.5 tonnes mgw and under 7.5 tonnes mgw	20				
Goods vehicle 7.5 tonnes mgw & over	21				
Goods vehicle - unknown weight	98				
M/cycle 50cc and under	02				
M/cycle over 50cc and up to 125cc	03				
M/cycle over 125cc and up to 500cc	04				
Motorcycle over 500cc	05				
Motorcycle - cc unknown	97				
Electric Motorcycle	23				
Pedal cycle	01				
Bus or coach (17 or more passenger seats)	11				
Minibus (8-16 passenger seats)	10				
Agricultural vehicle (include diggers etc)	17				
Ridden horse	16				
Mobility scooter	22				
Tram / Light rail	18				
Other vehicle 1	90				
2	90				
3	90				
4	90				

2.6 TOWING AND ARTICULATION ✗➡

	Code	Vehicle 1	2	3	4
No tow or articulation	0				
Articulated vehicle	1				
Double or multiple trailer	2				
Caravan	3				
Single trailer	4				
Other tow	5				

2.22 AGE OF DRIVER (Estimate if necessary)

Vehicle 001		Vehicle 002	
Vehicle 003		Vehicle 004	

2.27 DRIVER HOME POSTCODE
or Code: 1- Unknown 2- Non UK Resident 3 - Parked & unattended

Vehicle 001		
Vehicle 002		
Vehicle 003		
Vehicle 004		

2.23 BREATH TEST ✗➡

	Code	Vehicle 1	2	3	4
Not applicable	0				
Positive	1				
Negative	2				
Not requested	3				
Refused to provide	4				
Driver not contacted at time of col'	5				
Not provided (medical reasons)	6				

2.24 HIT AND RUN ✗➡

	Code	Vehicle 1	2	3	4
Not hit and run	0				
Hit and run	1				
Non-stop vehicle, not hit	2				

2.21 SEX OF DRIVER ✗➡

	Code	Vehicle 1	2	3	4
Male	1				
Female	2				
Not known	3				

2.9 VEHICLE LOCATION AT TIME OF ACCIDENT RESTRICTED LANE/AWAY FROM MAIN C'WAY ✗➡

	Code	Vehicle 1	2	3	4
On main carriageway not in restricted lane	00				
Tram / Light rail track	01				
Bus lane	02				
Busway (inc. guided busway)	03				
Cycle lane (on main carriageway)	04				
Cycleway or shared use footway (not part of main carriageway)	05				
On lay-by / hard shoulder	06				
Entering lay-by/ hard shoulder	07				
Leaving lay-by / hard shoulder	08				
Footway (pavement)	09				

2.10 JUNCTION LOCATION OF VEHICLE ✗➡

	Code	Vehicle 1	2	3	4
Not at or within 20m of junction	0				
Approaching junction or waiting /parked at junction approach	1				
Cleared junction or waiting/ parked at junction exit	2				
Leaving roundabout	3				
Entering roundabout	4				
Leaving main road	5				
Entering main road	6				
Entering from slip road	7				
Mid junction– on roundabout or on main road	8				

2.7 MANOEUVRES ✗➡

	Code	Vehicle 1	2	3	4
Reversing	01				
Parked	02				
Waiting to go ahead but held up	03				
Slowing or stopping	04				
Moving off	05				
U turn	06				
Turning left	07				
Waiting to turn left	08				
Turning right	09				
Waiting to turn right	10				
Changing lane to left	11				
Changing lane to right	12				
O'taking moving veh on its offside	13				
O'taking stationary veh on its offside	14				
Overtaking on nearside	15				
Going ahead left hand bend	16				
Going ahead right hand bend	17				
Going ahead other	18				

2.11 SKIDDING AND OVERTURNING ✗➡

	Code	Vehicle 1	2	3	4
No skidding, jack-knifing or overturning	0				
Skidded	1				
Skidded and overturned	2				
Jack - knifed	3				
Jack - knifed and overturned	4				
Overturned	5				

2.12 HIT OBJECT IN CARRIAGEWAY ✗

	Code	Vehicle 1	2	3	4
None	00				
Previous accident	01				
Roadworks	02				
Parked vehicle	04				
Bridge - roof	05				
Bridge - side	06				
Bollard / Refuge	07				
Open door of vehicle	08				
Central island of roundabout	09				
Kerb	10				
Any animal (except ridden horse)	12				
Other object	11				

2.13 VEHICLE LEAVING CARRIAGEWAY ✗

	Code	Vehicle 1	2	3	4
Did not leave carriageway	0				
Left carriageway nearside	1				
Left carriageway nearside and rebounded	2				
Left carriageway straight ahead at junction	3				
Left carriageway offside onto central reservation	4				
Left carriageway offside onto central reserve and rebounded	5				
Left carriageway offside and crossed central reservation	6				
Left carriageway offside	7				
Left carriageway offside and rebounded	8				

2.14 FIRST OBJECT HIT OFF CARRIAGEWAY ✗

	Code	Vehicle 1	2	3	4
None	00				
Road sign / Traffic signal	01				
Lamp post	02				
Telegraph pole / Electricity pole	03				
Tree	04				
Bus stop / Bus shelter	05				
Central crash barrier	06				
Nearside or offside crash barrier	07				
Submerged in water (completely)	08				
Entered ditch	09				
Wall or fence	11				
Other permanent object	10				

2.16 FIRST POINT OF IMPACT ✗➡

	Code	Vehicle 1	2	3	4
Did not impact	0				
Front	1				
Back	2				
Offside	3				
Nearside	4				

2.29 JOURNEY PURPOSE OF DRIVER/RIDER ✗

	Code	Vehicle 1	2	3	4
Journey as part of work	1				
Commuting to / from work	2				
Taking school pupil to/from school	3				
Pupil riding to / from school	4				
Other	5				
Not known	6				

Subject to local directions, boxes with a grey background need not be completed if already recorded

UNCLASSIFIED

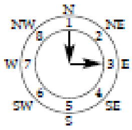
2.8 DIRECTION OF VEHICLE TRAVEL

1. Using the Example shown complete the FROM and TO boxes for the vehicles concerned, indicating direction of travel FROM and TO
2. If PARKED enter '00'

Vehicle 001		Vehicle 002	
FROM	TO	FROM	TO
Vehicle 003		**Vehicle 004**	
FROM	TO	FROM	TO

EXAMPLE

FROM	TO
1	3



CASUALTY RECORD

3.4 VEHICLE REFERENCE NUMBER
Enter VEH No. which CASUALTY occupied (for pedestrians, code vehicle that struck them first) e.g. 001,002 etc.

Casualty 001	0			Casualty 002	0		
Casualty 003	0			Casualty 004	0		
Casualty 005	0			Casualty 006	0		

3.18 CASUALTY HOME POSTCODE
or Code: 1- Unknown
2- Non UK Resident

Casualty 001	
Casualty 002	
Casualty 003	
Casualty 004	
Casualty 005	
Casualty 006	

3.7 SEX OF CASUALTY ✗➡

		CASUALTY 1	2	3	4	5	6
Male	1						
Female	2						

3.8 AGE OF CASUALTY (Estimate if necessary)
For children less than a year enter 00

Casualty 001		Casualty 002	
Casualty 003		Casualty 004	
Casualty 005		Casualty 006	

3.6 CASUALTY CLASS ✗

		1	2	3	4	5	6
Driver/Rider	1						
Veh./pillion Passenger	2						
Pedestrian	3						

3.9 SEVERITY OF CASUALTY ✗➡

		1	2	3	4	5	6
Fatal	1						
Serious	2						
Slight	3						

3.20 CYCLE HELMET WORN ✗

		CASUALTY 1	2	3	4	5	6
Not a cyclist	0						
Yes	1						
No	2						
Not known	3						

3.15 CAR PASSENGER (not driver) ✗➡

		1	2	3	4	5	6
Not a car passenger	0						
Front seat passenger	1						
Rear seat passenger	2						

3.16 BUS OR COACH PASSENGER ✗➡
(17 passenger seats or more)

		1	2	3	4	5	6
Not a bus or coach passenger	0						
Boarding	1						
Alighting	2						
Standing passenger	3						
Seated passenger	4						

LOCAL STATISTICS

3.14 SEAT BELT IN USE ✗➡

		1	2	3	4	5	6
Not applicable	0						
Worn and independently confirmed	1						
Worn but not independently confirmed	2						
Not worn	3						
Unknown	4						

PEDESTRIAN CASUALTIES ONLY

3.10 PEDESTRIAN LOCATION ✗➡

		CASUALTY 1	2	3	4	5	6
In carriageway, crossing on pedestrian crossing facility	01						
In carriageway, crossing within zig-zag lines at crossing approach	02						
In carriageway, crossing within zig-zag lines at crossing exit	03						
In carriageway, crossing elsewhere within 50m of pedestrian crossing	04						
In carriageway, crossing elsewhere	05						
On footway or verge	06						
On refuge, central island or central reservation	07						
In centre of carriageway, not on refuge, island or central reservation	08						
In carriageway, not crossing	09						
Unknown or other	10						

3.12 PEDESTRIAN DIRECTION ✗➡

		CASUALTY 1	2	3	4	5	6
Standing still	0						
Northbound	1						
Northeast bound	2						
Eastbound	3						
Southeast bound	4						
Southbound	5						
Southwest bound	6						
Westbound	7						
Northwest bound	8						
Unknown	9						

3.19 PEDESTRIAN ROAD MAINTENANCE WORKER ✗➡

		1	2	3	4	5	6
No / not applicable	0						
Yes	1						
Not known	2						

3.11 PEDESTRIAN MOVEMENT ✗➡

		CASUALTY 1	2	3	4	5	6
Crossing from driver's nearside	1						
Crossing from driver's nearside-masked by parked or stationary veh'	2						
Crossing from driver's offside	3						
Crossing from driver's offside-masked by parked or stationary veh'	4						
In carriageway, stationary - not crossing (standing or playing)	5						
In carriageway, stationary -not crossing (standing or playing), masked by parked or stationary veh'	6						
Walking along in carriageway-facing traffic	7						
Walking along in carriageway-back to traffic	8						
Unknown or other	9						

UNCLASSIFIED

CONTRIBUTORY FACTORS

1. Select up to six factors from the grid, relevant to the accident.
2. Factors may be shown in any order, but an indication must be given of whether each factor is ***very likely*** ***(A)*** or ***possible (B)***.
3. Only include factors that you consider contributed to the accident. (i.e. do NOT include "Poor road surface" unless relevant).
4. More than one factor may, if appropriate, be related to the same road user.
5. The same factor may be related to more than one road user.
6. The participant should be identified by the relevant vehicle or casualty ref no. (e.g. 001, 002 etc.), preceded by "V" if the factor applies to a vehicle, driver/rider or the road environment (e.g. V002), or "C" if the factor relates to a pedestrian or passenger casualty (e.g. C001).
7. Enter U000 if the factor relates to an uninjured pedestrian.

Road Environment Contributed	**103**	**102**	**101**	**110**	**108**	**107**	**109**	**104**	**105**	**106**
	Slippery road (due to weather)	Deposit on road (e.g. oil, mud, chippings)	Poor or defective road surface	Sunken, raised or slippery inspection cover	Road layout (e.g. bend, hill, narrow carriageway)	Temporary road layout (e.g. contraflow)	Animal or object in carriageway	Inadequate or masked signs or road markings	Defective traffic signals	Traffic calming (e.g. speed cushions, road humps, chicanes)
Vehicle Defects	**201**	**202**	**203**	**204**	**205**	**206**				
	Tyres illegal, defective or under-inflated	Defective lights or indicators	Defective brakes	Defective steering or suspension	Defective or missing mirrors	Overloaded or poorly loaded vehicle or trailer				
Injudicious Action	**308**	**306**	**302**	**301**	**307**	**310**	**305**	**304**	**309**	**303**
	Following too close	Exceeding speed limit	Disobeyed Give Way or Stop sign or markings	Disobeyed automatic traffic signal	Travelling too fast for conditions	Cyclist entering road from pavement	Illegal turn or direction of travel	Disobeyed pedestrian crossing facility	Vehicle travelling along pavement	Disobeyed double white lines
Driver/ Rider Error or Reaction	**405**	**406**	**403**	**408**	**409**	**401**	**402**	**404**	**407**	**410**
	Failed to look properly	Failed to judge other person's path or speed	Poor turn or manoeuvre	Sudden braking	Swerved	Junction overshoot	Junction restart (moving off at junction)	Failed to signal or misleading signal	Too close to cyclist, horse or pedestrian	Loss of control
Impairment or Distraction	**501**	**502**	**508**	**503**	**509**	**510**	**505**	**504**	**507**	**506**
	Impaired by alcohol	Impaired by drugs (illicit or medicinal)	Driver using mobile phone	Fatigue	Distraction in vehicle	Distraction outside vehicle	Illness or disability, mental or physical	Uncorrected, defective eyesight	Rider wearing dark clothing	Not displaying lights at night or in poor visibility
Behaviour or Inexperience	**602**	**605**	**601**	**603**	**607**	**606**	**604**			
	Careless, reckless or in a hurry	Learner or inexperienced driver/rider	Aggressive driving	Nervous, uncertain or panic	Unfamiliar with model of vehicle	Inexperience of driving on the left	Driving too slow for conditions or slow vehicle (e.g. tractor)			
Vision Affected by	**701**	**703**	**706**	**707**	**708**	**705**	**710**	**702**	**704**	**709**
	Stationary or parked vehicle(s)	Road layout (e.g. bend, winding road, hill crest)	Dazzling sun	Rain, sleet, snow or fog	Spray from other vehicles	Dazzling headlights	Vehicle blind spot	Vegetation	Buildings, road signs, street furniture	Visor or windscreen dirty, scratched or frosted etc.
Pedestrian Only (Casualty or Uninjured)	**802**	**808**	**803**	**801**	**806**	**807**	**805**	**804**	**809**	**810**
	Failed to look properly	Careless, reckless or in a hurry	Failed to judge vehicle's path or speed	Crossing road masked by stationary or parked vehicle	Impaired by alcohol	Impaired by drugs (illicit or medicinal)	Dangerous action in carriageway (e.g. playing)	Wrong use of pedestrian crossing facility	Pedestrian wearing dark clothing at night	Disability or illness, mental or physical
Special Codes	**901**	**902**	**903**	**904**						***999**
	Stolen vehicle	Vehicle in course of crime	Emergency vehicle on a call	Vehicle door opened or closed negligently						Other – Please specify below

Driver/Rider Only (Includes Pedal Cycles and Horse Riders)

	1st	*2nd*	*3rd*	*4th*	*5th*	*6th*
Factor in the accident						
Which participant? (e.g. V001, C001, U000)						
Very likely (A) or Possible (B)						

*If 999 Other, give brief details

(Note: Only use if another factor contributed to the accident ***and include it in the text description of how the accident occurred***)

These factors reflect the reporting officer's opinion at the time of reporting and may not be the result of extensive investigation

RESTRICTED

Appendix 4: TARN Variables

The TARN dataset supplied by Cambridge University Hospitals contained 43 variables which are listed below with a description of the data in each variable.

Variable name	Contents
Submission ID	12-digit reference number
Age	Years to 1 decimal place
Sex	Male or Female
Mechanism	Cause of the trauma, in this case 'Vehicle incident/collision'
ISS	ISS score of the patient
ISS band	3 bands; 1-8; 9-15; >15
GCS (Ps calculation)	Glasgow Coma Score; 3-15, 3 being least responsive
Intubation	Yes or No
Ps	Probability of survival: % to one decimal place
Outcome at 30 days	Alive or Dead
Incident date	dd/mm/yyyy
Incident time	hh:mm:ss not always present
Arrival date	dd/mm/yyyy
Arrival time	hh:mm:ss
Discharge date	dd/mm/yyyy
LOS	Length of Stay; overnights in whole days
ICU LOS	Intensive (Critical) Care Unit Length of Stay; overnights in whole days
Transfer	Transfer In; Transfer Out; No Transfer
Previous Hospital	Name as appropriate
Next Hospital	Name as Appropriate
Mode of arrival	If recorded; Aircraft (for ETARN); Ambulance; Ambulance and Helicopter; Car; Helicopter; Walking: With police; Not applicable
Visited	Yes or No
Incident Postcode	If recorded; may be full or partial (first string)
Home postcode	First string
Triage Tool	Positive; Negative; Not recorded
Pre-Alert	Yes; No; Not recorded
PRF number	Patient Report Form reference number
Ward 1	1st ward admitted to
Ward 2	2nd ward admitted to
Ward 3	3rd ward admitted to
NICE Head Injury Criteria	Yes or No
Shock	Yes or No
GOS	Glasgow Outcome Scale; 1-5; 1=Death; 2=Prolonged Disorder of

	Consciousness; 3=Severe Disability; 4=Moderate Disability; 5=Good Recovery
Most severely injured body region	Head; Face; Chest; Abdomen; Spine; Pelvis; Limbs; Multiple
Head	Maximum AIS
Face	Maximum AIS
Chest	Maximum AIS
Abdomen	Maximum AIS
Spine	Maximum AIS
Pelvis	Maximum AIS
Limbs	Maximum AIS
Other	Maximum AIS
Injuries	Long hand description

Appendix 5: Information Sharing Protocols

This appendix contains the three information sharing protocols put in place to allow access to the data required for the research. The first presented being the agreement between Loughborough University and Cambridge University Hospitals.

Loughborough University

Data Sharing Agreement

1.0 Organisations

This Data Sharing Agreement (the Agreement) is drawn up between:

Cambridge University Hospitals NHS Foundation Trust (CUHFT), the host Trust for the East of England Trauma Network at Hills Road, Cambridge, CB2 0QQ

And:

Loughborough University of Ashby Road, Loughborough, LE11 3TU **(the End User)**

(separately a "Party" and together the "Parties").

This Agreement grants to the End User, on behalf of CUHFT, a time limited non-exclusive licence to use Trauma Network data defined in Section 3 of this Agreement (hereinafter referred to as **'the Data'**). The Data must only be used in accordance with the terms set out in this Agreement.

2.0 Duration

This Agreement commences on 01/07/2017, and will terminate or be extended prior to 01/04/2020.

3.0 Data required

A description of data required for the Project is found in Schedule 1 to this Agreement.

Records in this dataset are anonymised to the extent that they do not exceed the requested data. The End User will not use the Data to attempt to obtain or derive information relating specifically to an identifiable individual nor to claim to have obtained or derived such information.

4.0 Purpose for which Data is to be used

This Data is provided to the end-user exclusively for work which contributes to the activities described in Schedule 2 to this Agreement (the Project)

5.0 Specific Conditions

The following conditions apply to this Agreement:

- Use of this Data is for the sole purpose set out above. This Data must not be shared with any other organisation or named individual not explicitly referred to within this Agreement. If there is an FOI or other request to share the Data, then agreement from CUHFT must be sought.
- The End User undertakes not to assign to any other person, firm or company the rights granted by this licence.

- The End User must not download, print-off, re-format or reproduce the Data or make the Data available in hard copy or machine-readable form to any third party without the prior written consent of CUHFT.

- This Agreement allows only the End User to view and process the Data. The End User undertakes to make only such copies of the Data as are necessary for processing or security purposes.

- The end-user acknowledges that no warranty is given by CUHFT as to the accuracy and comprehensiveness of the Data.

6.0 Data sharing

No individual other than those named in this Agreement can access the Data and the Data must only be used for the explicit purpose set out above. In case of staff changes, the End User will inform CUHFT of these changes prior to new staff members gaining access to the Data listed in this Agreement.

Named individual to have access	**Job title**
James Nunn	*Post Graduate Researcher*
Jo Barnes	*Lecturer*
Emily Petherick	*Lecturer*
Andrew Morris	*Professor*

7.0 User Obligations

Users of the Data supplied are obliged to abide by all relevant legislation, regulations, codes of practice, guidance and any further requirements imposed on them when accessing the shared information.

8.0 Audit

During the period of this Agreement CUHFT reserve the right to undertake an audit of the End User to ensure that all terms of this Agreement are being abided by.

9.0 Transfer of Data from CUHFT to the End User

A description of how CUHFT will securely provide the data to the End User is found in Schedule 3.

10.0 Storage of Data

In order to receive the Data the End User organisation must maintain up to date Data Protection Registration. The registration number is Z3179802.

A detailed statement of how data security measures will be applied by the End User is found in Schedule 4.

11.0 Data Retention

The Data will be retained until the end date of the Agreement or relevant review period. Extension of the retention period is subject to a formal review by CUHFT.

12.0 Data Destruction

Upon request of either of CUHFT (the Discloser), the End User shall promptly return or destroy all Data in its possession, custody or control provided that the End User may retain copies of the Data; (a) as part of archival records (including backup systems) that the End User keeps in the ordinary course of its business, (b) as may be required by law, or as legal proof of exchange (c) as may be relevant to a dispute or possible dispute between the parties. The End User shall confirm in writing to Discloser that it has to its reasonable knowledge and belief complied with its obligation to return or destroy Discloser's Data in accordance with this paragraph.

13.0 Breach of Conditions

Notification of breach The End User agrees to report immediately to CUHFT instances of breach of any of the terms of this Agreement.

Right to terminate access The breach of any of the terms of this Agreement may result in the immediate termination of access to the Data and the return of the Data to CUHFT in the manner to be advised by CUHFT.

Sanctions The breach of any of the provisions of this Agreement may result in sanctions being sought against the end user.

14.0 Changes to Terms of Agreement

CUHFT has the right to change the terms of this Agreement and these will be notified to the End User in writing. On such occasion unless the End User informs CUHFT in writing within 14 days of receiving notice of any changes CUHFT will assume that the Agreement will continue under the revised terms.

15.0 Publications

The Project will form part of the actual carrying out of a primary charitable purpose of the End User; that is, the advancement of education through teaching and research.

Publications arising from the Project shall be permitted with the consent of CUHFT, not to be unreasonably withheld.

All proposed publications (including, but not limited to, scientific publications, patent applications and non-confidential presentations), shall be submitted in writing to CUHFT for review at least thirty (30) days before submission for publication or before presentation, as the case may be. Notification of the requirement for amendment or delay in publication must be received by the End User within thirty (30) days after receipt of the proposed publication by CUHFT, failing which the End User shall be free to assume that CUHFT has no objection to the proposed publication.

16.0 Intellectual Property

Intellectual Property arising as a result of the Project shall vest and be owned as follows:

> To the extent that the Intellectual Property arising as a result of the Project is generated or developed by CUHFT alone, then it shall vest in and be owned absolutely by CUHFT;

To the extent that the Intellectual Property arising as a result of the Project is generated or developed by CUHFT jointly with the End User, then it shall vest in and be owned jointly by CUHFT and the End User;

To the extent that the Intellectual Property arising as a result of the Project is generated or developed by the End User, without CUHFT's intellectual contribution, then it shall vest in and be owned absolutely by the End User.

The End User hereby grants to CUHFT, a royalty-free, irrevocable, non-transferable, non-exclusive, right and licence to use its Intellectual Property arising as a result of the Project for the sole purpose of internal research and development.

CUHFT hereby grants to the End User a royalty-free irrevocable, non-transferable, non-exclusive licence to use its Intellectual Property arising as a result of the Project for their own non-commercial activities such as teaching and scientific research.

17.0 Liability

Except where any limitation is proscribed by law such as but not limited to death or personal injury resulting through the negligence of the End User, under no circumstances shall the total aggregate liability of the End User for loss and/or damage under or in connection with the Agreement or its subject matter due to the End User's breach, tort (including negligence), breach of statutory duty or otherwise howsoever arising exceed £10,000 (ten thousand pounds sterling).

For the avoidance of doubt, nothing contained in this Agreement or any other agreement between the Parties whether expressed or implied shall be agreement to indemnification by one Party to the other Party in respect of any claims for indirect or consequential loss or damages such as, but not limited to, loss of profit, revenue, contracts or the like.

18.0 Governing Law and Jurisdiction

This Agreement shall be governed by English Law, and the Parties submit to the exclusive jurisdiction of the Courts of England and Wales for the resolution of any dispute which may arise out of this Agreement.

19.0 Dispute Resolution

The Parties shall use reasonable endeavours to negotiate in good faith and settle amicably any dispute that arises in connection with this Agreement.

Any dispute not capable of resolution by the Parties shall be settled as far as possible by mediation in accordance with the Centre for Effective Dispute Resolution (CEDR) Model Mediation Procedure.

No Party may commence any court proceedings in relation to any dispute arising out of this Agreement until they have attempted to settle it by mediation, but any such mediation may be terminated by any of the Parties in dispute at any time of such Party wishing to commence court proceedings.

Nothing in this Agreement shall restrict the right of any Party to seek (without proof of special damage) the remedies of injunctive relief for any actual or threatened breach of the provisions of this Agreement

Signatures

For and on behalf of:

Loughborough University

Signed:

Print Name:

Post/Title:

Date:

For and on behalf of:

Cambridge University Hospitals NHS Foundation Trust

Signed

Print Name: Michelle Ellerbeck

Post/Title: Information Governance Lead

Date: 15/08/2017

Schedule 1 – Data Required

Trauma Network data to allow the identification of the specific collision incident in which the injuries occurred and the anonymised epidemiological data related to the injured person.

The data set is the anonymised Trauma Audit and Research Network (TARN) data set. The field list is available at www.tarn.ac.uk (appendix 1)

Schedule 2 – Project Description

Attached is the full project outline document.

TRIP Project Outline v2.pdf

The TRIP project will look in detail at crashes that cause severe injury and death, in particular examining the types of drivers that are involved in these crashes. This innovative project brings together partners from the local authority, emergency services and CUHFT to explore whether prevention strategies targeted at groups of drivers similar to those considered culpable for crashes, rather than targeting groups who are likely to be injured, have an impact on road safety.

The TRIP project is split into two work packages:

WP1 – A detailed epidemiological analysis of collisions to explore whether prevention strategies targeted at high risk profiles, in contrast to road user profiles derived solely from road crash and casualty data (as recorded by STATS19), have an impact on casualty reduction.

WP2 – The development of a framework for the delivery of research-led practice in road safety.

The requested data will facilitate the identification of the specific collisions in which the severe injuries were caused. This will allow the continuation of the project to identifying culpable drivers.

Schedule 3 – Transfer of Data to the End User

Information shared between CUHFT and Loughborough University should be distributed electronically password protected electronic files via approved and verified e-mail addresses or through the physical transfer of an encrypted USB device.

It is not acceptable for information to be transferred to a CD/DVD or an unencrypted USB device which is then sent via a postal service.

Before being shared, information should be protectively marked as follows: Protected.

Information that is shared should be labelled with the name of its originator, so that obligations around withdrawal of consent, updating to maintain accurate records and reporting any breaches etc. can be fulfilled.

Schedule 4 – Data Security Measures

Partners to this agreement undertake that information shared under the agreement will only be used for the specific purpose for which it was shared, in line with this agreement. It must not be shared for any other purpose outside of this agreement.

In each case, the originating organisation remains the primary information owner and record keeper for the information that is shared. Where information is edited by the receiver, they must make it clear this is an altered copy.

The following destruction process will be used when the information is no longer required:

Hard copies should be securely disposed of (i.e. shredded).

Electronic copies should be deleted.

If a partner leaves the agreement, decisions must be taken and followed on what happens to :

The information that has already been shared with the signatories by the departing organisation.

The information that has already been shared with the departing organisation by the other signatories.

Appendix 1

Trauma Audit Research Network – Data Dictionary

Data Dictionary with mandatory fields iden

The second protocol presented being between Loughborough University and Cambridgeshire Constabulary.

Amendment No.1 to Data Sharing Agreement

THIS AMENDMENT is dated [10 JULY 2018]

Between

1. **Loughborough University**, of Epinal Way, Loughborough, Leicestershire LE11 3TU

and

2. **The Chief Constable, Cambridgeshire Constabulary** of Hinchingbrooke Park, Huntingdon PE29 6NP Oxford Road, Manchester, M13 9PL

(The aforesaid organisations are hereinafter referred to individually as "Party" and collectively as the "Parties").

WHEREAS:

The Original Parties have entered into a Data Sharing Agreement dated 3rd March 2018 (the "Original Agreement").

The Parties now wish to amend the terms of the Original Agreement, including but not limited to:

(i) Amend the Specific Conditions

NOW IT IS HEREBY AGREED AS FOLLOWS:

1. INTERPRETATION

1.1 Unless otherwise provided in this Amendment, terms used in this Amendment shall have the same meaning where defined in the Original Agreement.

2. AMENDMENTS TO THE COLLABORATION AGREEMENT

2.1 The Parties hereby agree to amend the Original Agreement as follows:

Clause 5 shall be modified to read as follows:

The following conditions apply to this Agreement:

- Use of this Data is for the sole purpose set out above. This Data must not be shared with any other organisation or named individual not explicitly referred to within this Agreement. If there is an FOI or other request to share the Data, then agreement from The Chief Constable, Cambridgeshire Constabulary must be sought.
- The End User undertakes not to assign to any other person, firm or company the rights granted by this licence.
- The End User must not download, print-off, re-format or reproduce the Data or make the Data available in hard copy or machine-readable form to any third party without the prior written consent of The Chief Constable, Cambridgeshire Constabulary.

- This Agreement allows only the End User to view and process the Data. The End User undertakes to make only such copies of the Data as are necessary for processing or security purposes.

- The end-user acknowledges that no warranty is given by The Chief Constable, Cambridgeshire Constabulary as to the accuracy and comprehensiveness of the Data.

- Personal data will not be provided beyond sex, age and postcode of persons involved in a collision. Surnames of individuals can be provided for validation purposes.

- Data provided electronically will be marked as 'Official' and will not contain names (except surnames for validation purposes), addresses or DOB or persons involved.

- Access to CRASH and ROADS records.

- If more in-depth detail is required, supervised access will be allowed to electronic data held within the Forensic Collision Investigation Unit at Cambridgeshire HQ.

3. GENERAL

3.1 Except as modified herein, the provisions of the Original Agreement shall remain in full force and effect.

3.2 The amendments to the Original Agreement as set out herein shall be effective as of 1 April 2018

The Parties hereto have caused this Amendment to be executed the day and year first before written.

SIGNED by ....

Position ...Research Grants & Contracts Manager
For and on behalf of Loughborough University

Date: ...9/7/18...

Loughborough
University

SIGNED by .....[signature].....

Position .....Chief Inspector, Roads Policing
For and on behalf of The Chief Constable, Cambridgeshire Constabulary

Date: .....27/6/18.....

The final protocol presented being between Loughborough University and Cambridgeshire County Council.

Data Sharing Agreement

1.0 Organisations

1.1 Sharing information and data are key elements of effective service delivery. Too often information is not shared effectively and efficiently due to a variety of reasons such as misunderstanding of legislation, concerns about privacy and data protection. This information sharing agreement enables regular information sharing to take place and ensure that the correct processes are in place.

1.2 This information sharing agreement has been drawn up under the umbrella of the Cambridgeshire Information Sharing Framework, which sets out the core information sharing principles which have been agreed by its signatory organisations.

This Data Sharing Agreement (the Agreement) is drawn up between:

Cambridgeshire County Council of Shire Hall, Cambridge, CB3 0AP

And:

Loughborough University of Epinal Way, Loughborough, LE11 3TU **(the End User)**

(Separately a "Party" and together the "Parties").

This Agreement grants to the End User, on behalf of Cambridgeshire County Council Highways Services Road Safety Education Team, a time limited non-exclusive licence to use collision data defined in Section 3 of this Agreement (hereinafter referred to as **'the Data'**). The Data must only be used in accordance with the terms set out in this Agreement.

2.0 Duration

This Agreement commences on 01/07/2017, and will terminate or be extended prior to 31/03/2020.

3.0 Data required

A description of data required for the Project is found in Schedule 1 to this Agreement.

Records in this dataset will be pseudonymised as soon as possible during the process. The End User will not use the Data to attempt to obtain or derive information relating specifically to an identifiable individual or household, nor to claim to have obtained or derived such information.

4.0 Purpose for which Data is to be used

This Data is provided to the end-user exclusively for work which contributes to the activities described in Schedule 2 to this Agreement (the Project)

5.0 Legalisation for sharing

The Project is being conducted in relation to Cambridgeshire County Council's statutory duty under the Highways Act 1988 (Chapter 52 Section 39) to "...carry out studies into accidents arising out of the use of vehicles [and] in the light of those studies, take such measures as appear to the authority to be appropriate to prevent such accidents..."

Personal data will be processed in line with Schedule 2 Condition 6 of the Data Protection Act: "The processing is necessary for the purposes of legitimate interests pursued by the data controller or by the third party or parties to whom the data are disclosed, except where the processing is unwarranted in any particular case by reason of prejudice to the rights and freedoms or legitimate interests of the data subject".

6.0 Specific Conditions

The following conditions apply to this Agreement:

- Use of this Data is for the sole purpose set out above. This Data must not be shared with any other organisation or named individual not explicitly referred to within this Agreement. If there is an FOI or other request to share the Data, then agreement from Cambridgeshire County Council must be sought.
- The End User undertakes not to assign to any other person, firm or company the rights granted by this licence.
- The End User must not download, print-off, re-format or reproduce the Data or make the Data available in hard copy or machine-readable form to any third party without the prior written consent of Cambridgeshire County Council.
- This Agreement allows only the End User to view and process the Data. The End User undertakes to make only such copies of the Data as are necessary for processing or security purposes.
- The end-user acknowledges that no warranty is given by Cambridgeshire County Council as to the accuracy and comprehensiveness of the Data.

7.0 Data sharing

No individual other than those named in this Agreement can access the Data and the Data must only be used for the explicit purpose set out above. In case of staff changes, the End User will inform Cambridgeshire County Council of these changes prior to new staff members gaining access to the Data listed in this Agreement.

Named individual to have access	Job title
James Nunn	*Post Graduate Researcher*
Jo Barnes	*Lecturer*
Emily Petherick	*Lecturer*
Andrew Morris	*Professor*

8.0 User Obligations

Users of the Data supplied are obliged to abide by all relevant legislation, regulations, codes of practice, guidance and any further requirements imposed on them when accessing the shared information.

9.0 Audit

During the period of this Agreement Cambridgeshire County Council reserve the right to undertake an audit of the End User to ensure that all terms of this Agreement are being abided by.

10.0 Transfer of Data from Cambridgeshire County Council to the End User

A description of how Cambridgeshire County Council Highways Services Road Safety Education Team will securely provide the data to the End User is found in Schedule 3.

11.0 Storage of Data

In order to receive the Data the End User organisation must have a Data Protection Registration number. This is Z3179802.

A detailed statement of how data security measures will be applied by the End User is found in Schedule 4.

12.0 Data Retention

The Data will be retained until the end date of the Agreement or relevant review period. Extension of the retention period is subject to a formal review by Cambridgeshire County Council.

13.0 Data Quality

The Data goes through a process of validity checks, error procedures and submission according to Department for Transport (STATS21) guidance. A degree of error exists, and this forms some of the basis for combining more than one data set in this Project.

13.0 Data Destruction

Upon request of either of Cambridgeshire County Council (the Discloser), the End User shall promptly return or destroy all Data in its possession, custody or control provided that the End User may retain copies of the Data; (a) as part of archival records (including backup systems) that the End User keeps in the ordinary course of its business, (b) as may be required by law, or as legal proof of exchange (c) as may be relevant to a dispute or possible dispute between the parties. The End User shall confirm in writing to the Discloser that it has to its reasonable knowledge and belief complied with its obligation to return or destroy Discloser's Data in accordance with this paragraph.

14.0 Breach of Conditions

Notification of breach The End User agrees to report immediately to Cambridgeshire County Council instances of breach of any of the terms of this Agreement.

Right to terminate access The breach of any of the terms of this Agreement may result in the immediate termination of access to the Data and the return of the Data to Cambridgeshire County Council in the manner to be advised by Cambridgeshire County Council.

Sanctions The breach of any of the provisions of this Agreement may result in sanctions being sought against the end user.

15.0 Changes to Terms of Agreement

Cambridgeshire County Council has the right to change the terms of this Agreement and these will be notified to the End User in writing. On such occasion unless the End User informs Cambridgeshire County Council in writing within 14 days of receiving notice of any changes Cambridgeshire County Council will assume that the Agreement will continue under the revised terms.

16.0 Publications

The Project will form part of the actual carrying out of a primary charitable purpose of the End User; that is, the advancement of education through teaching and research.

Publications arising from the Project shall be permitted with the consent of Cambridgeshire County Council, not to be unreasonably withheld.

All proposed publications (including, but not limited to, scientific publications, patent applications and non-confidential presentations), shall be submitted in writing to Cambridgeshire County Council for review at least thirty (30) days before submission for publication or before presentation, as the case may be. Notification of the requirement for amendment or delay in publication must be received by the End User within thirty (30) days after receipt of the proposed publication by Cambridgeshire County Council, failing which the End User shall be free to assume that Cambridgeshire County Council has no objection to the proposed publication.

17.0 Intellectual Property

Intellectual Property arising as a result of the Project shall vest and be owned as follows:

> To the extent that the Intellectual Property arising as a result of the Project is generated or developed by Cambridgeshire County Council alone, then it shall vest in and be owned absolutely by Cambridgeshire County Council;
>
> To the extent that the Intellectual Property arising as a result of the Project is generated or developed by Cambridgeshire County Council jointly with the End User, then it shall vest in and be owned jointly by Cambridgeshire County Council and the End User;
>
> To the extent that the Intellectual Property arising as a result of the Project is generated or developed by the End User, without Cambridgeshire County Council's intellectual contribution, then it shall vest in and be owned absolutely by the End User.

The End User hereby grants to Cambridgeshire County Council, a royalty-free, irrevocable, non-transferable, non-exclusive, right and licence to use its Intellectual Property arising as a result of the Project for the sole purpose of internal research and development.

Cambridgeshire County Council hereby grants to the End User a royalty-free irrevocable, non-transferable, non-exclusive licence to use its Intellectual Property arising as a result of the Project for their own non-commercial activities such as teaching and scientific research.

18.0 Liability

Except where any limitation is proscribed by law such as but not limited to death or personal injury resulting through the negligence of the End User, under no circumstances shall the total aggregate liability of the End User for loss and/or damage under or in connection with the Agreement or its subject matter due to the End User's breach, tort (including negligence), breach of statutory duty or otherwise howsoever arising exceed £10,000 (ten thousand pounds sterling).

For the avoidance of doubt, nothing contained in this Agreement or any other agreement between the Parties whether expressed or implied shall be agreement to indemnification by one Party to the other Party in respect of any claims for indirect or consequential loss or damages such as, but not limited to, loss of profit, revenue, contracts or the like.

19.0 Governing Law and Jurisdiction

This Agreement shall be governed by English Law, and the Parties submit to the exclusive jurisdiction of the Courts of England and Wales for the resolution of any dispute which may arise out of this Agreement.

20.0 Dispute Resolution

The Parties shall use reasonable endeavours to negotiate in good faith and settle amicably any dispute that arises in connection with this Agreement.

Any dispute not capable of resolution by the Parties shall be settled as far as possible by mediation in accordance with the Centre for Effective Dispute Resolution (CEDR) Model Mediation Procedure.

No Party may commence any court proceedings in relation to any dispute arising out of this Agreement until they have attempted to settle it by mediation, but any such mediation may be terminated by any of the Parties in dispute at any time of such Party wishing to commence court proceedings.

Nothing in this Agreement shall restrict the right of any Party to seek (without proof of special damage) the remedies of injunctive relief for any actual or threatened breach of the provisions of this Agreement

Signatures

For and on behalf of:

Loughborough University

Signed:

Print Name: Louise Dannitt
Post/Title: Research Grants & Contracts Manager
Date: 12/9/17

Loughborough
University

For and on behalf of:

Cambridgeshire County Council

Signed

Print Name: Matt Staton
Post/Title: Road Safety Education Team Leader
Date: 25/8/17

Schedule 1 – Data Required

Long format data from STAT19

Long format data from CRASH

Mosaic information regarding postcodes within the Cambridgeshire County Council and Peterborough Unitary Authority Geographical areas

Schedule 2 – Project Description

The TRIP project will look in detail at crashes that cause severe injury and death, in particular examining the types of drivers that are involved in these crashes. This innovative project brings together partners from the local authority, emergency services and Cambridge University Hospitals to explore whether prevention strategies targeted at groups of drivers similar to those considered culpable for crashes, rather than targeting groups who are likely to be injured, have an impact on road safety.

The TRIP project is split into two work packages:

WP1 – A detailed epidemiological analysis of collisions to explore whether prevention strategies targeted at high risk profiles, in contrast to road user profiles derived solely from road crash and casualty data (as recorded by STATS19), have an impact on casualty reduction.

WP2 – The development of a framework for the delivery of research-led practice in road safety.

Schedule 3 – Transfer of Data to the End User

Information shared between Cambridgeshire County Council and Loughborough University should be distributed electronically via secure e-mail (CCC Managed File Transfer).

It is not acceptable for information to be transferred to a CD/DVD or an unencrypted USB device which is then sent via a postal service.

Information that is shared should be labelled with the name of its originator, so that obligations around withdrawal of consent, updating to maintain accurate records and reporting any breaches etc can be fulfilled.

Schedule 4 – Data Security Measures

Partners to this agreement undertake that information shared under the agreement will only be used for the specific purpose for which it was shared, in line with this agreement. It must not be shared for any other purpose outside of this agreement.

In each case, the originating organisation remains the primary information owner and record keeper for the information that is shared. Where information is edited by the receiver, they must make it clear this is an altered copy.

The following destruction process will be used when the information is no longer required:

Hard copies should be securely disposed of (i.e. shredded).
Electronic copies should be deleted.

If a partner leaves the agreement, decisions must be taken and followed on what happens to :

The information that has already been shared with the signatories by the departing organisation.
The information that has already been shared with the departing organisation by the other signatories.

Appendix 6: STATS19 Application to the Robertson and Drummer (1994) scoring tool composite table showing available data

<table>
<tr><th colspan="2">Scoring guidelines used for Robertson and Drummer (1994, p. 247) responsibility analysis</th><th rowspan="2">STATS19 Variables, contributory factors or narrative use</th></tr>
<tr><th>Mitigating category</th><th>Score</th></tr>
<tr><td colspan="2">1. Condition of Road
Sealed road*
Two or more lanes and smooth — 1
Divided road — 1
Two or more lanes and rough — 2
Unmarked, thin and smooth — 2
Unmarked, thin and rough — 3
Unsealed road
Smooth — 2
Rough and/or corrugated — 3</td><td>Variables:
Road Type
1. Roundabout
2. One-way street
3. Dual carriageway
6. Single carriageway
7. Slip Road
9. Unknown
Special Conditions at Site
5. Road surface defective
Contributory factors:
101. Poor of defective road surface
104. Inadequate or masked signs or road markings
STATS19 Narrative required? Limited to any information regarding a new road surface or if the road was unmade</td></tr>
<tr><td colspan="2">2. Condition of Vehicle
Roadworthy — 1
Unroadworthy (contribution to accident unclear) — 2
Unroadworthy (contributing to accident) — 4</td><td>Variables: None
Contributory factors:
201. Tyre illegal, defective or under-inflated
202. Defective lights and indicators
203. Defective brakes
204. Defective steering or suspension
205. Defective or missing mirrors
206. Overloaded or poorly loaded vehicle or trailer
999. Other contributory defect not listed above
STATS19 Narrative required? Limited to non-contributory defects</td></tr>
<tr><td colspan="2">3. Driving Conditions
Day
Clear and/or cloudy — 1
*Fog and/or mist, clear and windy (>40 kph) — 2</td><td>Variables:
Light Conditions
1. Daylight
4. Darkness: street lights present and lit</td></tr>
</table>

*Visibility good and road wet	2
Showers and/or rain	3
Night	
†‡Clear	1
‡Cloudy	2
Fog/mist/showers/rain/ice/ wind	3

5.	Darkness: street lights present but unlit (note ‡)
6.	Darkness: no street lighting (note ‡)
7.	Darkness: street lighting unknown (note ‡)

Weather

1.	Fine without high winds (note ‡)
2.	Raining without high winds
3.	Snowing without high winds
4.	Fine with high winds
5.	Raining with high winds
6.	Snowing with high winds
7.	Fog or mist – if hazard
8.	Other
9.	Unknown

Contributory factors:

707.	Rain, sleet, snow or fog
103.	Wet Road (only for light conditions code 1.)

STATS19 Narrative required? Limited to any information regarding a new road surface

4. Type of Accident

Single-vehicle	
No influence from other vehicles	1
Influence from other vehicles	3
Multi-vehicle	
Striking vehicle attempting to avoid	2
Striking vehicle not attempting to avoid	1
Struck vehicle in the wrong	1
Struck vehicle in the right	3

Variables:

Number of vehicles (non-motor vehicles discounted)

First Point of Impact

Hit and Run

Vehicle Type (discounting non-motor vehicles)

Contributory factors:

701	Stationary or parked vehicle

STATS19 Narrative required? Yes, the narrative will give information on the vehicle relative movements and assist in determining if parked vehicles contributed to the collision or were merely present

5. Witness Observations

No apparent reason	1
Reckless	
Swerving	1
Irregular driving	1
Negligent	
Witnessed road infringement	1
Lack of road sense	1

Variables: None

Contributory factors:

102.	Deposit on road (e.g. oil, mud, chippings)
103.	Slippery road (due to weather)
401.	Junction overshoot
402.	Junction restart (moving off at junction)
406.	Failing to judge other person’s path or speed
409.	Swerved

Vehicle fault	3
Driver not to blame	4

410.	Loss of control
601.	Aggressive driving
602.	Careless, reckless or in a hurry
603.	Nervous, uncertain or panic
604.	Driving too slow for conditions, or slow vehicle (e.g. Tractor)
605.	Learner or inexperienced driver/rider
606.	Inexperience of driving on the left
702.	Vegetation
704.	Buildings, road signs, street furniture
705.	Dazzling headlights
706.	Dazzling sun
708.	Spray from other vehicles
709.	Visor or windscreen dirty, scratched or frosted etc.
710.	Vehicle blind spot
801.	Crossing road masked by stationary or parked vehicle
802.	Failed to look properly
803.	Failed to judge vehicle's path or speed
804.	Wrong use of pedestrian crossing facility
805.	Dangerous action in carriageway (e.g. playing)
806.	Impaired by alcohol
807.	Impaired by drugs (illicit or medicinal)
808.	Careless, reckless or in a hurry
809.	Pedestrian wearing dark clothing at night
810.	Disability or illness, mental or physical

STATS19 Narrative required? Unless mentioned

6. Road Law Obedience

Was driver obeying road laws?	
Yes	3
No	1

Variables:

Breath Test

1.	Positive

Contributory factors:

301.	Disobeyed automatic traffic signal
302.	Disobeyed "Give Way" or "Stop" sign or markings
303.	Disobeyed double white lines
304.	Disobeyed pedestrian crossing facility
305.	Illegal turn or direction of travel
306.	Exceeding speed limit

<table>
<tr><td></td><td></td><td>
<table>
<tr><td>307.</td><td>Travelling too fast for conditions</td></tr>
<tr><td>308.</td><td>Following too close</td></tr>
<tr><td>309.</td><td>Vehicle travelling along pavement</td></tr>
<tr><td>403.</td><td>Poor turn or manoeuvre</td></tr>
<tr><td>404.</td><td>Failed to signal or misleading signal</td></tr>
<tr><td>405.</td><td>Failed to look properly</td></tr>
<tr><td>407.</td><td>Too close to cyclist, horse rider or pedestrian</td></tr>
<tr><td>408.</td><td>Sudden braking</td></tr>
<tr><td>501.</td><td>Impaired by alcohol</td></tr>
<tr><td>502.</td><td>Impaired by drugs</td></tr>
<tr><td>504.</td><td>Uncorrected, defective eyesight</td></tr>
<tr><td>506.</td><td>Not displaying lights at night or in poor visibility</td></tr>
<tr><td>508.</td><td>Driver using mobile phone</td></tr>
<tr><td>509.</td><td>Distraction in vehicle</td></tr>
<tr><td>510.</td><td>Distraction outside vehicle</td></tr>
<tr><td>904.</td><td>Vehicle door opened or closed negligently</td></tr>
</table>
STATS19 Narrative required? May indicate a standards of driving offence</td></tr>
<tr><td colspan="2">7. Difficulty of Task Involved</td><td rowspan="8">Variables:
For ‘Across lanes’ incidents the ‘Junction control variable was applicable.
<table>
<tr><td>2.</td><td>Automatic traffic signal (note §)</td></tr>
</table>
Overtaking, contained within the manoeuvres variable
<table>
<tr><td>13.</td><td>Overtaking moving vehicle on its offside</td></tr>
<tr><td>14.</td><td>Overtaking stationary vehicle on its offside</td></tr>
<tr><td>15.</td><td>Overtaking on nearside</td></tr>
</table>
Contributory factors:
<table>
<tr><td>108.</td><td>Road layout (e.g. bend, hill, narrow carriageway)</td></tr>
<tr><td>703.</td><td>Road layout (e.g. Bend, winding road, hill crest)</td></tr>
</table>
STATS19 Narrative required? Unless mentioned</td></tr>
<tr><td>Straight road or sweeping bend</td><td>1</td></tr>
<tr><td>§Across lanes in</td><td></td></tr>
<tr><td>Heavy traffic</td><td>2</td></tr>
<tr><td>Light traffic</td><td>1</td></tr>
<tr><td>Winding road/sharp bend/U-turn</td><td>2</td></tr>
<tr><td>Overtaking</td><td>2</td></tr>
<tr><td>Avoiding unexpected traffic</td><td>3</td></tr>
<tr><td colspan="2">8. Level of Fatigue</td><td rowspan="2">Variables: None
Contributory factors:
<table>
<tr><td>503.</td><td>Fatigue</td></tr>
</table>
STATS19 Narrative required? Unless mentioned</td></tr>
<tr><td>Only if mentioned in police reports</td><td>2</td></tr>
<tr><td>* Add 1 if road has been newly surfaced.
† If in heavy traffic, add 1 point.</td><td></td><td>These factors are contained within the specific criteria above</td></tr>
</table>

‡ If not lighted, add 1 point. § Scores 1, if under the guidance of traffic signals.		

Appendix 7: Robertson and Drummer (1994) to STATS19 application composite table showing variable application and scoring

1. Condition of Road	Applied data and considerations	Score
Sealed road*	Assumed to be sealed unless stated in description	
Two or more lanes and smooth	Road type – single carriageway (6) or slip road (7) if more than one lane or one-way street (2) if more than one lane	1
Divided road	Road type – dual carriageway (3) or roundabout (1)	1
Two or more lanes and rough	Road type – single carriageway (6) or slip road (7) if more than one lane or one-way street (2) if more than one lane combined with contributory factor – poor of defective road surface (101) or Special Conditions at site – Road surface defective (5)	2
Unmarked, thin and smooth	Road type – single carriageway (6), slip road (7) or one-way street (2) if either does not have separate lanes	2
Unmarked, thin and rough	Road type – single carriageway (6), slip road (7) or one-way street (2) if either does not have separate lanes combined with contributory factor – poor of defective road surface (101) or Special Conditions at site – Road surface defective (5)	3
Unsealed road	Assumed to be sealed unless stated in description	
Smooth	Assumed to be sealed unless stated in description	2
Rough and/or corrugated	Assumed to be sealed unless stated in description combined with contributory factor – poor of	3

	defective road surface (101) or Special Conditions at site – Road surface defective (5)	
2. Condition of Vehicle		
Roadworthy	No vehicle defect contributory factors	1
Unroadworthy (contribution to accident unclear)	Contributory factors 201-206 or 999 present but no indication in the description of their influence	2
Unroadworthy (contributing to accident)	Contributory factors 201-206 or 999 present with indication in the description of their influence	4
3. Driving Conditions		
Day	Light conditions variable – daylight (1)	
Clear and/or cloudy	Light conditions variable – daylight (1) combined with Weather conditions variable – Fine without high winds (1)	1
*Fog and/or mist, clear and windy (>40 kph)	Light conditions variable – daylight (1) combined with Weather conditions variable – Fine with high winds (4) or Fog or mist – if hazard (7)	2
*Visibility good and road wet	Light conditions variable – daylight (1) combined with Weather condition variable – Fine without high winds (1) and Contributory factor – Wet road (103)	2
Showers and/or rain	Light conditions variable – daylight (1) combined with Weather conditions variable – Rain without high winds (2) or Rain with high winds (5)	3
Night	Lighting conditions variable -Darkness: street lights present and lit (4) or Darkness: street lights	

	present but unlit (5) or Darkness: no street lighting (6) or Darkness: street lighting unknown (7)	
†‡Clear	Lighting conditions variable -Darkness: street lights present and lit (4) or Darkness: street lights present but unlit (5) or Darkness: no street lighting (6) or Darkness: street lighting unknown (7) combined with Weather conditions variable – Fine without high winds (1)	1
‡Cloudy	There are no STATS19 data relating to cloudy conditions	2
Fog/mist/showers/rain/ice/wind	Lighting conditions variable -Darkness: street lights present and lit (4) or Darkness: street lights present but unlit (5) or Darkness: no street lighting (6) or Darkness: street lighting unknown (7) combined with Weather conditions variable – Rain without high winds (2) or Snowing without high winds (3) or Fine with high winds (4) or Rain with high winds (5) or Snowing with high winds (6) or Fog or mist – if hazard (7)	3
4. Type of Accident		
Single-vehicle		
No influence from other vehicles	Number of vehicles variable indicates one vehicle or if the number of vehicles variable indicates more than one vehicle but in examining the vehicle type variable only one of the vehicles was a motor vehicle	1

Influence from other vehicles	There can be no direct mapping of this criteria as an influencing vehicle would be recorded in STATS19 as a vehicle and hence the collision be a multi-vehicle	3
Multi-vehicle		
Striking vehicle attempting to avoid	Number of vehicles variable indicates more than one and examining the vehicle type variable indicates more than one motor vehicle, combined with the first point of impact variable, the manoeuvres variable and content of the description.	2
Striking vehicle not attempting to avoid	Number of vehicles variable indicates more than one and examining the vehicle type variable indicates more than one motor vehicle, combined with the first point of impact variable, the manoeuvres variable and content of the description.	1
Struck vehicle in the wrong	Number of vehicles variable indicates more than one and examining the vehicle type variable indicates more than one motor vehicle, combined with the first point of impact variable, the manoeuvres variable and content of the description.	1
Struck vehicle in the right	Number of vehicles variable indicates more than one and examining the vehicle type variable indicates more than one motor vehicle, combined with the first point of impact variable, the manoeuvres variable and content of the description.	3
5. Witness Observations		
No apparent reason	Collisions occurring for no reason are not supported by STATS19 variables or contributory factors	1
Reckless		

Swerving	Contributory factor ‘swerved’ (409)	1
Irregular driving	There are no direct mapping options for STATS19 data to the construct of irregular driving	1
Negligent		
Witnessed road infringement	See section six	1
Lack of road sense	Failing to take account of factors presented in the contributory factors presented in table 5.24	1
Vehicle fault	See section two or contributory factor codes 201-206 and 999	3
Driver not to blame	No variables, contributory factors or material in the description indicating the driver was at fault for the collision	4
6. Road Law Obedience		
Was driver obeying road laws?		
Yes	No offences indicated by contributory factors or variable codes	3
No	Breath test variable code one (positive), any of the contributory factor codes indicated in table 5.28, any defects indicated in section two, any combination of factors indicated in section five which may combine to indicate a standards of driving offence	1
7. Difficulty of Task Involved		
Straight road or sweeping bend	Contributory factors 108 or 703 not present	1
§Across lanes in	Not indicated directly by STATS19, see below	
Heavy traffic	Manoeuvre variable, left (07) or right (09) turn combined with the description indicating heavy traffic	2
Light traffic	Manoeuvre variable, left (07) or right (09) turn combined with the description indicating light traffic	1
Winding road/sharp bend/U-turn	Contributory factors 108 or 703 present	2
Overtaking	Manoeuvre variable, overtaking (13-15)	2
Avoiding unexpected traffic	Not indicated directly by STATS19 but may be described in the description	3
8. Level of Fatigue		
Only if mentioned in police reports	Contributory factor ‘fatigue’ (503) present	2

Appendix 8: Brubacher, Chan and Asbridge (2012) to STATS19 application composite table showing variable application and scoring

(1) Road type	Applied data and considerations	Score
One-way traffic	Road type variable ‘one way street’ (2)	
Road class = anything other than ramp	Road type variable ‘one way street’ (2)	1
Road class = ramp	Road type variable ‘slip road’ (7)	2
Two-way traffic	Road type variable ‘roundabout’ (1), ‘duel carriageway’ (3), ‘single carriageway’ (6)	
Between intersection	Junction location of vehicle variable ‘not at, or within 20 metres of a junction’ (0)	2
At intersection	Junction location of vehicle variable, all codes except ‘not at, or within 20 metres of a junction’ (0)	3
Ramp	Road type variable ‘slip road’ (7)	3
Police list roadside hazard or poor design as contributory factor	Contributory factor codes ‘traffic calming’ (106), or Temporary road layout’ (107) or special conditions at site variable ‘road surface defective’ (5)	5
(2) Driving condition = road surface and visibility/weather conditions	Applied data and considerations	Score
Road surface		
Dry road/asphalt or concrete	Surface conditions ‘dry’ (1) the road surface assumed to be asphalt or concrete unless otherwise stated	1
Dry road/gravel, oiled gravel, brick, stone, earth, or wood	Surface conditions ‘dry’ (1) alternative road surfaces are not dealt with directly in STATS19 although this may be mentioned in the description if it was a factor in the collision	2
Wet road/asphalt or concrete	Surface conditions ‘wet’ (2) the road surface assumed to be asphalt or concrete unless otherwise stated	2
Wet road/gravel, oiled gravel, brick, stone, earth, or wood	Surface conditions ‘wet’ (2) alternative road surfaces are not dealt with directly in STATS19 although this may be mentioned in the description if it was a factor in the collision	3
Road muddy or covered with snow or slush or ice	Surface conditions ‘snow’ (3) of Surface conditions ‘frost/ice’ (4). Contributory factors ‘deposit on road (e.g. oil, mud, chippings)’ (102) or ‘slippery road (due to weather)’ (103)	4
Road surface listed as contributory factor	Contributory factor ‘poor or defective road surface’ (101) or Special conditions at site ‘road surface defective’ (5)	5
Visibility and weather		
Weather = clear or cloudy	Weather conditions ‘fine without high winds’ (1)	1
If lighting condition = dark with partial or no illumination	Light conditions ‘darkness: street lights present but unlit’ (5) or ‘darkness: no street lighting’ (6)	2
Weather = raining, smog or smoke, or strong wind	Weather conditions ‘raining without high winds’ (2) or ‘fine with high winds’ (4) or ‘raining with high winds’ (5) or ‘fog or mist – if hazard’ (7)	2
If lighting condition = dark with partial or no illumination	Light conditions ‘darkness: street lights present but unlit’ (5) or ‘darkness: no street lighting’ (6)	3
Weather = snow, sleet, hail, fog	Weather conditions ‘snowing without high winds’ (3) or ‘snowing with high winds’ (6) or ‘fog or mist – if hazard’ (7)	3
If lighting condition = dark with partial or no illumination	Light conditions ‘darkness: street lights present but unlit’ (5) or ‘darkness: no street lighting’ (6)	4

Police list visibility or weather as a contributory factor	Contributory factor ‘slippery road (due to weather)’ (103), there may also be reference to the weather in the description	5
(3) Vehicle condition	Applied data and considerations	Score
Vehicle condition not listed as contributory factor in crash	Contributory factors 201-206 or 999 not present	1
Police list vehicle condition as contributory factor in crash	Contributory factors 201-206 or 999 present	5
(4) Unsafe driving actions	Applied data and considerations	Score
Driver not obeying road laws or driving in unsafe manner	Breath test variable ‘positive’ (1) or Contributory factors ‘disobeyed automatic traffic signal’ (301), ‘disobeyed "Give Way" or "Stop" sign or markings’ (302), ‘disobeyed double white lines’ (303), ‘disobeyed pedestrian crossing facility’ (304), ‘illegal turn or direction of travel’ (305), ‘exceeding speed limit’ (306), ‘travelling too fast for conditions’ (307), ‘following too close’ (309), ‘vehicle travelling along pavement’ (309), ‘poor turn or manoeuvre’ (403), ‘failed to signal or misleading signal’ (404), ‘failed to look properly’ (405), ‘too close to cyclist, horse rider or pedestrian’ (407), ‘sudden braking’ (408), ‘impaired by alcohol’ (501), ‘impaired by drugs’ (502), ‘uncorrected, defective eyesight’ (504), ‘not displaying lights at night or in poor visibility’ (506), ‘driver using mobile phone’ (508), ‘distraction in vehicle’ (509), ‘distraction outside vehicle’ (510), ‘vehicle door opened or closed negligently’ (904), also failing to deal with the following contributory factors adequately to avoid a collision or driving in the manner described in the contributory factor are likely to constitute offences under the standards of driving matters, ‘defective traffic lights’ (105), ‘road layout (e.g. bend, hill, narrow carriageway)’ (108), ‘junction overshoot’ (401), ‘junction restart (moving off at junction)’ (402), ‘failing to judge other person’s path or speed’ (406), ‘aggressive driving’ (601), ‘careless, reckless or in a hurry’ (602), ‘nervous, uncertain or panic’ (603), ‘driving too slow for conditions, or slow vehicle (e.g. Tractor)’ (604), ‘learner or inexperienced driver/rider’ (605), ‘inexperience of driving on the left’ (606), ‘vegetation’ (702), ‘road layout (eg. Bend, winding road, hill crest)’ (703), ‘buildings, road signs, street furniture’ (704), ‘dazzling headlights’ (705), ‘dazzling sun’ (706), ‘spray from other vehicles’ (708), ‘visor or windscreen dirty, scratched or frosted etc’ (709), ‘vehicle blind spot’ (710)	1
Driver obeying road laws and driving safely	None of the variables or contributory factor present	5
(5) Contribution from other parties	Applied data and considerations	Score
No contribution from other parties	Number of vehicles variable indicates one vehicle or if the number of vehicles variable indicates more than one vehicle but in examining the vehicle type variable only one of the vehicles being a motor vehicle or Multi-vehicle collisions determined by the number of vehicles variable indicates more than one and examining the vehicle type variable indicates (see table 5.17) more than one motor vehicle, combined with the driver of the vehicle having a determination of ‘Driver not obeying road laws or driving in unsafe manner’ in section four	1

Contribution from other parties	Multi-vehicle collisions determined by the number of vehicles variable indicates more than one and examining the vehicle type variable indicates (see table 5.17) more than one motor vehicle, combined with the driver of the vehicle having a determination of 'Driver obeying road laws and driving safely' in section four with one of the drivers of another vehicle having a determination of 'Driver not obeying road laws or driving in unsafe manner' in section four	5
(6) Type of collision	Applied data and considerations	Score
Unsafe driving (factor 4)	See section four	1
No unsafe driving	This is the position regarding the result of section four and does not score individually, the below factors are then taken into account for the driver and scored accordingly	
Single vehicle without pedestrian	See result of section 5 for the driver	1
Single motor vehicle crash involving pedestrian	This is the heading for the single vehicle vs pedestrian circumstances and does not score individually, the below factors relating to the pedestrian are then taken into account for the driver and scored accordingly, see the result for section 5 for the driver	
Pedestrian action	This is the heading for the pedestrian actions listed below and does not score individually, the below factors are then taken into account for the driver and scored accordingly	
Standing/walking on a sidewalk	Pedestrian location variable 'on footway or verge' (06) and Pedestrian movement variable 'unknown or other' (9)	1
Crossing with signal	Pedestrian location variable 'in carriageway, crossing on pedestrian crossing facility' (01) and Pedestrian movement variable 'crossing from driver's nearside' (1), 'crossing from driver's offside' (3)	1
Crossing, no signal, marked crosswalk	Pedestrian location variable 'in carriageway, crossing on pedestrian crossing facility' (01) and Pedestrian movement variable 'crossing from driver's nearside' (1), 'crossing from driver's offside' (3) and Contributory factor 'wrong use of pedestrian crossing facility' (804)	1
Crossing, no signal, no crosswalk	Pedestrian location variable 'in carriageway, crossing elsewhere within 50 metres of pedestrian crossing' (04) or 'in carriageway, crossing elsewhere (05) and Pedestrian movement variable 'crossing from driver's nearside' (1), 'crossing from driver's offside' (3)	3
Crossing against signal	Pedestrian location variable 'in carriageway, crossing on pedestrian crossing facility' (01) and Pedestrian movement variable 'crossing from driver's nearside' (1), 'crossing from driver's offside' (3) and Contributory factor 'wrong use of pedestrian crossing facility' (804)	4
Child getting on/off bus	STATS19 does not have variables or contributory factors which constitute these circumstances although it may be indicated in the description	2
Adult getting on/off vehicle	STATS19 does not have variables or contributory factors which constitute these circumstances although it may be indicated in the description	2
Emerging from in front of or behind a parked vehicle	Pedestrian location variable 'in carriageway, crossing elsewhere within 50 metres of pedestrian crossing' (04) or 'in carriageway, crossing elsewhere (05) and Pedestrian movement variables 'crossing from driver's nearside - masked by parked or stationary vehicle' (2) or 'crossing from driver's offside - masked by parked or stationary vehicle' (4) or 'in carriageway, stationary - not crossing (standing or playing), masked by parked or stationary vehicle' (6)	3

Pushing or working on a vehicle	STATS19 does not have variables or contributory factors which constitute these circumstances although it may be indicated in the description	1
Walking along highway with or against traffic	Pedestrian location variable 'in carriageway, not crossing' (09) or 'unknown or other (10) and Pedestrian movement variables 'walking along in carriageway - facing traffic' (7) or 'walking along in carriageway - back to traffic' (8)	1
Working in roadway	Pedestrian location variable 'in carriageway, not crossing' (09) or 'unknown or other (10) and Pedestrian movement variables 'In carriageway, stationary - not crossing (standing or playing)' (5) or 'in carriageway, stationary - not crossing (standing or playing), masked by parked or stationary vehicle' (6) or 'walking along in carriageway - facing traffic' (7) or 'walking along in carriageway - back to traffic' (8) or 'unknown or other' (9) with reference to working in the carriageway in the description	1
Playing in roadway	Pedestrian location variable 'in carriageway, not crossing' (09) and Pedestrian movement variable 'in carriageway, stationary - not crossing (standing or playing) (5) or 'in carriageway, stationary - not crossing (standing or playing), masked by parked or stationary vehicle' (6) and Contributory factor 'dangerous action in carriageway (e.g. playing)' (805)	2
Multivehicle crash	See the result of section five for the driver	
"Innocent third party"	See the result of section four for the driver	5
Stopped/parked	Manoeuvres variable 'parked' (02) then one of the following indicating the vehicle was stopped at the time of impact 'waiting to go ahead but held up' (03) or 'waiting to turn left' (08) or 'waiting to turn right' (10)	
Lead vehicle in rear-end collision	Manoeuvres variable 'slowing or stopping' (04) or one of the following indicating the vehicle was stopped at the time of impact 'waiting to go ahead but held up' (03) or 'waiting to turn left' (08) or 'waiting to turn right' (10) combined with First point of impact variable 'back' (2)	
Third or subsequent vehicle in crash (entity # ≥3–this only applies to crashes with more than 2 vehicles)		
Loss of control prior to crash	Contributory factor 'loss of control' (410)	
Precollision action = swerving, spinning, yaw, jackknifing, skidding	Skidding and overturning variable 'Skidded' (1) or 'skidded and overturned' (2) or 'jack-knifed' (3) or 'jack-knifed and overturned' (4) or Contributory factor 'swerved' (409) or 'loss of control' (410) (for spinning)	1
Maneuvering vehicle: precollision action = left turn, right turn, U-turn, overtaking, etc.	Manoeuvres variable 'u turn' (06) or 'turning left' (07) or 'turning right' (09) or 'overtaking moving vehicle on its offside' (13) or 'overtaking stationary vehicle on its offside' (14) or 'overtaking on nearside' (15)	
Striking vehicle (determined from damage location)	The striking construct may be determined by combining First point of contact variable, the Movement to variable, the Movement from variable, the Manoeuvres variable and the information held in the collision description.	1
Indeterminate vehicle (determined from damage location)	The indeterminate construct may be determined by combining First point of contact variable, the Movement to variable, the Movement from variable, the Manoeuvres variable and the information held in the collision description.	1
Struck vehicle (determined from damage location)	The struck construct may be determined by combining First point of contact variable, the Movement to variable, the	2

	Movement from variable, the Manoeuvres variable and the information held in the collision description.	
If right turn rear ended	First point of contact variable ‘back’ (2) and Manoeuvres variable ‘turning right’ (09), however, this scoring tool was designed for vehicles driving on the right. For a UK context with vehicles driving on the left this criterion should be vehicles turning left, this is represented by the Manoeuvres variable ‘turning left’ (07)	3
Precollision action = traveling straight, crash configuration∗ = rear end	First point of impact variable ‘back’ (2) and Manoeuvres variable ‘going ahead left hand bend’ (16) or ‘going ahead right hand bend’ (17) or ‘going ahead other’ (18)	
Striking vehicle (determined from damage location)	The striking construct may be determined by combining First point of contact variable, the Movement to variable, the Movement from variable, the Manoeuvres variable and the information held in the collision description.	1
Indeterminate vehicle (determined from damage location)	The indeterminate construct may be determined by combining First point of contact variable, the Movement to variable, the Movement from variable, the Manoeuvres variable and the information held in the collision description.	3
Struck vehicle (determined from damage location)	The struck construct may be determined by combining First point of contact variable, the Movement to variable, the Movement from variable, the Manoeuvres variable and the information held in the collision description.	5
Precollision action = traveling straight, crash configuration = intersection, off road	Manoeuvres variable ‘going ahead left hand bend’ (16) or ‘going ahead right hand bend’ (17) or ‘going ahead other’ (18) combined with a Junction location variable (see table 5.430 of ‘mid junction - on roundabout or on main road’ (8)	
Striking vehicle (determined from damage location)	The striking construct may be determined by combining First point of contact variable, the Movement to variable, the Movement from variable, the Manoeuvres variable and the information held in the collision description.	1
Indeterminate vehicle (determined from damage location)	The indeterminate construct may be determined by combining First point of contact variable, the Movement to variable, the Movement from variable, the Manoeuvres variable and the information held in the collision description.	1
Struck vehicle (determined from damage location)	The struck construct may be determined by combining First point of contact variable, the Movement to variable, the Movement from variable, the Manoeuvres variable and the information held in the collision description.	3
Precollision action = traveling straight, crash configuration = any turn, overtaking—that is, other vehicle manoeuvring	Manoeuvres variable ‘going ahead left hand bend’ (16) or ‘going ahead right hand bend’ (17) or ‘going ahead other’ combined with the Manoeuvre variable for the other vehicle involved in the collision being (18) ‘turning left’ (07) or ‘turning right’ (09) or ‘changing lane to left’ (11) or ‘changing lane to right’ (12) or ‘overtaking moving vehicle on its offside’ (13) or ‘overtaking stationary vehicle on its offside’ (14) or ‘overtaking on nearside’ (14)	
Striking vehicle (determined from damage location)	The striking construct may be determined by combining First point of contact variable, the Movement to variable, the Movement from variable, the Manoeuvres variable and the information held in the collision description.	3
Indeterminate vehicle (determined from damage location)	The indeterminate construct may be determined by combining First point of contact variable, the Movement to variable, the Movement from variable, the Manoeuvres variable and the information held in the collision description.	3
Struck vehicle (determined from damage location)	The struck construct may be determined by combining First point of contact variable, the Movement to variable, the	4

	Movement from variable, the Manoeuvres variable and the information held in the collision description.	
Precollision action = traveling straight, crash configuration = head on, sideswipe)	Manoeuvres variable ‘going ahead left hand bend’ (16) or ‘going ahead right hand bend’ (17) or ‘going ahead other’ (18) combined with First point of impact variable ‘front’ (1) or ‘offside’ (3) or ‘nearside’ (4)	
Striking vehicle (determined from damage location)	The striking construct may be determined by combining First point of contact variable, the Movement to variable, the Movement from variable, the Manoeuvres variable and the information held in the collision description.	3
Indeterminate vehicle (determined from damage location)	The indeterminate construct may be determined by combining First point of contact variable, the Movement to variable, the Movement from variable, the Manoeuvres variable and the information held in the collision description.	3
Struck vehicle (determined from damage location)	The struck construct may be determined by combining First point of contact variable, the Movement to variable, the Movement from variable, the Manoeuvres variable and the information held in the collision description.	3
Precollision action = traveling straight, crash configuration = unknown	Manoeuvres variable ‘going ahead left hand bend’ (16) or ‘going ahead right hand bend’ (17) or ‘going ahead other’ (18) with no other details	
Striking vehicle (determined from damage location)	The striking construct may be determined by combining First point of contact variable, the Movement to variable, the Movement from variable, the Manoeuvres variable and the information held in the collision description.	2
Indeterminate vehicle (determined from damage location)	The indeterminate construct may be determined by combining First point of contact variable, the Movement to variable, the Movement from variable, the Manoeuvres variable and the information held in the collision description.	
Struck vehicle (determined from damage location)	The struck construct may be determined by combining First point of contact variable, the Movement to variable, the Movement from variable, the Manoeuvres variable and the information held in the collision description.	4
(7) Task involved	Applied data and considerations	Score
Unsafe driving (Factor 4)	See section four	1
No unsafe driving	This is the position regarding the result of section four and does not score individually, the below factors are then taken into account for the driver and scored accordingly	
Avoiding object on road	Carriageway hazard variable ‘dislodged vehicle load in carriageway’ (1), ‘other object in carriageway’ (2), ‘involvement with previous incident’ (3), ‘pedestrian in carriageway – not injured, (6), ‘any animal in carriageway (except ridden horse)’ (7), contributory factors ‘animal or object in carriageway’ (109), ‘cyclist entering road from pavement’ (310), although the criteria is avoiding object in carriageway this does not preclude that the driver did hit the object so consideration must be given to the ‘Hit object in carriageway’ variable, ‘previous accident’ (01), ‘roadworks’ (02), ‘parked vehicle’ (04), ‘bridge – roof’ (05), ‘bridge – side’ (06), ‘bollard/refuge’ (07), ‘open door of vehicle’ (08), ‘central island of roundabout’ (09), ‘kerb’ (10), ‘other object ‘ (11), ‘any animal (except ridden horse)’ (12)	5
Parked, stopped in traffic *a*	Manoeuvres variable ‘parked’ (02) or ‘waiting to go ahead but held up’ (03), ‘waiting to turn left’ (08), ‘waiting to turn right’ (10) or Contributing factor ‘Stationary or parked vehicle’ (701)	5
Changing lanes, merging	Manoeuvres variable ‘changing lane to left’ (11), ‘changing lane to right’ (12), ‘overtaking moving vehicle on its offside’ (13), ‘overtaking stationary vehicle on its offside’ (14),	3

	‘overtaking on nearside’, (15). Merging is not a construct used in STATS19	
Turning and backing	Manoeuvres variable ‘reversing’ (01), ‘U-turn’ (06), ‘turning left’ (07), ‘turning right’ (09)	2
All other precollision actions	No unsafe driving under section four and none of the four above criteria apply	1

Appendix 9: Inter-rater Expert Profiles

This appendix contains the profiles of the three experts who assisted with the validation of the culpability scoring undertaken in chapter five. This information is drawn from the profile pages Loughborough University Design School (www.lboro.ac.uk/departments/design-school/staff/) for expert one and for expert two and three from their company website (www.fcir.co.uk).

Expert one.

Steven Reed, BTech, BEng.

Research Associate. He joined Loughborough University in 2004 as an accident investigator working on the assessment of passenger car performance in real-world crashes, his engineering background and expertise in this field has allowed him to develop his investigation skills to other transport modes, including motorcycle and pedal cycle crashes, and provide expert witness services for civil and criminal prosecution cases.

Since 2008 he has worked as a research associate and has been involved in a wide range of road safety initiatives, funded by both industry and grant schemes; during this period, studies have covered topics including: the development of a European fatal accident database, truck head light standards, assessment of direct and indirect vision from heavy goods vehicle cabs, investigation of cycle fatalities in London and examination of vehicle seat comfort in simulator studies. In the course of this work he has worked on large European projects through to small scale commercial studies across a variety of sectors.

He is an experienced accident investigator with a 15 year history of investigating real world collisions involving a range of different road users. His expertise in crash performance and vehicle engineering has led him to develop and run a number of training programmes for collision investigators in Australia, India and Belarus along with providing expert knowledge to both civil and criminal prosecution cases.

In addition, he has developed accident investigation and vehicle engineering modules for master's courses in road safety and designed and run outreach sessions for STEM programmes.

Expert two.

Mark Crouch, MSci., CPhys, ChFP (Collision), AAE, FInstP, FCSFS, FIMI, FIHE, MITAI.

Head of Investigations. He has a master's degree in Applied Physics (MSci. Hons.) from the University of London.

His work in the field of Collision Investigation has led to him achieving Chartered Physicist (CPhys) status from the Institute of Physics and also Chartered Forensic Practitioner (Collision). He is an Advanced Automotive Engineer (AAE), Licentiate of the City and Guilds Institute (LCGI), a Fellow of the Institute of Physics (FInstP), a Fellow of the Chartered Society of Forensic Sciences (FCSFS), a Fellow of the Institute of the Motor Industry (FIMI) and a Fellow of the Institute of the Highways Engineers (FIHE). He is a Member Institute of Traffic Accident Investigators (MITAI). He is also a Fully Vetted Expert for the UK Register of Expert Witnesses.

He worked for the Metropolitan Police as a Forensic Collision Investigator for many years before forming FCIR. He has conducted investigations into hundreds of road traffic collisions, attending collision scenes, writing detailed reports, peer reviewing the work of others and researching new techniques within the field.

He is also the current External Examiner for De Montfort University overseeing the UCPD, Cert HE, FdSc and BSc courses in Collision Investigation.

He draws on both academic and practical experience in compiling his findings. He is experienced at giving evidence in Court and is accepted as an Expert within his field. He is also a 1st Tier Expert for the Association of Personal Injury Lawyers (APIL).

Expert three.

Stephen Cash, IEng, AAE, MIMechE, MIMI, MITAI.

Principal Consultant. His work and accompanying research and development in the field of Collision Investigation have led to him obtaining Incorporated Engineer (IEng) status from the Engineering Council and attaining Membership of the Institution of Mechanical Engineers (MIMechE). He is also a Member of the Institute of the Motor Industry (MIMI) with whom he is registered as an Advanced Automotive Engineer (AAE), and a Member of the Institute of Traffic Accident Investigators (MITAI).

Stephen entered into the field of Collision Investigation as a Police Forensic Collision Investigator from an Engineering background. However, during the final 3 years of his Police career he also practiced outside of the Police on a consultancy basis. Consequently, whilst a serving Police Officer, he would routinely be instructed in cases of Civil Litigation and Criminal Defence and give live evidence at trial.

In his opinion this was a period that crystallised his independence in any investigation. This independence, combined with the clarity and thoroughness of his investigations, typically results in his evidence being effortlessly resilient to the rigours of the judicial process.

Appendix 10: The Culpability Scoring Validation And Reliability Exercise Briefing Document

Thank you for agreeing to assist with the validation and reliability testing of the culpability scoring study in my research project. This briefing document should give you sufficient information to be able to undertake the validation process and make a significant contribution to the project.

The overall project aims to look at a new way of targeting road safety interventions at the culpable drivers in serious injury road traffic collisions. The project focuses on the county of Cambridgeshire and has been assisted by the County Council, Constabulary and Cambridge University Hospitals in providing data. The funding has been provided through the Road Safety Trust and Addenbrookes Charitable Trust.

The project was split into three studies. The first study which has been completed and validated involves the linking of police collision data (STATS19) with hospital trauma patient data (Trauma Audit and Research Network data) to allow the extraction of the collisions which resulted in medically categorised serious injury (as opposed to the injury severity categorisation by the reporting police officer) at the level of MAIS3+. The Abbreviated Injury Scale (AIS) being an internationally used scale for categorising injury where of the 1 to 6 levels that of 3 being designated as serious. This research examines the level of 3 and above (hence 3+), the M refers the maximum level of all the injuries sustained by an individual casualty across all body regions. These are the section of casualties immediately below the fatalities in injury severity.

The second study involves the culpability scoring of the motor vehicle drivers involved in the collisions identified in the first study. Culpability is a construct which is not related to blame or any legal criteria. Culpability is determined by examining the circumstances of the collisions and the actions or lack of actions of particular drivers against standards to determine if they can be considered culpable, contributory or non-culpable. For a driver to be non-culpable effectively the only way they could have avoided the collision was to have been somewhere else when it occurred.

The culpability scoring has been undertaken and you will be assisting in the validation of that process and reliability of the results.

The third study will involve the geodemographic and geospatial profiling of the drivers to examine whether there are opportunities to target populations containing culpable drivers with interventions as an alternative to using blanket application.

Validation and Reliability

There are two stages to the process. The first task involves the validation of the variable/contributory factors/narrative to scoring tool application. The second task tests the reliability of the scoring process using the applied tool. The tasks can be undertaken consecutively or separately, however, they must be completed in order. It is envisaged that each task should not take more than an hour to complete.

Task one

The first task is to examine the application of the variables, contributory factors and narrative available in STATS19 across to the scoring categories within the scoring tool.

The scoring tool being used is the one devised by Robertson and Drummer (1994). You have been supplied with a copy of the original publication which is fully explanatory and will not be repeated here. This should be read prior to undertaking the task.

STATS19 has a considerable number of variables, there are also a significant number of contributory factors which an officer can attach to the report. STATS19, as supplied, also contains a brief description of the circumstance, such a V1 pulled out into the path of V2, or similar. The Department for Transport provides a guidance document for the completion of STATS19 in the form of the STATS20 document which acts as a data dictionary for the STATS19 variables. You will be supplied with a copy of STATS20. Please become familiar with this prior to starting the task.

The Robertson and Drummer scoring tool has eight scoring categories. To achieve a valid score there must be a score in at least 6. If 6 or 7 categories are present the average score per category is calculated and then multiplied by 8 to give a result. It is not possible to score the individual if there are only 5 categories or less represented.

Your first task is to examine the descriptions in each of the Robertson and Drummer scoring categories and then determine which STATS19 variables and/or contributory factors and/or the narrative description can be used to build the information required to determine an appropriate score. Each scoring category can contain any combination of variables, contributory factors or the narrative. A table for recording your allocations is available either in hard copy or electronically.

Your application results will be cross referenced with the model created by the researcher to determine concordance. There will be an opportunity to discuss the results to achieve consensus.

Task 2

The second task involves the use of the applied scoring tool to score a sample of the motor vehicle drivers produced by the first study.

You will be provided with anonymised data for 40 drivers involved in collisions to be scored, this sample comprises 10 percent of the drivers present in the dataset produced by study one, of the project. The drivers have been selected chronologically to include single vehicle and multi-vehicle collisions. The drivers will be from completed collisions, in that, for multi-vehicle collisions you will get all the drivers involved. It should be borne in mind that for multi-vehicle collisions any combination of culpability may occur. Scoring sheets are available in either hard or electronic format.

Your results will be compared with the results obtained by the researcher and there is an option for a discussion for each stage to consolidate the results.

Appendix 11: Acorn Geodemographic Coding

Category	Group		Types	
1 Affluent Achievers	A	Lavish Lifestyles	1	Exclusive enclaves
			2	Metropolitan money
			3	Large house luxury
	B	Executive Wealth	4	Asset rich families
			5	Wealthy countryside commuters
			6	Financially comfortable families
			7	Affluent professionals
			8	Prosperous suburban families
			9	Well-off edge of towners
	C	Mature Money	10	Better-off villagers
			11	Settled suburbia, older people
			12	Retired and empty nesters
			13	Upmarket downsizers
2 Rising Prosperity	D	City Sophisticates	14	Townhouse cosmopolitans
			15	Younger professionals in smaller flats
			16	Metropolitan professionals
			17	Socialising young renters
	E	Career Climbers	18	Career driven young families
			19	First time buyers in small, modern homes
			20	Mixed metropolitan areas
3 Comfortable Communities	F	Countryside Communities	21	Farms and cottages
			22	Larger families in rural areas
			23	Owner occupiers in small towns and villages
	G	Successful Suburbs	24	Comfortably-off families in modern housing
			25	Larger family homes, multi-ethnic areas
			26	Semi-professional families, owner occupied neighbourhoods
	H	Steady Neighbourhoods	27	Suburban semis, conventional attitudes
			28	Owner occupied terraces, average income
			29	Established suburbs, older families
	I	Comfortable Seniors	30	Older people, neat and tidy neighbourhoods
			31	Elderly singles in purpose-built accommodation
	J	Starting Out	32	Educated families in terraces, young children
			33	Smaller houses and starter homes
4 Financially Stretched	K	Student Life	34	Student flats and halls of residence
			35	Term-time terraces
			36	Educated young people in flats and tenements
	L	Modest Means	37	Low cost flats in suburban areas
			38	Semi-skilled workers in traditional neighbourhoods
			39	Fading owner occupied terraces
			40	High occupancy terraces, many Asian families
	M	Striving Families	41	Labouring semi-rural estates
			42	Struggling young families in post-war terraces
			43	Families in right-to-buy estates
			44	Post-war estates, limited means
	N	Poorer Pensioners	45	Pensioners in social housing, semis and terraces
			46	Elderly people in social rented flats
			47	Low income older people in smaller semis
			48	Pensioners and singles in social rented flats
5 Urban Adversity	O	Young Hardship	49	Young families in low cost private flats
			50	Struggling younger people in mixed tenure
			51	Young people in small, low cost terraces
	P	Struggling Estates	52	Poorer families, many children, terraced housing
			53	Low income terraces
			54	Multi-ethnic, purpose-built estates
			55	Deprived and ethnically diverse in flats
			56	Low income large families in social rented semis
	Q	Difficult Circumstances	57	Social rented flats, families and single parents
			58	Singles and young families, some receiving benefits
			59	Deprived areas and high-rise flats
6 Not Private Households	R	Not Private Households	60	Active communal population
			61	Inactive communal population
			62	Business addresses without resident population

For full descriptions please refer to the Acorn user guide (CACI Limited, 2014).

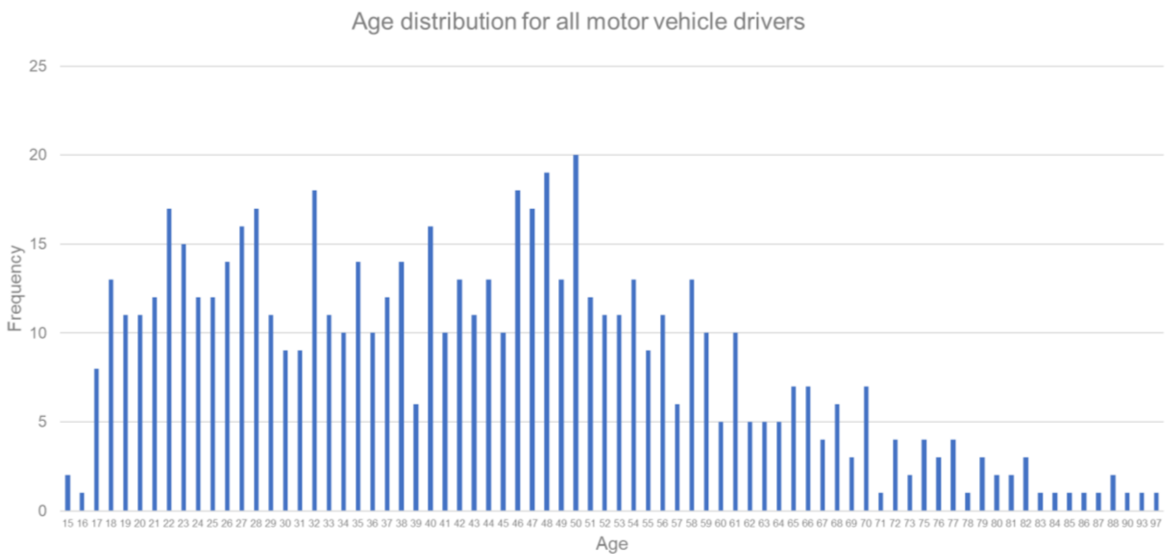
Appendix 12: Expanded Analysis Results

This appendix contains the age distribution histograms, the risk index histogram comparison and full tabulated results for the statistical tests undertaken in chapter 7 of the thesis. Tables are presented on separate pages to prevent splitting the table across page breaks.

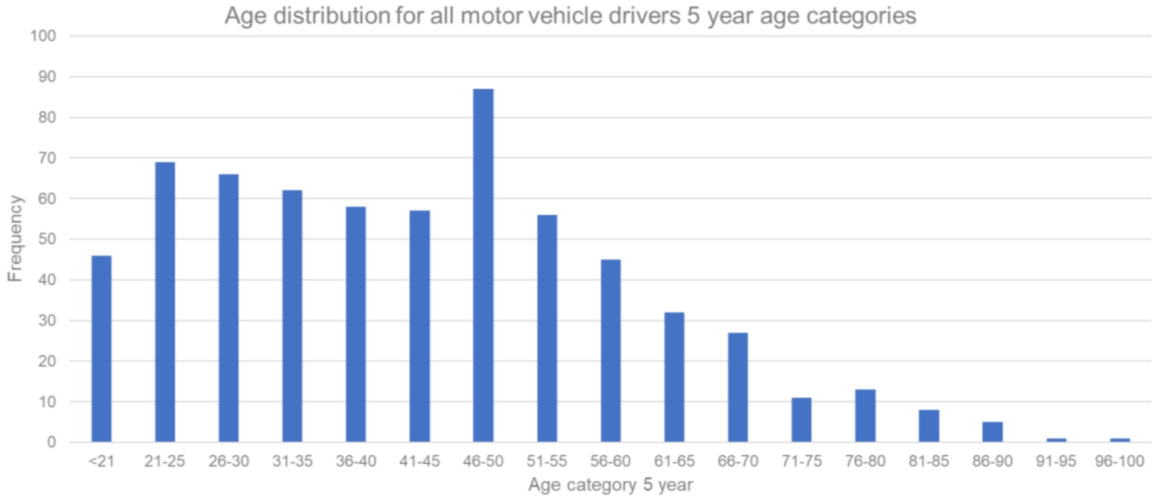
The age distribution for the motor vehicle driver groups are presented in histograms where frequency is plotted gains the age, the age is represented in three ways, firstly the actual age, then five year age groups and then 10 year age groups. The five and ten year age groups are included in many studies relating to motor vehicle drivers use age groups to present the distributions and this allows comparison.

The motor vehicle driver groups are represented on separate pages.

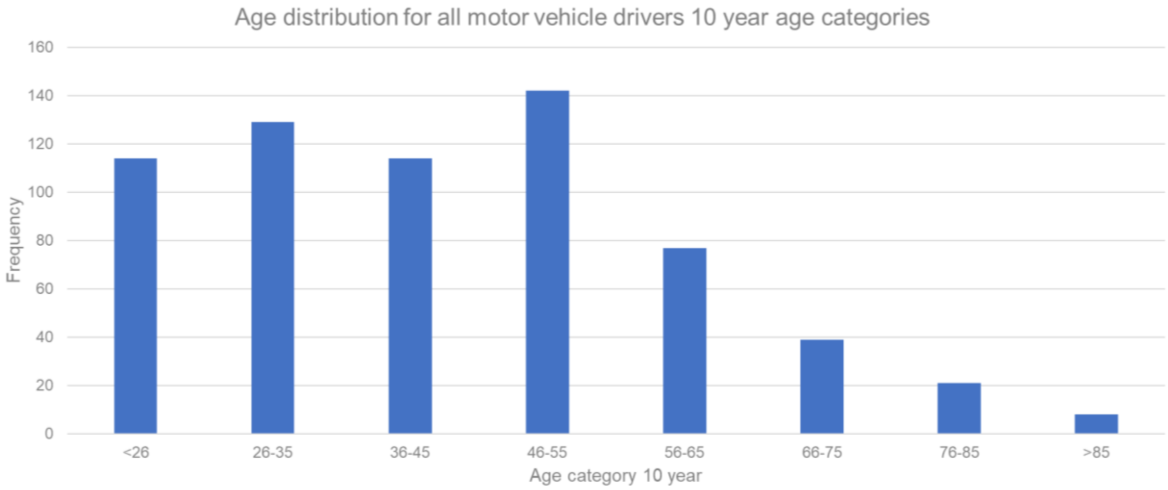
All motor vehicle drivers regardless of collision injury severity, motor vehicle driver culpability or residence are presented in figures 1 to 3 below.



Appendix 12, Figure 1, Age distribution for all motor vehicle drivers

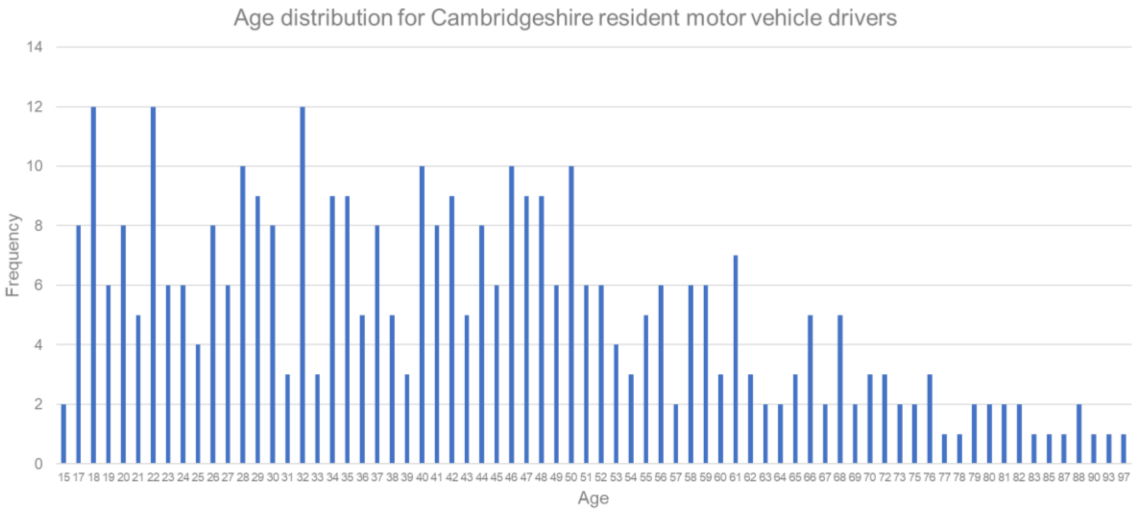


Appendix 12, Figure 2, Age distribution for all motor vehicle drivers five-year age categories

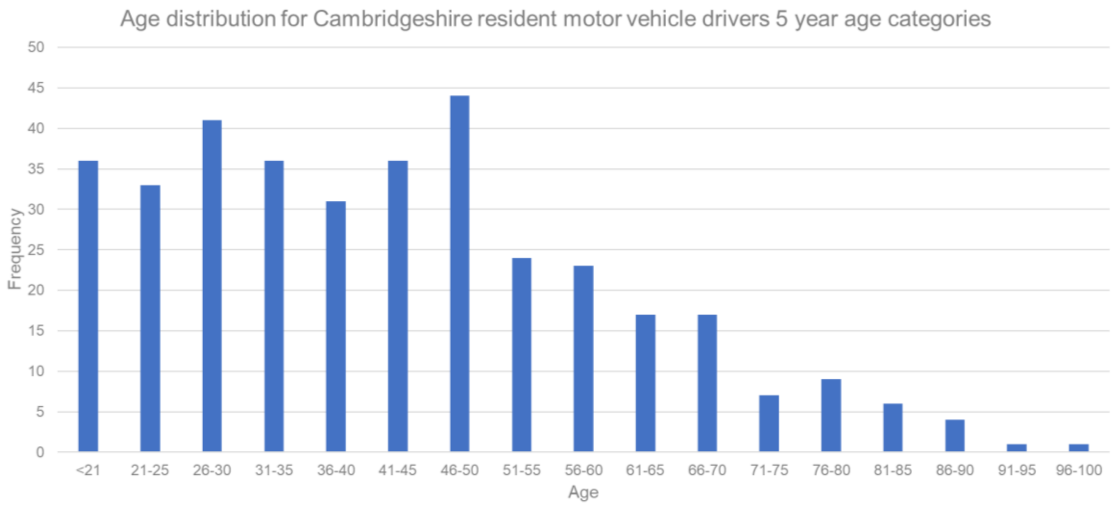


Appendix 12, Figure 3, Age distribution for all motor vehicle drivers ten-year age categories

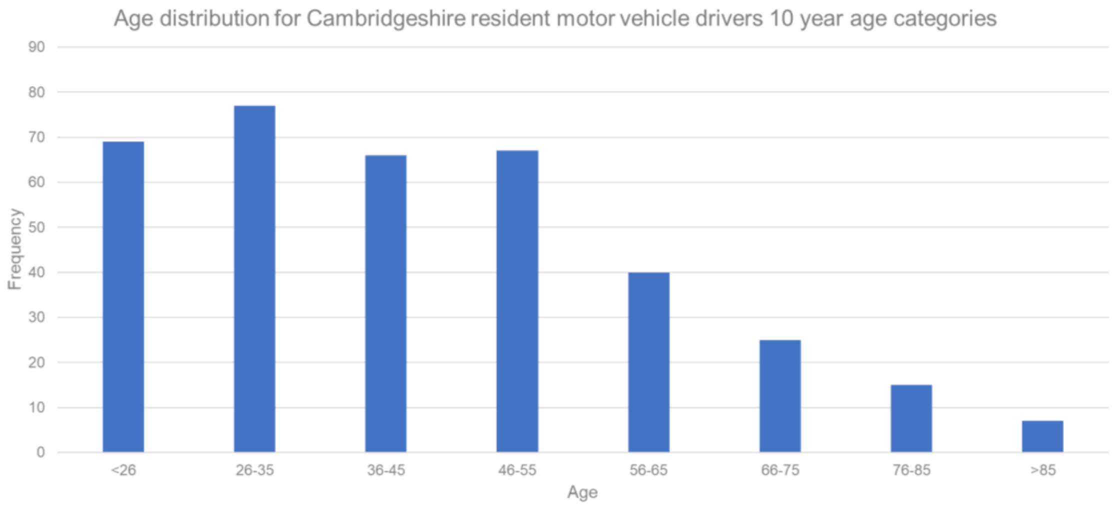
Cambridgeshire resident motor vehicle drivers regardless of culpability of collision injury severity are presented in figures 4 to 6 below.



Appendix 12, figure 4, Age distribution for Cambridgeshire resident motor vehicle drivers

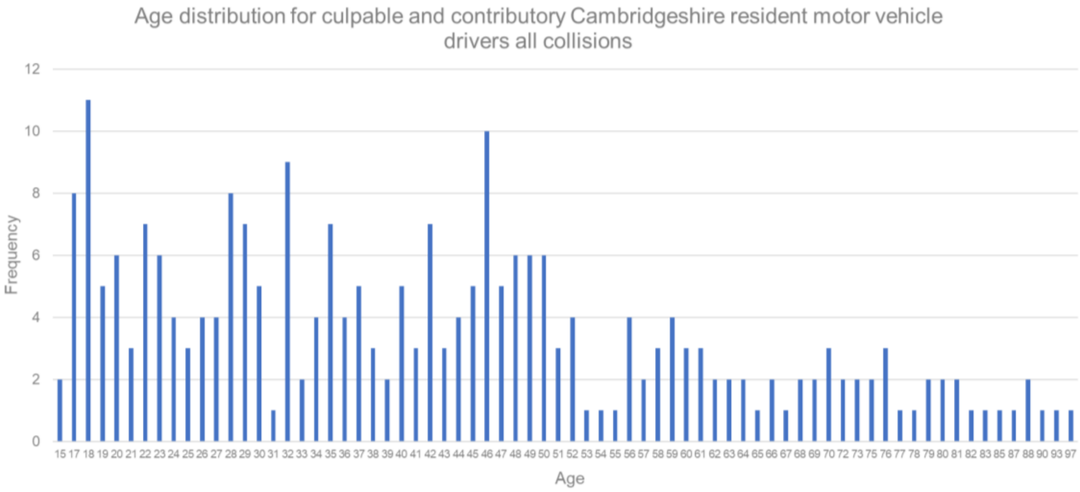


Appendix 12, figure 5, Age distribution for Cambridgeshire resident motor vehicle drivers five-year age categories

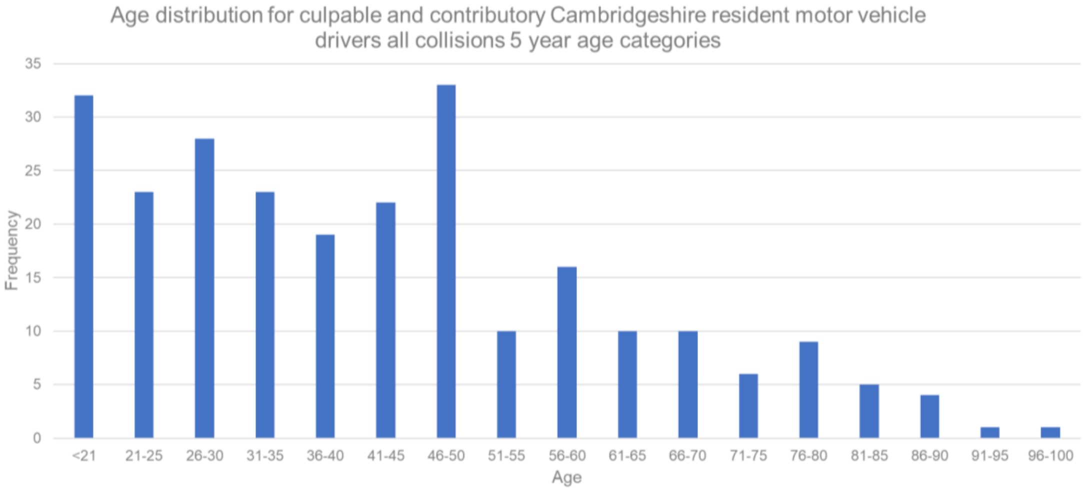


Appendix 12, figure 6, Age distribution for Cambridgeshire resident motor vehicle drivers ten-year age categories

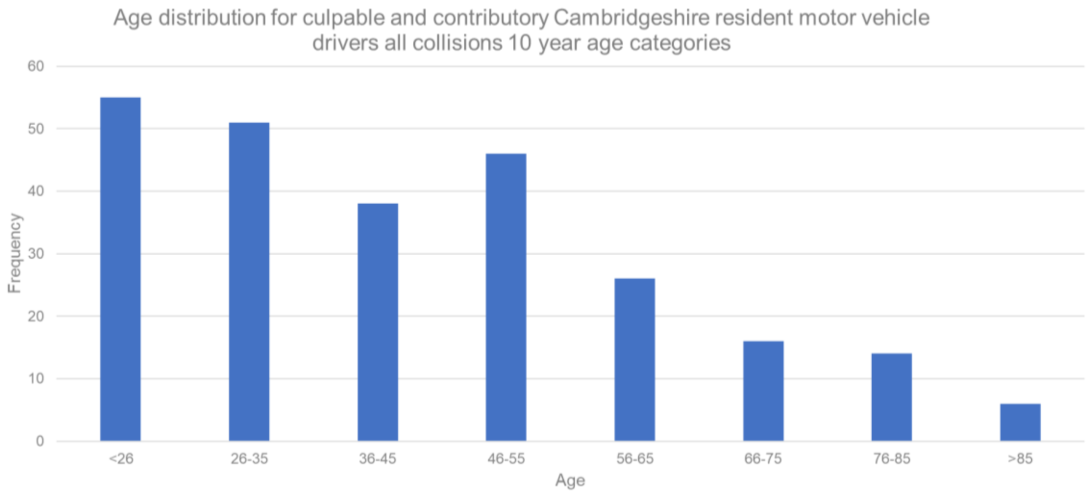
Culpable and contributory Cambridgeshire resident motor vehicle drivers regardless of collision injury severity are presented in figures 7 to 9 below.



Appendix 12, figure 7, Age distribution for culpable and contributory Cambridgeshire resident motor vehicle drivers all collisions

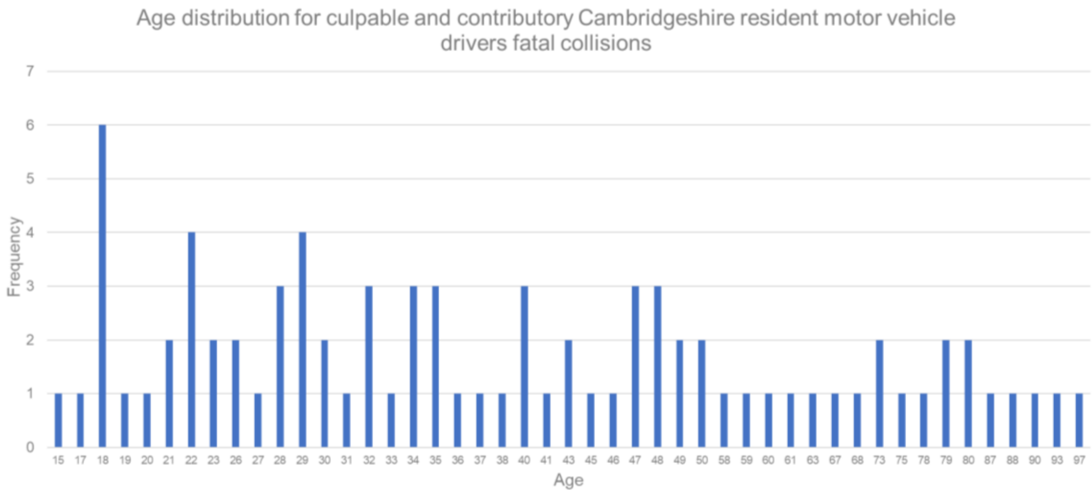


Appendix 12, figure 8, Age distribution for culpable and contributory Cambridgeshire resident motor vehicle drivers all collisions five-year age categories

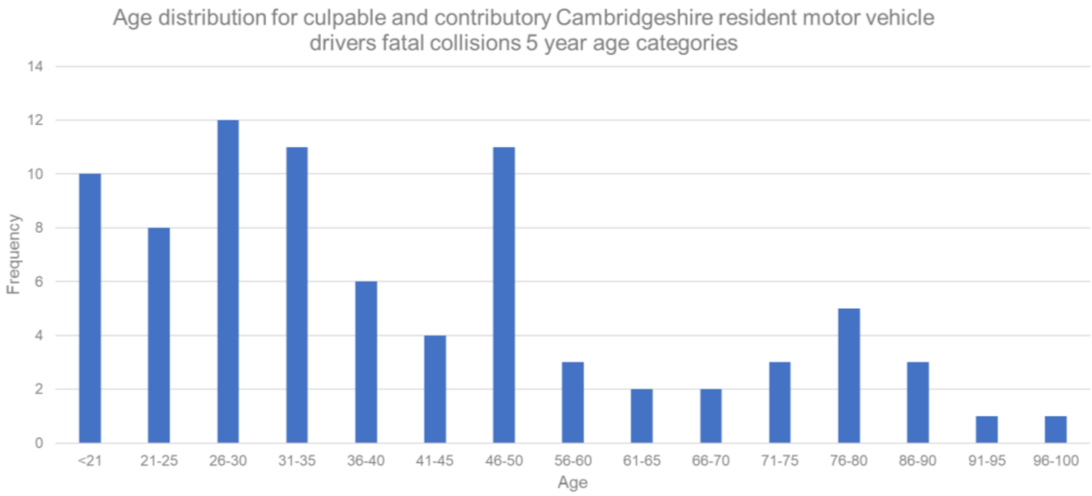


Appendix 12, figure 9, Age distribution for culpable and contributory Cambridgeshire resident motor vehicle drivers all collisions ten-year age categories

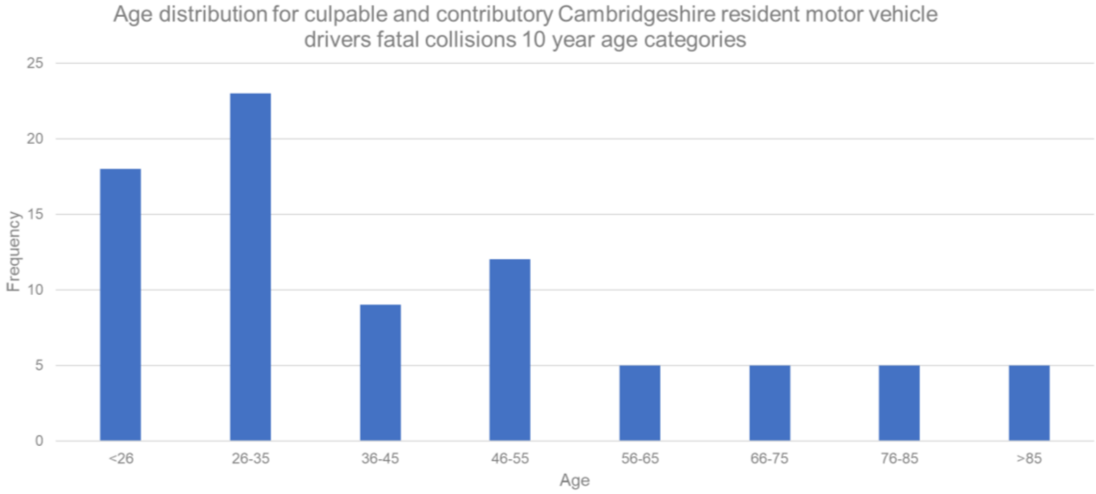
Culpable and contributory Cambridgeshire resident motor vehicle drivers involved in fatal collisions are presented in figures 10 to 12 below.



Appendix 12, figure 10, Age distribution for culpable and contributory Cambridgeshire resident motor vehicle drivers, fatal collisions

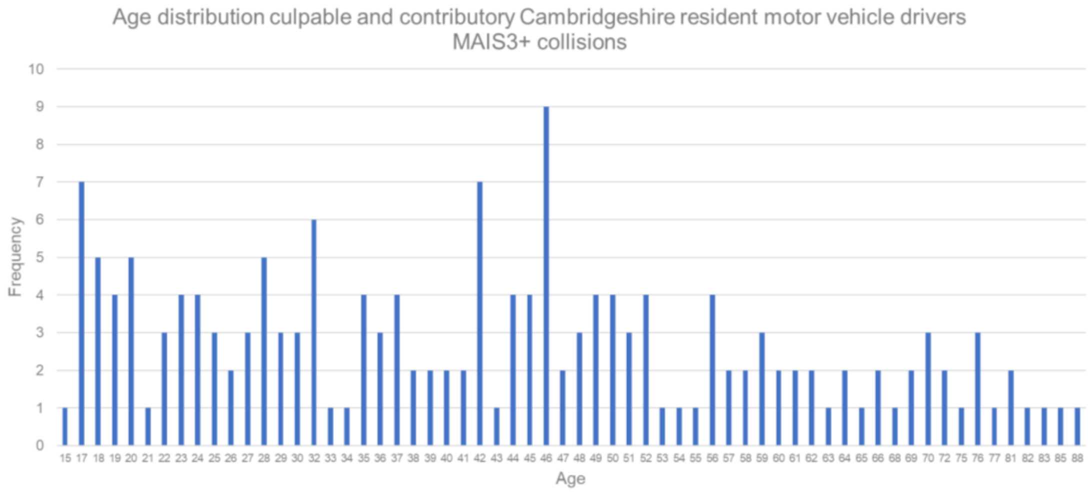


Appendix 12, figure 11, Age distribution for culpable and contributory Cambridgeshire resident motor vehicle drivers, fatal collisions five-year age categories

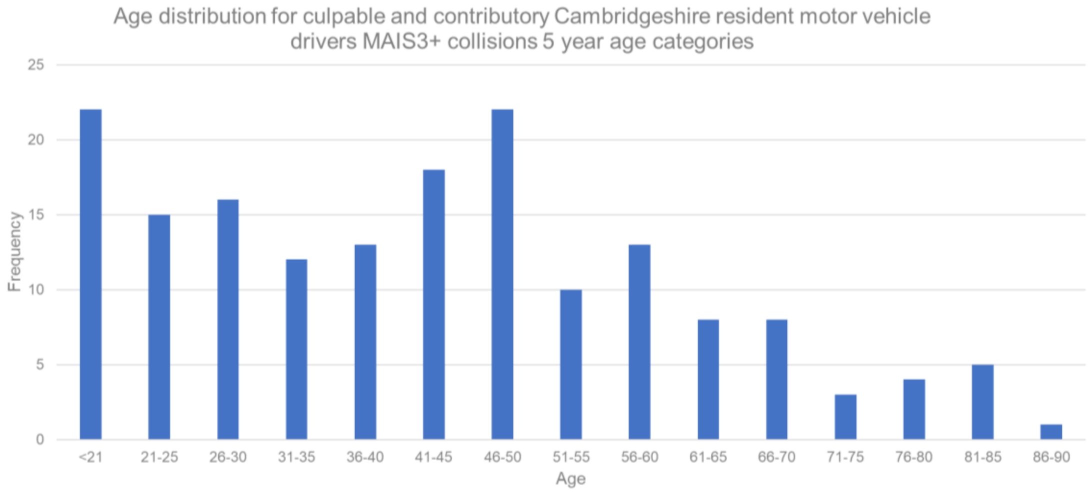


Appendix 12, figure 12, Age distribution for culpable and contributory Cambridgeshire resident motor vehicle drivers, fatal collisions ten-year age categories

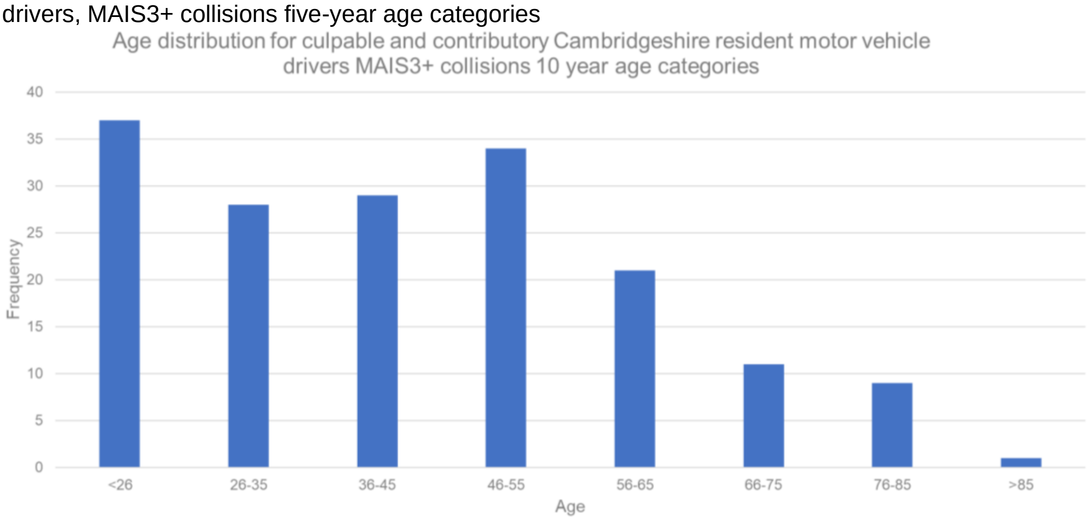
Culpable and contributory Cambridgeshire resident motor vehicle drivers involved in MAIS3+ injury collisions are presented in figures 13 to 15 below.



Appendix 12, figure 13, Age distribution for culpable and contributory Cambridgeshire resident motor vehicle drivers, MAIS3+ collisions

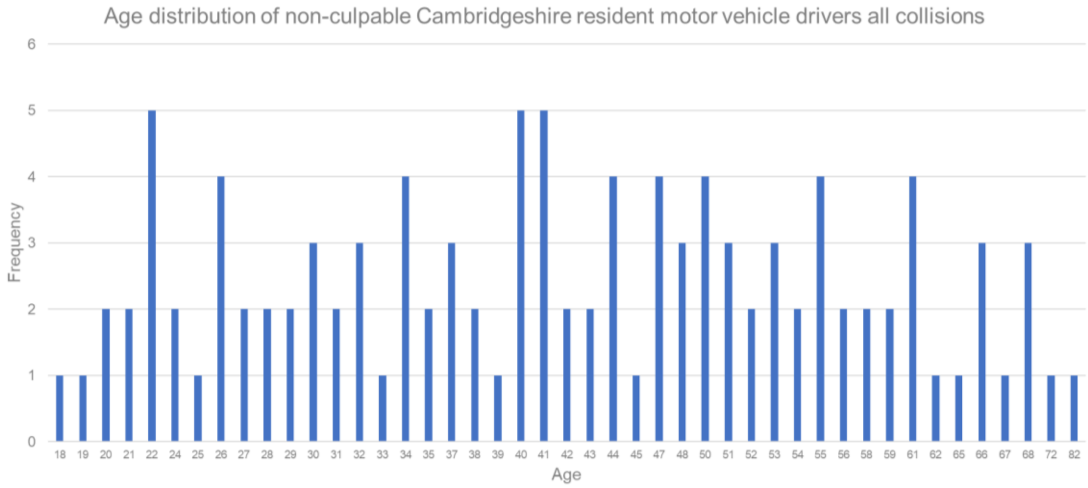


Appendix 12, figure 14, Age distribution for culpable and contributory Cambridgeshire resident motor vehicle drivers, MAIS3+ collisions five-year age categories

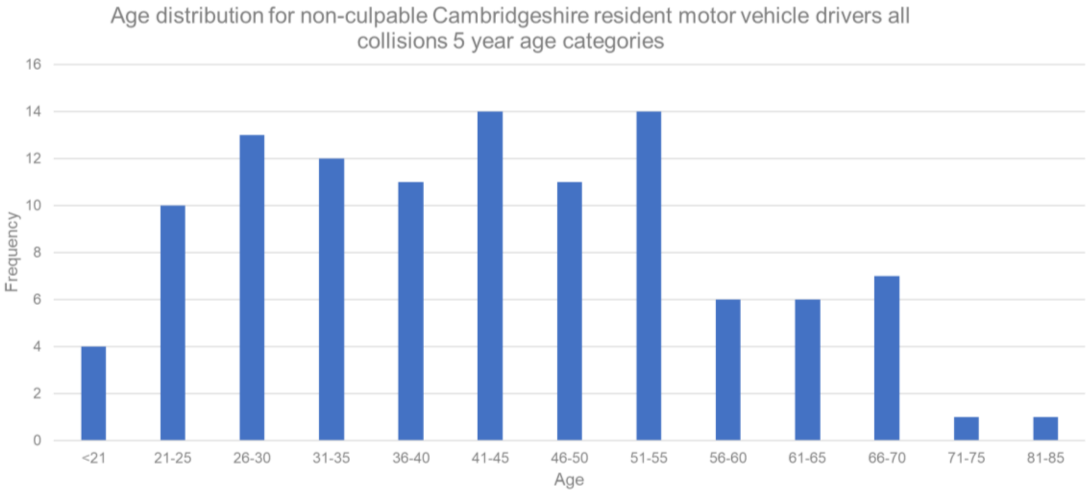


Appendix 12, figure 15, Age distribution for culpable and contributory Cambridgeshire resident motor vehicle drivers, MAIS3+ collisions ten-year age categories

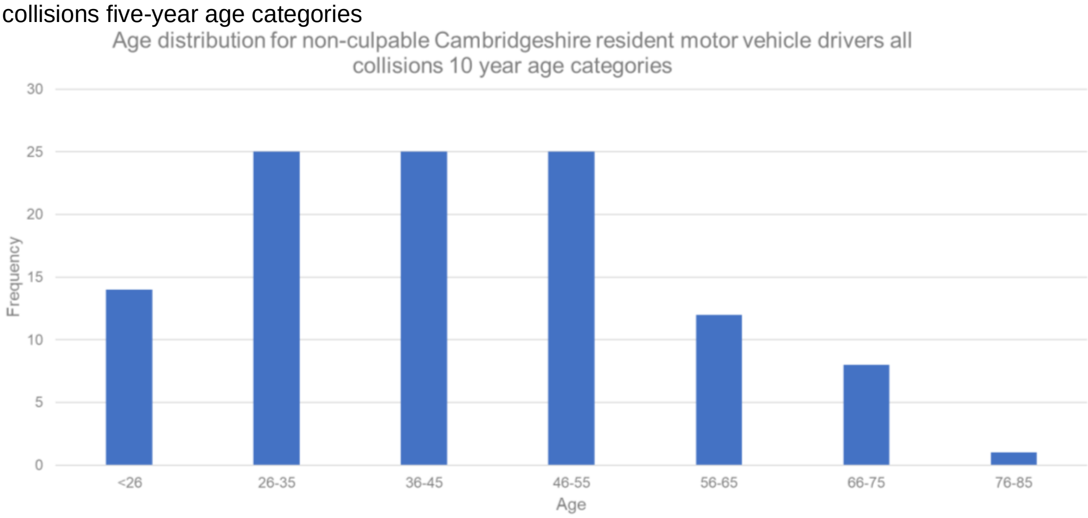
Non-culpable Cambridgeshire resident motor vehicle drivers regardless of collision injury severity are presented in figures 16 to 18 below.



Appendix 12, figure 16, Age distribution for non-culpable Cambridgeshire resident motor vehicle drivers all collisions

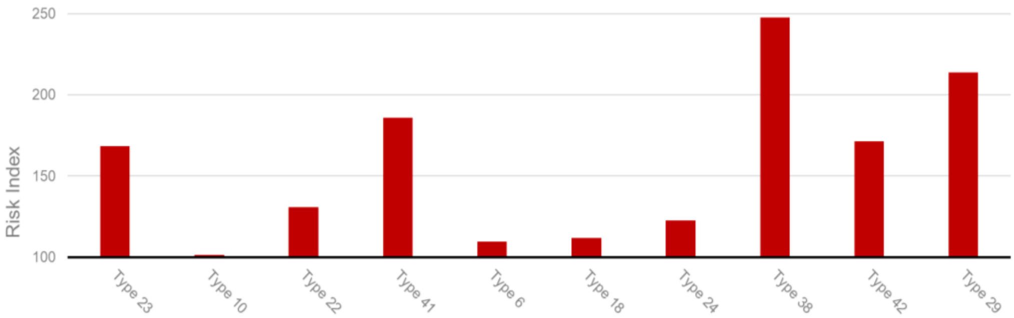


Appendix 12, figure 17, Age distribution for non-culpable Cambridgeshire resident motor vehicle drivers all collisions five-year age categories

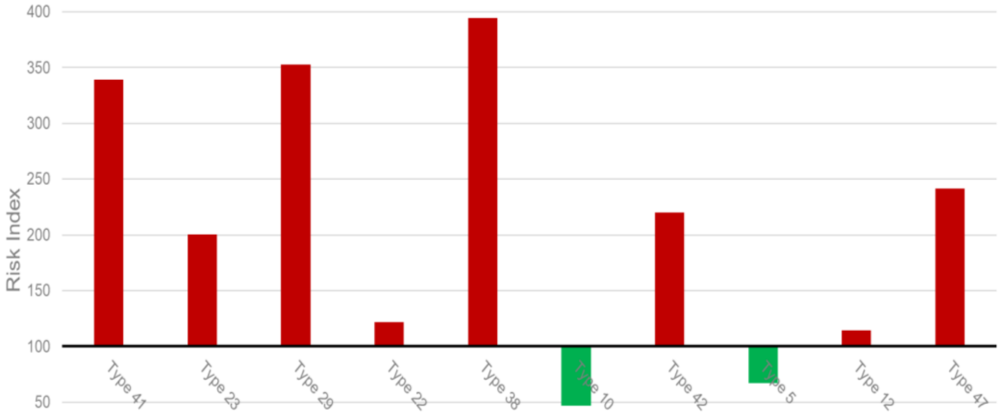


Appendix 12, figure 18, Age distribution for non-culpable Cambridgeshire resident motor vehicle drivers all collisions ten-year age categories

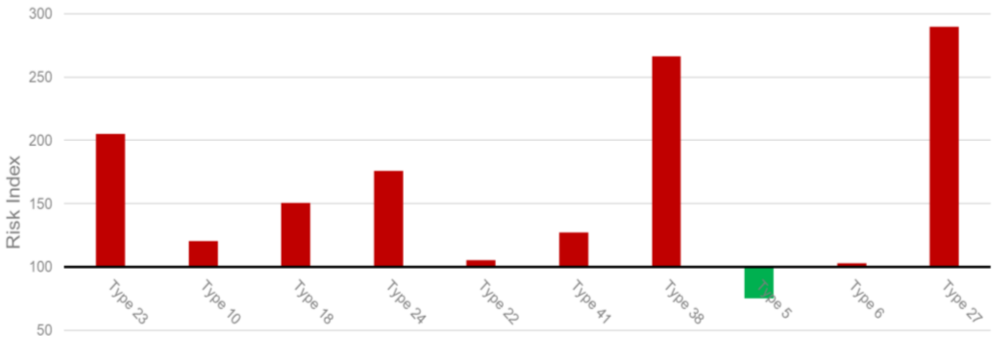
Risk Index for top ten Acorn types by frequency, all Cambridgeshire motor vehicle drivers



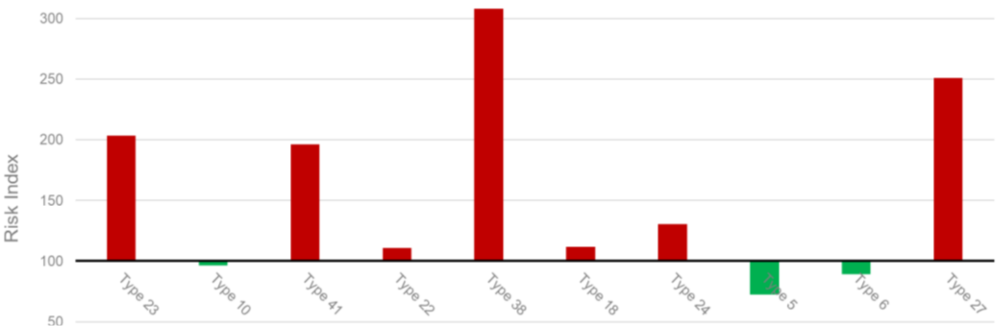
Risk Index for top ten Acorn types by frequency, culpable and contributory Cambridgeshire motor vehicle drivers, fatal collisions



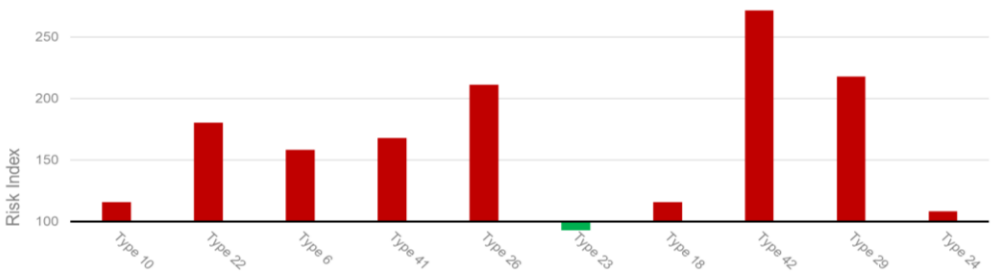
Risk Index for top ten Acorn types by frequency, culpable and contributory Cambridgeshire motor vehicle drivers MAIS3+ collisions



Risk Index for top ten Acorn types by frequency, culpable and contributory Cambridgeshire motor vehicle drivers fatal and MAIS3+ collisions



Risk Index for top ten Acorn types by frequency, non-culpable Cambridgeshire motor vehicle drivers MAIS3+ collisions



Appendix 12, figure 19, Risk index distribution direct comparison

Appendix 12, table 1, Shapiro-Wilk normality analysis results

Motor vehicle driver group	**Result (df)**	**Probability**
All motor vehicle drivers present within the dataset	W (644) = 0.97	*p* = .000
All motor vehicle drivers, fatal collisions	W (295) = 0.96	*p* = .000
All motor vehicle drivers, MAIS3+ collisions	W (349) = 0.97	*p* = .000
Culpable and contributory motor vehicle drivers within the dataset	W (427) = 0.95	*p* = .000
Culpable and contributory motor vehicle drivers, fatal collisions	W (176) = 0.93	*p* = .000
Culpable and contributory motor vehicle drivers MAIS3+ collisions	W (251) = 0.97	*p* = .000
Non-culpable motor vehicle drivers within the dataset	W (213) = 0.98	*p* = .007
Non-culpable motor vehicle drivers, fatal collisions	W (119) = 0.98	*p* = .062
Non-culpable motor vehicle drivers, MAIS3+ collisions	W (94) = 0.98	*p* = .111
Cambridge resident motor vehicle drivers within the dataset	W (366) = 0.96	*p* = .000
Cambridge resident motor vehicle drivers within the dataset involved in fatal collisions	W (135) = 0.94	*p* = .000
Cambridge resident motor vehicle drivers within the dataset involved in MAIS3+ collisions	W (231) = 0.97	*p* = .000
Cambridge resident culpable and contributory motor vehicle drivers within the dataset	W (252) = 0.95	*p* = .000
Cambridge resident culpable and contributory motor vehicle drivers, fatal collisions	W (82) = 0.91	*p* = .000
Cambridge resident culpable and contributory motor vehicle drivers, MAIS3+ collisions	W (170) = 0.96	*p* = .000
Cambridge resident non-culpable motor vehicle drivers within the dataset	W (110) = 0.98	*p* = .052
Cambridge resident non-culpable motor vehicle drivers, fatal collisions	W (53) = 0.97	*p* = .126
Cambridge resident non-culpable motor vehicle drivers, MAIS3+ collisions	W (57) = 0.97	*p* = .280

Appendix 12, table 2, Levene's robust test statistic with Brown and Forsythe alternatives results culpability groups

Motor vehicle driver group	Motor vehicle driver groups compared	Result (df)	Probability
All motor vehicle drivers	Culpable and contributory/non-culpable	W_0 = 11.20 (1, 688) W_50 = 10.47 (1, 688) W_10 = 10.46 (1, 688)	*p* = .001 *p* = .001 *p* = .001
Motor vehicle drivers involved in fatal collisions	Culpable and contributory/non-culpable	W_0 = 4.14 (1, 293) W_50 = 3.39 (1, 293) W_10 = 3.44 (1, 294)	*p* = .043 *p* = .067 *p* = .065
Motor vehicle drivers involved in MAIS3+ collisions	Culpable and contributory/non-culpable	W_0 = 5.00 (1, 343) W_50 = 5.08 (1, 343) W_10 = 4.97 (1, 343)	*p* = .026 *p* = .025 *p* = .026
All Cambridgeshire resident motor vehicle drivers	Culpable and contributory/non-culpable	W_0 = 9.78 (1, 360) W_50 = 9.20 (1, 360) W_10 = 9.15 (1, 360)	*p* = .002 *p* = .003 *p* = .003
Cambridgeshire resident motor vehicle drivers involved in fatal collisions	Culpable and contributory/non-culpable	W_0 = 9.80 (1, 133) W_50 = 5.54 (1, 133) W_10 = 8.26 (1, 133)	*p* = .002 *p* = .020 *p* = .005
Cambridgeshire resident motor vehicle drivers involved in MAIS3+ collisions	Culpable and contributory/non-culpable	W_0 = 2.50 (1, 255) W_50 = 2.53 (1, 255) W_10 = 2.51 (1, 255)	*p* = .115 *p* = .113 *p* = .114

Appendix 12, table 3, Levene's robust test statistic with Brown and Forsythe alternatives results collision injury severity groups

Motor vehicle driver group	**Motor vehicle driver groups compared**	**Result (df)**	**Probability**
All motor vehicle drivers	Fatal/MAIS3+	W_0 = 0.31 (1, 642) W_50 = 0.26 (1, 642) W_10 = 0.24 (1, 642)	*p* = .579 *p* = .610 *p* = .626
Culpable and contributory motor vehicle drivers	Fatal/MAIS3+	W_0 = 0.08 (1, 459) W_50 = 0.01 (1, 459) W_10 = 0.01 (1, 459)	*p* = .781 *p* = .907 *p* = .911
Non-culpable motor vehicle drivers	Fatal/MAIS3+	W_0 = 0.42 (1, 211) W_50 = 0.44 (1, 211) W_10 = 0.39 (1, 211)	*p* = .516 *p* = .507 *p* = .531
All Cambridgeshire resident motor vehicle drivers	Fatal/MAIS3+	W_0 = 0.85 (1, 364) W_50 = 0.44 (1, 364) W_10 = 0.49 (1, 364)	*p* = .356 *p* = .508 *p* = .483
Cambridgeshire resident culpable and contributory motor vehicle drivers	Fatal/MAIS3+	W_0 = 3.53 (1, 250) W_50 = 1.72 (1, 250) W_10 = 2.72 (1, 250)	*p* = .062 *p* = .190 *p* = .100
Cambridgeshire resident non-culpable motor vehicle drivers	Fatal/MAIS3+	W_0 = 0.26 (1, 108) W_50 = 0.24 (1,108) W_10 = 0.25 (1, 108)	*p* = .608 *p* = .628 *p* = .620

Appendix 12, table 4, Age motor vehicle driver group variance test selection

Motor vehicle driver group	Motor vehicle driver groups compared	Normality	Equality of variance	Test
All motor vehicle drivers	Culpable and contributory/non-culpable	No/No	No	W test
All motor vehicle drivers	Fatal/MAIS3+	No/No	Yes	W test
Motor vehicle drivers involved in fatal collisions	Culpable and contributory/non-culpable	No/Yes	No (alternative criteria Yes)	W test
Motor vehicle drivers involved in MAIS3+ collisions	Culpable and contributory/non-culpable	No/Yes	No	W test
All Cambridgeshire resident motor vehicle drivers	Culpable and contributory/non-culpable	No/Yes	No	W test
Cambridgeshire resident motor vehicle drivers involved in fatal collisions	Culpable and contributory/non-culpable	No/Yes	No	W test
Cambridgeshire resident motor vehicle drivers involved in MAIS3+ collisions	Culpable and contributory/non-culpable	No/Yes	Yes	W test
Culpable and contributory motor vehicle drivers	Fatal/MAIS3+	No/No	Yes	W test
Non-culpable motor vehicle drivers	Fatal/MAIS3+	Yes/Yes	Yes	Fisher’s ANOVA
All Cambridgeshire resident motor vehicle drivers	Fatal/MAIS3+	No/No	Yes	W test
Cambridgeshire resident culpable and contributory motor vehicle drivers	Fatal/MAIS3+	No/No	Yes	W test
Cambridgeshire resident non-culpable motor vehicle drivers	Fatal/MAIS3+	Yes/Yes	Yes	Fisher’s ANOVA

Appendix 12, table 5, Age motor vehicle driver group variance results

Motor vehicle driver group	Motor vehicle driver groups compared	Test	Result (df)	Probability
All motor vehicle drivers	Culpable and contributory/ non-culpable	W test	Wtest (2, 8.06) = 2.62	*p* = .133
All motor vehicle drivers	Fatal/MAIS3+	W test	Wtest (1, 612.93) = 0.05	*p* = .833
Motor vehicle drivers involved in fatal collisions	Culpable and contributory/ non-culpable	W test	Wtest (2, 758.17) = 1.58	*p* = .206
Motor vehicle drivers involved in MAIS3+ collisions	Culpable and contributory/ non-culpable	W test	Wtest (2, 8.07) = 1.12	*p* = .373
All Cambridgeshire resident motor vehicle drivers	Culpable and contributory/ non-culpable	W test	Wtest (2, 8.12) = 0.23	*p* = .799
Cambridgeshire resident motor vehicle drivers involved in fatal collisions	Culpable and contributory/ non-culpable	W test	Wtest (2, 354.58) = 0.05	*p* = .947
Cambridgeshire resident motor vehicle drivers involved in MAIS3+ collisions	Culpable and contributory/ non-culpable	W test	Wtest (2, 8.11) = 0.28	*p* = .765
Culpable and contributory motor vehicle drivers	Fatal/MAIS3+	W test	Wtest (1, 357.38) = 0.04	*p* = .838
Non-culpable motor vehicle drivers	Fatal/MAIS3+	Fisher's ANOVA	F (1, 211) = 0.08	*p* = .782
All Cambridgeshire resident motor vehicle drivers	Fatal/MAIS3+	W test	Wtest (1, 260.40) = 0.14	*p* = .710
Cambridgeshire resident culpable and contributory motor vehicle drivers	Fatal/MAIS3+	W test	Wtest (1, 136.59) = 0.00	*p* = .997
Cambridgeshire resident non-culpable motor vehicle drivers	Fatal/MAIS3+	Fisher's ANOVA	F (1, 108) = 0.51	*p* = 476

Appendix 12, table 6, Kolmogorov-Smirnov and Mann-Whitney (Wilcoxon) age distribution test results

Motor vehicle driver group	**Motor vehicle driver groups compared**	**Test**	**Result (df)**	**Probability**
All motor vehicle drivers	Culpable and contributory/ non-culpable	K-S test M-W test	$D = 0.14$ $z = -2.97$	$p = .009$ $p = .003$
All motor vehicle drivers	Fatal/MAIS3+	K-S test M-W test	$D = 0.04$ $z = -0.09$	$p = .987$ $p = .932$
Motor vehicle drivers involved in fatal collisions	Culpable and contributory/ non-culpable	K-S test M-W test	$D = 0.18$ $z = -2.52$	$p = .025$ $p = .012$
Motor vehicle drivers involved in MAIS3+ collisions	Culpable and contributory/ non-culpable	K-S test M-W test	$D = 0.16$ $z = -1.73$	$p = .059$ $p = .084$
All Cambridgeshire resident motor vehicle drivers	Culpable and contributory/ non-culpable	K-S test M-W test	$D = 0.10$ $z = -0.77$	$p = .369$ $p = .439$
Cambridgeshire resident motor vehicle drivers involved in fatal collisions	Culpable and contributory/ non-culpable	K-S test M-W test	$D = 0.16$ $z = -0.71$	$p = .393$ $p = .481$
Cambridgeshire resident motor vehicle drivers involved in MAIS3+ collisions	Culpable and contributory/ non-culpable	K-S test M-W test	$D = 0.11$ $z = -0.64$	$p = .705$ $p = .523$
Culpable and contributory motor vehicle drivers	Fatal/MAIS3+	K-S test M-W test	$D = 0.07$ $z = -0.59$	$p = .774$ $p = .553$
Non-culpable motor vehicle drivers	Fatal/MAIS3+	K-S test M-W test	$D = 0.06$ $z = 0.18$	$p = .988$ $p = .857$
All Cambridgeshire resident motor vehicle drivers	Fatal/MAIS3+	K-S test M-W test	$D = 0.11$ $z = -0.82$	$p = .280$ $p = .412$
Cambridgeshire resident culpable and contributory motor vehicle drivers	Fatal/MAIS3+	K-S test M-W test	$D = 0.12$ $z = -0.62$	$p = .428$ $p = .538$
Cambridgeshire resident non-culpable motor vehicle drivers	Fatal/MAIS3+	K-S test M-W test	$D = 0.14$ $z = -0.61$	$p = .681$ $p = .540$

Appendix 12, table 7, Gender distribution analysis results

Motor vehicle driver group	Motor vehicle driver groups compared	Result	Probability
All motor vehicle drivers	Culpable and contributory/ non-culpable	$\chi^2 = 0.59$	p = .440
All motor vehicle drivers	Fatal/MAIS3+	$\chi^2 = 1.26$	p = .262
Motor vehicle drivers involved in fatal collisions	Culpable and contributory/ non-culpable	$\chi^2 = 0.00$	p = .974
Motor vehicle drivers involved in MAIS3+ collisions	Culpable and contributory/ non-culpable	$\chi^2 = 1.66$	p = .197
All Cambridgeshire resident motor vehicle drivers	Culpable and contributory/ non-culpable	$\chi^2 = 0.00$	p = .952
Cambridgeshire resident motor vehicle drivers involved in fatal collisions	Culpable and contributory/ non-culpable	χ^2 0.86	p = .354
Cambridgeshire resident motor vehicle drivers involved in MAIS3+ collisions	Culpable and contributory/ non-culpable	$\chi^2 = 0.98$	p = .321
Culpable and contributory motor vehicle drivers	Fatal/MAIS3+	$\chi^2 = 0.29$	p = .587
Non-culpable motor vehicle drivers	Fatal/MAIS3+	$\chi^2 = 2.19$	p = .138
All Cambridgeshire resident motor vehicle drivers	Fatal/MAIS3+	$\chi^2= 0.42$	p = .515
Cambridgeshire resident culpable and contributory motor vehicle drivers	Fatal/MAIS3+	$\chi^2= 0.02$	p = .878
Cambridgeshire resident non-culpable motor vehicle drivers	Fatal/MAIS3+	$\chi^2= 2.34$	p = .126

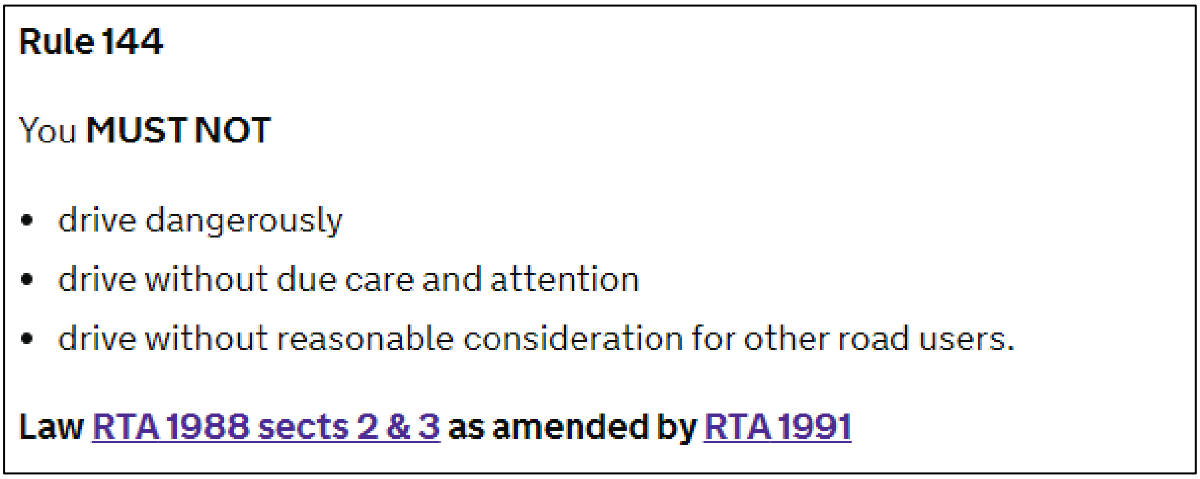
Appendix 12, table 8, Distribution of most frequent contributory factors in fatal and serious injury collisions GB 2017

Fatal	**% of collisions in category**
Loss of control, 410	27
Fail to look properly, 405	26
Careless, reckless in hurry, 602	17
Poor turn or manoeuvre, 403	15
Exceeding speed limit, 306	14
Fail to judge another's path or speed, 406	13
Pedestrian failed to look properly	10
Impaired by alcohol, 501	9
Travelling too fast for conditions, 307	9
Aggressive driving, 601	7
Impaired by drugs, 502	7
Illness or disability, mental or physical, 505	7
Serious	**% of collisions in category**
Fail to look properly, 405	35
Fail to judge another's path or speed, 406	17
Careless, reckless in hurry, 602	16
Loss of control, 410	15
Poor turn or manoeuvre, 403	13
Pedestrian failed to look properly	12
Exceeding speed limit, 306	7
Travelling too fast for conditions, 307	7
Impaired by alcohol, 501	6
Aggressive driving, 601	4
Impaired by drugs, 502	2
Illness or disability, mental or physical, 505	3

(Department for Transport, 2020b)

Appendix 13: Highway Code Rules and the Alternative Scoring Tool

An example of a legal requirement rule can be observed in figure 1 below, note that where there are legal requirements in the Highway Code legislative summaries are provided, in the electronic form which links directly to the relevant page of the legislation.gov.uk website.



Rule 144

You **MUST NOT**

- drive dangerously
- drive without due care and attention
- drive without reasonable consideration for other road users.

Law RTA 1988 sects 2 & 3 as amended by RTA 1991

Appendix 13, figure 1, Highway Code rule 144 (Department for Transport, 2015e)

In this case the legislation applicable to the rule are *section 2, Road Traffic Act 1988* which relates to dangerous driving and *section 3, Road Traffic Act 1988* which relates to driving without due care and attention or without due consideration for other road users.

The Highway code gives guidance regarding circumstances when there are more hazards, these can be created by the weather or road layout, for example. There are multiple rules for each but an example from each category are provided below.

Rule 227, see figure 2 below, gives weather based advice regarding driving in wet weather.

Rule 227

Wet weather. In wet weather, stopping distances will be at least double those required for stopping on dry roads (see ‘Typical stopping distances’). This is because your tyres have less grip on the road. In wet weather

- you should keep well back from the vehicle in front. This will increase your ability to see and plan ahead
- if the steering becomes unresponsive, it probably means that water is preventing the tyres from gripping the road. Ease off the accelerator and slow down gradually
- the rain and spray from vehicles may make it difficult to see and be seen
- be aware of the dangers of spilt diesel that will make the surface very slippery (see Annex 6: Vehicle maintenance, safety and security)
- take extra care around pedestrians, cyclists, motorcyclists and horse riders.

Appendix 13, figure 2, Highway Code rule 227 (Department for Transport, 2015d)

Rule 170, see figure 3 below, gives of road layout based advice regarding dealing with junctions.

Rule 170

Take extra care at junctions. You should

- watch out for cyclists, motorcyclists, powered wheelchairs/mobility scooters and pedestrians as they are not always easy to see. Be aware that they may not have seen or heard you if you are approaching from behind
- watch out for pedestrians crossing a road into which you are turning. If they have started to cross they have priority, so give way
- watch out for long vehicles which may be turning at a junction ahead; they may have to use the whole width of the road to make the turn (see Rule 221)
- watch out for horse riders who may take a different line on the road from that which you would expect
- not assume, when waiting at a junction, that a vehicle coming from the right and signalling left will actually turn. Wait and make sure
- look all around before emerging. Do not cross or join a road until there is a gap large enough for you to do so safely.

Appendix 13, figure 3, Highway Code rule 170 (Department for Transport, 2015g)

Rule 89, see figure 4 below, gives advice relating to vehicle condition.

Rule 89

Vehicle condition. You **MUST** ensure your vehicle and trailer comply with the full requirements of the Road Vehicles (Construction and Use) Regulations and Road Vehicles Lighting Regulations (see '<u>The road user and the law</u>').

Appendix 13, figure 4, Highway Code rule 89 (Department for Transport, 2015f)

The factors which only assess the motor vehicle driver's culpability can be combined into a scoring tool, this tool being set out as an alternative in table 1 below. All of the data are available in STATS19 directly form variables or contributory factors, it does not require subjective interpretation of constructs or the collision narrative.

Appendix 13, table 1, Alternative scoring tool for the UK context

<table>
<tr><td></td><td>Applied data and considerations</td><td>Culpable?</td></tr>
<tr><td>Single motor vehicle in collisions</td><td>Number of vehicles variable indicates one vehicle or if the number of vehicles variable indicates more than one vehicle but in examining the vehicle type variable only one of the vehicles can be considered a motor vehicle</td><td>Yes</td></tr>
<tr><td>Factor present indicating culpability</td><td>Breath test variable code one (positive)
Any of the contributory factor codes indicated in the table below.
<table>
<tr><td>102.</td><td>Deposit on road (e.g. oil, mud, chippings)</td></tr>
<tr><td>103.</td><td>Slippery road (due to weather)</td></tr>
<tr><td>105</td><td>Defective traffic lights</td></tr>
<tr><td>108</td><td>Road layout (e.g., bend, hill, narrow carriageway)</td></tr>
<tr><td>201.</td><td>Tyre illegal, defective or under-inflated</td></tr>
<tr><td>202.</td><td>Defective lights and indicators</td></tr>
<tr><td>203.</td><td>Defective brakes</td></tr>
<tr><td>204.</td><td>Defective steering or suspension</td></tr>
<tr><td>205.</td><td>Defective or missing mirrors</td></tr>
<tr><td>206.</td><td>Overloaded or poorly loaded vehicle or trailer</td></tr>
<tr><td>999.</td><td>Other contributory defect not listed above</td></tr>
<tr><td>301.</td><td>Disobeyed automatic traffic signal</td></tr>
<tr><td>302.</td><td>Disobeyed "Give Way" or "Stop" sign or markings</td></tr>
<tr><td>303.</td><td>Disobeyed double white lines</td></tr>
<tr><td>304.</td><td>Disobeyed pedestrian crossing facility</td></tr>
<tr><td>305.</td><td>Illegal turn or direction of travel</td></tr>
<tr><td>306.</td><td>Exceeding speed limit</td></tr>
<tr><td>307.</td><td>Travelling too fast for conditions</td></tr>
<tr><td>308.</td><td>Following too close</td></tr>
<tr><td>309.</td><td>Vehicle travelling along pavement</td></tr>
<tr><td>401</td><td>Junction overshoot</td></tr>
<tr><td>401</td><td>Junction restart (moving off at junction)</td></tr>
<tr><td>403.</td><td>Poor turn or manoeuvre</td></tr>
<tr><td>404.</td><td>Failed to signal or misleading signal</td></tr>
<tr><td>405.</td><td>Failed to look properly</td></tr>
<tr><td>406</td><td>Failing to judge other person's path or speed</td></tr>
<tr><td>407.</td><td>Too close to cyclist, horse rider or pedestrian</td></tr>
<tr><td>408.</td><td>Sudden braking</td></tr>
<tr><td>409.</td><td>Swerved</td></tr>
<tr><td>410.</td><td>Loss of control</td></tr>
</table></td><td>Yes</td></tr>
</table>

<table>
<tr><td></td><td>
<table>
<tr><td>501.</td><td>Impaired by alcohol</td></tr>
<tr><td>502.</td><td>Impaired by drugs</td></tr>
<tr><td>504.</td><td>Uncorrected, defective eyesight</td></tr>
<tr><td>506.</td><td>Not displaying lights at night or in poor visibility</td></tr>
<tr><td>508.</td><td>Driver using mobile phone</td></tr>
<tr><td>509.</td><td>Distraction in vehicle</td></tr>
<tr><td>510.</td><td>Distraction outside vehicle</td></tr>
<tr><td>601.</td><td>Aggressive driving</td></tr>
<tr><td>602.</td><td>Careless, reckless or in a hurry</td></tr>
<tr><td>603.</td><td>Nervous, uncertain or panic</td></tr>
<tr><td>604.</td><td>Driving too slow for conditions, or slow vehicle (e.g. Tractor)</td></tr>
<tr><td>605.</td><td>Learner or inexperienced driver/rider</td></tr>
<tr><td>606.</td><td>Inexperience of driving on the left</td></tr>
<tr><td>607.</td><td>Unfamiliar with model of vehicle</td></tr>
<tr><td>702</td><td>Vegetation</td></tr>
<tr><td>703</td><td>Road layout (e.g. Bend, winding road, hill crest)</td></tr>
<tr><td>704</td><td>Buildings, road signs, street furniture</td></tr>
<tr><td>705</td><td>Dazzling headlights</td></tr>
<tr><td>706</td><td>Dazzling sun</td></tr>
<tr><td>707.</td><td>Rain, sleet snow or fog</td></tr>
<tr><td>708</td><td>Spray from other vehicles</td></tr>
<tr><td>709</td><td>Visor or windscreen dirty, scratched or frosted etc.</td></tr>
<tr><td>710</td><td>Vehicle blind spot</td></tr>
<tr><td>804.</td><td>Wrong use of pedestrian crossing facility</td></tr>
<tr><td>805.</td><td>Dangerous action in carriageway (e.g. playing)</td></tr>
<tr><td>806.</td><td>Impaired by alcohol</td></tr>
<tr><td>807.</td><td>Impaired by drugs (illicit or medicinal)</td></tr>
<tr><td>808.</td><td>Careless, reckless or in a hurry</td></tr>
<tr><td>809.</td><td>Pedestrian wearing dark clothing at night</td></tr>
<tr><td>810.</td><td>Disability or illness, mental or physical</td></tr>
<tr><td>904.</td><td>Vehicle door opened or closed negligently</td></tr>
</table>
</td><td></td></tr>
<tr><td>No factors present indicating culpability</td><td>Where there are contributory factors allocated to the collisions and the driver concerned has not been attributed any of the contributory factors.</td><td>No</td></tr>
<tr><td>Absence of contributory factors in the collision data only</td><td>The manoeuvre variable for each driver should be examine.
If the driver was undertaking one of the manoeuvres involving the vehicle being in motion and changing direction or road position in the table below.
<table>
<tr><td>01.</td><td>Reversing</td></tr>
<tr><td>04.</td><td>Slowing or stopping*</td></tr>
<tr><td>05.</td><td>Moving off</td></tr>
<tr><td>06.</td><td>U turn</td></tr>
<tr><td>07.</td><td>Turning left</td></tr>
<tr><td>09.</td><td>Turning right</td></tr>
<tr><td>11.</td><td>Changing lane to left</td></tr>
<tr><td>12.</td><td>Changing lane to right</td></tr>
<tr><td>13.</td><td>Overtaking moving vehicle on its offside</td></tr>
<tr><td>14.</td><td>Overtaking stationary vehicle on its offside</td></tr>
<tr><td>15.</td><td>Overtaking on nearside</td></tr>
</table>
However, if the driver was undertaking one of the manoeuvres where the vehicle was stationary or going ahead, see table below
<table>
<tr><td>02.</td><td>Parked</td></tr>
<tr><td>03.</td><td>Waiting to go ahead but held up</td></tr>
<tr><td>04.</td><td>Slowing or stopping*</td></tr>
<tr><td>08.</td><td>Waiting to turn left</td></tr>
<tr><td>10.</td><td>Waiting to turn right</td></tr>
<tr><td>16.</td><td>Going ahead left hand bend</td></tr>
<tr><td>17.</td><td>Going ahead right hand bend</td></tr>
<tr><td>18.</td><td>Going ahead other</td></tr>
</table>
*If the driver was slowing or stopping (4) the first point of impact variable should be examined. If the driver was hit from behind then they will not be culpable, a front or side impact would indicate culpable.</td><td>Yes

No</td></tr>
</table>

Appendix 14: Alternative culpability scoring tool validation process briefing document

Alternative culpability scoring tool validation briefing document

This document is designed to allow a non-expert in collision reconstruction to culpability score motor vehicle drivers from a sample of collisions from Cambridgeshire between 2012 and 2017. The data required will be supplied on a separate excel spreadsheet and will be limited to the data required to use the scoring tool. The tool will result in a motor vehicle driver being deemed either culpable or non-culpable.

The factors which only assess the motor vehicle driver's culpability can be combined into a scoring tool, this tool being set out as an alternative in table 1 below. All of the data are available in STATS19 directly form variables or contributory factors, it does not require subjective interpretation of constructs or the collision narrative.

The scoring should be undertaken in the order in which it is presented in the table, once a driver has been scored later categories should not be applied, i.e., if a driver is involved in a single motor vehicle collision and categorised as culpable then contributory factors and vehicle manoeuvres should not then be explored, if culpability is determined by contributory factors, then manoeuvres should not be explored, the use of manoeuvres will only be the case if the STATS19 record does not contain any contributory factors.

This process is to validate the scoring tool and the data provided will already be manipulated from the raw STATS19 data to provide the required data.

Table 8.3 Alternative scoring tool for the UK context

	Applied data and considerations	Culpable?
Single motor vehicle in collisions	Number of vehicles variable indicates one vehicle or if the number of vehicles variable indicates more than one vehicle but in examining the vehicle type variable only one of the vehicles can be considered a motor vehicle	Yes

Factor present indicating culpability	Breath test variable code one (positive) Any of the contributory factor codes indicated in the table below.		Yes
	102.	Deposit on road (e.g. oil, mud, chippings)	
	103.	Slippery road (due to weather)	
	105	Defective traffic lights	
	108	Road layout (e.g., bend, hill, narrow carriageway)	
	201.	Tyre illegal, defective or under-inflated	
	202.	Defective lights and indicators	
	203.	Defective brakes	
	204.	Defective steering or suspension	
	205.	Defective or missing mirrors	
	206.	Overloaded or poorly loaded vehicle or trailer	
	999.	Other contributory defect not listed above	
	301.	Disobeyed automatic traffic signal	
	302.	Disobeyed "Give Way" or "Stop" sign or markings	
	303.	Disobeyed double white lines	
	304.	Disobeyed pedestrian crossing facility	
	305.	Illegal turn or direction of travel	
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	410.	Loss of control	
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	502.	Impaired by drugs	
	504.	Uncorrected, defective eyesight	
	506.	Not displaying lights at night or in poor visibility	
	508.	Driver using mobile phone	
	509.	Distraction in vehicle	
	510.	Distraction outside vehicle	
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	604.	Driving too slow for conditions, or slow vehicle (e.g. Tractor)	
	605.	Learner or inexperienced driver/rider	
	606.	Inexperience of driving on the left	
	607.	Unfamiliar with model of vehicle	
	702	Vegetation	
	703	Road layout (e.g. Bend, winding road, hill crest)	
	704	Buildings, road signs, street furniture	
	705	Dazzling headlights	
	706	Dazzling sun	
	707.	Rain, sleet snow or fog	
	708	Spray from other vehicles	
	709	Visor or windscreen dirty, scratched or frosted etc.	
	710	Vehicle blind spot	
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	805.	Dangerous action in carriageway (e.g. playing)	
	806.	Impaired by alcohol	
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	808.	Careless, reckless or in a hurry	
	809.	Pedestrian wearing dark clothing at night	
	810.	Disability or illness, mental or physical	

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<tr><td></td><td><table><tr><td>904.</td><td>Vehicle door opened or closed negligently</td></tr></table></td><td></td></tr>
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<tr><td>Absence of contributory factors in the collision data only</td><td>The manoeuvre variable for each driver should be examine.
If the driver was undertaking one of the manoeuvres involving the vehicle being in motion and changing direction or road position in the table below.
<table>
<tr><td>01.</td><td>Reversing</td></tr>
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</table>
*If the driver was slowing or stopping (4) the first point of impact variable should be examined. If the driver was hit from behind then they will not be culpable, a front or side impact would indicate culpable.</td><td>Yes

No</td></tr>
</table>

Once the scoring tool has been applied a yes/no should be entered in the blank culpability column on the spreadsheet.

Many thanks for your assistance.