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Improving safety for older public transport users (OPTU) - a feasibility study

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Improving Safety for Older Public Transport Users (OPTU)

A Feasibility Study



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Improving Safety for Older Public Transport Users (OPTU) - A Feasibility Study

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Executive Summary

On the whole, the UK public transport system is generally considered to provide a safe means of mobility. However, each year, around 6,000 people are reported by the UK police to be injured whilst using buses with more than 400 persons killed or seriously injured. Approximately 50% of those injured or killed are aged over 65 years (Department for Transport 2008). However it is thought that there are many more injured older bus-users who are not included in the national statistics and whom may now avoid travelling on public transport because of previous injuries and experiences. Whilst free travel (particularly on buses) has allowed senior citizens the freedom to travel for pleasure and social inclusion, injuries or near-falls that may occur during the journey can impact on future decisions to travel leading in some cases to anxiety/fear of sustaining further injury, loss of personal mobility and ultimately social isolation.

This Feasibility Study was funded within the Medical Research Council (MRC) Lifelong Health and Wellbeing programme in order to examine the general safety (but not security) of older public transport users. It explores injury type and causation and proposes design interventions for injury prevention with an overall objective of exploring how public transport use could possibly be made safer for older transport-users.

A mixed methods design was used to collect and collate data from a number of sources. These included published research literature, national accident datasets, bus-operator records, service user consultations and other stakeholder consultations with groups representing the 60+ year's age group. The ultimate aim was to develop a pilot injury surveillance database that could in principle be used to determine vehicle design requirements, transport operator procedures and transport-user behaviors that could prevent injuries from occurring.

The findings from the feasibility study identified a major gap in the literature which explores causation of injury to older transport users. Whilst some literature was available which proposed improvements in public transport design, such literature was relatively outdated. Bus design in particular has improved substantially in recent years and allows ease of boarding access for vulnerable adults including older users, wheelchairs and mothers with prams. However, the national data identified that the 60+ years age-group were over-represented in the bus accident casualty rates despite the changes made to bus designs. With increased age, the risk of injury was even more evident with those aged over 80 years sustaining more serious injuries particularly to the lower extremities. Standing passengers also tended to have more serious injuries but this was independent of age. Very notably in the accident data was the fact that the majority of injuries sustained occurred in non-collision incidents.

Consultations with stakeholders were quite revealing regarding the perceived need for better data systems. Industry stakeholders in particular supported the concept of having a national injury surveillance database that could enhance public transport safety and inform policy and procedure. Older bus passengers enjoyed the freedom that 'free' bus travel brought to their everyday lives and this social impact pre-dominated the discussion with them. However, many had witnessed near-falls and 'stumbling' on buses and some had also experienced this type of event. However interestingly, many did not report these events to the drivers and almost accepted that it was an everyday happening as a result of the driving speed of the bus. In terms of their individual behavior patterns none of the interviewees normally asked the drivers to wait for them to sit down after they had boarded the bus before the bus left the bus-stop - but they also complained that the drivers were not obliging in this regard in any case. Further to this many older passengers were also observed standing up to alight for a considerable length of time prior to the bus stopping at their individual stops thereby significantly increasing their chances of falling. This was mainly caused by fear of missing the stop altogether.

Speed and sudden braking were considered the main driver behavioral problem with cornering being particularly problematic. Capability to grab at handrails

when necessary and accessibility to handrails was an issue for some older users and this particular issue was used as a prime example of possible design intervention in the modelling of improved/alternative designs in the study.

As a result of interviews with the bus-drivers it was found that they were mostly aware of the issues that older bus-users had when they were standing or manoeuvring along the bus prior to sitting down. They were also aware of individual bus manoeuvres that could potentially cause an injurious incident. However the overall mismatch of passenger and driver behaviour could account for some of the injury incidents and if addressed could readily negate a number of problems.

Modelling design solution using the DHM SAMMIE CAD system illustrated the difficulty that older passengers could have traversing through the bus whilst reaching handrails to support themselves particularly if they were encumbered with a bag or walking stick in their hand.

Overall this study identified potential circumstances and incidents in which older bus passengers are injured. However of concern were the discrepancies between national datasets and the relatively incomplete bus operator datasets. An utilisable national injury surveillance database would rely on complete data from all bus operators to capture those injury incidents not included in the national datasets. Furthermore a standard data collection protocol would be required which specified the types of data that should be collected in order to target injury prevention strategies at the user and design intervention levels. With this would be a need to pilot the accident data collection protocol which would provide the necessary data to support such targeted injury prevention.

Introduction

The general age of the UK population is increasing - coupled with enhanced life expectancy this suggests there will be an impact on transport user demographics and related transport planning in the years ahead. The increasing age of the population, enhanced life expectancy and working longer will have an impact on road user demographics and an impact on transport planning.

Personal car use is often seen as the ultimate means of independence for a high proportion of older people and disabled road users. However at some point the physical impact of age related conditions will shift people out of their vehicles and into public transport. Public transport has therefore been shown to be vital for social inclusion, transport to work and accessibility to hospital appointments particularly in low income neighbourhoods (Lucas et al 2008). From 1 April 2006, free local concessionary bus travel was introduced in local areas of England for disabled passengers and those aged 60+. From April 2008 this was extended to cover bus travel throughout England¹. Overall it is estimated that 8.8 million older people hold a concessionary bus pass in England (9.8 million if disabled holders are included) and over one- billion concessionary bus journeys are made per year. For each pass held there are approximately 105 journeys taken per year including 227 journeys per pass in London and 86 journeys outside of London².

Public transport is generally considered to be a safe means of mobility, however, more than 6000 people are reported by the UK police to be injured whilst using buses with more than 400 of these killed or seriously injured. Approximately 50% of these are aged over 65 years (Department for Transport 2008). However, as reporting of injuries in the public domain is scant and reliant on cursory information regarding time and place, the figures quoted are likely to be a gross under-estimate of the

¹ https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/8937/nts2010-06.pdf

² https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/244323/concessionary-travel-statistics-2012-13.pdf

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scale of the problem. Furthermore, subjective judgments by police with regard to injury severity using the STATS 19 reporting system (e.g. 'Slight', 'Serious', Fatal') may also mean that the issue is further expounded (Simpson 1996, Ward et al 2005). Other data that may be collected regarding transport user- injury can be spread across multiple individual databases often with restricted access. With no single database providing data in sufficient depth and detail to enable a detailed description of the size and nature of the problem it is difficult to identify potential countermeasures which may reduce the risk of injury and the cost-benefit of such measures.

Future improvements in safety need to be based on comprehensive knowledge including the nature, mechanism and source of injury to ensure the design and evaluations of safety countermeasures or service operator procedures are robust. This will promote a positive perception of public transport and enhance the users' confidence; a necessity for those wholly reliant on its use.

This study aimed to explore the frequency, characteristics and causes of injuries experienced during public transport use by older people with the purpose of triangulating the knowledge into single database that could be used in future injury prevention strategies. The overall aim and objectives of the study are set out below.

Aims

This feasibility study aimed to establish a unique dataset that will address the gaps in research for the older public transport user.

The initial phase of the study was to establish the current knowledge of public transport injuries to older users and to develop a database using existing data sources.

The second phase of the study aimed to analyse the database and identify particular injury types, injury causation and to examine the potential for addressing injury prevention through design solutions.

The study was divided into two phases as shown below;

Assessing the current knowledge - Phase 1

Objectives

- Conduct a literature review to establish current knowledge
- To undertake an initial analysis of the national data for older public transport users
- Identify currently available data pertaining to public transport injuries and analyse the data to examine specific features of the public transport system which may influence injury outcomes to the older person
 - including design features and service operator guidelines;
- Consult stakeholders regarding current accident / injury database existence and usage and ascertain the potential needs of stakeholders
- To disseminate the results of the pilot-study to stakeholders and users of the transport system.

Data analysis and potential use of the data for designing injury countermeasures – Phase 2

Objectives

- To develop a database of injuries that occur to older people during public transport use taking into account the initial results of the accident analysis in order to identify 'clusters' of injury types and determine the extent to which countermeasures for injury prevention are feasible in public transport vehicles.
- The study will explore at the possibility of using the database results in design evaluations. In particular, it will assess (in case-study format) the suitability of a current design in a public transport vehicle for the older public transport users and will generate hypotheses concerning design countermeasures that could be tested in a larger study.

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- The study will develop a protocol for in-depth accident investigations where serious and fatal injury has occurred. This protocol would be trialled on a small scale to assess the “root causes” of the accident. It is acknowledged that the UK Police routinely investigate fatal accidents, usually limited to culpability rather than helping to identify root-causes and indicate mitigation possibilities. Therefore this protocol will be predominantly research- focused.
- The study will also assess the possibility of expanding the methodology more widely within the UK so that a comprehensive database and methodology can be used as a UK surveillance system for older public transport users.
- To develop a foundation from which the database can be developed in the future to be representative of the UK
- To conduct a preliminary cost-benefit analysis to determine the most effective deployment of future resources in order to improve the safety of public transport users - thereby delivering a public transport system that is perceived by the public as ‘safe’ as well as reducing accident casualty costs;
- The study would look at the feasibility of conducting cost-benefit analyses in respect of future regulatory action that may be introduced as a result of a wider study of public transport use.
- Finally the results of the study will be reported at a final workshop to which the stakeholders (including local authorities, service operators, manufacturers, the HSE etc.) of the public transport system will be invited

This report is presented as a series of individual reports of studies that were undertaken by the various partners to address the overall aims and objectives. Other groups / people were also involved in the project development and project-steering in order to achieve the aims and objectives. These included the following;

- Consultations with older user groups were undertaken at meetings chaired by Dr Simon Conroy's though his position as chair of the PPI forum in his role as Head of Service – geriatric medicine (PPI – patient and public involvement in research). Piloting of questionnaires and invitations for feedback from the PPI members

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were valuable in developing the study tools. Presentations of the findings were made to the PPI forums to ensure they had feedback on the study outcomes.

- The University of the third-age (U3A) were also consulted and piloted the older passenger survey.
- Carol Henderson at First buses was able to provide assistance to the study regarding bus operator procedures and was an invaluable addition to the study.
- Tom Morgan at Kinch buses provided access to a bus for use in the incident modelling.
- The UK Passenger Transport Executive Group (PTEG)

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Department for Transport 2005

Phase 1

Assessing Current Knowledge

Literature review

To establish the current state of knowledge for injuries sustained by older public transport users a review of the literature was undertaken.

This systematic literature review concentrated on the epidemiology of non-collision injuries occurring to older people during use of public buses, trains and trams in high income countries.

Introduction

Public transport is often perceived as one of the safest means of transport as the proportion of casualties that occur on public transport is very low [1].

However, each year more than 6000 people are injured on buses alone in the UK with over 400 being killed or seriously injured [2], with approximately 50% are aged 65 and over. Older people may be at increased risk of injury as a result of age-related health conditions such as stroke, arthritis, Parkinson's disease, dementia, leading to sensory or cognitive impairment, balance or mobility problems and frailty. In addition, older people may be deterred from using public transport if they are afraid of falling [3].

There are 10 million people in the UK who are over 65 years old. The latest projections are for 5½ million more older people over the next 20 years and the number will have nearly doubled to around 19 million by 2050 [4]. These people expect to live many years after retirement in good health, providing an ever increasing number of older people available to use public transport if they choose to. In addition, there is a group of older people who become reliant on public transport due to income, subsidies for public transport, loss of a partner who drove and loss of a driving license due to physical or cognitive impairments. A study of 81 older people's experiences of outdoor mobility [5] found that the barriers and enablers to using public transport were a complex mix of environmental, health, societal and psychological factors. One of the key messages reported was that by improving independence in outdoor mobility, wellbeing can be maintained. To gain this independence, public transport needs to be safe and accessible but also needs to be perceived to be so by older people. People aged 80 years of age and

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over, make half the number of outdoor journeys and travel less than one-quarter of the distance of those aged 50-54 years [6]. Plus there is evidence that older people find it difficult to participate in transport services because of an inability to carry heavy loads and a fear of crime when outside at night [7]. This is worrying as public transport has been found to be vital for older people to provide access to goods and services to enable independent living, to enable older people to contribute to society through working, caring responsibilities or volunteering and to avoid social isolation with its attendant negative impact on health [8].

The aim of this systematic review was to synthesise the published literature on the epidemiology of non-collision injuries occurring to older people during their use of public transport, to enable understanding of the size and nature of the problem of injuries and to explore strategies for improving the safety of public transport for older people.

Methods

Criteria for considering studies for this review

Studies were eligible for inclusion if they were cross sectional studies, case-control studies or cohort studies, which included people aged 60 years and older (including studies that included participants of all ages), living in high income countries as defined by the World Bank

(http://data.worldbank.org/about/country-classifications/country-and-lending-groups#High_income), who were travelling on public buses or coaches (defined as 17 seats or more), over ground trains or trams and incurred a non-collision injury whilst boarding, alighting or travelling on the vehicle. Studies reported only injuries resulting from collision incidents were excluded. Studies reporting injuries resulting from both non-collision and collision incidents which did not separately report non-collision incidents were included and this has been highlighted in the description of their findings.

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The review focused on mass transport that is currently available in multiple locations across the UK. Underground trains were excluded as these are only currently in use in London, Newcastle and Glasgow. Mini-buses (defined as 8-16 seats), taxis and transport designed specifically to meet the needs of older/disabled people were also excluded.

Search strategy for identification of studies

We searched Pubmed, Embase, CINAHL, Web of Science and Transport International Research Documentation (TRID) which combines records from TRB's Transportation Research Information Services (TRIS) Database and the OECD's Joint Transport Research Centre's International Transport Research Documentation (ITRD) Database from the date of their inception to July 2012. Articles were restricted to English language articles. The search terms used for each database are given in appendix 1. We also searched reference lists of included studies.

Methods of the review

Study selection

Titles and abstracts of articles were scanned independently by two reviewers to identify relevant articles to retrieve in full. Where an article appeared to be potentially eligible based on the title but no abstract was available, the full article was retrieved. Disagreements between reviewers were resolved by consensus forming discussions with a third reviewer.

Full articles were independently reviewed for inclusion by pairs of reviewers using a standardised data extraction form containing the inclusion criteria (study design, participants, transport and outcomes). Reasons for exclusion were recorded. Disagreements between reviewers were resolved by discussions between all three reviewers.

Data collection process:

A standard form was designed for data extraction which included measures of injury occurrence, of injury mechanisms and risk and protective factors for injury. Sub group analyses (e.g. injury occurrence by age, gender, transport mode etc.) were recorded where these were reported. Data were

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extracted independently by pairs of reviewers. Disagreements between reviewers were resolved by discussions between all three reviewers.

Risk of bias in included studies

A recent systematic review of tools for assessing quality and susceptibility to bias in observational studies in epidemiology identified a number of useful assessment tools [9]. Two of these can be used to assess cohort, case-control and cross sectional studies [10, 11] and both cover the three domains considered by their authors as fundamental in terms of assessing risk of bias; appropriate selection of participants, appropriate measurement of variables and appropriate control of confounding. The tool by Fowkes and Fulton also produced a summary statement [11] and this was used for assessing risk of bias in studies included in this review.

The risk of bias in included studies was assessed independently by pairs of reviewers using the Fowkes and Fulton tool [11] and descriptions of the extent to which a study met the criteria were reported. Disagreements between reviewers were resolved by consensus forming discussions between all three reviewers.

Data synthesis

A narrative synthesis of data was undertaken. The occurrence of injuries was described using the measures reported by included studies (e.g. incidence rates, proportions etc. and 95% CI where these were reported). Injury mechanisms were described using frequencies and percentages. Risk and protective factors for injuries were described using frequencies and percentages and measures of association (e.g. relative risks, odds ratios and their 95% CI) where these were reported by studies. Findings have been summarised in tabular format, categorised by transport type (bus, train).

Results

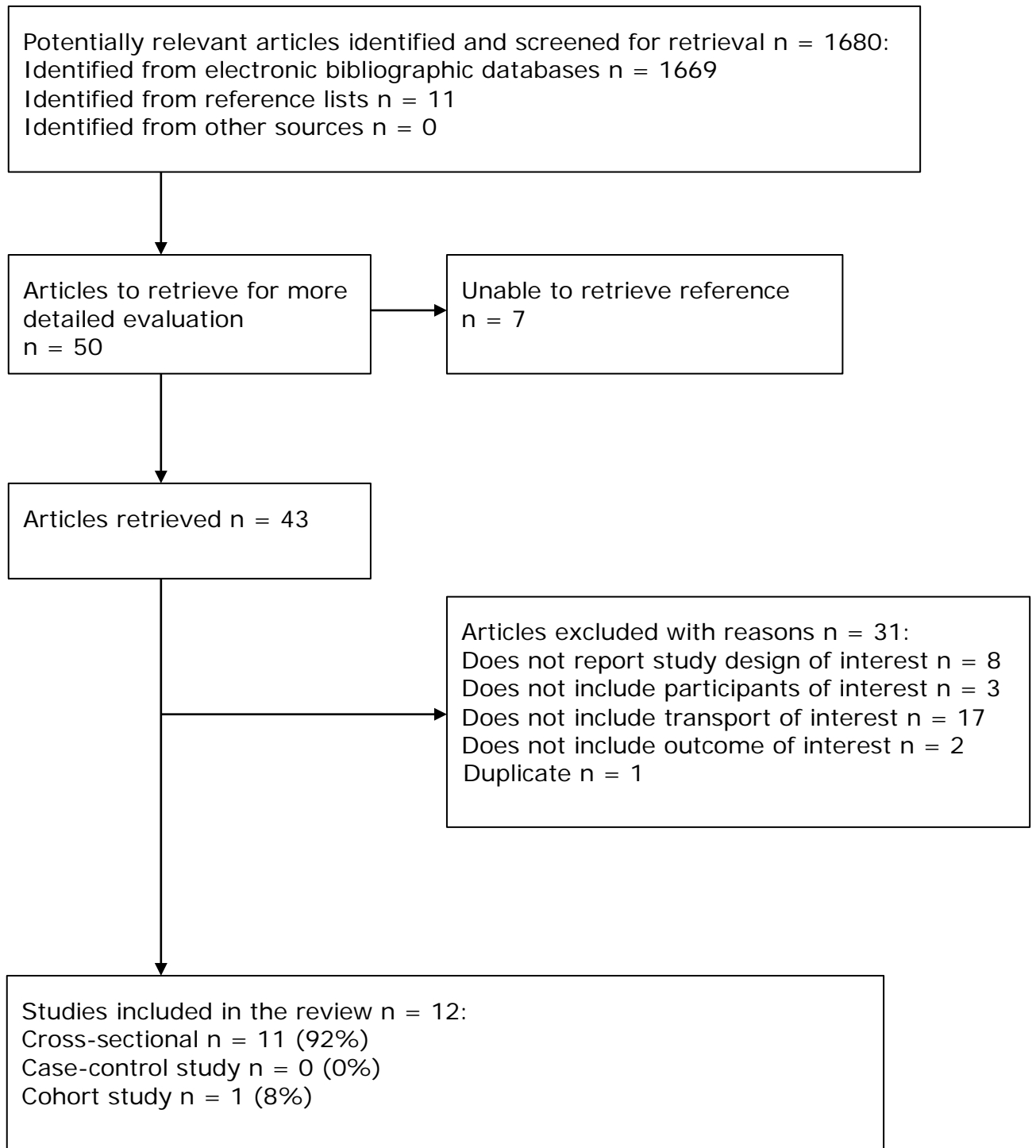
The process of study selection is shown in figure 2.1. A total of 1669 potentially eligible articles were found from the searches. Fifty of these were

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assessed as needing article retrieval for more detailed evaluation. Seven of these (14%) could not be found. Of the 43 articles evaluated for inclusion, 31 were excluded, most commonly because they did not include the types of transport of interest (n=18) or did not report a study design of interest (n=8). Twelve studies were included in the review, 11 (92%) of which were cross sectional studies and one was a cohort study (8%).

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Figure 1 Process of selecting studies for the review



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Characteristics of included studies

The list of included studies is shown in Appendix 2 A1 and their characteristics are shown in Appendix 2 A2. All studies were published between 1980 and 2010, with 5 (42%) being published since 2000. Five (42%) were from the UK, three (33%) from the USA, two (17%) from Israel and two (17%) from Denmark. Eight (67%) reported injuries to bus passengers, two (17%) reported injuries to bus and coach passengers and two (17%) reported injuries to train passengers.

Four of the studies relating to injuries on buses or coaches reported only non-collision incidents or reported non-collision incidents separately [11][12][14][15]. The remaining six studies relating to buses or coaches reported injuries occurring in non-collision incidents. These comprised between 8% [16] and 94% [17] of all incidents included in the studies. In one study the proportion of non-collision incidents was unclear [18], although from descriptions of the passenger action at time of injury, at least some injuries occurred in non-collision events. Both studies relating to train injuries reported non-collision injuries. All studies reported either the mechanism of injury or passenger action at the time of injury and all studies reported some risk factors for injury, most commonly age and sex, which were reported in nine (69%) studies.

The findings from the assessment of risk of bias are shown in Appendix 2 A3. The study design was judged to be appropriate for all studies. In several Emergency Department (ED) studies it was unclear if the study sample comprised all ED attenders or whether some attenders chose not to participate and if so, how these compared to those participating in the study. One study excluded "unreliable and questionable accident reports" [12], but the judgments on which this was based and numbers not included in the study as a result of this were unclear. The extent of missing data appeared to be small in most studies.

The generalizability of most studies was limited, either by data being collected only in one or two EDs, by single bus operators or by the use of national data restricted to incidents reported to the police. In addition,

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studies of ED attenders will fail to capture non-medically attended injuries and those studies relying on self-reported injuries will be subject to some degree of under-reporting. Therefore the scale of the problems of injuries to older public transport users will be underestimated in our review. One study reported on only a proportion of injuries. The propensity to self-report injuries may change over time; hence caution should be taken when interpreting within-study comparisons over time. Legislative changes or changes in vehicle design over time may also mean that conclusions and recommendations from older studies may no longer be relevant. Many studies did not describe their data collection in enough detail to allow an assessment of the quality control procedures and the reproducibility of their data.

The findings from each study are summarised in Appendix 2 A4. The number of participants ranged from 30 to 9100. None of the studies specifically recruited older adults.

Injuries occurring on buses or coaches

Age and sex of passengers

Two studies recruited participants of all ages but did not report on age of participants [12, 13]. Four studies reported the age range of participants, ranging from 3-89 years [14], 2-81 years [15], 3-88 years [16] and 13-91 years [17]. Two studies reported the mean age of participants, which were 56.8 years [15] and 55.6 years [17]. Two studies reported the median age of participants which were 58 years (interquartile range (IQR) 6-88) for women and 28 years (IQR 3-84) for men [16] and 60 years for both sexes combined [17]. Age was reported as a percentage in 3 studies; the first reported 56% of participants were aged 55 years or older and 20% aged 75 years and older [14], the second reported 60% of participants were aged over 60 years [18] and the third reported 36% were aged over 60 years and 16% were of unknown age [19]. Two studies reported that the age at which most serious or fatal injuries occurred was 10-14 years for males and 70-85+ years for females [20, 21]. One study reported that injured women were significantly older than injured men ($p < 0.01$) [16] and one reported that those aged 60 years and over were significantly more likely to be involved in non-collision events than collision events [19] (statistical significance not reported).

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Two studies did not report the sex of injured passengers [12, 13, 22]. All other studies reported a higher proportion of injured female passengers than male passengers [14-21] ranging from 67% [16] to 81% [18]. One study reported that a significantly higher proportion of injured passengers were females than males ($p < 0.01$) [16].

Time of day, day of week, month of injury

Five studies reported the time of day, day of week or month of injuries. [12, 14, 16-18]. The highest number occurred between 06.00 and 19.00 in all studies. Two studies from Israel found the highest number of injuries to occur between 12.00 and 19.00 [14] and at 10.00 [17]. Two Danish studies found the highest number of injuries occurred between 09.00-11.00 and 15.00-17.00 [16] and at midday [18]. One study from the USA found two times at which the highest number of injuries occurred; 06.00-8.30 and 15.00-19.00, and two times with a lower peak in the number of injuries; 11.00 and 14.00 and these latter two times coincided with driver change over times. [12] Two studies reported the days of the week when injuries occurred, one finding significantly more injuries occurred on weekdays than weekends ($p < 0.01$) [18] and the second finding the highest number of injuries occurred on Fridays and lower numbers occurred at weekends [16]. Two studies reported the month in which injuries occurred. One found most injuries occurred in January and May (no figures or statistical significance reported) and one found no significant difference in injury occurrence by month [12].

Passenger action at time of injury and injury mechanism

Seven studies reported passenger action at the time of injury. Studies of emergency department (ED) attenders found injuries most commonly occurred whilst standing or moving around the bus. One study of ED attenders in Israel found 56% of passengers were standing, 25% were moving around the bus and 19% were sitting at the time of injury [14]. A study of ED attenders in Denmark found 46% of injuries occurred whilst riding on the bus, 24% whilst boarding and 29% whilst alighting and 68% of injured passengers had luggage in one or both hands at time of injury. [16] Similar figures were found for a second study of ED attenders in Denmark with 62% of injuries occurring whilst riding the bus, 25% whilst alighting and 8% whilst boarding.

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For injuries occurring during riding the bus, 83% of passengers were standing and 14% were sitting at the time of injury [18]. In each of these studies, at least 90% of injuries resulted from non-collision incidents.

Two studies of fatal and serious non-collision injuries reported to the police in the UK found most injuries occurred whilst passengers were seated. The first study of fatal and serious injuries reported to the police between 1994 and 1998 found 43% of serious injuries occurred whilst seated, 28% occurred whilst standing, 18% occurred whilst alighting and 11% whilst boarding. For fatal injuries, 42% occurred when occupant was standing, boarding or alighting, many resulting from a fall, slip or trip (figures not reported). [20] An update to this study using data from 1999 to 2001 found 44% of fatal and serious injuries occurred whilst seated, 30% whilst standing, 17% whilst alighting and 9% whilst boarding. For fatal injuries, 69% occurred when occupant was standing, boarding or alighting, many resulting from a fall, slip or trip. (figures not reported).[21]

One study of injuries reported by one bus operator in the USA found most injuries occurred whilst alighting (36%), with similar numbers occurring during boarding (19%), whilst seated (18%) and whilst moving around the bus (16%). Only 1% resulted from being caught in doors. However, the majority (89%) of the injuries included in this study resulted from collision incidents and those occurring in non-collision incidents were not reported separately [12].

One study of passengers receiving injuries requiring hospital treatment on public buses operated by 30 British operators restricted their description of boarding and alighting injuries to those occurring whilst the bus was moving. This study found few injuries occurred whilst alighting from a moving bus (4%) or attempting to board a moving bus (3%), and the vast majority of injuries occurred from a fall in the bus (69%), with a smaller number occurring from falls to the ground (14%), door entrapment (3%) and other (8%). They reported that those aged 60 and over were significantly more likely to have injuries boarding buses, in gangways when the bus was moving off and door entrapment injuries than the under 60s. No significant difference in alighting accidents was found by age group. Females were significantly

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more likely to have gangway injuries than males and there was no significant difference in door entrapment injuries by sex. Females aged 60 and over were less likely to be involved in staircase incidents than those aged under 60 (statistical significance not reported). Males aged 60 and over were more likely to be injured in staircase incidents than females aged 60 and over (no figures or statistical significance reported)[19].

In terms of injury mechanism, six studies reported that acceleration and deceleration were important causes of injury, with one, more detailed study highlighting these were more common mechanisms for injuries occurring during riding the bus and on boarding. One study of ED attenders in Israel found 51% of injuries occurred on acceleration or deceleration [14] and 9% occurred when the bus swerved to make a turn. A second study of attenders at one ED in Israel reported that falling whilst standing due to acceleration, deceleration or sudden turns was most common injury mechanism (no figures reported) [17].

One study of ED attenders at one UK hospital found 50% of injuries occurred when the bus braked suddenly whilst passengers were waiting to alight and 20% occurred when the bus moved off quickly after boarding, with 30% occurring when the bus braked suddenly whilst passengers were seated [15]. Another study of ED attenders at another UK hospital found one third of injuries occurred when the bus halted suddenly [13].

A study of ED attenders in Denmark explored injury mechanism by passenger action at time of injury and found that 37% of boarding injuries resulted from acceleration, 40% resulted from stumbling over steps whilst the bus was stationary and 23% resulted from doors closing too early, trapping hands or causing falls. For injuries occurring during riding the bus, 26% resulted from acceleration, 52% from deceleration and 16% occurred when the velocity was constant. Most (68%) passengers were standing when these injuries occurred. For injuries occurring during alighting, 47% were caused by stumbling over steps whilst the bus was stationary, 19% by the doors closing too soon, 15% from kerbstones or road works at bus stops or crowding whilst alighting and 19% from acceleration[16].

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One study of passengers receiving injuries requiring hospital treatment on public buses operated by 30 British operators found 29% of injuries occurred as a result of an emergency stop or the driver taking other action to prevent an accident. They also reported that 29% of non-collision injuries occurred when the bus was moving off and 19% when the bus was stopping or slowing down. The majority (85%) of the moving off injuries occurred when moving from a bus stop and 47% of these were caused to passengers who were still boarding whilst the bus moved off. Accelerating injuries accounted for 23% of gangway accidents, 83% of which were caused to passengers moving to their seats. In terms of injuries occurring whilst the bus was slowing down, 37% occurred on the bus platform, most commonly amongst passengers waiting to alight and 24% occurred in gangways, most commonly to passengers moving down the gangway to alight. Staircase injuries represented a large proportion of moving-bus accelerating and decelerating injuries (figures not reported). In terms of injuries occurring whilst the bus was stationary, 96% of these occurred at bus stops with 75% of these injuries occurring on the ground or in the platform area. Seventy per cent of ground accidents occurred whilst boarding (i.e. passengers fell off the bus whilst climbing on). Seventy one per cent of accidents in the platform area occurred whilst alighting (i.e. passengers fell within the bus whilst getting off). [19]

Injury type, body part injured, severity and outcome of injury

Four studies reported on the type of injury received. The first three studies reported injuries received by bus passengers attending EDs in the UK [15] and Denmark [16, 18], but used different systems for classifying injuries. At least 90% of passenger injuries in the two Danish studies occurred in non-collision events [16, 18] but the proportion of injuries occurring in non-collision events in the UK study was not reported [15]. The first study reported bruising was the most common (frequency unspecified) injury and that 33% of passengers suffered fractures [15], the second reported sprains to be the most common injury (51%), followed by contusions and superficial wounds (23%) and fractures and dislocations (18%) [16] and the third reported contusions to be the most common injury (45%), followed by fractures (22%). [18] None of these studies compared injury type by age, sex, or other factors. The fourth study, a national survey of bus operators in the UK, reported injuries

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occurring in non-collision incidents and reported injury type by body part injured [19]. It is unclear in this study if the injuries represent self-reported injuries and, or medically attended injuries.

They reported cuts, grazes or bruises to the head or neck were the most common injury (29%), followed by cuts, grazes or bruises to leg or foot (22%) and cuts, grazes or bruises to arm or hand (11%). Shock was reported for 14% of injuries, but this term was undefined. Fractures to the leg or foot were the most common type of fracture (3%), followed by fractures to the arm or hand (2%) and fractures to other parts of the body (0.8%). Fractures to the head or neck accounted for 0.5% of injuries. Injury type did not vary by age or sex, except shock was less commonly reported in males under 60 and cuts, grazes or bruises to legs or feet were commonly reported in those aged ≥ 60 (statistical significance was not reported). Cuts, grazes and bruises to head or neck were more common in gangway accidents and when entering or leaving seats. Cuts, grazes and bruises to legs and feet were more common in doorway and platform accidents. Fractures were most often reported for doorway and gangway accidents (statistical significance was not reported)[19].

Five studies reported on the body part injured. The first four of these studies reported injuries received by bus passengers attending EDs in the UK [13], Denmark [16, 18] and Israel [14]. Injuries occurring in non- collision incidents accounted for 37% [13], 90% [16], 94% [18] and 100% [14] of injuries. One of these studies described only the body part injured for fractures and not for other injuries [18]. The fifth study reporting data from a national survey of bus operators, reported body part injured by injury type in non-collision incidents and has been described above [19]

Two of the three studies reporting body part for all injuries, found limbs were most commonly involved, with the proportion of limb injuries ranging from 33% [14] to 66% [16]. The third study, which mainly reported collision incidents [13] reported injuries to the head and face were most common (47%), followed by those to the neck (16%), upper limbs (11%) and lower limbs (11%). The fourth study, which only reported the body part injured for fractures, found upper limb fractures to be most common (43%), followed by

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lower limb (27%) and trunk (27%), with skull fractures only accounting for 2% of fractures. [18]

Only one study reported injury severity. The first was a study of bus passengers attending an ED in Denmark [16] in which 90% of the injuries occurred in non-collision incidents. They found 61% of injuries were minor (Abbreviated injury Scale (AIS) =1), 23% were moderate (AIS=2), 13% were serious (AIS=3) and 2% were severe (AIS=4). No significant difference was found in injury severity by passenger action at the time of injury.

Only three studies reported on outcome of ED attendance. The first from Denmark, with non-collision injuries comprising 94% of all injuries, reported on outcome of ED attendance [18]. The majority (70%) of attenders required no further treatment, 14% were admitted to hospital (of which, one patient died), 13% were referred to out-patient follow up and 3% were referred for GP follow up. The second study, involving non-collision incidents occurring in Israel, reported that 92% were discharged home, 6% were admitted to hospital and 2% (soldiers) were sent for observation at a military clinic [17]. The third study, from the UK reported only that 13% of participants were admitted to hospital [15].

Other risk factors for injury

One study of injuries reported by one bus operator in the USA reported that 75% of injuries (collision and non-collision injuries combined) occurred in clear weather and 80% during daylight. They also reported that more than 65% of injuries occurred on clear roads; most injuries (80%) occurred at intersections and that more non-collision than collision injuries occurred at stop signs (figures not reported). [12]

One study reporting a national survey of bus operators in the UK reported on the objects struck by passengers during non-collision events. They found the road surface (22%) and the bus floor (22%) were the most common objects struck, followed by staircase steps (8%), platform floor (8%), platform steps (6%) and seat backs (5%). They also explored injuries by vehicle type, finding 2-door double deck buses had a significantly higher proportion of alighting injuries than single door double deck buses. Boarding and alighting

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injuries were significantly more common in rear open platform double deck buses than in single front door double deck buses. Falls on single front door buses most commonly occurred at bus stops, falls on rear platform buses most commonly occurred when the bus was moving off from a bus stop. Doorway injuries were significantly more common whilst the vehicle was moving in rear platform buses than in single front door buses. A significantly greater proportion of boarding and alighting injuries occurred on intermediate floor buses than in low floor buses. More injuries occurred on vehicles with doorway dividing stanchions and one or both doors fitted with diagonal handrails than buses with doorway dividing stanchions but no diagonal handrails. Gangway injuries were significantly more common with simple gangway designs (those with fewer gradient or level changes). Those aged 60 years and older were over represented in injuries occurring in simple and complex gangways than in intermediate gangways. No significant difference was found in the proportion of injuries occurring in buses with 3 or fewer vertical stanchions compared to those with more. [19]

Two studies of fatal and serious non-collision injuries reported to the police in the UK found the vast majority of injuries (94% [20], 93% [21]) occurred on roads with 30mph speed limits. The first study also reported findings from the National Travel Survey showing that women travel further on buses than men and make more local journeys, hence suggesting women have greater exposure to injuries that occur whilst standing, boarding and alighting than men. Overall it was estimated that women aged 16-59 years travel 47% further on local buses than men.

Injuries occurring on trains

Two studies reported passenger injuries occurring on trains. The first, a study comprising people reporting injuries to transit agencies across the USA found the mean number of injuries to passengers boarding or alighting reduced between 1995 and 2000 from 1.24 to 0.75 per million passenger trips (statistical significance not reported). The main focus of the paper was to compare injury rates by platform and door types. They found a significantly higher mean number of injuries with mixed level platforms and manually operated doors (2.47), versus high level platforms and remote controlled

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doors (0.15) or low level platforms and remote controlled doors (0.90). They found no significant difference between 2 and 4 steps into railway carriages in low level platform and remote controlled door systems by platform and entranceway type. [23]

The second study comprised (a) people reporting injuries to New Jersey Transit rail network in the USA, (b) passengers observed boarding and alighting trains and (c) gap measurements on NJ Transit Rail network on all tracks with high level platforms and explored "gap" and "non-gap" injuries between 2005 and 2008. Statistical significance was not reported for any comparisons.

Non-gap injuries comprised 71% (2006, 2007), 76% (2008) and 83% (2005) of all injuries. Passenger gap injury rates per 100 million passenger miles were 2.16 in 2005 and 2.75 in 2008. Passenger gap injury rates per 100 million passengers carried were 56.7 in 2005 and 75.0 in 2008.

Most gap injuries occurred in those aged 30-40 years (20%), 40-50 years (17%), 50-60 (16%) and over 60 (16%). Most non-gap injuries occurred in those aged 50-60 (25%) and over 60 years (22%). More women had gap (69%) and non-gap (66%) injuries than men.

Most gap and non-gap injuries occurred between 3pm and 7pm (38% and 34% respectively) and between 7am and 10am (25% and 29% respectively). Gap injuries in women were significantly more likely to occur during morning and evening peak times than for men (64% for women versus 39% for men). Most gap (78%) and 87% of non-gap injuries occurred on weekdays.

Most (66%) gap injuries occurred whilst boarding. During the morning non-peak time (12am-7am) there was a higher percentage of gap injuries whilst boarding (16%) compared to alighting (6%). During the evening non-peak time (7pm-12am) there was a higher percentage of gap injuries whilst alighting (27%) than boarding (15%). The highest percentage of gap injuries occurred in October (12%), followed by June (11%) and December (10%). The highest percentage of non-gap injuries occurred in July (13%).

Exploring age and sex differences in gap and non-gap injuries revealed little difference in the percentage of gap injuries occurring during boarding and

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alighting at age 30 and above. Women were more likely to have gap injuries whilst boarding than men (70% for women, 56% for men, significance not reported). The highest percentage of gap injuries occurring whilst boarding for women was from 10am-3pm (37% for women, 22% for men). The highest percentage of gap injuries occurring whilst boarding for men was from 7pm-12am (28% for men, 20% for women, significance not reported). Gap injuries in women were significantly more likely to occur between October and December (34% for women, 27% for men). Women were less likely to have gap injuries whilst alighting (29% for women, 44% for men, significance not reported). The highest percentage of gap injuries occurring whilst alighting for women and men occurred during the period 7pm-12am (41% for women, 39% for men, significance not reported). Newark Penn Station (n=28) and New York Penn Station (n=26) had the highest number of gap injuries. These stations also had the highest number of boarding and alighting passengers.

Observations of 681 passengers boarding and 531 alighting found 86% of boarding passengers and 76% of alighting passengers were looking down whilst boarding or alighting. For boarding passengers 86% of female passengers were looking down compared to 90% of male passengers. For alighting, 76% of female and 78% of male passengers were looking down. The most common distraction was carrying luggage (36% boarding and 20% of alighting passengers), followed by using mobile phones (7% boarding and 10% alighting passengers).

The maximum gap at stations ranged from 6.6 to 24.5 inches and no relationship was found between maximum gap size and injury frequency or rate.

Discussion

Main findings

Our review has found only a small amount of published literature on non-collision injuries occurring to older people on public buses, coaches and trains in high income countries, therefore our findings must be interpreted with caution.

In terms of non-collision injuries on public buses or coaches, we found older people and women are over represented in non-collision injuries occurring on

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public buses or coaches in high income countries. Most injuries occurred in day time hours and on weekdays. They most commonly occurred whilst passengers were standing and either moving around the bus, boarding or alighting and whilst the bus was accelerating or decelerating. The data provides some evidence that older people are more likely to have injuries boarding buses, in gangways and from door entrapment than younger people. There is also some evidence that older people are more likely to have gangway injuries than younger people and women are more likely to have gangway injuries than men; older men are more likely to have stair case injuries than older women, and older women are more likely to have staircase injuries than younger women. Studies of ED attenders report bruising to be the most common injury, but between 18% and 33% suffer fractures and or dislocations, with limbs being most commonly injured. Most injuries resulting in ED attendance are minor, but approximately 40% are moderate to severe. Most ED attenders are discharged home but between 6% and 14% are admitted to hospital and 2% to 13% are referred to outpatient clinics. Studies frequently concluded that many injuries to older public transport users were preventable.

We found no studies reporting non-collision injuries to passengers on public trams. We found only two studies reporting non-collision injuries to passengers on public trains. These studies found mixed level platforms and manually operated doors were associated with a higher rate of injuries than high level platforms and remote controlled doors or low level platforms and remote controlled doors. The second study found most injuries were non-gap injuries and although non-gap injuries were more common in the over 60s than in some age groups, the absolute difference between age groups was small. Most injuries occurred at morning and evening peak times. More women had gap and non-gap injuries than men; gap injuries in women were significantly more likely to occur during peak times, women were more likely to have gap injuries whilst boarding and less likely to have gap injuries whilst alighting than men. Passenger observations revealed most, but not all passengers looked down whilst boarding or alighting and common distractions whilst boarding or alighting were carrying luggage and use of mobile phones.

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Strengths and limitations of the review

The most important limitation of this review must be the overall dearth of published literature. Despite using broad search criteria and including literature from all higher income countries, we found surprisingly few published studies in this area. In addition, many studies were reported in insufficient detail to enable a comprehensive assessment of the risk of bias. We found that the generalizability of most studies was limited and most did not report on the data collection in sufficient detail to enable an assessment of the quality of the procedures and the reproducibility of the data. One study excluded an unspecified number of participants whose injury reports were judged to be unreliable or questionable (undefined) making it difficult to assess the extent of selection bias this may have introduced. None of the studies included in our review included a comprehensive assessment of injuries occurring on public transport, as that requires data from multiple sources including health service, police, transport operator and self-reported data. Consequently the scale of the problem of injuries to older public transport users will be underestimated in our review.

Few studies reported a wide range of participant characteristics or injury details, including several that did not report age and sex of participants. Some studies reported collision and non-collision injuries combined, so the specific contribution of non-collision injuries is difficult to assess. The classifications used for injury mechanism, action at time of injury, body part injured and injuries received varied between studies making it difficult to compare between studies. Very few studies reported injury severity. None of the studies explored the longer term impact of injuries on public transport on older people. People who have already sustained an injury, or been frightened of being injured on public transport may be deterred from using public transport, which may impact negatively on well-being. Hence, not only was there little published literature, the quality of the literature was limited and the current literature will underestimate the scale of the problem, and longer term impact of injuries in older public transport users.

Despite these limitations, this review is the first review to focus on passenger injuries sustained by older people using public transport.

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Although there are methodological problems in examining the literature, our findings demonstrate these injuries are an important, and underestimated, public health problem. The review demonstrates the need for large scale studies, using multiple data sources and the need to follow people up for longer periods to assess the consequences.

Comparisons with published literature

We have found one literature review, published in 2005, with which to compare our findings. The review included literature on bus and coach incidents causing serious injury and death in Europe, published between 1980 and February 2004. The review included seven studies and reported findings similar to ours with respect to age, sex and injury mechanism. Women and older people were over represented in non-collision incidents leading to serious injury or death and boarding and alighting were common injury mechanisms as was emergency braking. [24]

Recommendations for reducing injuries amongst older public transport users

One study (and a subsequent update) specifically reviewed design features associated with bus and coach injuries. The review concluded that slips, trips and falls on vehicles may be caused by slippery floors, weather conditions, uneven floors, unexpected or high stops, steep slopes, lack of visual cues and physiological changes in older people which affect fall risk, vision, hearing or memory. Slips, trips and falls whilst boarding or alighting may be caused by the step on to or from the bus being too high, riser steps of different heights and passengers carrying objects. Falls may be caused by acceleration when the vehicle pulls away before a passenger is seated; deceleration when a passenger is standing waiting to get off the bus, sharp turns into and out of bus stops and emergency manoeuvres. Bus stops that are too small physically for stopping require sharp turns to enter or exit the stop. Timetable constraints and congestion can contribute to acceleration injuries and passengers may feel they need to stand up before bus stops to enable them to get off the bus in time or in case the driver does not stop. Use of single operator buses (i.e. no conductors on board buses) may increase bus driver stress and make it more difficult to keep to schedule. Several design features may lead to injuries when passengers make contact with internal

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parts of the bus including unprotected metal grab rails in areas where seated passengers' heads fall forwards and passengers' arms may be struck if they fall against ticket machines, card readers and rubbish bins with hard edges. [20, 21]

Two studies included in our review reported being unable to make recommendations about bus design features because of insufficient evidence.[12, 19]. The remaining studies made recommendations for improving bus and train passenger safety. In terms of bus safety, four studies recommended restricting numbers of standing passengers, prohibiting standing on buses [13, 16, 18] or restricting the standing area to rear or centre of the bus.[14] Three studies recommended less tight schedules, to make driving less stressful for drivers.[14, 18, 20] Two studies recommended the use of restraints within buses [13, 15] and the use, or improved design of handrails.[13, 14] One study recommended lowering level of the bus floor, improving design of steps, raising level of bus stops by the use of ramps, repair of roads at bus stops, increased visual control outside the bus, modifications of door closing mechanisms, mechanisms to prevent the bus starting before passengers have entered or exited the bus and improving braking systems and shock absorbers.[16] Another recommended minimum seat widths, minimum seat spacing, minimum spacing of doors, minimising the number and height of steps, minimising floor slopes, using textured floors to prevent slips, use of visual cues for floor obstructions and minimising hard or sharp protrusions in the bus interior.[14] One study recommended ensuring bell pushes are in easy reach of all seats, providing conductors on busy routes at busy times to help passengers, collect fares, deal with unruly passengers to leave the driver to concentrate on driving, better design of features around the ticket/driver area and near doors to minimise contact injuries and systems to ensure drivers are aware of seated passengers wishing to alight and passengers need reassurance that the driver is aware of this.[20] One study recommended an increased number of exclusive bus lanes to prevent some instances of deceleration.[18]

In terms of train injuries, one study concluded that systems with only one type of platform (i.e. high or low level) and with remote controlled doors have lower passenger injury rates than systems with mixed platform types. Some

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doors are left open between stations due to systems having mixed platform types. Entranceway designs which allow closing of doors after each station stop should be introduced and mixing of platform types and use of manually operated doors should be avoided.[23] A second study concluded gap injuries could be reduced by additional platform staff during peak periods and at stations with high gap injury rates, use of easily viewed platform monitors indicating train and track numbers and departure times, large track number signs that are placed consistently on each track, use of pre-recorded “watch the gap” messages, use of reflective markings at train door thresholds and at platforms with large gaps, use of coloured hand rails and reduction of unusually large gaps where feasible. Additional training to station staff was recommended including involving train conductors in the development and deployment of solutions to reduce gap injuries, raising awareness of gap injury rates and target goals for reducing these and alerting conductors to passenger types and stations where assistance may be needed. A public awareness campaign targeted at women advising looking down whilst boarding and alighting was also recommended.[25]

Two studies made the important point that UK legislation in 2001 to make buses more accessible for people with disabilities will make access on and off vehicles easier, enabling more vulnerable people to travel on buses. These people will be at greater risk of falls and injuries. In addition, it will reduce the number of seats on buses, which may mean a higher number of standing passengers, which may increase falls risk. Older buses are not required to comply with new legislation until 2017. The average age of the public service fleet in Great Britain in 2001 was 8.4 years, so these changes will take some time to be fully implemented.[20, 21] A further study noted that newer buses can accelerate more quickly than older buses and also have fewer seats and more standing space.[14]

Implications for research, policy and practice

More research is needed to quantify the size and nature of the problem of non-collision injuries to older people using public transport in higher income countries. Large studies are required which are representative of the varied modes of transport used in relevant countries, including modes of transport, such as trams, which are increasingly being used in cities in higher income

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countries. Studies also need to ascertain the full range of injuries, which will require combining data from different sources such as from hospital and primary care records, self-reports from injured passengers, reports from public transport operators and from incidents reported to the police.

Detailed information needs collecting on passenger characteristics, injury mechanism, action of the vehicle and passenger at time of injury, vehicle components involved in the injury, injury details including injury severity and outcome and the impact of injuries on older people's future travel and use of public transport. Without such studies, the problem of non-collision injuries in older people will remain underestimated, opportunities to prevent such injuries will be missed and their impact on the mobility and well-being of older people will not be acknowledged or addressed.

The Department of Transport, public transport designers, planners and operators need to work with older people to ensure their needs are taken account of when designing new vehicles, planning transport infrastructure and in managing public transport services. Moreover they need to consider the recommendations for reducing injuries made in the studies included in this review. In addition, the longer term impact of injuries to older people using public transport in terms of future mobility and use of public transport need to be considered. Health services, social services and age-related charities could act as organisations that might help train older people to use public transport as in the USA and Australia.

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National Data Analysis

National Road Traffic Statistics - STATS 19 Analysis: An Analysis of Bus and Coach Crashes in Great Britain

National data is collected annually by the UK Department for Transport (DfT) on road traffic accidents and is published accordingly. The following describes the nature and circumstances of accidents involving older public transport users in Great Britain.

Permissions were granted to access STATS 19 data and cases were selected for analysis based on the criteria listed below.

- Cases selected from STATS19 2008-2012
- Restricted to buses and coaches, not minibuses
- Older passengers are those aged 60+
- Selected on vehtype = 11(bus/coach) and cas_class=2 (passenger) since sometimes minibus occupants are counted in bus_pass variable

Frequency of bus and coach casualties

Nationally, there were 28,206 bus/coach passenger casualties over the 5-year period, accounting for 2.7% of all known casualty types (Table 1).

Overall there is an apparent reduction in the number of casualties although proportionately the number of bus/coach casualties remains fairly constant. Around 35% of all the Bus/Coach passenger casualties are aged 60 or over.

Table 1 Proportion of bus and coach casualties among all casualties

	BUS/Coach	All	%bus/coach
2008	6275	230905	2.7
2009	5735	222146	2.6
2010	5718	208648	2.7
2011	5688	203950	2.8
2012	4790	195723	2.4

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Nationally, there were 10010 bus/coach passengers aged 60+ over the 5 year period accounting for 8.5% of all 60+ casualties (Table 2).

Table 2 Proportion of bus and coach casualties aged 60+ among all casualties aged 60+

	BUS/Coach	All	%bus/coach
2008	2181	24484	9
2009	2113	24415	8.7
2010	2010	23522	8.5
2011	2048	23979	8.5
2012	1658	23357	7.1

Over the 5 year period the number of bus and coach casualties in the over 60+ years has fallen although they are over represented as bus/coach casualties. However travelling rates by bus is higher in the 60+ years than other age groups except the 17-29 age groups. Also the proportion of people aged 60+ who said they use a local bus at least once a week increased from 28% in 2005 to 40% in 2010. Over the same period the proportion of people in this age group who said they use a bus less than once a year or never fell from 46% to 32%³.

Severity of bus and coach casualties

Casualty severity is presented in Table (3) and shows predominantly that 'slight' injuries are the most prevalent. The fatality rate is very low in bus/coach passengers however 70% of the actual fatalities were to the older 60+ age group; 58% of the 'serious' casualties and 34% of the 'slight' casualties. These figures suggest that older people on buses are more at risk of serious injury than the other age groups.

³ https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/8937/nts2010-06.pdf

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Table 3 Distribution of injury severity of bus and coach passengers

	All ages and severity	% of severity for 60+ years
Fatal	43 (0.2%)	70 (n=30)
Serious	1674 (5.9%)	58 (n=964)
Slight	26489 (94%)	34 (n=9016)
Total	28206	10010 (35.5%)

When examining the data for age groups for the 60+ years the proportion of fatalities and serious injuries increased as age increased whilst the slight injuries tended to remain fairly constant.

Table 4 Casualty age by casualty severity, bus and coach passengers aged 60+

	60-69	70-79	80+
Fatal	5	12	13
Serious	250	344	370
Slight	3425	3254	2337

Gender was known for 10008 of the 60+ casualties, the majority of which were females (75% n=7543). Females also were more likely to sustain an injury compared to men but as they are the main bus users in this age group this is not surprising; although fatalities were fairly evenly distributed between the genders (Figure 2).

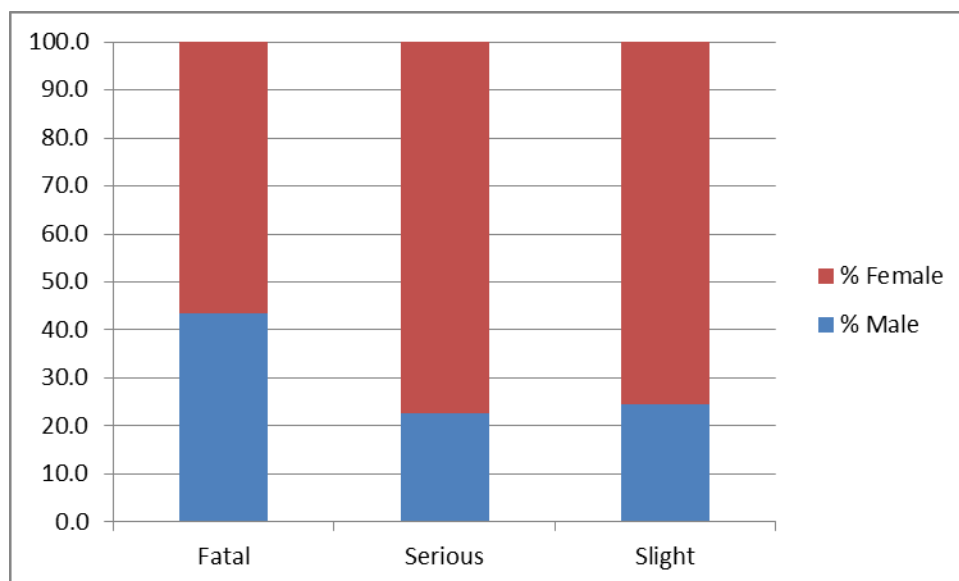


Figure 2 Injury severity and gender distribution

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Severity of Bus and Coach Passenger Casualties by Passenger Location

Passengers are categorised into 4 possible locations and overall the majority of injuries are sustained by those passengers seated or standing, particularly the most serious / fatal injuries (Table 5). Boarding the bus seemed to be problematic for the 60+ age group with 63% of boarding incidents occurring amongst the over 60's. Of note, although the number of fatal and serious injuries was small overall the over 60-years accounted for some 71% of serious injury on boarding and 83% of fatalities. This was also

noted in the standing and seated locations in that the over 60 years accounted for 79% and 62% of standing fatalities and 63% of serious injuries on standing. This suggests that the 60+ age group are more at risk of having serious or fatal injuries in certain locations within the bus.

Table 5 Bus and coach passenger severity by passenger location (n=28168 all ages with known location and n=9999 60+ years with known location)

	Boarding	Alighting	Standing Passenger	Seated Passenger
Fatal – all	6	2	14	21
(60+ years)	(n=5 83%)	(n=1 50%)	(n=11 79%)	(n=13 62%)
Serious – all	143	186	642	702
(60+ years)	(n=102 71%)	(n=101 54%)	(n=403 63%)	(n=403 51%)
Slight – all	1615	1406	6859	16572
(60+ years)	(n=1008 62%)	(n=570 40%)	(n=2683 39%)	(n=4744 29%)
Total n– all	1764	1594	7515	17295
(60+ years)	(n=1115 63%)	(n=672 42%)	(n=3097 42%)	(n=5115 30%)

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Cost of casualties

The latest road casualty costs for 2012 are presented below in Table 6 and the costs for all bus and coach casualties in Table 7.

Table 6 UK casualty costs 2012¹

Casualty Type	Cost per Casualty in £2012
Fatal	1,703,822
Serious	191,462
Slight	14,760

Just under a half of all bus and coach passenger costs for 2012 were attributed to the over 60+ years (Table 7).

Table 7 Cost (£) of bus and coach casualties by casualty age and accident year

	All ages	60+ years
2008	170,960,344	76,211,144
2009	164,918,066	83,517,644
2010	159,303,728	67,247,954
2011	150,555,934	74,388,380
2012	139,011,302	67,395,066

The general trend shows that overall bus and coach casualty costs have been declining over the past 5 years (Figure 3) however for the 60+ years there has been no steady decline with a peak in 2009 and a dip in 2010.

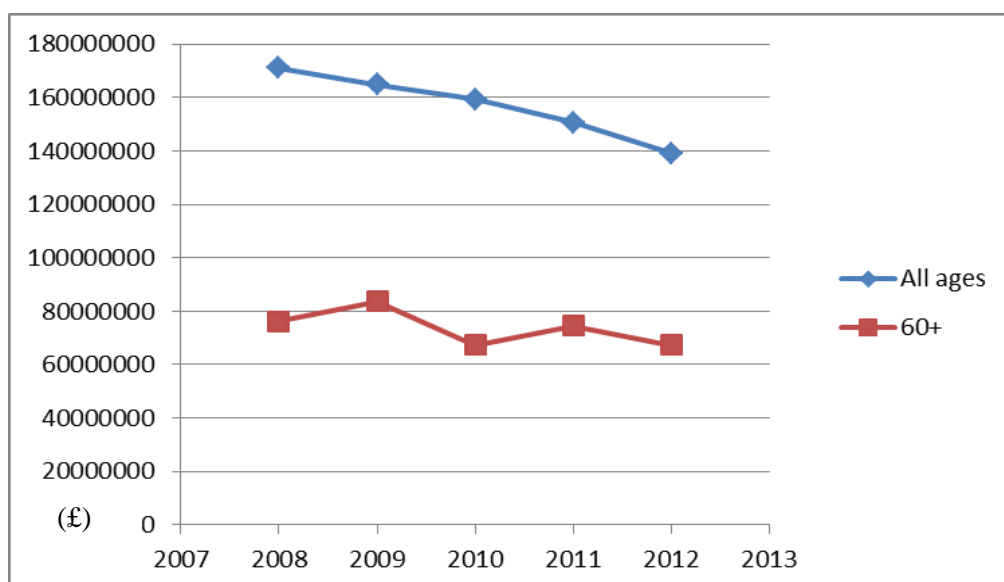


Figure 3 Casualty costs in £ for all bus and coach passengers and 60 + years

¹https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/244913/rrcgb_2012-02.pdf

Identification of available data sources

The original aim of the feasibility study was to obtain data from one locality – The East Midlands, however there was limited data released or available within this area to conduct the research. Subsequently the geographical area was expanded to England and potential data sources were targeted to maximise the amount of data for analysis.

Aim

- To identify as many data sources of public transport injuries in older users with the aim of combining the data and developing a database to drive injury prevention through design solutions.
- The objectives were to determine whether it is possible to identify specific types of public transport incidents from any databases and if it is possible how we could obtain the data.

Method

Approaches were made to public transport companies, health service providers, Universities, government and police authorities in an attempt to obtain anonymised injury data for older public transport users. These requests were made to firstly establish the feasibility of obtaining data and secondly whether the data could be made available for use. Figure 4 identifies the process used to identify and request data and also the data outcomes achieved.

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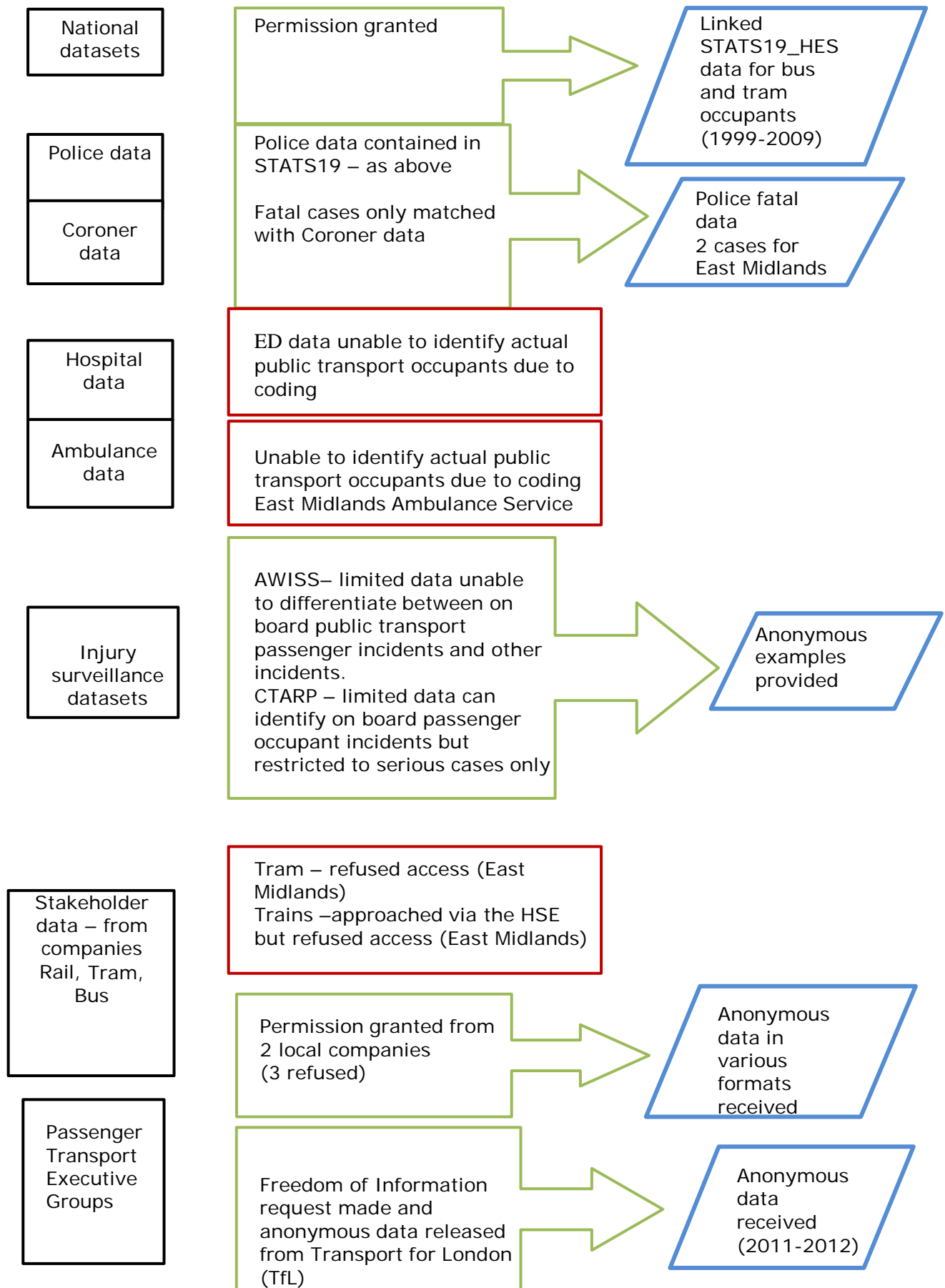


Figure 4 Identification of data sources²

² HES- Hospital Episode Statistics; AWISS- All Wales Injury Surveillance System; CTARP - Cambridgeshire Trauma Audit and Research Project; HES – Health and Safety Executive; EMAS – East Midlands Ambulance Service [Type text]

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The requests for data were channeled through known contacts, data controllers and Collision/Crash Investigation Units. A stakeholder group (namely the Passenger Transport Executive Group - PTEG) were interested and supported the study but its members did not have any direct influence on the bus companies to request them to release their incident data. However one of the members stated access would be granted from one large geographical area if requested via freedom of information channels. Overall the transport companies were reluctant to release incident data for fear of direct comparisons being made with rival companies. Furthermore, some did not collect the data in database format which could allow release of the data anonymously. Other transport companies refused to release any information including a general incident figure involving older persons. Other data sources stated they would not be able to identify the information that we were requesting. This was usually a result of data coding processes on particular systems that would not allow for easy data selection on relevant variables of interest.

There are current national datasets available on request that identify the extent of casualties on roads and includes bus and trams (STATS19). Further to this, recent work has been undertaken to link the STATS19 data with hospital data (HES) to enhance information about the injuries sustained. Therefore the huge benefit to the study is the fact that a linked dataset already exists (STATS19_HES) which negated the need to develop a 'new linked' dataset from scratch. However this linked dataset is limited to all reportable road crashes that had an 'inpatient' hospital record to match the incident. Ultimately a huge neglected portion of injuries on public transport is unknown because of the incidents that occur but which are not reportable as road crashes or medical treatment is sought as in ED or GP surgeries only. The ideal for the study would be to combine the stakeholder company data with ED data and the linked dataset to establish complete incident injury surveillance for public transport users. This study analysed the data obtained from the various sources to determine if such an injury surveillance database could be established and what benefits it could bring for the future of prevention of injury to older public transport users. Furthermore all the data were analysed to understand more about the types of injuries sustained and also injury causation.

Datasets available for analysis

STATS19_HES linked dataset

STATS19 is a database of road accidents on the public highway in Great Britain, reported to the police and which involve human injury or death, are recorded by police officers onto a STATS19 report form. The form collects a wide variety of information about the accident (such as time, date, location, road conditions) together with the vehicles and casualties involved and contributory factors to the accident (as interpreted by the police). The form is completed at either the scene of the accident, or when the accident is reported to the police.

The Department for Transport has overall responsibility for the design and collection system of the STATS19 data. The Standing Committee on Road Accident Statistics (SCRAS) is the body set up to oversee the STATS19 process for road accident data collection.

The STATS19 data is the only national source to provide detailed information on accident circumstances, vehicles involved and resulting casualties and is the most detailed and reliable single source on accidents that can be used for longitudinal research in Great Britain. However, it should be borne in mind that it is not a complete record of all injury accidents and resulting casualties, due to some accidents not being reported.

Police Forces will submit STATS19 forms up to six months after an accident. Where serious accidents have occurred, Police Forces will follow up with the hospital. Should a fatality occur within 30 days of the accident, this will be recorded on the form. www.adls.ac.uk/departments-for-transport/stats19-road-accident-dataset

The Department for Transport has undertaken work to link data from STATS19 and Hospital Episode Statistics (HES) at individual record level (DfT 2012).

Overall the HES have details of all NHS inpatient treatment, outpatient appointments and A&E attendances in England. It includes private patients treated in NHS hospitals, patients resident outside of England and care delivered by treatment centres (including those in the independent sector) funded by the NHS.

Each HES record contains a wide range of information about an individual patient admitted to an NHS hospital, including:

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- clinical information about diagnoses and operations
- information about the patient, such as age group, gender and ethnicity
- administrative information, such as time waited, and dates and methods of admission and discharge
- geographical information such as where patients are treated and the area where they live⁵.

The matched data for this study includes HES data extracted on the *external cause of injury* and did not include any fatal casualties and only includes admitted patients⁶. The HES extract also excludes elective (i.e. planned, non-emergency) admission to exclude repeated admissions to hospital after a road accident. No fatal incidents were included in the STATS19 data extract used in the linkage. For the period 1999-2009 a third (32%) of HES records were linked to STATS19 and 37% of STATS19 serious records were linked to HES. It is suggested that due to the likelihood of missed matches in the linkage the percentage linked is an under-reporting of the true matches. Overall, 41% of traffic accident admissions within the scope of STATS19 recorded in HES is linked to STATS19. This rises to 48% for traffic accidents excluding non-collision pedal cycle accidents. Given the likely underestimation of the number of records linked, this suggests that over half of those admitted to hospital are recorded in STATS19.

When classifying injury it would be expected that all casualties appearing in the HES data would be recorded as police 'serious' severity. Overall, it was found that 58% of linked casualties are correctly coded as serious with the remainder being coded slight. It is possible that some of those misclassified by police as slightly injured have relatively minor injuries but are admitted to hospital for observation. Vulnerable road users had the highest proportion of seriously injured casualties linked to a HES record (pedestrians 44%; motorcyclist 41%); bus occupants had the lowest rates (16%).

This linked dataset illustrates the capability of the linkage methodology of police and hospital inpatient data for England over a number of years however it is an imperfect match.

⁵ <http://www.hscic.gov.uk/hesdata>

⁶ Inpatients are defined as patients who are admitted to hospital and occupy a bed, including both admissions where an overnight stay is planned and day cases. Those who attend A&E only are not included.

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With this knowledge in mind the linked dataset for 'bus and coach or streetcar' cases was requested from the Department for Transport. The relevant data confidentiality agreements were signed to allow use of the data for research purposes which also requests that the dataset is deleted following analysis. The dataset released for research purposes does not contain any unique identifiers furthermore a restriction to using STATS19 data is that the data cannot be used to identify specific individuals. The only 'specific' useful variables that could be used for linking to other datasets are the crash date, time and broad geographical area.

Transport for London (TfL)

Transport for London released data through the freedom of information act for the 25 month period (Jan 2011 – Jan 2013) for older public transport users for bus, light rail and underground incidents. The TfL are a local government body responsible for the maintenance of transport across Greater London and was set up in 2000.

The data released to the study contained N=2655 records for older passengers of which 473 were underground incident records and 2182 bus records. Overall 90 (19%) of the underground records were actual passengers others were incidents outside of the train and 2119 (97%) were passenger incidents that occurred on the bus. All the data were anonymous although there is a potential to use 'specific' variables namely the accident date and time for further linkage to other datasets.

Other Bus company data

Data from two other bus companies were released to us for analysis however confidentiality agreements ensures that we do not name the bus companies.

Analysis of Available Datasets

Each data set was analysed using descriptive statistics, frequencies and where applicable Chi squared statistics to explore associations between circumstances and injury outcomes.

Linked Data – Stats19_HES

Linked data were requested from the Department for Transport (DfT) selected by public transport vehicle type either 'bus or coach' or 'tram'. A total of 4,352 inpatient records were received for the period 1999-2010 from the linked dataset. The data by definition are all police recorded bus passenger incidents that appear in the national STATS19 road traffic accident data and also have a linked medical record in the National Hospital Episode Statistics data. Records were further selected based on the 'Casualty type' being recorded as a bus / coach passenger or streetcar occupant. This resulted in a total 1,748 cases, of which 3% (n=58) were tram occupants and 9% (n=160) were recorded as not being a bus or coach passenger and were predominantly pedestrians struck by a bus. It was decided to focus on bus passengers as it appears to be the main public transport mode for older users leaving a total of 1,530 known bus passengers. Overall once passengers under 60 years were removed a total sample of 1,016 passengers were available for analysis (Figure 5).

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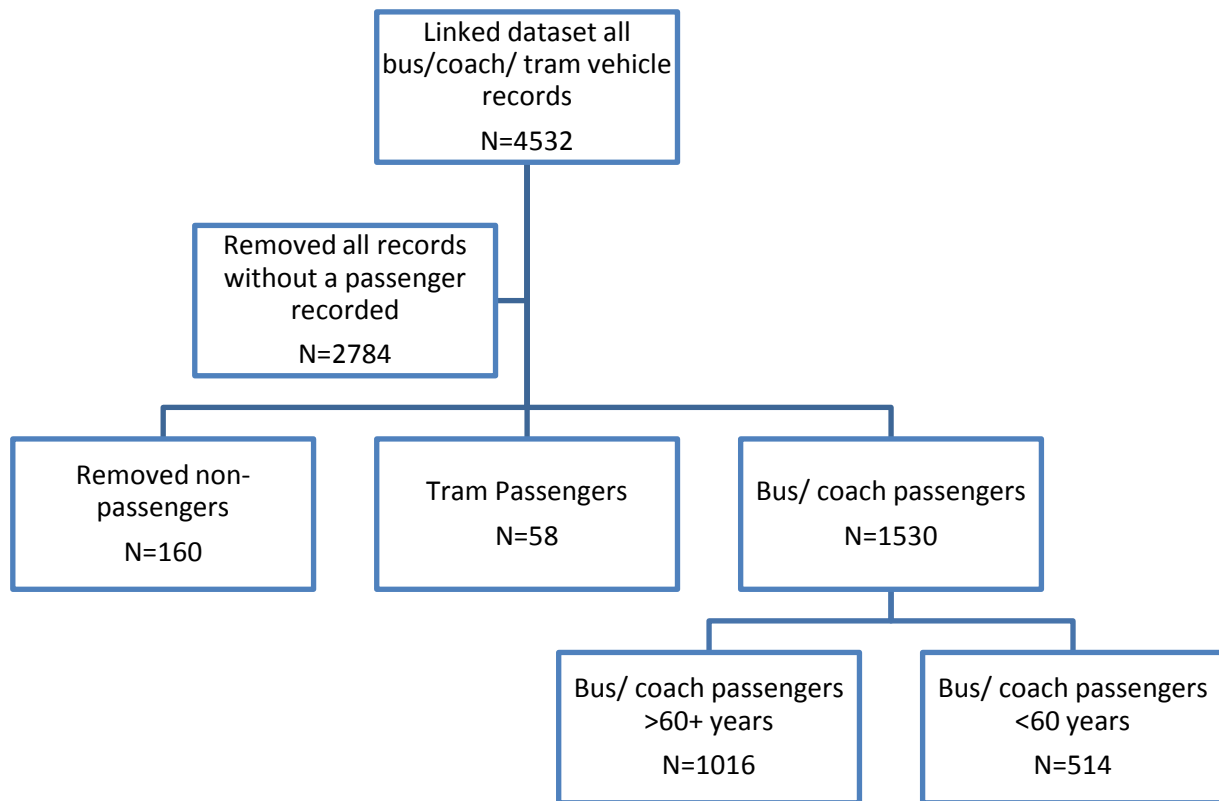


Figure 5 Flow chart of available data for analysis

Results

Passenger Location

Bus passengers were categorised into locations within the bus at the time of the injury, alighting, boarding, seated or standing. Collision type was sub-divided into either a collision (with other vehicle/ object) or non- collision, furthermore the bus manoeuvre at the time of the incident was also re-categorised into the vehicle moving mid-journey, moving off, slowing down or parked/ waiting/other (Table 8).

From the table it can be seen the highest proportion of all injuries occurred in non-collision episodes (62%) whatever the location of the passenger. The majority of passengers were female (78%) and the highest proportion (46%) were in the 80+ year category with the majority of all injuries occurring mid journey. There was an even distribution of casualty severity in STATS19 of either 'Slight' (46%) or 'Serious' (54%) there were no 'Fatal' cases reported in the dataset. The casualty severity definitions provided by

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the Department for Transport are listed below to allow consistent interpretation of their road accident data (DfT 2004).

- "Slight injury: An injury of a minor character such as a sprain (including neck whiplash injury), bruise or cut which are not judged to be severe, or slight 'shock' requiring roadside attention. This definition includes injuries not requiring medical treatment."
- "Serious injury: An injury for which a person is detained in hospital as an 'in-patient', or any of the following injuries whether or not they are detained in hospital: fractures, concussion, internal injuries, crushing, burns (excluding friction burns), severe cuts, severe general shock requiring medical treatment and injuries which cause death 30 or more days after the accident. An injured casualty is recorded as seriously or slightly injured by the police on the basis of information available within a short time of the accident. This generally will not reflect the results of a medical examination, but may be influenced according to whether the casualty is hospitalised or not. Hospitalisation procedures will vary regionally."

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	Collision category (n=1016)			Bus manoeuvre (n=1015)				Casualty severity (n=1016)		Gender (n=1016)		Age (n=1016)		
	Yes	No	N/K	Mid journey	Moving off	Slowing down	Parked, waiting other	Slight	Serious	Male	Female	60-69 years	70-79 years	80+ years
Alighting (n=143)	9 (6%)	104 (73%)	30 (21%)	26 (18%)	28 (20%)	24 (17%)	65 (45%)	70 (49%)	73 (51%)	35 (25%)	108 (75%)	18 (13%)	45 (31%)	80 (56%)
Boarding (n=103)	2 (2%)	76 (74%)	25 (24%)	9 (9%)	25 (24%)	7 (7%)	62 (60%)	66 (64%)	37 (36%)	21 (20%)	82 (80%)	14 (14%)	28 (27%)	61 (59%)
Seated (n=348)	83 (24%)	181 (52%)	84 (24%)	260 (75%)	25 (7%)	53 (15%)	10 (3%)	136 (39%)	212 (61%)	87 (25%)	261 (75%)	83 (24%)	136 (39%)	129 (37%)
Standing (n=422)	23 (6%)	267 (63%)	132 (31%)	199 (47%)	67 (16%)	132 (31%)	23 (6%)	192 (46%)	230 (54%)	80 (19%)	342 (81%)	89 (21%)	138 (33%)	195 (46%)
Total n= 1016	117 (11%)	628 (62%)	271 (27%)	494 (49%)	145 (14%)	216 (21%)	160 (16%)	464 (46%)	552 (54%)	223 (22%)	793 (78%)	204 (20%)	347 (34%)	465 (46%)

Table 8 Characteristics of older bus passengers by location

Injury data for older bus passengers

The Hospital Episode Data identifies and codes specific injury diagnosis codes using the World Health Organisation (WHO) ICD-10 coding system. The inpatient HES data in the linked dataset contained the ICD10 codes for up to 6 different injuries based on the first 3 significant numbers of the codes; for example S828 relates to a fracture of lower leg including ankle and S028 refers to facial fractures – see below.

S828 - Fractures of other parts of lower leg including.:

- Fracture (of):
- ankle NOS
- bi-malleolar
- tri-malleolar
- <http://apps.who.int/classifications/icd10/browse/2010/en#/S80-S89>

S028 Fractures of other skull and facial bones

- Including.:
- Alveolus
- Orbit NOS
- Palate
- Excl.:
- orbital:
- floor (S02.3)
- roof (S02.1)

Any one person could have up to 6 ICD codes depending on injury and also complications following injury. Overall there were 2136 Injury codes and 38 complication codes. From the HES data each injury record had an ICD code, injury description, body region and injury type (see below).

(S828) (Fracture of lower leg including ankle)(Lower leg) (Fracture) (MAIS)

Further to this each casualty has a DfT-derived Maximum Injury Severity Score (MAIS) generated for the most serious injury sustained. The algorithm was

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developed by The University of Navarra to allow the application of injury severity scores to mass databases holding ICD data (ECIP 2006).

MAIS is aligned to the Abbreviated Injury Scale (AAAM 1998) which ranks individual injuries from 1 to 6; where 1 is minor, 2-moderate, 3-serious, 4-severe, 5-critical and 6-maximal (currently untreatable). For any one person their most serious injury will dictate the MAIS. From table 9, an even distribution can be seen between the MAIS 1, MAIS 2 and MAIS 3 categories with a small percentage of MAIS4+ injuries; however 180 bus passengers nearly 18% of the total sample had an injury from which a MAIS could not be calculated. The number of casualties with a known MAIS is n=836.

Table 9 Distribution of MAIS categories

	N=1016	%
MAIS 1	275	27.1%
MAIS 2	284	28%
MAIS 3	261	25.7%
MAIS 4	11	1%
MAIS 5	1	0.1%
MAIS 6	4	0.4%
MAIS 9 (unknown MAIS)	180	17.7%

The expectation was that 'Slight' casualties would sustain MAIS 1 injuries with some leeway for more serious lacerations where "on-scene" they may be classed as a slight skin wound but hospital records would code them as MAIS 2 injuries. Some fractures for example to the fingers or facial bones are AIS 1 injuries and in the absence of other injuries would be assigned a MAIS 1, however these injuries because they are fractures could appear in STATS19 as 'Serious' casualties. Furthermore an overnight stay would render the casualty 'Serious' despite the severity of injury sustained, based on the STATS19 coding criteria. The distribution of MAIS and STATS19 casualty severity are shown in Figure 6. Although there are more MAIS 3+ injuries in the 'Serious' casualties there still remains 102 MAIS 3+ injuries in the 'Slight' casualty figures.

A similar number of injuries are assigned a MAIS 2 in both the casualty severities. Proportionally there are higher numbers of MAIS 1 injuries in the

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'Slight' casualties as one would expect with some 'Serious' casualties having MAIS 1 injuries. However this may be explained by having an overnight stay or sustaining AIS 1 fractures.

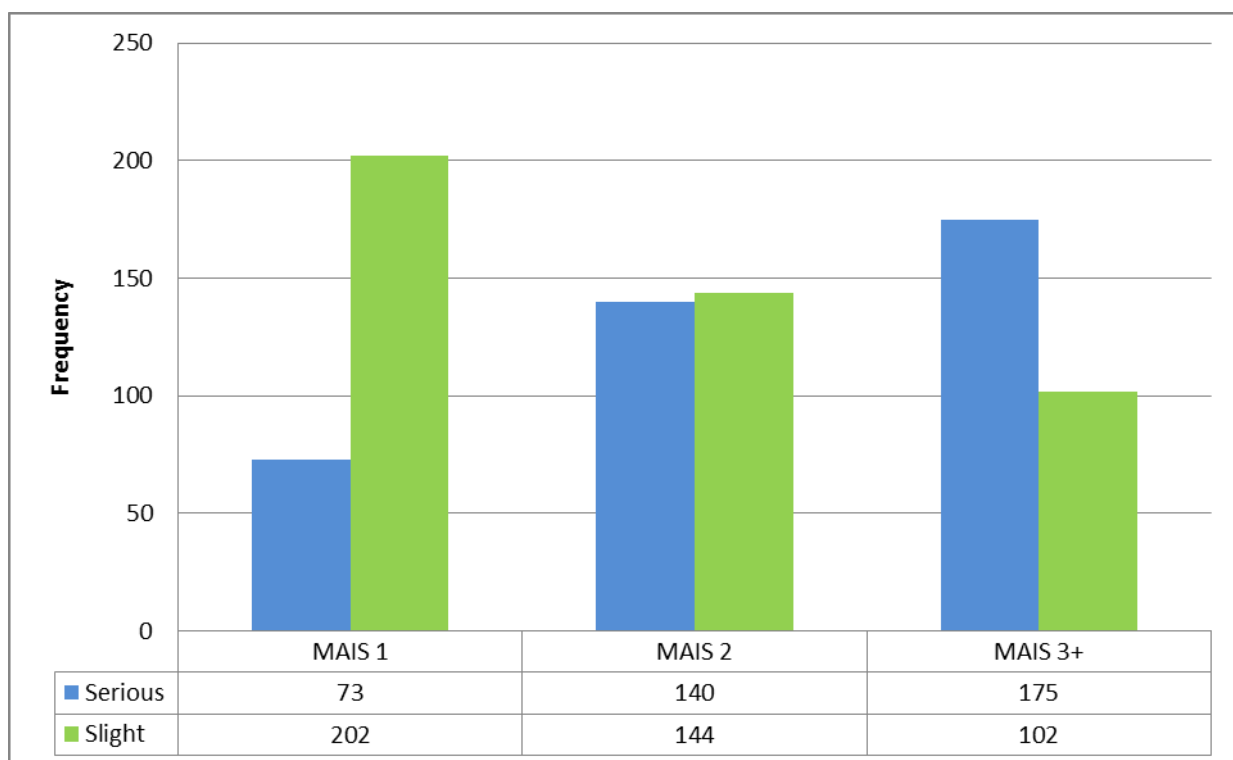


Figure 6 Frequency of MAIS injuries and police casualty severity classification

This figure 6 also identifies the discrepancies between the Slight injury severity casualties in the STATS19 database and the corresponding MAIS severity from the linked HES data. Although there are almost double the number of MAIS 3+ injuries in the 'Serious' casualties compared to the 'Slight' casualties one however would expect there to be no MAIS 3+ injuries in this category. This suggests that there is both underestimation of casualty severity by the police in the STATS19 data with some 9% (n=73) being underestimated. Conversely there is also over-estimation of casualty severity by the police with some 29% (n=246) of 'Slight' casualties sustaining MAIS2+ injuries and proportionally 42% of these (n=102) are grossly under-estimated.

The distribution of the 1381 types of injuries sustained for all the casualties are shown for 'Slight' and 'Serious' severities Figure 7.

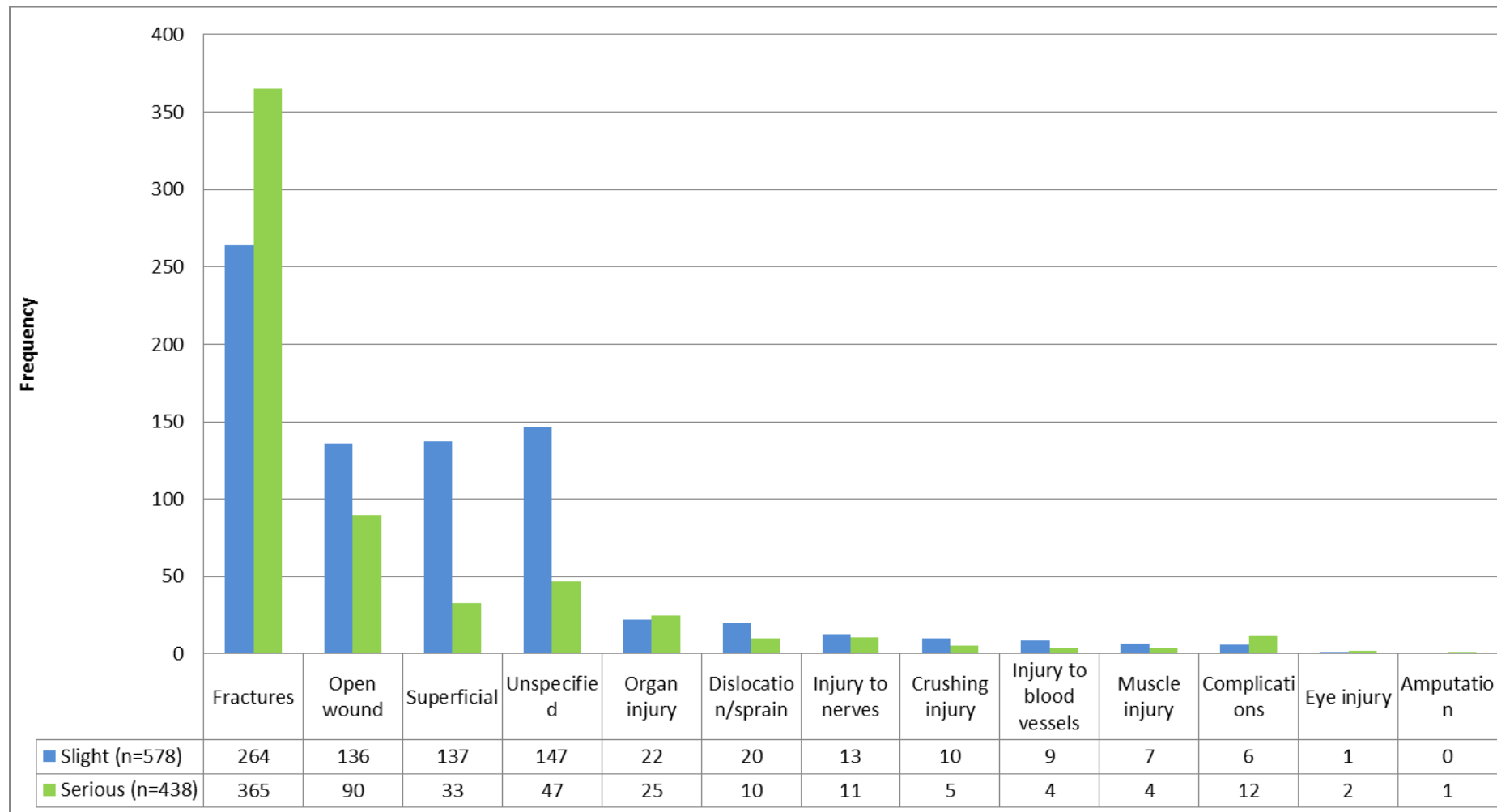


Figure 7 Distribution of injury types and police casualty severity

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To explore the injuries further the primary diagnosis was reviewed and excluding people with multiple injuries and unspecified injuries there were 996 injury codes which could be grouped into 5 body regions (Table 10). There was a significant difference in the body region injured according to passenger location. It appears that head and neck injuries are more common amongst seated and standing passengers, whilst lower extremity injuries are more common amongst those alighting or boarding. (χ^2 80.693 df 12 $p < 0.0001$). Overall head/neck and lower extremities predominate the type of injury sustained with relatively few chest or trunk/lower back injuries whatever the passenger location. Upper extremity injuries had a fairly even distribution for each passenger location.

Table 10 Distribution of primary body region injured and passenger location

	Alighting	Boarding	Seated	Standing	Total (n=996)
Head/neck	24 (17%)	16 (16%)	145 (43%)	125 (30%)	310 (31%)
Chest	4 (3%)	6 (6%)	34 (10%)	36 (9%)	80 (8%)
Trunk/ lower back	10 (7%)	4 (4%)	19 (6%)	37 (9%)	70 (7%)
Upper extremity	24 (17%)	14 (14%)	47 (14%)	72 (17%)	157 (16%)
Lower extremity	77 (55%)	63 (61%)	95 (28%)	144 (35%)	379 (38%)
Total	139	103	340	414	

The distribution of known MAIS for passenger location suggests that there is a significant difference in the severity of injuries sustained. It appears that more MAIS 2 and serious (MAIS 3+) injuries were sustained when standing (Table 11). Passengers alighting the bus also tended to have more serious (MAIS3+) injuries, whereas passengers boarding and seated on the bus tended to have minor (MAIS 1) injuries (χ^2 28.232, df 6 $p < 0.0001$).

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Table 11 Distribution of MAIS by passenger location

Total (n=836)	MAIS 1	MAIS 2	MAIS 3+
Alighting (n=126)	32 (25%)	42 (33%)	52 (41%)
Boarding (n=89)	47 (53%)	27 (30%)	15 (17%)
Seated (n=271)	98 (36%)	90 (33%)	83 (31%)
Standing (n=350)	98 (28%)	125 (36%)	127 (36%)

The passenger location and the age of the passengers suggests there is significant difference in sustaining an injury. Older passengers in the 80+ year age group tended to have more injuries irrespective of location, although alighting and boarding appear to be more problematic.

Passengers between 60 and 79 years sustained more injuries whilst seated.

Overall standing passengers tended to have more injuries and an increase in age irrespective of location increase the number of injuries. (Table 12) (Chi2 26.418 df 6 p 0.0002).

Table 12 Distribution of passenger location and age of injured passenger

Total (n=1016)	60-69 years	70-79 years	80+ years
Alighting (n=143)	18 (13%)	45 (32%)	80 (56%)
Boarding (n=103)	14 (14%)	28 (27%)	61 (59%)
Seated (n=348)	83(24%)	136 (39%)	129 (37%)
Standing (n=422)	89 (21%)	138 (33%)	195 (46%)

Again it appeared that age and injury severity showed significant differences with the older passenger tending to be sustain more serious injuries (Table13) (Chi2 19.408 df 6 p<0.004).

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Table 13 Distribution of injured passenger age and MAIS severity

Total n=836	MAIS 1	MAIS 2	MAIS 3+	Total
60-69 years	54 (20%)	71 (25%)	35 (13%)	160
70-79 years	91 (33%)	97 (34%)	90 (32%)	278
80-89 years	130 (47%)	116 (41%)	152 (55%)	398
Total	275 (100%)	284 (100%)	277 (100%)	

The severity of injuries and the bus manoeuvre suggests that MAIS 1 injuries tended to occur whilst the bus was parked or stationary which would coincide with alighting and boarding passengers. MAIS 2 injuries tended to be more prevalent during the moving off phase of the bus and mid journey and MAIS 3+ injuries during the deceleration of the bus (Chi2 13.886 df 6 $p < 0.031$).

Injuries for alighting passengers were more likely to occur when the bus was parked or stationary (46%), the same for boarding passengers (60%) as would be expected. However the data suggests some errors such as boarding and alighting passengers which were shown to be injured during the mid-journey, moving off or slowing down phases. This illustrates the discrepancies in the data as passengers could be moving down the bus post boarding and the bus moves off hence could explain the 'moving' bus rather than 'stationary'. However these passengers are standing and moving through the bus having boarded and would suggest that a further category might be required to capture these passengers as well as those standing pre-alighting which again would be recorded as alighting incidents rather than on-board.

There was a significant difference between the bus manoeuvre and the passenger location at the time of the incident. The majority of the seated passengers tended to be injured during the mid-journey phase (75%) and the standing passengers tended to be either injured during mid-journey 47% or when slowing down 31% (Chi2 444.334 df 9 $p < 0.0001$).

Key Findings

- 66% of injured bus passengers were aged over 60 years
- Non-collision incidents predominantly were a cause of injury compared to collision incidents
- Women made up 78% of the sample and just under half were aged over 80 years
- Overall the majority of injuries were at the MAIS2+ severity
- There is a discrepancy between the police injury severity categories 'slight' and 'serious' and the injury derived severity scale (MAIS)
- Head /neck and leg injuries were the main body regions injured mainly for the seating and standing passenger
- Overall however standing passengers were associated with more serious injuries
- The over 80's had more serious injuries (MAIS3+) wherever they sat

Bus Company Data

Aim

Overall the aim was to collect data from varied sources to enable a database of injuries to be developed for the older public transport user. Knowing that the linked STATS19_HES Data would only contain those passengers who had an accident reported to the police and a hospital inpatient record we wanted to establish the types of injuries older users sustain whilst using buses from the company incident forms thus identifying those that do not become a national statistic.

Method

This section of the study was also testing the feasibility of obtaining the data from bus companies and how readily the information would be released. Hence the local bus companies were contacted and permission sought to release anonymous information for research purposes. Data were granted for 2 bus companies however 1 company did not routinely collect incident data on a database only paper forms. This company would not release these forms but did release the electronic data from insurance claims from incidents on the buses as they had been entered onto a database and could be anonymised. A second bus company released their incident data for a 10 year period. Two other companies refused access to this data and also refused to confirm any numbers of incidents that occur to older passengers on their buses. Following discussions with the Passenger Transport Executive Group, a Freedom of Information request was sent to a large PTEG group requesting the incident data for older passengers for research purposes.

The incident data received from 2 different companies were categorised as 'older people' or 'concessionary pass holders' and varied in their data variables and also time period of collection and also geographical area of collection. It was decided to analyse the data separately for each company and determine if there were any consistent findings for older bus passengers.

The insurance data from 1 company was also analysed separately.

Results

Bus Company 1

Incident data were received from July 2009 to May 2012 (35 months) for older passenger bus incidents as defined by 'concessionary bus pass holders 60+ years' rather than actual age. A total of 50 cases were received for the East Midlands area within the above time frame; gender was unknown.

Overall 62% (n=31) of passengers were on double decker buses when the incident occurred with the remaining on single decker buses (36%, n=18) and 1 missing record. Passenger location is shown in table 14 with the majority of incidents during boarding (30%) or standing (24%).

Table 14 Distribution of passenger location

	Frequency (n=50)	Percentage
Alighting	2	4%
Boarding	15	30%
Seated	7	14%
Standing	4	8%
Standing post-alighting	8	16%
Fall	7	14%
Other – medical, outside, mixed, n/k	7	14%

Overall 70% (n=35) of the passengers did not attend a hospital following the incident, 20% (n=10) did attend hospital and 1 person was reported as (2%) staying overnight and there were 5 missing records (10%). Of those that did not attend hospital 21 were recorded as having sustained a minor injury and included 1 person with rib fracture (it is assumed these are self-reported injuries to the company). Further exploration of the injuries reveals in the incident records 2 people are reported as having fractured hips thus it would be expected that at least 2 people would have been detained in hospital (Figure 8). The one person who was reported as staying overnight sustained rib fractures. Overall 30% (n=15) did not sustain any injuries, 62% (n=31) sustained minor injuries or at least not further defined anything beyond the basic body region description of 'leg' or 'back' and 8% (n=4) sustained fracture injuries to the ribs and hips. The accuracy of this data for the injury descriptors has to be questioned

considering the mismatch between hospital in patient and a fractured hip not being classified as staying in hospital.

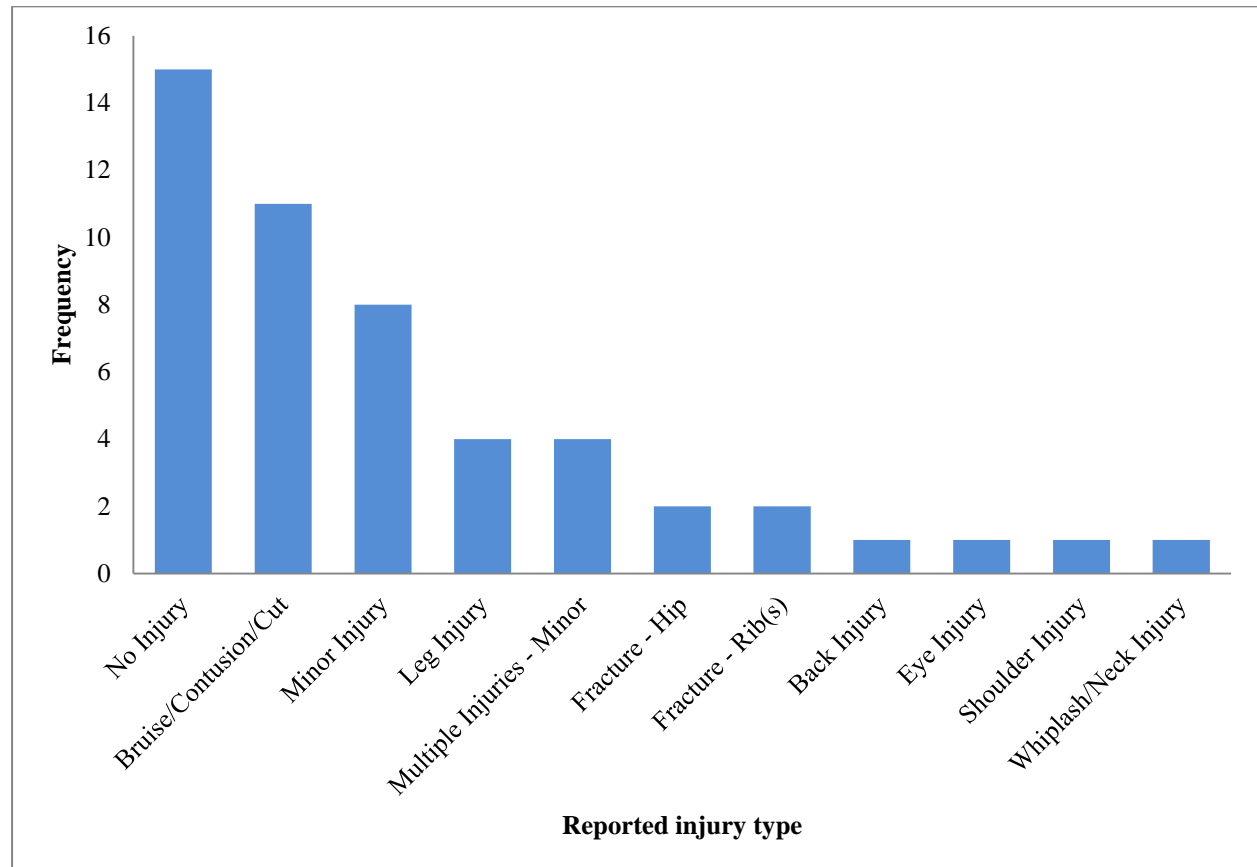


Figure 8 Distribution of injury types

The other aspect of the bus company data that didn't accurately reflect the passenger location for the serious injuries were those reported as 'falls'. On the whole passengers were recorded as a fall rather than standing or seating prior to the incident. The fall incidents following 'sudden braking' caused rib fractures and a further 2 standing passengers sustained hip fractures. This illustrates the difficulty of identifying where the passenger was and what they were doing at the time of the incidents and without the narratives provided it has to be assumed that 'fall' was the cause of the injury rather than sudden braking. These incidents highlight the difficulty of using inaccurate data to identify key problem areas for passenger safety to develop injury prevention strategies. Ideally any incidents occurring on the bus would be categorised routinely and consistently that could be included in an injury surveillance database aimed at targeting key injury prevention strategies.

From the narratives of the incidents most boarding incidents were recorded as tripping whilst getting on to the bus. Standing passengers tended to have an incident after the bus moved off from stops or traffic lights. Those passengers recorded as seated tended to have an incident recorded following sudden

braking or an aversion manoeuvre. For those categorised as falls (n=6), resulted from sudden braking, 1 fell whilst bus pulling into a stop and 1 was a fall following a slip on fruit peel.

Following the 15 boarding incidents most of the older passengers were recorded as 'non-injury' incidents (n=8). The other 7 non-injury incidents were a mixture of other passenger locations.

Bus Company 2

Data were received for the period January 1st 2011 to January 21st 2013 (25 months) for older passenger bus incidents – a total of 2,182 cases for the London Borough.

This database included all types of incidents including medical conditions, assaults and robberies these were removed for the analysis to be comparable with actual 'bus' incidents resulting from a particular bus or passenger manoeuvre or behaviour resulting in 2,119 incident records. TfL defines major injury incidents as those where a person is taken to hospital for treatment independent of whether hospital treatment was required and usually defined at the scene rather than at follow up.

A total of 1,531 (72%) incidents were recorded on double decker buses, 582 (27%) on single decker buses with 6 (<1%) not stated. The majority of the older passengers were female (n=1,498, 71%); 9 unknown <0.5%. Predominantly the injuries sustained were minor with 4 fatalities (Table 15). Three of the fatalities were a result of a 'fall' after either braking heavily (n=2) or pulling away (n=1) and the fourth fatality was a medical incident according to the narratives but was coded as a 'boarding' incident in the database.

Table 15 Distribution of injury severity

	Frequency	%
Fatal	4	0.2%
Major	629	30%
Minor	1486	70%

The types of injuries sustained are presented in Figure 9 with minor injuries classified as cuts, bruising, sprains, minor roadside shock and whiplash injury and 'unknown' injury classified as minor. Major injury appears to be categorised as anyone that attends hospital has a fracture, internal injury or concussion. Unfortunately there is no variable for body region that was injured so in all but the

concussion and neck / whiplash cases, the injury site is unknown unless the narratives are used to establish this detail.

Incident Narratives

To establish the depth of the narrative for identifying the body region injured during an incident, a random sample of 100 narratives (every 21st incident) were reviewed. From this review it was evident that the narratives varied greatly and only 30% of incidents mentioned a body region in the narrative statement.

Examples of the narratives are given below;

'Bus pulling into bus stop at (name of place) an elderly female passenger in her 60s approached the rear doors ready to exit the bus when she tried to hold the handrails, the passenger missed the hand rail and fell and hit her head on the step at the rear end of the bus. The passenger was bleeding from the back of her head as a result; the driver came out of her cab and called code blue for an ambulance'

'Driver braked hard to avoid car and passenger hit face on pole'

Other examples of the narratives are below where the incident is described but no-body region mentioned.

'Bus braked abruptly, elderly female passenger slid forward on seat and fell onto the bus floor, declined medical assistance'.

'Passenger fell as bus was moving off'

All of the examples above are captured in the database as incident type being a 'Knock, Trip or Fall within bus'; only 2 had an immediate cause assigned 'heavy braking' and 'passenger action', 3 were assigned an injury severity of 'minor' with 1 'major' with injury descriptions recorded as unknown, 'taken to hospital', 'other minor injury' and bruises.

Without the help of the narratives the bus manoeuvre is not known at the time of the incident as only 29% (n=464) of any incidents had this variable completed in the whole database. Further to this only 22% (n=617) of any incidents had the variable completed for the passenger location at the time of the incident but even then it cannot be determined if a passenger was standing or seated. The narratives only provided evidence in 2 cases where a passenger was definitely described as standing or seated.

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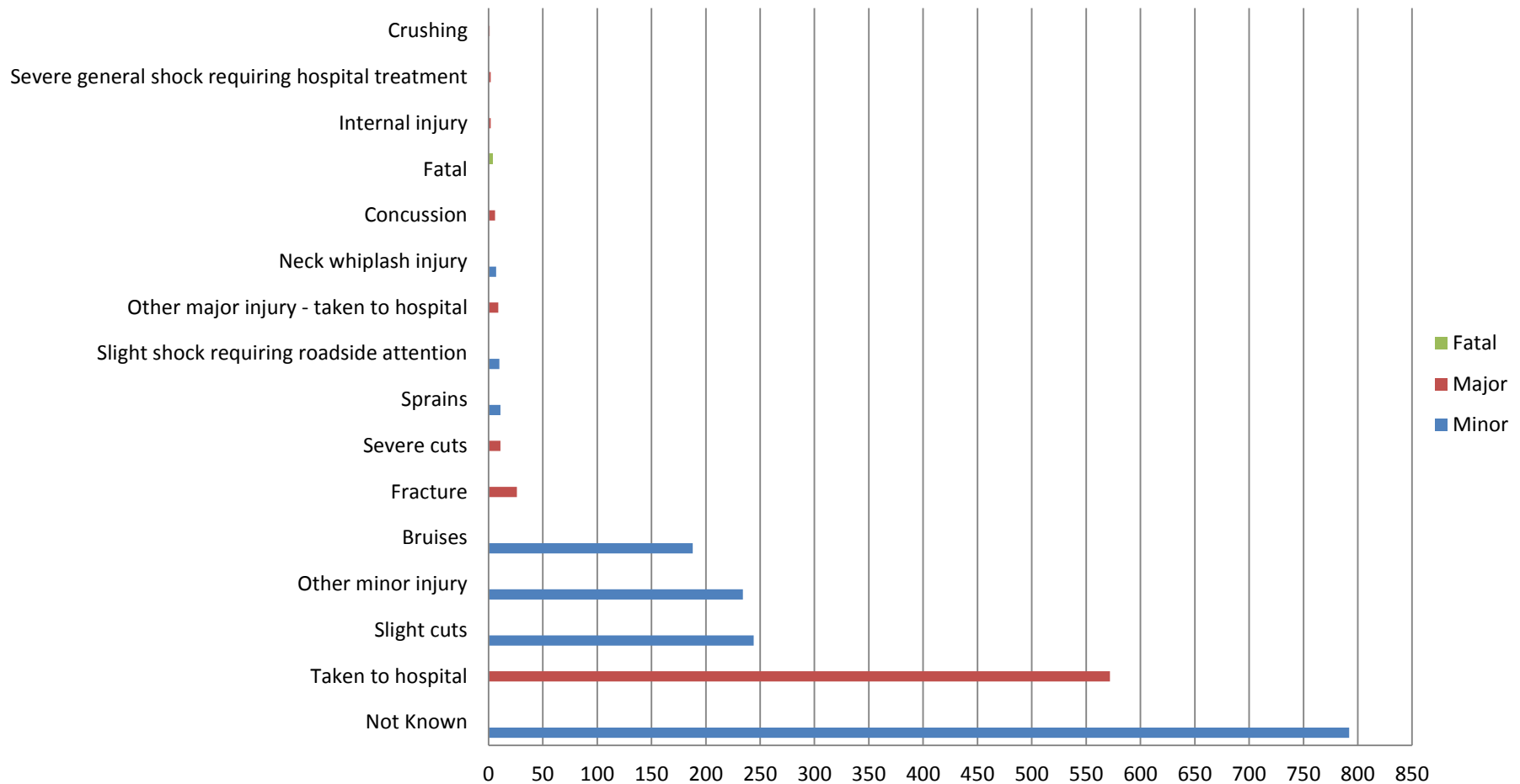


Figure 9 Distribution of injury type and severity category

Bus Company 3

One company provided data for 118 older passengers who had made a claim against the bus company's insurance for their incident injury. This is the only data that is held on a database as all other incidents are held in paper form and access was denied to these. The insurance cases spanned a 3 year policy period and provided no information about the events leading to the injury and little injury data. The mean age of the cases was 72 years, median 70 years (range 60-91 years), and no gender data was provided. Overall 72 insurance claim cases had been completed (61%) and the remainder were open or re-opened. The injury data identified 'injury type' for 28% of cases (Table 16) showing 'whiplash' to be the most frequently claimed for. For injury location (Table 17) 77% were not recorded and as would be expected the 'neck' was the most frequently injured body region claimed for.

Table 16 Distribution of injury type

	Frequency	%
N/K	85	72
Whiplash	10	8.5
Neck Injury	6	5.1
Bruising	4	3.4
Back Injury	2	1.7
Fracture	2	1.7
Head Injury	2	1.7
Arm Injury	1	0.8
Crushing	1	0.8
Finger Injury	1	0.8
Hand Injury	1	0.8
Nose Injury	1	0.8
Teeth Injury	1	0.8
Torn Ligaments	1	0.8

Table 17 Distribution of body region injured

	Frequency	%
N/k	91	77.1
Neck	11	9.3
Hip/pelvis	3	2.5
Ribs	3	2.5
Shoulder	3	2.5
Back/spine	2	1.7
Arm	1	0.8
Foot	1	0.8
Head/face	1	0.8
Leg	1	0.8
Nose	1	0.8

This data did not provide any really useful data for injury causation but does offer some 'detailed' injury location (Table 17) but limited injury type data (Table 16).

Other data sources

Emergency Department Data

A search was conducted of two East Midland Emergency Department Admissions for a 12 month period (Queens Medical Centre, Nottingham and Leicester Royal Infirmary). At the Royal Infirmary it was found that patients could not be identified as bus passengers using a simple search strategy as the primary code was 'RTA', therefore data was not requested from this hospital. The search at the Nottingham also found that the external cause codes for the patient injuries were more likely to be coded as RTA or falls and without the specific cause code to identify the person as a bus passenger the data could not be easily extracted. It was found that searches on the 'free text' would have to be made to extract the passenger information. It was suggested that the data was not an accurate reflection on potential cases as it was dependent on the coding of patient data. Two people were recorded as being bus passengers in a 12 month period who attended the ED and these were identified because the external cause code for bus passenger was completed however no such code exists to identify 'tram' passengers. Again data were not requested for these 2 patients as they would not accurately reflect the extent of the problem under study.

The lack of identifiable bus passenger data within the East Midlands was a disappointment for the study and as a consequence the geographical area was widened to include known injury surveillance systems to ascertain whether 'bus passengers' are identifiable as a study population

Injury Surveillance Data – AWISS

The All-Wales Injury Surveillance System is designed to collect data on all injuries from all accident and emergency departments in Wales and to calculate population based event rates. The dataset contains numerous variables that allow for identification of specific incidents, however it was noted that to perform a search to provide relevant data the free text has to be searched.

The Injury Surveillance Data for Wales was searched on our behalf by Swansea University from March 2009 to June 2010 and identified 259 episodes of incidents where 'bus' was mentioned in the free text of which 31% were over 60 years and for 'trains' 58 records were identified of which 12% were over 60 years (Tables 18 & 19). This report identified the main injury mechanism as

'slips, trips or falls' and cautioned for the fact that these records were related to incidents occurring internally and externally to the vehicles under study. Due to the incompleteness of some of the Emergency Department Data Set (EDDS), it was noted that 0.04% of all ages were missing and 23.21% of all mechanism of missing injury was also for the dates searched (01/07/2009 – 30/06/2010).

Bus Injuries

259 records were returned when the single word bus was searched for. These records were reported to be a mixture of road traffic injuries involving a bus, injuries on a bus or injuries at a bus station. Of these records 30.5% were aged 60 years (table 18) and over and in the total sample 39% were the result of a fall/slip/trip (table 19). No division of age and injury mechanism was provided to the study.

Table 18 Age band of bus passengers recorded in the database

Age Band	Total (n=79)
60-69 years	21 (27%)
70-79 years	30 (38%)
80+ years	28 (35%)

Table 19 The mechanics of how the 'bus' injury was sustained

Mechanism of Injury	Total (n=259)
Fall / slip / trip	101 (39%)
Blunt force (blow from person, animal, machine)	71 (27.4%)
Crushing injury	6 (2.2%)
Other	49 (19%)
Unspecified	32 (12.4%)

Train injuries

58 records were returned when the single word train was searched for. These records were a mixture of injuries on a train or injuries at a train station. Of these records 12% were aged 60 years and over and 21% of the total sample were the result of a fall/slip/trip (Tables 20 & 21).

Table 20 Age band of train passengers recorded in the database

Age Band	Total 60+ years
60-69 years	21
70-79 years	0
80+ years	0

Table 21 The mechanics of how the ‘train’ injury was sustained

Mechanism of Injury	Total (n=58)
Fall / slip / trip	12 (21%)
Other	19 (33%)
Unspecified	27 (46%)

Injury Surveillance Data – CTARP

The dataset the Cambridgeshire Trauma Audit and Research Project is a linked database covering the years 2000-2004. The nature of this dataset means that it will only contain patients who have had a serious injury and were admitted to hospital for at least 72 hours. Approaches were made to the data holder to ascertain whether there were any cases of older public transport passengers that could be identified within the dataset. The dataset was searched on our behalf by Magpas. A brief description of the linked data is below and illustrated in Appendix 3.

- Consists of 2014 patients injured within the geographical area of Cambridgeshire and resulting in a pre-hospital trauma death or hospital admission that met TARN 07 criteria.
- Datasets include, HES, TARN, STATS19, emergency services data, coroners, ONS.

Search

The search was undertaken on our behalf using the CTARP data using the following search strategy (traffic codes 1+5) and ICD10 (codes V70-79 +V81 +V82).

Codes

1-Traffic: motor vehicle accident – not motorcycle (the injured patient is an occupant or passenger of a motor vehicle; i.e., car, pickup truck, van, heavy transport vehicle, bus)

5 - Traffic: other (the injured patient is an occupant or passenger of other means

V70-V79 - Bus occupant injured in transport accident

V81 Occupant of railway train or railway vehicle injured in transport accident

V82 Occupant of powered streetcar injured in transport accident

This search identified two cases of injured passengers aged 60+ years within the geographically county of Cambridgeshire and who met CTARP entry criteria, however both had the same case number and all other variables are identical and suggests that there is duplicate data for 1 person.

Age	Gender	ISSCode	NISS	Utstein	ICD10	Outcome	DominantInjury1
78	2	4	4	1	V78	1	4 Thorax
78	2	4	4	1	V78	1	4 Thorax

This record is for a 78 year old female bus passenger injured in a non-collision transport accident and based on the injury data had an AIS2 chest injury.

East Midlands Ambulance Service (EMAS)

Requests were made to the Research lead at the EMAS however following discussions it was considered that this request for public transport users was not feasible as the data could not be easily filtered out into the requested public transport passenger categories.

Victorian Injury Surveillance Data (Australia)

A comprehensive injury surveillance system was made available to us by one of the study partners based in Australia and a separate analysis was undertaken of this data. The aim of which was to establish the potential value of a comprehensive surveillance system in injury prevention strategies. This study aimed to identify injurious events to users of public transport systems in Victoria, Australia to assist in the UK project on Improving the Safety for Older Public Transport Users. Two analyses were undertaken comprising an analysis of surveillance data (the Victorian Emergency Minimum Dataset), collected at a number of participating trauma hospitals in the state of Victoria, and an analysis of National Coronial Information System (NCIS) data in Australia. For the VEMD database, details of injuries were recorded on attendance and the patients' account of the circumstances of the accident and causation factors were noted. Data from the NCIS involved a collection of coronial data on deaths reported to the Australian coroner from 2000. The full report is attached as an appendix 4.

Police Authorities

The police complete a series of forms when they attend any notified road traffic incident. These reports are filed in case numbers making it difficult to extract specific incident types e.g. bus passengers. Loughborough University has a good working relationship with local police forces and it was decided to request access to any fatal cases that had occurred in the East Midlands as passengers on buses. An internet search was undertaken to identify any fatal bus cases in the East Midlands and two bus passenger fatalities were identified having occurred in Nottinghamshire and Derbyshire Police Force areas. A request was made to Derbyshire Police force to allow us to examine their fatal case and following security clearance checks, permission was granted and access allowed (case 1). The data reviewed consisted of police incident report forms from the scene, witnesses at the scene, expert statements and coroner's findings.

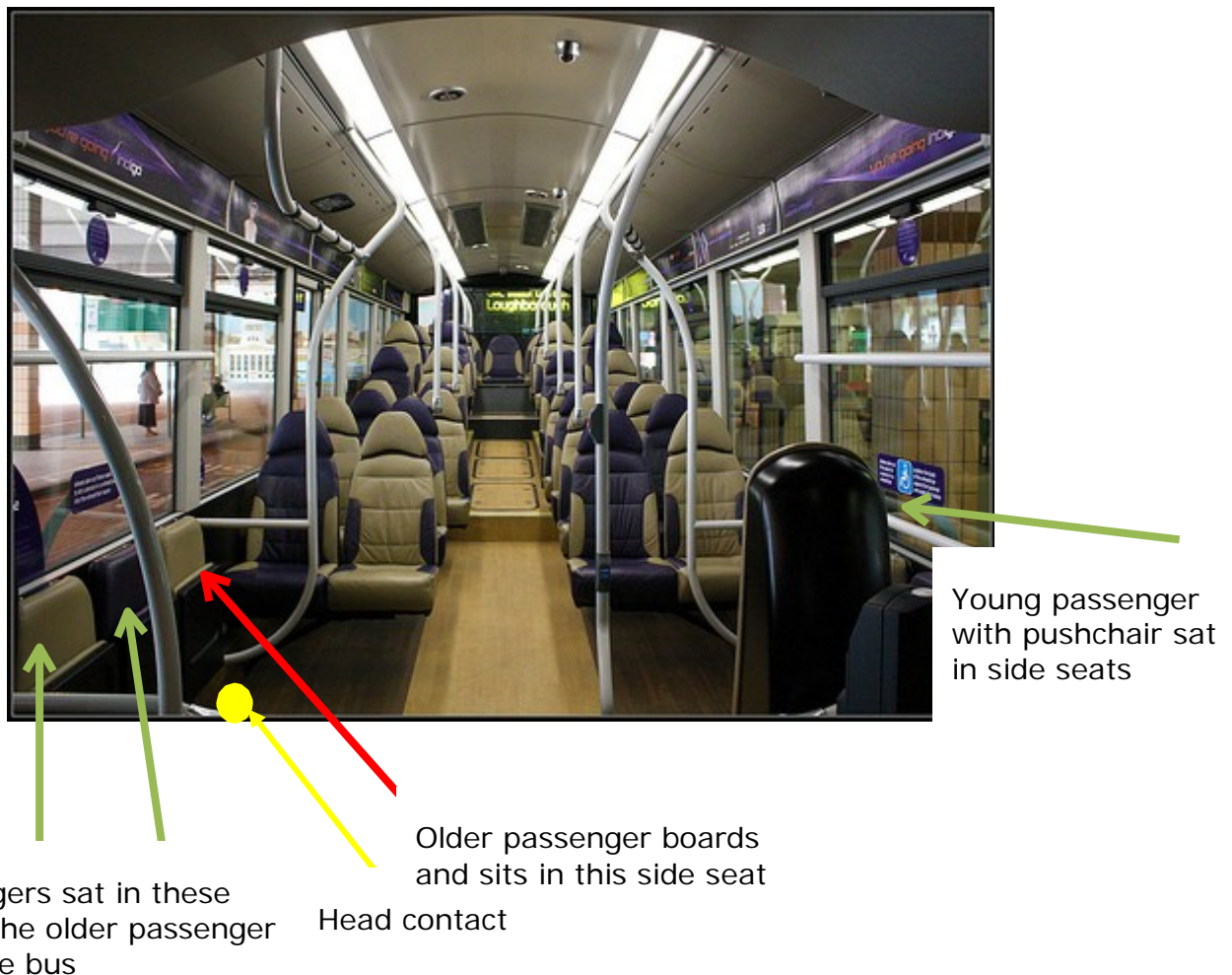
Due to data restrictions related to other studies between Loughborough University and the Nottinghamshire Police access to the full police records was denied.

However some data was shared and a discussion held about the case which satisfied the question of what happened to the older person (case 2). Post mortem reports were requested and received for both individuals.

Police Fatal Case 1

An older passenger boarded a Volvo B7RLE / Wright Eclipse Interior 704 (Indigo bus / single deck) at 10.54 sitting on the 3rd flip down side seat as the first two were occupied (Figure 10). The older passenger was holding a walking stick in her right hand and a bag in her left hand.

Figure 10 Internal view of Volvo B7RLE / Wright Eclipse Interior 704 showing passenger location



The 2 passengers sat in the side seats adjacent alight at the next stop – their seats flip back up leaving a void to the older passenger's right side. The bus then pulls away from stop and then brakes suddenly causing the older passenger to fall sideways from her seat and hitting her head on the plastic covering of the wheel arch at 10.58 only 4 minutes after getting on the bus.

Older passenger details

The passenger was an 82 year old female - slightly built and short stature (1.53m, 45kgs). Apart from some bruising to the right side of her forehead, scalp, nose and chest wall, she also sustained a fatal fracture dislocation between the 1st & 2nd cervical vertebrae with a fracture of the base of the odontoid peg.

The coroner involved in this case stated they wished 'to make a formal finding that the design and location of this seat did contribute to (name) fall. It is easy to see why older passengers would be drawn to these seats'. Further to this they proposed writing to the bus company to 'ask for them to consider the suitability and the design of those seats on that type of bus'.

Other comments relating to this incident suggested that the 2 single side seats forward of the side seats and the first after boarding are too high because they are raised over the wheel arches and difficult to access. Therefore the first seats that are easily accessible are the side seats but are in an upright position which encourages passengers to "sit further forward in the seat with a potential to reduce stability and increase risk of losing balance". Also the seats are 'flat' seats with no shaping and are 'slippery' the younger passenger opposite stated they found it difficult to stay on the seats because of the slipperiness of the material surface. Incidentally the material used for the seating is leather rather than 'fabric'.

A previous incident of a fall from the side seats was noted in the records resulting in a serious injury (hip fracture).

The side seats and this particular area in the bus is usually defined as 'priority' seating for the older person or less able bodied persons and are required by the EU Directive (EU 2001/85/EC). This Directive is to guarantee the safety of passengers, it is also necessary to provide technical prescriptions to allow accessibility for persons of reduced mobility to the vehicles covered by the Directive, in accordance with the Community transport and social policies. Furthermore priority seating is considered as an additional space for passengers with reduced mobility and marked accordingly. However accordingly to the EU regulation 107 a priority passenger is not just an older person but means all passengers who have a difficulty when using public transport, such as disabled people (including people with sensory and intellectual impairments, and wheelchair users, people with limb impairments, people of small stature, people

with heavy luggage, older people, pregnant women, people with shopping trolleys, and people with children (including children seated in pushchairs).

Police Fatal Case 2

The other fatal case involved an 86 year old man who boarded a double decker bus and climbed the stairs to sit down (65kg and 170cm tall). The CCTV shows the man at the top of the stairs reach for a handrail but misses (the bus is moving off at this point) and then falls down the stairs. This fall resulted in serious chest injuries – including 10 fractured ribs on the right side of the chest and a further five fractured on the left. Although the injury itself was not fatal the consequences due to compromised chest capacity resulted in his death some 10 days later from infection.

Summary of other data sources

The data from other sources again varied between databases due to set criteria fit for their purpose. It was further evident that 'searching for', 'identifying' and 'selecting' particular cases of interest was difficult for the various data sources identified. It is further highlighted that many bus passenger injuries fall below the radar because they are considered as 'falls' or categorised as 'RTA' but not further specified into road user type.

The fatal police cases identify the importance of using detailed 'real-world' reports to aid in the study and understanding of injury causation. The assumption exists that both these fatal cases would have been reported as falls however it is apparent that there is more to understanding injury causation than just what the bus was doing and also the limited 4 options of passenger locations in STATS19. The specific detail particularly in case 1 identified the bus interior type, seating material and seat used and also potentially identified a reason why they chose to sit there rather than the immediate 1st two inaccessible seats. Without the extra data from the records we would not have these details to identify what seat the passenger was sat on or what happened on the stairs which appear to be important factors in identifying what caused the person to fall. Only understanding the causes can we design solutions however this requires the collection of data beyond STATS19 and an extension of what bus companies currently collect.

It is expected as these cases were fatal, they contained more detailed records about the incident - however all police reported incidents have at least some of

the information needed for example where they were sat on the bus, some narrative of the cause leading up to the incident and basic injury information. Thus, there is the potential to obtain police records for all incidents to help further the understanding of the causes of injuries to older people on buses. However this would require a number of confidentiality agreements with police forces to be in place before such data could be routinely collected. However, as part of this study it was found that one police force is considering handing over the investigation of bus incidents to the local council.

Key Findings

- There is discrepancy in the data to establish the actual cause of injury and passenger location at the time.
- 70% of incidents do not attend hospital although an injury has been sustained in a proportion of these cases (60%).
- Bus company data is varied and incomplete and difficult to obtain
- The bus company data identified the difficulty in monitoring injury and injury causation using only the quantitative data as the narratives were required to provide more evidence but even then these are not detailed to complete the whole bus passenger incident
- Knocks, trips or falls are recorded as the most common incident type however the cause of these falls is not identifiable in the bus company data and cannot be addressed in any injury prevention strategy.
- Missing data for passenger location and cause of incidents for over 70% of bus company incidents renders it difficult to address injury causation
- The benefit of the fatal incidents identified the rich source of injury causation data that is captured in various written reports for example witness statements, CCTV and injury type from post mortem data. This acts to illustrate there is potential for complete and reliable data about incidents to be captured for 'Serious' casualties, however this detailed data capture is not routine for STATS19 or bus company data.

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Department for Transport 2004
Instructions for the Completion of Road Accident Reports – STATS20

European Center for Injury Prevention, University of Navarra
Algorithm to transform ICD-10 codes into AIS 90 (98 update)
version 1.0 for STATA Pamplona, Spain 2006

Abbreviated Injury Scale 1990 (1998 revision)
Association for the Advancement in Automotive Medicine; Des Plaines Illinois

Directive 2001/85/EC of the European Parliament and of the Council of 20 November 2001 relating to special provisions for vehicles used for the carriage of passengers comprising more than eight seats in addition to the driver's seat, and amending Directives 70/156/EEC and 97/27/EC

Regulation No 107 of the Economic Commission for Europe of the United Nations (UN/ECE) — Uniform provisions concerning the approval of category M2 or M3 vehicles with regard to their general construction

Stakeholder Consultations – Industry

Consultations were held with stakeholders to explore issues relating to injury, data and needs relating to travel using public transport.

Aims

- Identify current accident / injury database existence and usage
 - To ascertain if and how injury data regarding passengers is currently collected and the extent and nature of that data.
 - If data is collected what is it currently used for by stakeholders.
- Explore the potential introduction of a new national database
 - To gain stakeholders opinions as to whether a national database would be useful to their organisation.
 - To gain stakeholders opinions as to how they would use a national / local database of accidents/ injuries incurred by older users whilst using public transport
 - To provide stakeholders with an opportunity to discuss what type of data they would like to be collected
 - To provide stakeholders with an opportunity to discuss any concerns regarding the data collection and how the data could be used.
- Obtain opinions / views on accident scenarios involving older transport users and potential solutions
 - To gain stakeholders opinions on the nature of accidents incurred by older users, causes and solutions.

The consultation process aimed to involve stakeholders from within five key groups these included;

- Vehicle manufacturers
- Vehicle Operators
- Passenger Transport Executive Groups (PTEGS)
- User groups
- Industry groups

Stakeholder consultations were not constrained to the Midlands and were broadened out to the whole of the U.K to gain feedback from all potential stakeholders on the development of a National accident/injury database. Table 22 presents the stakeholders that were identified and contacted.

Table 22 Stakeholder Groups Contacted

Manufacturers
Plaxton
Alexander Dennis
Wrightbus
Operators
Trent Barton
Arriva
First Buses
NetTrams
Passenger Transport Executives (PTE's)
Transport for London
Transport for Greater Manchester
Centre
Metro
Strathclyde
South Yorkshire Passenger Transport Executive (SYPTE)
Industry Groups
Confederation of Passenger Transport
User Groups
Transport for All
Passenger Focus
Age UK
Disabled Persons Transport Advisory Committee (DPTAC)

Method

Interviews / online questionnaire

Initial contact was made via a telephone conversation. This point of contact was used to gain access to the most relevant person within the organisation. An informal interview was then conducted to explain the nature of the research and to gain initial insight to any issues regarding data collection of accident / injuries involving older passengers. This was then followed up with the completion of an online questionnaire to formally record respondents' comments / views. The online questionnaire provided a structured approach to data collection and provided stakeholders time to think and reflect on the relevance / problems they perceived to be associated within their organisations, in terms of collection and use of accident / injury data of older passengers. A copy of the online

questionnaire is presented in Appendix 5. Furthermore, contacts made via telephone conversation with the Passenger Transport Executive Group and the Confederation of Passenger Transport resulted in these contacts volunteering to distribute the questionnaire direct to other people within their organisation they thought of relevance to the study. In the case of the passenger transport Executive Group the online questionnaire was forwarded to the other 6 participating regions and in the case of the Confederation of Passenger Transport this was sent out to their Safety and Claims and Insurance Committees. Therefore exact numbers regarding questionnaire distribution are not available.

Presentations

Contact with the Passenger Transport Executive (PTEs) resulted in an invitation to the project team to present at the PTEs Health and Safety Group's quarterly meeting in July 2013. A presentation of the research was made followed by a round table discussion and further support was offered to the study team and a return invite to present the findings in January 2014. The issue of data access was discussed and the potential of developing a standard data collection protocol which would enable a database to be populated and used for injury prevention in the future was well received as a valuable tool.

Results

Number of respondents

Eight telephone interviews were conducted resulting in 18 online questionnaires being completed. Response rate could not be calculated as the actual final number of questionnaires distributed is unknown due to the agreement for some contacts to forward the link to the questionnaire to other interested or relevant people within their organisation to complete.

Respondents: Types of organisation

Participants from the following stakeholder groups participated; Operators (n=4), Manufacturers (n=4), Suppliers (n=1), User groups (n=3) and the Passenger Transport Executive Groups (n=6) (Figure 11). The participating organisations collectively covered the whole of the UK.

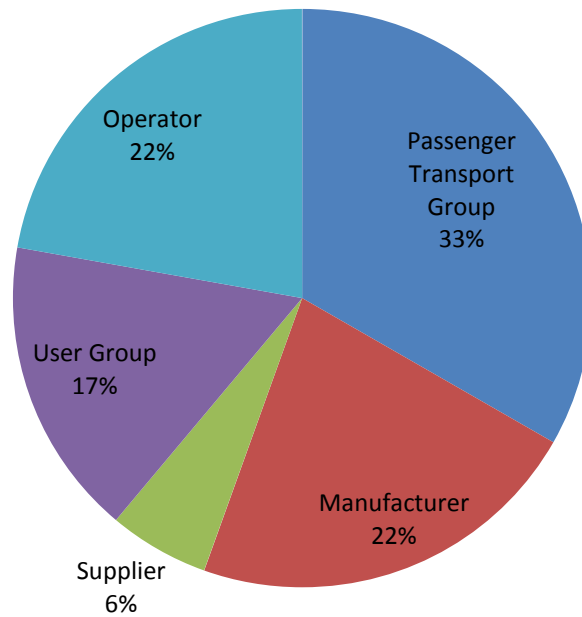


Figure 11 Number of respondents from each stakeholder group

Modes of transport

All organisations dealt with buses (n=18, 100%), and under half dealt with trains (8, 44%), followed by coaches (7, 39%), trams (6, 33%), and minibuses (5, 28%) (Figure 12) shows the types of transport covered by each type of the participating stakeholder group.

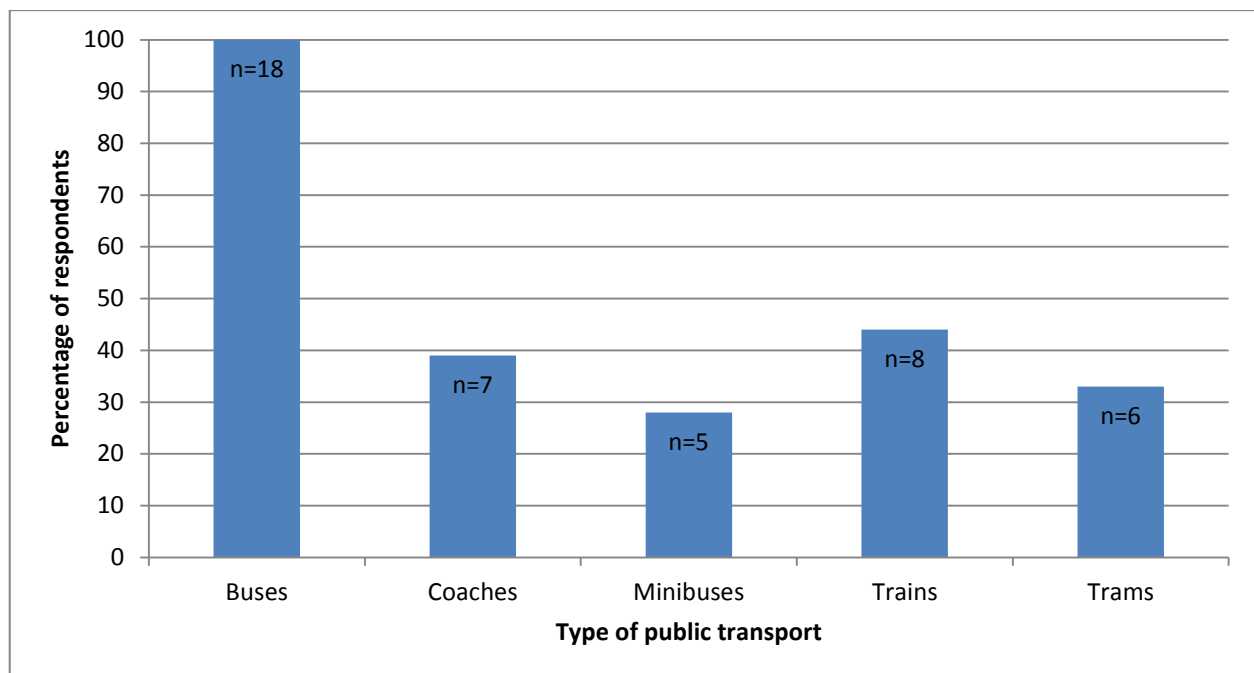


Figure 12 Types of public service vehicle respondent organisations dealt with

Current accident / Injury data collection

Figure 13 shows that 50% (n=9) of all respondents reported that to the best of their knowledge accident/ injury data of passengers was collected by their organisation. In addition two respondents (one user group and one supplier) stated that their organisation, although not collecting it themselves, did have access to other accident injury data collected elsewhere. Figure 14 presents the percentage of each stakeholder group and whether accident /injury were collected in house by the organisation or elsewhere. All participating Operators and all but one respondent from the Passenger Transport Executive reported collecting data. The three respondents that reported that their organisation did not collect data or have access to data were two of the User groups and one from Passenger Transport Executive group.

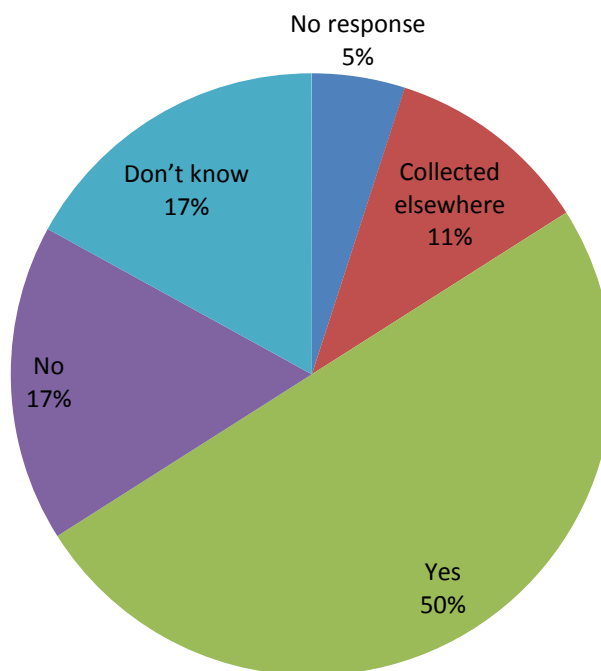


Figure 13 Number of respondents and whether their organisation collects accident / injury data of passengers

Four respondents stated that the accident / injury data they had access to was shared with other organisations. These were as follows;

- One Passenger Transport Executive Group (PTE) stated they shared the data with operators of public service vehicles and other PTEs.
- One user group said the data was put on their website for public view.
- One supplier stated that the data they had access was also shared with user groups and insurance companies.
- One operator reported the data was given to insurance companies and also to user groups.

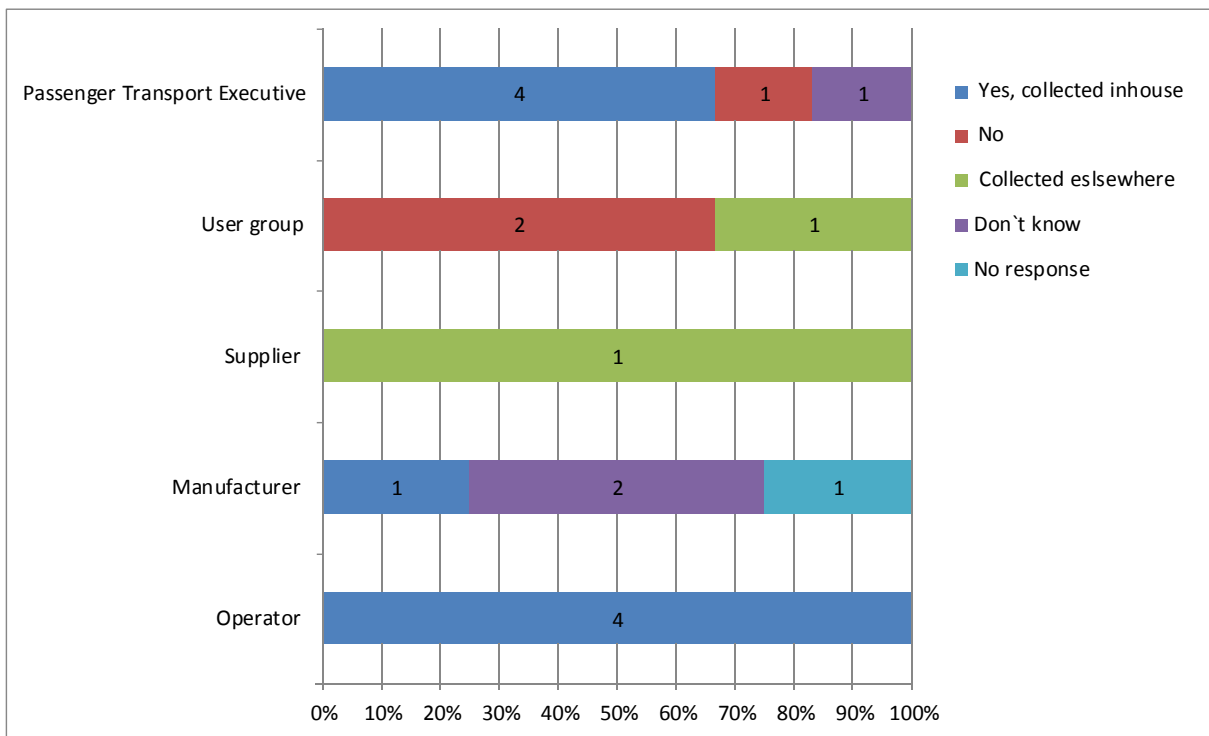


Figure 14 The percentage of each stakeholder group and whether accident / injury data are collected in house by the organisation or elsewhere

Use of current accident/injury data

The ways in which each stakeholder group currently use the accident / injury data are presented below;

Passenger Transport Executive (PTEG)

- Monitoring performance on a comparative basis bus station to bus station.
- Monitoring trends and performance against targets albeit accident/incident data does not differentiate by age or sex. Currently details of mobile older people (MOP) ages etc. are not often available/supplied.
- Evaluating safety performance and assessing risks.

- As a means to kick start an investigation.
- To identify root and causal factors that the PTEG can improve upon.

User groups

- Observe/monitor.

Suppliers

- No responses

Manufacturers

- Looking at driver and passenger safety during new product development.
- We rely on European legislation for design guidelines and standards- we assume that these are based on things such as accident and injury data, so we do not use accident/injury data directly ourselves.

Operators

- Statistical analysis for accident reduction strategies. To try and look at patterns/reasons for injuries occurring and to see if we can reduce the likelihood of them occurring in the future
- To calculate costs to the business as a result of these incidents

Insurance claims

- Annual insurance renewal

National database of accident / injury data involving older users of public transport – how useful would this be if available?

Opinions on usefulness

Overall 67% (n=12) of respondents reported that they would find a national database focusing on accidents/ injuries incurred by older users of public transport as useful. Of the remaining 33% (n=6), 22% (n=4) did not respond to the question and 11% (n=2) did not know.

The online questionnaire presented a list of suggested potential uses for the national database and asked each respondent to rate them in terms of usefulness to their organisations, results are presented in Figure 15. The results show that the five highest rated uses from the presented list were;

- To illustrate / inform the need for new vehicle design features, interior and exterior.
- Provide comparative data to assess the effectiveness of the introduction of any new safety practices/training initiatives.

Older Public Transport Users

- Provide comparative data to assess the effectiveness of the introduction of any new vehicle design features.
- To develop guidance for passengers.
- To illustrate the need for drivers to adhere to current driving guidance /best practice.

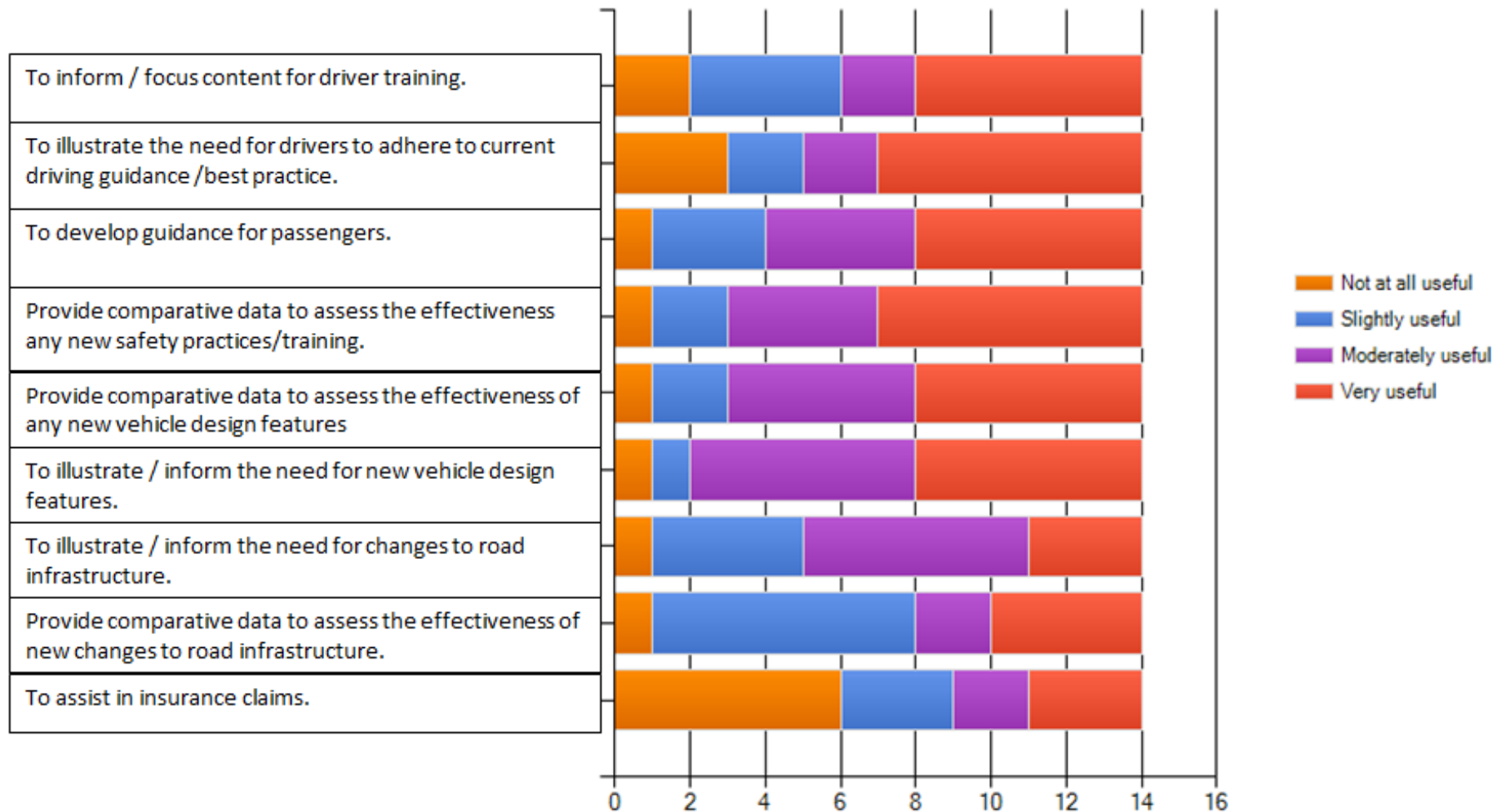


Figure 15 Suggested potential uses for a national database and percentage of respondents rating them in terms of usefulness to their organisations, from ‘Not at all useful’ to ‘Very useful’.

A follow on question asked respondents to state any other ways in which they would potentially use the data, a summary of the responses are presented below.

Passenger Transport Executive Groups

- To inform the existing risk assessment process.
- To inform discussions with representatives of that age group in order to introduce effective change.
- To establish a national baseline.
- Benchmark against similar organisations.
- Campaigns – currently Transport for Greater Manchester (TfGM) campaigns are typically one offs or a direct response to an occurrence or an identified need. It was reported that the data collected through a national database may help focus campaigns and assist in making more long term strategic plans for campaigns.
- Help promote culture change- the data/project could help illustrate the need for changes and identify areas where new changes are required or would be of benefit.
- Prevention- this would be an ideal opportunity at the moment as TfGM are currently developing and building 5 new inter-changes and have a large budget in the future development of the transport system within Greater Manchester area.
- Human factors / user trials- Currently they are finding that architects or construction are not aware of the end users, safety or maintenance issues that they need to consider.

User groups

- We work as a regional organisation and, as such, we would need data to be easily extracted from a broader national database such that we can target the specific data that is relevant to our work.
- We might potentially use data to support campaigns and policy-influencing activities should this be an area of importance to those we represent.

Suppliers

- Tailoring driver training to reduce accidents.

Manufacturers

- To influence design features and layouts.

- Data would be used in the development of new vehicles.
- Hand pole arrangements and seating layouts.

Operators

- No responses.

What data should be collected when recording incidents?

Participants were asked if they had any particular suggestions or requests as to what type of data should be collected when recording accidents involving older public transport users. Requests included were;

- Age
- Time of accident
- Type of vehicle
- Type of accident
- How the accident occurred / Suspected cause of accident
- Type of injury (minor/serious/life changing)
- Reason for injury
- Whether first aid was administered / ambulance called etc.
- How the accident was dealt with
- Whether alcohol was a factor
- Whether a walking frame or other mobility aids were used
- Respondents also provided information as to what additional information they would like collected for an investigation of a fatal accident involving older public transport users. The responses were as follows;
- Details of the Coroner's findings once known
- Driver's previous experience and accident record
- Driver training record
- Passenger - Items relating to previous experiences with public transport and the purpose of their journey

Concerns relating to a National database

The online questionnaire present an open ended question in which respondents were asked to express any concerns they had regarding;

- the collection of data for a national database focusing on older users of PSV and

- The use of that data.

A summary of the responses are presented below. Table 23 presents the full responses from each stakeholder group.

Data collection

Suggestions / concerns regarding the collection of the data included;

- Collecting the data -often there is a real problem getting older passengers to record incidents.
- Injury data-collection cannot be completely separated from issues related to access. Therefore data relating to access and actual use would also have to be collected and presented to provide a context for the data.
- need to protect the anonymity of operators and injured parties
- Data collection should not be restricted to the transport element of public service transport but should also incorporate all relevant areas i.e. in bus stations, on platforms.

Data use

Concerned that the data may;

- Be used for regulatory authorities to target specific organisations.
- Be used to make comparisons between different companies, regions, transport modes which may not be suitably matched in other areas to make such comparisons reliable.
- Adversely affect older people, i.e increase insurance costs, scare articles, etc.
- Over constrain some areas of the design
- Lead to some clashes of information i.e. the database highlights the need to change something away from the legal requirement. A manufacturer provided an example commenting that - "UK weight restriction of 18 tonnes (compared to EU of 19 tonnes) has a significant impact on deciding what safety features we can install as typically these are extra weight, difficult to maintain a balance - increase in main body weight of vehicle means a need to decrease chassis weight or make reductions in luggage allowances (but luggage allowance needs to match allowances allowed on a plane) or reduction in passenger capacity."

Table 23 Stakeholder responses to concerns of having a national database

Stakeholder group	Concerns regarding how the data may be collected or used
Passenger Transport Executive	Concerned that it may be used as a focus for regulatory authorities to target specific organisations.
	No concerns, however I do believe that this survey should not be restricted to the transport element of PST but should clearly incorporate all relevant areas i.e. in bus stations, on platforms. Often there is a real problem getting older passengers MOP to record incidents (not got time/not hurt badly/own fault etc.) and often even more difficult to get them to provide personal
	Lack of consistency in data collection methods and definitions; inconsistency in regulation of public transport systems especially buses; temptation to compare cities in spite of operational differences.
User group	If public transport wide care would need to be taken when comparing different modes. You'd also need to establish guidelines on boundaries - i.e. would accidents at the train station be included?
	I would have concerns if the data were used in any manner that might adversely affect older people. E.g. rationalising increased insurance costs for older people, articles using data to depict an unrealistic image of all older people as frail and injury-prone, scare-articles likely to deter freedom of older people's public travel. Injury data-collection cannot be completely separated from issues related to access. For example, access to the London Underground is not good for all older people so, while there is less evidence of older passenger accidents this does not
Supplier	None
Manufacturer	Potentially if it was used by operators on top of the European directive it could over constrain some areas of the design and even lead to some clashes of information i.e. the database highlights the need to change something away from the legal requirement.
Operator	You would need to protect the anonymity of operators and injured parties; otherwise unscrupulous people could use this for phishing for information for claims.

Respondent's views and opinions on accident / injuries involving older public transport users

Accident scenarios

Respondents were asked about what type of accidents they were aware of that were occurring involving older users of public service vehicles, the responses are presented below for buses and trains.

Buses

- Tripping at entrance or exit of the bus
- Falling whilst getting to and from the seat
- Falling off seats when bus brakes suddenly
- Falling over by getting up too soon or the bus pulling away before they have sat down.
- Accidents on stairs of double decker vehicles.

Trains

- Getting caught in the doors
- Slip trips and falls due to jerk rate (i.e. change in acceleration rate)
- Falls within stations

Respondents were asked whether they considered accidents on public service vehicles involving older passengers differed to those involving younger passengers. Of the 12 people that responded to this question, 58% (n=7) said 'Yes' they did differ and 25% (n=3) said 'No' they did not differ and 17% (n=2) 'Didn't know'. Six respondents then went on to explain how they thought accidents involving older users of public transport differed to younger users. One respondent commented that the accidents are the same, "they do not differ however the outcomes are significantly different, with older passengers typically incurring more severe injuries than younger passengers"- this issue is discussed more in the following section. The main reported reasons for differences between accidents involving older passengers compared to younger passengers were;

Older people are less stable- older people tend to fall over completely whereas younger people tend to maintain their balance.

Older people tend to be slower- therefore slower at getting seated.

Full accounts of the reasons reported by each stakeholder groups are presented in Table 24.

Table 24 Stakeholder groups opinions/views on how accidents involving older passengers differ to those involving younger passengers.

Stakeholder group	Views on how accidents of older passengers differ to younger passengers
Passenger Transport Executive	Older people tend to fall over completely whereas younger people tend to maintain their balance
User group	Need caution here. Accidents will be similar - i.e. falling over - but impacts of that fall higher with age.
	More frail older people are often unsteady on their feet and often take longer to take their seats on public transport.
	More frail older people can be more susceptible to more serious injury where accidents have occurred.
	Many older people are more reliant on public transport so implications of safety have greater comparative impact.
Supplier	Older passengers are slower and more infirm. Consequences for older passengers more severe than for younger ones.
Manufacturer	No response
Operator	Accidents occur more often to older users and are often more severe due to frailty of older people.
	Youngsters more mobile and flexible
	Older users are often less steady on their feet and slower to take a seat so more likely to fall than a more able bodied person.
	Poor eyesight perhaps leaves them unable to see edges of steps clearly.

Injuries

Respondents were asked if they considered injuries on public service vehicles involving older passengers differed to those of younger passengers. Of the 12 people that responded to this question, 75% (n=9) said 'Yes' they did differ and 8% (n=1) said 'No' they did not differ. Nine respondents then went on to explain how they thought injuries of older users of public transport differed to younger users. The main reported reasons for differences between injuries involving older user compared to younger users were;

- Injuries are more likely to be more severe for older passengers;
- Cuts tend to be more serious because the skin is thinner and veins more often near the surface.
- Broken bones are more likely than for younger passengers.
- Reduced ability to counteract / reduce the impact of the accident.
- Often relate to the physical condition of the injured person e.g. if an elder person stumbles on a bus they are more likely to be injured due to inability to limit the fall and the impact of the consequence of the fall i.e. fracture rather than say bruising in a younger person.

Full accounts of the reasons reported by each stakeholder groups are presented in Table 25.

Table 25 Stakeholder groups opinions / views on how injuries of older passengers incurred on PSV differ to younger passengers.

Stakeholder group	Views on how injuries of older passengers incurred on PSV differ to younger passengers
Passenger Transport Executive	Often relate to the physical condition of the injured person e.g. if an elder person stumbles on a bus they are more likely to be injured due to inability to limit the fall and the impact of the consequence of the fall i.e. fracture rather than say bruising in a younger person.
	In connection with their general fitness
	Generally injuries are of a more serious nature and usually result in more hospital cases, ambulance calls.
User group	As before - More frail older people can be more susceptible to more serious injury where accidents have occurred.
	Frail older people can be more susceptible to sprains, breaks and bruising requiring medical attention than younger passengers.
Supplier	Injuries to older passengers are more likely to involve fractures and life changing injuries
Manufacturer	No response
Operator	Injuries occur more often and are often more severe due to frailty of older people
	Younger users accident result in less serious injuries
	Cuts tend to be more serious because the skin is thinner and veins more often near the service.
	Broken bones are more likely than on younger passengers. Also I think they tend to be more shaken by the experience even if the injury is relatively minor.

Contributing factors to accidents / injuries of older passengers

Stakeholders views on factors contributing to accidents / injuries of older passengers on buses and trains were collected for buses and trains, the results are presented below.

Buses

Design factors

- Respondents reported on factors relating to the design of the bus and it's fitting that they considered to contribute to accident / injuries of older passengers on buses, these were;
- Space from kerb to boarding platform
- Hand holds
- Inability to maintain a secure hand hold whilst standing
- Distance to walk to priority seating because the wheelchair access is at the front of the bus
- Location of stanchions resulting in long distances without something to hold on to
- Seat pitches
- Lack of restraint to side of seat so can topple over sideways
- No seat in front of priority seats to break fall
- Steps /stairs
- Stairs on double decker's
- Steps on vehicles
- Time to get seated - More about allowing passengers time to reach a seat rather than specific design failure.

Other factors

- Other factors (other than design of the vehicle) reported affecting accidents involving older passengers on buses were;
- Driver attitude and behaviour - acceleration, deceleration, waiting for people to take seats
- Weather conditions

- Passenger attitude
- Heavy acceleration and braking
- Illegal parking at bus stops
- People no longer give up seats for older people who then have to stand.
- Older people often feel concern at missing their stop or taking too long to get off the bus so they stand up well in advance of the bus reaching the stop
- Bad road conditions
- Bendy roads
- Traffic conditions

Trains

Design factors

Respondents reported the following factors about the design of the train carriages and its fittings that they considered to contribute to accident / injuries of older passengers on trains;

- The gap from coach to platform
- Sufficient seating
- Inability to maintain a secure hand hold whilst standing
- Position of fixtures and fittings
- Other factors
- Passenger education
- Steps at stations.

Factors that may reduce accidents / injuries of older passengers

Stakeholders were asked to provide their views on factors / issues which they thought may reduce the number / severity of accidents to older passengers. Respondents were asked to consider; road infrastructure, vehicle design, driver training, and understanding of the problems. Recurrent factors were;

- Road infrastructure
- Reducing pot holes

- Improved design of bus stops
- Kassel kerbs – A concave kerb designed to guide the tyre of the stopping bus, to improve the alignment of the low-floor buses with the kerb for better access
- Vehicle design
- Less steps
- Reposition wheelchair space
- Driver training
- Content that increases appreciation / awareness of the vulnerability of older passengers and behavioural issues particular to older people
- Understanding of the problems
- better analysis of accident causes by age groups
- Collect data from a greater number of operators

Tables 26 – Table 29 show the full set of results for each aspect from each stakeholder group.

Table 26 Views / opinions of each stakeholder group which factors relating to road infrastructure may reduce the number / severity of accident / injuries of older passengers.

	Road infrastructure
Operator	better bus stop design Kassel kerbing Lower kerbs Better enforcement of parking and bus lanes
	Reduce the number of potholes on roads leading to jolting of passengers
Manufacturer	Better bus lanes and connecting roads so less stop start and less road bends.
Supplier	Reduce the number of Pot-holes Improved design of bus stop and lay-by's Kassel kerbs
User group	No responses
Passenger Transport Executive	Road /station layout and design

Table 27 Views / opinions of each stakeholder group which factors relating to vehicle design may reduce the number / severity of accident / injuries of older passengers.

	Vehicle design
Operator	Less steps in vehicle saloon Improved design of double decker stairs Better CCTV coverage for drivers
	Reposition wheelchair space slightly further down the bus so that the first seats on entrance can be given to older passengers
Manufacturer	No responses
Supplier	More and better placed stations
User group	No responses
Passenger Transport Executive	No responses

Table 28 Views / opinions of each stakeholder group which factors relating to driver training may reduce the number / severity of accident / injuries of older passengers.

	Driver training
Operator	more training focussed on safety for vulnerable groups such as older passengers
	Include passenger safety as a module in the CPC training
Manufacturer	
Supplier	More on-road in service assessments and emphasis on vulnerable passengers and issues such as 'recoil braking'
User group	Incorporating specific input related to older people
	Probably key for older bus passengers. Covered in earlier answers
Passenger Transport Executive	Improved understanding of behavioural issues evident in older people
	appreciation of the vulnerability of older passengers

Table 29 Views / opinions of each stakeholder group which factors relating to 'understanding the problem' may reduce the number / severity of accident / injuries of older passengers.

	Understanding of the problems
Operator	information from a number of operators will help form a more detailed picture of accidents which can only be good for helping prevent them
Manufacturer	
Supplier	better analysis of accident causes by age groups
User group	
Passenger Transport Executive	

Comparing current and past design

Respondents were asked about their views on comparing current vehicle design and working practices of public transport vehicles to past designs / working practices. Results from each stakeholder group are presented in Table 30.

Table 30 Stakeholder groups' opinions / views on what is good/bad about current/past designs of vehicles or road infrastructure and or working practices in terms of accidents/ injuries occurring to older passengers

	Current		Past	
	Good	Bad	Good	Bad
Operator	More stanchions, bell pushes, seatbelts	More exposed seating	More seating in buses, less open	Higher entrance steps
	Low floor buses	Position of priority seating		Steps at the bus entrance
Manufacturer	Low floor access			
	Legislation to determine – hand poles, ramps, priority seating	Too large seat pitches due to disability requirements	Closer seat pitches and better hand pole layouts	
Supplier	Kneeling mechanism* Low floor local bus services	Insufficient stations on some design of buses	Conductors could assist passengers	High steps on buses
User group	Rail and bus seat design has helped e.g. rounded edges	Rail – stepping distance from platform to train. Bus has part sorted this with ramps		Rail – old slam doors required you to lean out of the window to open the door
Passenger Transport Executive				

*kneeling mechanism – this is a design feature that enables the driver to lower the passenger door closer to the pavement level, allowing easier boarding for the elderly, disabled passengers, or those with buggies/ luggage.

Key Findings

- A variety of stakeholders responded to the survey and all organisations had some dealings with buses
- Only 61% had access to accident / injury data with 50% of the stakeholders collecting data themselves
- Difficult to segregate the data for age and gender for some organisations
- Incident data a useful source of information that was used for a number of different reasons. Passenger transport executive groups and Operators reported already using incident data to assist in identifying injury prevention measures (For injury prevention PTEG specifically reported using incident data to evaluate safety performance and assessing risks and operators reported using data to conduct statistical analysis for accident reduction strategies. This was achieved by examining patterns/reasons for injuries occurring and how to reduce the likelihood of them occurring in the future.
- It was considered that a national injury database would be useful resource to their organisations for comparative assessments of new design features, safety practices, passenger and driver training and guidance
- Added value would be in the future design of transport hubs for inclusivity of all age and disability groups.
- Recognise that older users have a higher risk of injury than younger users but do not have large scale evidence to support design and procedural changes
- The stakeholders offered a number of variables which should be collected as a minimum that would be beneficial in future safety programmes and strategies.

Stakeholder Consultations – Older Public Transport Users

Aim

The aim of the consultation with older public transport users was to identify their opinions, beliefs and personal experiences relating to travel and their safety on public transport. To identify data that may not be officially recorded but which might provide additional insights into the problem of injuries on public transport for the older user.

Method

The study was presented to the PPI forum for older people following this meeting and initial interview schedule was developed for the study and returned to the PPI forum for comments. Constructive feedback was received from the forum panel and consideration given to their comments it was then decided to hold focus groups rather than questionnaire/interview data collection.

Focus Groups

The benefit of using focus groups is to elicit detailed information in a short space of time using a schedule to explore the areas stated above. The interaction between participants aims to provide a more naturalistic setting to resemble everyday conversations that people may have (Green and Thorogood 2009). A well facilitated group has the feel of an everyday discussion with participants interacting and joking and arguing with each other rather than through the facilitator. The aim of the focus groups was to inform the study of issues and themes pertinent to the study population rather than derive what we considered to be problems in the questionnaire /interview format.

A topic guide was developed to incorporate the following areas for exploration during the discussions;

- Use of public transport – e.g. what type and why
- Accessibility and information

- Negative / positive aspects of public transport use
- Safety
- Travel behaviours – e.g. seat choice, alighting
- Injury incidents / experiences
- Non use of public transport – why
- Improvement to travel

Due to the pilot nature of this study it was considered adequate to target local residents to Loughborough and the researcher site to contribute to the focus group discussions. Invitations were sent out to two independent living accommodation homes within Loughborough, the University of the 3rd age, consenting subjects held on a database at Loughborough Design School as well as community adverts in the supermarkets, community centres, local library's, museum café and the University intranet (poster appendix, letter). The target audience for the focus groups was 60+ years and who were able to contribute as either users of public transport or non-users.

Two focus groups were held at the independent living homes and a third at the University all were audio-recorded with a facilitator present and a second researcher to take any notes. All participants were given a High Street Gift Voucher for their time and contribution to the study.

All participants were consented and were asked to provide some basic demographic data including, age, gender, number of days they use public transport in a week and normal transport mode. They were also asked if they would complete the EuroQol5D as this would give some indication of their current mobility status and health; however they were all informed it was not compulsory and they didn't have to complete this.

All the recorded interviews were transcribed and imported into the computer assisted qualitative data analysis software NVivo 10 to enable thematic content analysis. The selection of NVivo 10 enabled the researchers to share access to the data and code easily. One researcher carried out all the analysis and coded paragraphs and sentences under broad or specific themes and would refer back to the original transcription to ensure context was maintained. A second researcher independently coded to the main themes to ensure inter-rater reliability (Green and Thorogood 2009).

Results

Three focus groups were held over a 3 week period with a total of 15 participants.

Overall there were 9 females (60%) and 6 males (40%) with a mean age 72 years (range 62 – 88 years, SD 76.69) and males tended to be younger than females (69 years and 74 years) respectively. There were 4 non users (or very occasional users) of public transport and those that used transport regularly travelled 3.6 days a week (SD1.7; median 4 days).

Four participants did not complete the EQ5D in its entirety. On the EQ5D out of the 15 participants 6 stated they had some mobility problems, only 1 person stated they had difficulty performing everyday activities but was associated with pain that also restricted their mobility. Those participants reporting some mobility problems also reported they had some or severe pain. The mean visual analogue score for perceived health state on a 20 cm scale (0 worst health state-100 best health state) for that day was 75.9 (range 40-100). Comparing this to the UK national norms only those aged 65+ could be used (n=14) due to the 5 year category breakdown of the national norm data. The mean national norm for 65+ years was 75.9 our sample was slightly higher at 78.8 although it is a small sample to make any comparisons.

This analysis produced key themes that emerged from the focus group data. The key themes were:

- Reasons for transport choices
- Bus passes and wellbeing (positive experiences)
- Access to travel and interaction with the transport
- Passenger behaviours
- Driver behaviour
- Negative experiences of bus travel

Reasons for transport choices

All participants had a preferred method for everyday mobility with three opting for cycling most places locally, some walked out of choice for some trips but 2 had no option but walk because they didn't drive and their local

bus service had been re-routed away from their homes. Others used combinations of travel modes which could include walking to bus stops or use of private cars and public transport.

The predominant type of public transport used by the participants was the bus with the free bus pass cited as the main driver for its use. Other transport used included trains which were for specific trips usually which entailed regularly booking in advance to get the best deals, however this mode of transport was considered to be prohibitively expensive for everyday travel. Although it is considered a pleasant way to travel and with a railcard the costs can be reduced.

‘I think trains [are] just for business people, those who pay it by the company.’ An ordinary ticket to London on the train was about £85. This was seven – eight years ago when I was working. (Male 69 years, bus user)

‘you used to be able to get concession on the train and people, my wife’s disabled, so she’s got a disabled ticket, [I] used to be able to go free on the trains but not now’ (Male 66 years, cyclist)

‘I used to go to the canteen and get a coffee or a tea and that and come back and sit down. It was great, it was alright. I had a railcard so my fares were cheap’ (Female 67 years, bus user)

‘I’m a regular user of [name of train company] Oh very good, excellent, very smooth, very comfortable and very safe! Very safe transport environment you know.’ (Male 62 years, cyclist).

The participants who owned a car used them mainly for shopping trips or travelling longer distances for trips or visiting relatives. The car was considered to be convenient and added a choice in selection of transport often where there was a gap in public transport service.

‘I do use a private car but it’s very few and far between, yeah, I have it purely for convenience as opposed to essential journeys’ (male 65 years cyclist).

'well I've given up because it takes so long, what with waiting and coming to [name of town] via every little back street, by the time you get here you ...think, oh no I don't have to come back, when I go back it's the same thing, then it's a long walk to where I live from where the bus stops in [name of town], so I'm afraid I'd rather drive'. (Male 66 years car)

'I use it for a specific journeyI drive there on a Saturday, she lives just at the end of the [route number] route, so just hop on the bus into [name of town] spend the afternoon in [name of town], exploring and whatever, there's lovely book shops and everything, and come back the same way'. (Male 66 years car)

There was one lady who was totally reliant on the generosity of car owners in her building to take her out if she needed any shopping, otherwise she wouldn't go out. The expense of taxis precluded their use and an incident on the bus has prevented her using the bus for the past year

'Anyone that would take me out! It's true! As long it's got wheels.' (Female 89 years reliant)

'I think a lot of people couldn't afford to go could they? I mean I couldn't afford taxis, if no one took me, I couldn't afford taxis, I admit I couldn't.' (Female 89 years reliant)

Taxis were considered a necessity for a particular reason at that time because they are expensive but were considered invaluable if for any reason they were required due to mobility limitations or requiring door to door service.

Only two participants used the community transport provided by a local charity which picked them up and dropped them back at home following attendance at the Centre including a 3 course lunch. This was fee paying but considered to be great value because lunch and a social activity were included with door to door service for £4.20.

Coaches were seen as a holiday mode of transport as concessions were available for travel although considered to be a time consuming way of travelling.

'When I've been on holiday; You do get concessions on the ...[coach] It's a long journey though.' (Female 76 years bus)

Trams as a travel mode had a mixed response as many hadn't used them although those who had used them by choice thought they were smooth, clean and comfortable modes of travelling. However others considered them to be a 'peculiar transport system' although they had never been on it.

'I'm a bit wary about that, it seems a peculiar transport system to me. I've never used them, I've seen them running but I've never actually used them.' (Male 66 years, bus)

One participant used public transport extensively to travel beyond the local area and expressed good examples of integrated travel modes in a particular City where you can go between trains and trams without walking more than 50 yards.

'you know it's fantastic, the interchange there. It obviously cost a lot of money but it's good' (Male 62 years cyclist)

Buses were the predominant mode of public transport used by the participants and the main driver for their use was the free bus pass. Nearly all the participants used buses on a regular basis with a few using buses infrequently through choice or enforced due to bus services.

'I'll walk to town and then always get the bus back but I don't walk back as well,'
(Female 67 years, bus-walk)

'I do occasionally use the buses, not a great deal, it's either walking or my bike' (Male 62 years, cyclist)

'Legs, because we don't have a bus where we live. I don't use it to go to [names of city], but I would use the local one but we don't have one' (Female 79 years, walk)

Bus passes and well being

The participants used buses because it was free to travel and considered to be a 'great advantage / help' and nice that they 'got something back after paying taxes all their life'. Most of the participants used public transport more

since having the free bus pass for essential everyday trips and leisure travel.

‘Not a lot (BEFORE) Well a couple of times a week probably, but now we can go out every day’. (Female 76 years bus)

‘Well I never travelled on a bus for I think decades practically till I got my bus pass. It’s quite an adventure going ...’ (Male 66 years car)

‘It just gives you the freedom to do it. I mean failing that, people would be confined to this block and they would, well they might have the personal friendships but you wouldn’t see the wider world at all and you’d be, I’m sure there would be depression set in and other things like that. If you went to (City name) on the bus, pay the full fare is about, over £6. £6 return, you wouldn’t be able to do it ... You couldn’t do it.’ (Male 69 years, bus)

The freedom of the bus pass enabled the participant’s to have a change of environment, ‘you can go somewhere where you probably wouldn’t probably go’. The option exists that they can go out every day is used recreationally to wander around or go out for a run. The use of the bus pass also made economic sense and a person stated they wouldn’t drive even if they had a car.

‘as I say I use it [bus pass] quite a lot, but now I use it almost recreationally, do you know what I mean When I don’t really have to! .. , if I think oh I want to look around the shops in [name of city], I’ll get the [name of bus] I don’t have to do that but ... I wouldn’t have done that if I had to pay’ (Male 62 years cyclist)

The bus pass opens up a lot of possibilities for the user it gives them freedom to get out without having to pay. Many wouldn’t get out much if they had to pay the fares as they ‘couldn’t afford it without a bus pass.’

‘Yeah of course it does,..... there’s a lot of old people that before passes came along, never left their homes. And now it’s like everybody that gets on, I don’t think they [bus companies] make much’. (Female 81 years bus).

Bus passes were perceived as a 'social' pass allowing older users to develop and maintain social contact with friends and acquaintances and also provided a change of scenery that was considered important to prevent social isolation that could lead to depression.

Access to travel and interaction with the transport

Access to the buses was considered to be good with most people having a bus stop within easy walking distance; however there were two ladies who did not have access to the local buses as the route had been changed.

These ladies had to walk to and from town to do their shopping despite appealing to the bus company to re-instate the route. Their walk one way took one of them 15 minutes but the other stated it was twice as long for her. There were also issues with some bus stops which are maintained by the Council and an overall desire for a bus garage to be re-instated in the Town Centre.'

'(City name) Bus Station's brilliant. You see you get more information, you know exactly where you're going, you know, you've got the offices there that you can go in and get your timetables and what have you' (Female 68years walk)

'It's a pity there's not a central bus station really' (Male 76 years car)

'there's no bus station, there are buses everywhere. And I think that's, well apart from causing a lot of congestion, I think that's dangerous for well pedestrians, town users, shoppers' (Male 62 years cyclist)

'Another thing around bus stops, the surface is not very good, especially for elderly people (male 76 years - bus.) It's peeling off plus. The surface is peeling off. And the council should be doing something towards it. If it's my shop, private shop, and they park bus one after the other, it's not good for me. And we should have a bus stop (station) with a nice café, because it can be a very sort of social place, people can sit' (Male 76 years - bus)

One lady had fallen at this particular bus stop and tried to report it to the local council office but was told she had to go the main County Hall which is some 12 miles away and would involve 6 buses for the round trip.

'I fell all my length there about two, three months ago because the holes in the pavement where the road's been patched up, the pavements have been patched up and my wheel got stuck in a hole, so I was outside the Nationwide, yeah and the Halifax ... Yeah, there's really holes you know that size, and I got toppled - I fell, my (walker) and me. And I know because I'd just had my trouser suit cleaned and it was a wet day. I didn't report it. ..Well I went to the council and I said, look, can something be done about that strip outside the thing and they said, oh you need to go to County Hall and I thought, oh well no chance of that you know.' (Female 76 bus)

Access onto the bus itself was not usually a problem particularly with the lower floors and the ability to just walk on with a walker although some kerbs had not been raised appropriately and it was difficult at certain bus stops to wheel a shopping trolley on and off. However once on the bus there were other obstacles to navigate round and this was difficult with a walker.

'Well here it's a very good bus service, you know, every half hour in the weekdays from here, so just down, we're down the cycle path there. So it's very handy.' (Female 76 years bus users)

'(If the bus has steps) Just fold it up (the walker) and lift it on, yeah. Well it's very seldom that happens because as I say, with the (company name) buses that come here, and you're off and on, you just wheel on you know.' (Female 76 years bus users)

'This is where the problem comes because I have a trolley, shopping trolley between us, so we help to share, lift it up. And the bus conductors, bus drivers, they don't park close enough. There's a kerb which has been raised up and they don't park up to there to make it easy for the passengers to climb up. They don't park near enough to the kerb' (Male 69years bus user)

'I know things have got to move with the times but it used to be you got on a bus and you could walk to middle or back, just walk, now there's a step up, halfway up there's a step up and then there's another step up. You know and I've seen people fall down there, elderly people.' (Female 76 years bus user)

'Well they forget, they're thinking about the old buses where you just walked up and sat down wherever you wanted to. Now there's, halfway up there's a step and then there's

another high step. And the steps are high. Yes, yes, I've helped them'. (Female 67years bus user)

'Sometimes I have to walk along sort of diagonally, going like that (motions crab like walking from handrail to handrail), to come to the front as we're coming up to the stop you want. Also I think there's somebody's there, perhaps their hair's on it, so you're afraid of grabbing hold of the hair' (on the back of the seat rails) (Male 66years car)

Pushchairs were an issue for the older bus users as they took up space near the front of the bus and blocked the aisle making it difficult to negotiate a path to the seats and for one created an injurious incident. One or two pushchairs were considered to be a sensible number as they can be tucked into the allotted space whereas more than that stuck out into the aisle without restriction of the number.

'there's always a lot of prams, yeah' (Female 63 years bus)

'Sometimes I think there's too many pushchairs you know on one bus: Nobody can get off at the next stop or the next stop,' (Female 67 years bus).

'Because if anybody came on with a (wheelchair), and they're as entitled to be on wheelchairs as pushchairs, they could never get on' (Female 63 years bus)

'I went on the bus but I had a problem when I caught my leg on the perambulator that's in there. And they're in the passage ... The prams that are in there, they've got big wheels and everything ...and then one lady said, well we're paying for our seats, you get them free. So that's why we've got prams ..., I hadn't got my walker with me... I'd got a stick ...I daren't take my walker. Because there's about two or three, I don't know whether anybody knows, it's two or three prams go on the bus, if you go on the bus ...that's what stopped me going on the bus. I bet I've not been on the bus for nearly 12 months. But I caught my leg and I had a terrible leg, last year. And I thought, oh well I can't go on again I mean I'd love to go on the bus, to take my walker so I can put shopping on but I can't, I couldn't, I wouldn't go on the bus even with a stick, that's when I got my leg caught' (Female 89 car-reliant on others).

Passenger behaviours

Seating choices

Where someone sat was a conscious choice and was dependent on a number of factors whether they were carrying shopping and also the seats available when they got on. Preference was shown for the forward facing seats at the front of the bus and sitting down as soon as possible.

'If I could, [sit near the front] yeah. There are too many steps near the back!' (Female 81 years bus)

'I prefer near the forward [or the] middle [but rear] is too swaying' (Male 76 years bus)

One participant would select a seat based on the fact it had a bell push to signal for the driver to stop the bus as not all seats have this facility. They further thought the best option was to sit down as soon as possible.

'One thing I hate is when you've got on in a bit of a hurry, the best thing to do is to grab hold of something solid, then sit down as soon as possible' (Male 66years car)

The flip down sides seats were only a choice when they had heavy shopping or a shopping trolley or a walker even though some felt unsafe and thrown around and had nothing to hold onto.

'I'm not bothered, no. I do on my trike [walker] you know. They're hard on your bum aren't they' (Female 76 years bus).

'If I had heavy shopping sometimes, if there's nowhere [else to sit]' (Female 73 years bus)

Others avoided these side seats because they considered them unsafe and often were unavailable because of the pushchairs parked there. The pushchairs further created problems because people had to negotiate a path round the pushchairs before they even got to a seat.

'They're not very safe to sit in the flip ups ...If they jolted they would go forward wouldn't you? You've got nothing to hold, there's nothing to hold on ...If there wasn't another one, yes I would ...if there wasn't another seat' (Female 63 years bus-walk).

'I wouldn't choose but if they was the only one available, yes I would. I just prefer the other ones. If it does jolt, you get hauled off,' (Female 68 years walk).

Going upstairs on the bus for a seat was only a viable option for two of the males who liked the view, everyone else always sat downstairs or if there wasn't a free seat would 'take their chances' standing than risk being thrown whilst traversing the stairs.

'No [I wouldn't go upstairs], you're going from side to side (Female 73 years bus)

Yeah, I'd rather stand and wait for a seat as well, rather than climb them stairs. If the bus jerked and you were just coming down the stairs say or something, or going up, oh no' (Female 65 years bus-walk).

'I think it's, when getting off, obviously you're not going to sit there until the bus stops and walk down the steps because I think the chap would, the driver would probably start off again ...and so you've got to be walking down the stairs while he's decelerating' (male 66 years car)

'I wouldn't risk going upstairs. It's coming down ... holding on and if the bus you know suddenly stops or he does stop, you, you know, you're pshh, you're down aren't you?' (Female 66 years walk)

The preferred option to stand downstairs was given for all of the participants who said they would not go upstairs and would hang onto handrails or wait for a seat. Many lamented the fact that no-one gives up their seats anymore to allow the older people to sit down but also felt that they shouldn't have to ask either.

'There could be half a dozen children sitting down, with these girls that have got them all and they will not say to just one of them, get up and give that lady a seat' [Female 63 years bus]

'And there are people sitting there and they've got one in the pram and toddler and the toddler's sitting in the seat and there's no way they're going to say... stand up and give this lady a seat you know ...' [Female 67 years bus]

'No they won't do that nowadays' [Female 63 years bus]

'That doesn't happen now dear!' [Female 81 years bus]

'You shouldn't have to ask should you?' [Female 67 years bus]

'I've had to ask them to move when I've got on [Female 89 years car]; that's all gone now, all gone.'

'A free for all getting on the bus, but they don't give up their seats' [Male 69 years bus]

Alighting and boarding

Alighting buses identified mixed behaviours with five of the participants stating they rang the bell and always waited for the bus to stop before they got up. For the others their choice was dependent on factors such as where they were sat, whether they had shopping bags, previous experiences or was a matter of routine for them.

'Primarily because there was an occasion last year or 18 months ago and the bus was absolutely 'chockablock', it was that crowded you could hardly move. And I was towards the back end of the bus and the bus was stopping at the stop I wanted to exit it from ...and it took me ages and ages, I was literally fighting my way through the people who were standing, and it was full of school children as well, and a lot of elderly people, and we had to ring the bell at least twice to make sure the driver stopped, maintained his position at the bus stop so people were exiting, because he didn't know who was coming off, who was getting off, who didn't want to get off, it was that crowded.'

So as a general rule I usually get up prior to him stopping, yeah (and hold onto) the vertical upright, the vertical pillars. No I take my chances '(Male 69 years bus)

*'I get up before, to make sure I get off! You know in time. I wait for it to stop if I've got shopping. I get up, but if it's me and my bags, that's it, I'll sit there till it stops'.
(Female 69 years bus)*

'There are normally a few people, I'm never normally the only person to get off, so I would wait till it stopped. But sometimes I don't' (Male 62 years cycle).

Interestingly one of the participants says she tries to stop some of the older users from standing up too soon because she recognises the risk of falling and has witnessed people getting hurt.

Well I do it, I hate, I've said it to you (name), elderly people panic, but they've rung the bell and they know they've a wee bit to go between stops. And they get up, and I say to them every time, I know it's none of my business, because I've seen people fall and be badly injured, wait till the bus stops. Because I sit with my shopping until it stops.

.....But it's this, older people can be their own worst enemies, I'm sorry!' (Female 63 years bus)

'... because I think that's when most accidents will happen I would have thought, if people are standing up and getting ready to get off and it stops suddenly for some reason There should be a sign saying you know stay in your seats until the bus stops ...' (Male 62 years cycle)

Boarding the bus was seen as problematic for a few people and they had observed that bus drivers didn't wait for people to sit down before moving off from the stop.

'but older people you know, who struggle on with their shopping bags and they don't give them time to sit down' (Female 63 years bus)

'No they don't' (Male 62 years cycle)

'the best thing to do is to grab hold of something solid, then sit down as soon as possible .. (I shut the window for an old lady but the bus) it took off like a rocket and I went flying down the bus, you know'. (Male 66 years car).

'Well I have to try and sit down quickly or at least get the pole to hang on to' (Female 73 years bus)

'They pull off before you're sitting down and that ..(I don't ask them to wait) No, I might get a rude answer' (Female 76years bus user)

However others reported that the driver always waited for them to sit down and possibly may be because of the frequency they travelled the route and also they used a walking aid which might make the driver more aware of their needs.

Bus drivers

Opinions about bus drivers fell into the appreciated and sometimes sympathetic category or they were slightly despairing of them. Some of the participants use a number of bus companies and compared their contrasting experiences.

'I don't really think on some routes, in some companies, they're not interested, the drivers are not interested and they're there to give you your ticket, end of story.

I mean when we got on that one that waited, and I looked at my (friend)... he's waited, he said I know he did, we were so surprised.

'I find the worst company is the (name of company) they need to send their drivers, all their drivers to charm school. but older people you know, who struggle on with their shopping bags and they don't give them time to sit down.

I've been using them (name of company) for about 18 months now and they're smashing, you get on, they say good morning to you and sometimes they pass the time of day if they've got time and you've got a smooth ride from here to (name of City), no problem.'
(Female 63 years bus)

'That bus driver today though, he was a very nice driver and he was saying hello to us all, which I thought was lovely because we don't normally get that, we don't normally get that, I was so surprised today.' (Female 67 years bus)

'(Company name) They used to be lovely drivers. Really good drivers and helpful, but not now Whether they've got the time limit or not I don't know, you know like, they used to be so helpful but now they just haven't got time to' (Female 89 years reliant)

'(they drive off) before everyone's sat down. And sometimes if people, you know, they'll stop a bit suddenly at a stop and if you happen to be standing up at that time, you really have to grab on to something otherwise you would, you'd fall' (Male 62 years bus)

'(Female drivers) they're more understanding, more sympathetic as well. If they can see someone struggling to get off, you know, they, if someone hasn't got up from his or her seat until the bus has stopped and they're at the back(!), it can quite a long time for someone who is very old to get to the front'. (Male 62 years bus)

'Because they whizz round the bends and throwing people all over the place. Well not actually off the seats but throwing you from, you know, you have to hold on to the upright bars, you know, the upright supports things to ensure you don't get thrown off

the seats really. Well it's not perfect but it's better than nothing. I mean had they not been there then, you know, for most people well I would have been on the floor myself on several occasions, off the seat's (Male 69year bus)

'And I don't know how fast they go, they race these drivers, you're sitting on the bus and you're like this if you're going round corners' (general agreement)

'My husband used to be a bus driver and they always say he should go back into driving school. Yeah, you can't help it you feel battered and bruised! I've seen them slamming back and forward yeah' (Female 81years bus)

'..and he waits for people, and they don't even have the decency have the decency to say thanks for that. So ... and that's true, and I've seen that happen a lot. Now it costs them nothing to say thank you for waiting' (Female 76 years, bus)

'but sometimes it's not their fault, if they have to stop suddenly, if some, you know if some, if the car in front of them stops suddenly or someone pulls out in front of them and they have to step on the brake, that's when it's dangerous because if you are stood up, if you are standing up, and that happens, you don't stand a chance really if you're quite elderly and get catapulted forward. Sometimes it's just bad driving,' (Male 62years bus)

'So I mean on occasions drivers leave a lot to be desired and on other occasions they take an awful lot of stick from the public which they don't deserve. So it's swings and roundabouts I suppose really' (Male 69 years bus)

Negative experiences

Most of the negative experiences for the participants related to the attitude of other passengers and often the driving skills of the driver. Often other passengers were perceived as rude particularly the younger passengers who did not give up their seats for them to sit down 'like the old days'. Other factors were the obstacles in the aisles which made it difficult to traverse the aisles to a seat. Some passengers became annoyed that social etiquette was often ignored but most would not say anything to the other passenger for fear of reprisals.

'I would have done (said something) when I was young. I just ignore it now' (Male 76 years, bus)

'The thing that gets me is people who aren't disabled using disabled seats, because you get some people go past and then you could get a couple of quite young people on who obviously are not disabled and they just, the nearest seat to the front, just plonk themselves there and that's it, you know, and it's like nobody, this is England, nobody dares say anything to them you know. The driver doesn't say anything, nobody says anything, the driver wants a quiet life' (Male 66 years, car)

'The mobile phones get on my nerves ... You know they're not very nice, because I know people have them and that they're essential but you get all the, whoever's sitting about two rows behind you, you get their life story of what they're doing and what they're going to do' (Female 76 years bus)

'Well you daren't say anything; Oh no way, I'd be too scared in case they were going to pull a knife out at me. (Would you feel confident speaking to the driver?) No, not really because the poor old driver can't do nowt. I feel sorry for the drivers because I bet they get a lot of stick and all, from these yobbos' (Female 69 years, bus)

'On one occasion I asked this pair of lads if they wouldn't mind turning the music down, turning the volume down a little bit, and I got some choice words in reply. you get on the bus and then you get people coming on with bloody McDonalds parcels and they start chewing burgers ...and it's revolting, absolutely repulsive. Then they just ...they just throw the empty packaging all over the place and then, for someone else to ... I don't know' (Male 69 years, bus)

All of the participants didn't feel able to inform the driver of any incidents either because they felt that the driver would be unable to intervene and so there was no point or they would get a 'mouthful' back.

'I just felt there's no point involving the driver; he'd have got a mouthful as well' (Female 76 years, bus)

'You get the feeling that the driver might not want to be bothered you know' (Male 66 years car)

'They pull off before you're sitting down and that (but I wouldn't say anything) No, I might get a rude answer' (Female 79 years bus).

There were two incidents experienced by the participants that involved stumbles and falls on the bus.

‘I was trying to negotiate my way down to the rear of the bus because that’s where the vacancies were (lady speaking in background) ... And all of a sudden he’s veered and I just fell on the floor, just lost my balance, fell on the floor, hurt my leg....I was sore for a couple of days afterwards’ (Male 69 years Bus)

‘I went on the bus but I had a problem when I caught my leg on the perambulator ... And I thought, oh well I can’t go on again’ (Female 89 years reliant)

The former incident wasn’t reported to the bus driver also the person felt that the bus driver was not even aware that the incident had happened. The experience didn’t put him off travelling on the bus *it’s a question of you either use the bus or you don’t use the bus*. In contrast to this a female participant had not been back on a bus since lacerating her leg on a pushchair in the aisle. There were a number of incidents witnessed that could potentially have caused injuries and others had heard of incidents happening to friends or acquaintances.

‘Some people stumble but not fall, sort of catch something or, right themselves, steady themselves from falling actually’. (Male 62 cyclist)

‘I’ve seen various incidences of people being thrown about, yes, and banged their heads and banged their face and the drivers who are obviously very concerned about it. I also, a friend of mine was on the bus, I don’t know a year ago, a couple of years ago, and the bus went round a particular roundabout quite sharply and this person was sitting on one of the front seats, was thrown on the floor and he cracked his head and he knocked, I understand he knocked himself unconscious and they had to call an ambulance, he was taken to hospital’ (Male 69 years bus)

The participants identified potential areas which could be an injury risk to older passengers.

‘Well obviously, usually it’s when people ... when the bus is moving away and people are trying to make their way to the seat, then they get thrown about, especially if they’ve got baggage, they can’t grab an upright support if they’ve got baggage you see, and they’re trying to sit down and they’re sort of half on the seat and half off the seat and the bus goes and they usually, well they usually either finish on the floor or struggle to maintain their, some form of equilibrium and sort of bang themselves about, which is not pleasant’ (Male 69 years bus)

'Well there's a seat evidently, a front, a single seat sort of adjacent to, on the other side of the bus, where the driver's position is ...And he was sitting there and there was no restraining facilities for him. Or he wasn't concentrating on where the bus was going and the bus went round this roundabout and he was just thrown off his seat and landed awkwardly in the aisle and whatever. I mean I wasn't there but I was told about it'
(Male 69 years, bus)

'I know things have got to move with the times but it used to be you got on a bus and you could walk to middle or back, just walk, now there's a step up, halfway up there's a step up and then there's another step up. You know and I've seen people fall down there, elderly people' (Female 67 years, bus)

'Some of them I've seen coming down and then all of a sudden bends. And you are sitting, say first seat (the seat near the window has something to brace your feet against and the other doesn't) and could be no bar on the front but instead you put your foot to stop yourself, there's a plastic sheet but there is this shape of space there, you can't put your foot there' (Male 76 years bus)

'There's nothing to stop you really, obviously the bus aisle, straight down the middle of the bus. I mean if you were standing up and the driver there just stood on the brakes then you would have to very quick to grab on to something. I think that's when you know ... I don't know what the incidence of accidents is but I would imagine that that's the sort of circumstance in which an accident, quite a bad accident could occur, someone gets flung forwards' (Male 62 years cyclist)

Key Findings

- Bus passes mean more to the older bus users than a free method of travel they provide freedom, route to social interactions, leisure opportunities, as well as the essential daily needs of shopping and banking.
- The choice of using the buses was for many their only option for transport compared to others who had various options for transport methods. However the 'free' travel was an incentive to use the bus rather than their car and many increased their bus travel following the receipt of their bus pass.
- Definite choices were made on the bus – choosing to sit near the front but not the side seats; whether to stand up before the bus stops to alight or remain seated until the bus stops completely; choosing to stand if there were no seats available rather than go upstairs.
- The need to sit down quickly after boarding the bus was recognised otherwise the driver would drive off and increased the need to hang on to something for balance.
- There was no consistency in driver behaviour or skill – some wait for you to sit down, others just drive off; speed was a problem particularly going round corners.
- Other passenger behaviour impacted on their journey experience and no awareness existed of the older passenger's needs; no-one stands up anymore; they don't thank the driver for waiting.
- Awareness of potential risks such as standing to get up before the bus stops as there was nothing to break a fall; sitting down quickly; obstacles in the aisle to negotiate before getting to a seat; nothing to hold onto in the side seat area.

If reviewed in the context of potential injurious situations the analysis identified various aspects of bus travel and how older passengers experience the journeys they make. Ultimately the older passengers want to sit near the front of the bus, be able to sit down before the bus drives off

from the stop, have something to hold onto and be offered a seat on a full bus. Most older users would wait until the bus stops before getting off however those that did stand up the choice was partly driven by the fear that the bus would not stop or wait for them to alight if they were not stood up looking like they were getting off. There were identified risks to potentially injurious situations which included standing on the bus, having nothing to hold onto and getting to the seat and the pushchairs as obstacles in the aisle. It was also noted there was a perceived difference between bus companies, bus routes and drivers in the older user's opinions of their journey.

To complement the focus group findings and to examine how older users interact with the transport and the choices they make during their journey an observational study and questionnaire survey were undertaken. Furthermore a postal driver survey was also conducted to obtain their opinions of risk factors for older users their experiences of falls / injuries and driving behaviour.

Observational Survey – Older Public Transport Users

Aim

The aim of the observational studies was to see how older users interact with the bus in 'real world' everyday travel situations to see if this varied from reported bus use. Observational studies are often considered the 'Gold Standard' of qualitative studies as it allows for naturally occurring situations in which behaviour and responses to it can be seen in situ (Green and Thorogood 2009). The results from this observational study should illustrate any differences between what happens on buses and interview data or statistical data.

Methods

The observations were non-participatory and were designed to record events happening rather than social interactions without the knowledge of the bus passengers or bus drivers to ensure their behaviours were considered to be 'normal everyday' incidences. Event coding was used to tally occurrences of pre-determined incidents thus providing frequency of incidences occurring (Robson 2002). Permission was sought from the bus companies for the researchers to ride on the buses and record their observations. The companies offered free company travel passes but these were declined, so the researchers were perceived as passengers ensuring the drivers were unaware of the researchers presence and would drive as normal.

Observational studies were undertaken on 10 bus journeys incorporating 4 different routes and included town and city travel and double and single decker buses. These were on 2 consecutive days incorporating a market day which is a known high use day for the older passengers. Two researchers travelled together and collected data on pre-designed collection sheets, one journey was used to pilot the survey tools. Each of the researchers had one of two pre-set data collection sheets where they observed set incidences rather than trying to observe every incident occurring and the results could be combined at the end to record the frequency of all events happening. Older users were defined as passengers who boarded the bus using a bus pass as payment for their journey.

Results

A total approximate number of miles travelled were 104, and the total number of stops on the routes was 658. Four of the journeys undertaken had to be estimated using Google as the company did not publish route miles on their websites nor respond to the request for the information. Only 27% of the bus stops were stopped at during the observational studies. Overall 313 people were observed boarding the buses and 147 of these were considered older users – defined by the use of a concessionary pass to get on the bus. All of the bus journeys were undertaken in the mornings and completed by 14.30, all morning journeys commenced after 9.30 apart from 1 which was the pilot journey which commenced at 8.22. This was a long journey and older users did use this bus but in a smaller proportion to the other journeys undertaken (9%). On average just under half of the observed bus users boarding were older users (47% n=147).

Three people were observed to have difficulty getting on the bus and also then had to manoeuvre round obstacles, however no-one asked the bus drivers to wait before they sat down. For 12% (n=17) of the older users the bus had accelerated away from the stop before they had sat down. The majority of the older users (67%) all sat within the front section of the bus up to the first 2 forward facing seats (Figure 16). Two people went upstairs and a further 11 people (5%) stood for all or part of their journey.

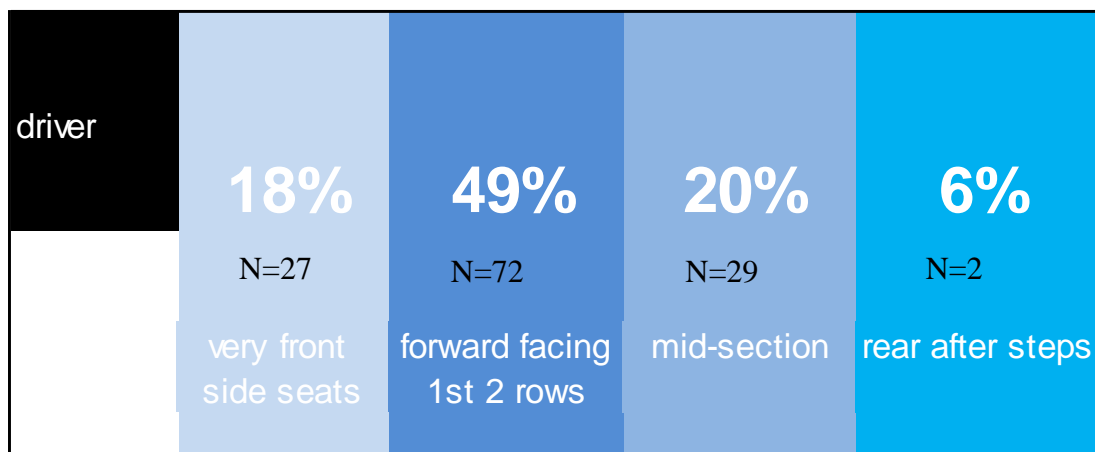


Figure 16 Observed seating patterns of older users on buses

There were 12 episodes of sudden braking by the driver of which 10 were on the same journey and one each on two separate journeys. There were a higher number of incidences of stumbling on the journey with the higher

number of sudden braking episodes; 4 compared to 6 stumbling episodes on 6 separate journeys. Three people were observed grabbing for handrails whilst sat down and 27 episodes of sudden grabbing of handrails when stood up. For those standing up it was not evident whether they were stood to get off the bus or standing for the whole journey. Of note was the high number of older users who chose to stand up in preparation to get off the bus before the driver had actually come to a stop (75%, n=110). Therefore many people were standing at any one time during the deceleration phase coming into the bus stop. Further to this 14 (9.5%) older users had to get out of their seats to reach a bell push to indicate for the driver to stop the bus.

Incidents Observed

The researchers observed one particular hazardous incident where a male older user boarded the bus and was walking towards the forward facing seats; the driver pulled off from the stop as soon as the man boarded the bus and then braked suddenly sending the man flying backwards and grabbed out at a handrail to prevent him falling. He then pulled down a side seat and sat down. A further episode of sudden braking occurred and the male lurched forward trying to grab at a handrail (there were none in close proximity) but managed to regain his balance and sat back down in the side seat.

General Observations

It was noted by the researchers that one bus journey the driver didn't always lower the bus floor despite passengers having to take a high step into the bus. There were numerous obstacles observed which prevented traversing the aisle easily and were mainly pushchairs sticking out in the front area of the bus and occasionally bags in the aisle. It was noted at one bus stop 4 pushchairs got onto the bus and blocked the aisle and one older user was observed having to reach out and grab a handrail to prevent herself stumbling as she tried to negotiate around the pushchairs.

One older user rang the bell for the stop but proceeded to stand for 2 stops before getting off, it is unsure whether this was to make sure they didn't miss their stop or rang the bell too early. An older user who remained seated had to shout out for the driver to stop as he hadn't stopped at the stop despite the stop bell request. Many older passengers were observed

using walkers and walking sticks, the actual numbers were not recorded, however they still chose to stand up before the bus came to a stop even though they had to grab out to steady themselves on the handrails and hold onto their walking aid.

It was further noted that traversing the handrails through the bus was difficult for some to reach from one side to the other more so in the women as they tended to be shorter.

Most of the older passengers appeared to aim towards the front forward facing seats and often would sit in the aisle seat rather than move across to the window seat especially if no-one was travelling with them.

Key Findings

- Notably older passengers stood up before the bus had come to a stop in 75% of cases
- None of the older passengers asked the driver to wait before they sat down
- Numerous incidents at grabbing out occurred for handrails when older users were stood up
- The majority of older users aim to sit near the front of the bus
- Pushchairs were observed to be a problem and blocked the aisles making it difficult to negotiate a path around them
- Sudden braking on one particular journey caused 2 potentially injurious situations for the same man and obviously in a short space of time.

Questionnaire Surveys - Older Public Transport Users

Aim

Questionnaire surveys were conducted by the researchers with the aim of quantifying injury incidents and also perceived difficulties using buses in a larger group of older bus users.

Method

A questionnaire survey was developed that could be asked to older users on the streets / bus stops that were useful for the study but not intrusive bearing in mind the data collection sites. The survey was piloted on a group of older 60+ male and females and items removed or added depending on their willingness to answer any questions on the street and also to establish an appropriate length of time that would be reasonable to stop and answer questions. Permission was sought from the local council to stand at bus stops and market areas and also the bus station managers. Two researchers conducted the surveys over 2 days in the mornings thus aiming for the peak travel times for older users based on their bus pass restrictions and observed bus use.

Results

One hundred and fifteen older persons were approached by the researchers at bus stops, bus stations and in the market area to answer questions. Overall a 79% response rate was achieved with a total of 91 older persons completing the questionnaire.

The majority of responders were female 65% (n=59) and 1 was missing gender. The majority of responders fell into the 70-79 years age group (Table 31).

Table 31 Distribution of age groups

Age group	Frequency (n=91)	Percentage
60-69 years	19	21
70-79 years	44	48
80+ years	28	31

Responders were asked to rate their level of difficulty with mobility with

66% (n=60) stating they had no difficulty with mobility (Table 32). However the researchers stated they would have rated some of the responders as having 'some difficulty' having observed the responders walking away from them.

Table 32 Distribution of older persons mobility assessment

Mobility difficulty	Frequency	Percentage
No difficulty	60	66
Slight difficulty	16	18
Some difficulty	11	12
A lot of difficulty	3	3
Missing / no response	1	1

All of the responders were concessionary pass holders with 70% (n=64) stating they used the buses more since having their bus passes and only 29% (n=26) saying their bus use was about the same (1 missing) (Table 33).

Table 33 Frequency of bus use by older persons

Frequency of bus travel	Frequency (n=91)	Percentage
Once a week	6	7
Everyday	29	32
2-3 days a week	23	25
3-6 days a week	16	18
Once a month	8	9
More than once a month	5	5
A few times a year	4	4
Once a year	0	0

Overall 16 (18%) responders stated that they had had a near fall on the buses in the past, of which 4 sustained an injury (Table 34).

Table 34 Frequency of near falls on buses by older persons

Action of the person	Frequency (n=16)	Injury occurred (n)
Getting on the bus	2	1
Walking to seat	1	0
Just sitting down in seat	2	1
Mid journey sat in seat	2	0
Just getting out of seat	1	1
Standing waiting to get off bus	3	1
Getting off bus	1	0
Other – going upstairs	2	0

Those that sustained an injury hurt their hand and lower back (n=1), forearm (n=2) and lower leg (n=1). Two responders sought medical treatment one from their GP for their forearm injury and another received ambulance treatment for a laceration to their leg. The latter responder was the only person who reported the incident to the driver and to the company. A second respondent reported their near fall and injury (hand and lower back) to the driver only. There was no statistical significant difference between whether a person had a mobility problem or not and their near fall experience (Chi² 0.152, df 2, p 0.453)

A further two responders sustained injuries whilst sitting down in their seats whilst the bus was in motion. Both were female and in the 60-69 year age range, one hurt her thumb and considered herself to have slight mobility difficulties, the other hurt her hips and considered herself to have some mobility difficulties. Neither reported the incident to the driver or the company nor did they change their bus use patterns or feelings towards using the bus. However three people who had experienced a near fall but not injured changed their pattern of behavior using the buses; one stated they

now stayed downstairs and do not go upstairs on a double decker; one asks the driver to wait until she is seated and the other doesn't sit on the side seats anymore. Overall 7% (n=6) of the older people surveyed had sustained an injury on the buses however only one received medical attention at the scene from an ambulance. Due to ambulance attendance this incident would be recorded in their official figures but the other reported injuries would not appear in any official national road or health statistics.

Difficulties using the bus

The majority of the respondents (64%, n=58) considered there were no difficulties using the bus. The main difficulty noted for the remaining 33 older users was sitting down in their seat (42% n=14), the bus driving off before they were sat down (24% n=8) walking down the bus aisle (n=8, 24%), other things mentioned were not enough bell pushes (n=3, 9%), getting to the bus stop (n=3, 9%), holding on and staying in the side seats (n=2, 6%), getting on or off the bus (n=4, 12%) and getting out of the seats to stand up before the stop (n=3, 9%).

Key Findings

- 75% of the responders used the buses regularly during the week of which 29% of these used the buses every day.
- The majority (70%) of older passengers used the buses more since having a bus pass
- 18% had experienced a near fall of which 4 sustained an injury
- Very few reported any incidences as only 1 of those injured reported it to the driver and the company
- Some behaviours changed as a result of a near fall and these were perceived to be for 'safety' reasons
- Potential difficulties were noted including the driver driving off before they had sat down, walking down the aisles and staying in the side due to no handrails to hold onto and often are slippery and lead to feelings of being unsafe.

Questionnaire Surveys – Bus drivers

Aim

Drivers are an integral part of the older bus users experience and this survey aimed to establish the driver's perspective on the potential problems older users have on the bus and what they consider would be beneficial to help prevent incidents and injuries occurring. Also the survey aimed to identify the number of injury incidences or near falls the driver had experienced on their buses.

Method

Three local bus companies were approached to ask permission to invite their drivers to take part in a questionnaire survey. One company refused access, a second company agreed but didn't respond to any further contact about the suitability of the content for their drivers and a third company was willing for their drivers to be approached. A questionnaire survey was developed and forwarded to the manager of the company to review and ensure the questions asked were not a) sensitive to bus company procedures and b) likely to be completed by the drivers.

Questionnaires were distributed to the drivers of the bus company and envelopes provided for completed forms to ensure the drivers considered their responses to be confidential. The distribution occurred on payday and the drivers received a questionnaire with their payslip to encourage their completion. Fifty questionnaires were provided as that was the approximate number of drivers employed by the company considered to be full time, part time and casual employees.

Results

A total of 28 completed questionnaires were returned however 15 uncompleted questionnaires remained in the box, therefore 7 questionnaires were not returned giving a total response rate of 80%. The majority of drivers were males (n=19, 67%), 6 were females (21%) and 3 were missing responses. Most of the drivers were between 50 and 59 years (Table 35).

Table 35 Distribution of bus driver age groups

Age Groups	Frequency	Percentage
20-29 years	5	18
30-39 years	4	14
40-49 years	5	18
50-59 years	11	39
60-69 years	2	7
Missing	1	4

Driving experience varied and those between 20-29 years and 30-39 years all had been driving for less than 5 years (Table 36). Those between 50-59 years had a wider range of driving experience from less than 5 years to more than 20 years. Only 1 driver stated they had been driving buses for more than 25 years and they were in the older age category 60-69 years.

Most of the drivers (43%) had received a 6 week training course and tended to be those with fewer driving years compared to those who had been driving longer and had shorter training time. Most of the drivers received 1 training day per year (n=11; 39%), 5 received between 2 and 8 days training and 9 (32%) were missing responses.

Table 36 Distribution of driver's age and bus driving experience

	Driving experience - years					
Age Group (n=28)	0-5 years	6-10 years	11-15 years	16-20 years	21-25 years	25+ years
20-29 years	5 (18%)	0	0	0	0	0
30-39 years	4 (14%)	0	0	0	0	0
40-49 years	1 (3.5%)	2 (7%)	2 (7%)	0	0	0
50-59 years	3 (11%)	4 (14%)	1 (3.5%)	1 (3.5%)	2 (7%)	0
60-69 years	0	0	0	0	0	1 (3.5%)
Not stated	-	-		1 (3.5%)		

When asked about whether they waited for older users to sit down before driving off 68% (n=19) stated they always waited, 29% (n=8) most of the time

and 1 stated never. In terms of whether a company policy existed stating the driver must wait until older passengers were seated elicited 15 'yes' (54%), 2 'no' (7%), 10 'didn't know' (36%) and 1 didn't state (4%).

Circumstances were given where a driver would not wait for an older user to sit down and these included whether the driver could see down the bus, they were taking too long and would affect the timetabling and if they chose to stand to chat to friends.

Only 4 drivers had experience of an older person being injured on their bus whilst driving but only 2 passengers had an incident form completed by the driver. However stumbling occurred more frequently than actual falls in older passengers (n=15) again just under a half had an incident form completed (n=6). Seven drivers didn't complete a form and 2 stated they didn't have to report the incident.

Awareness of whether a person has fallen on the bus was split with 11 drivers stating they would be aware and 11 stating the opposite and 4 didn't know whether they would always be aware (2 missing) (Table 37). The main reasons given for not being aware of falls was the passenger doesn't always report it (n=11) and the difficulty of seeing down a loaded bus.

Table 37 Main reasons why driver awareness of falls maybe low

Awareness of falls	Frequency
Passenger doesn't report it	11 (39%)
Difficult to see on loaded bus	10 (38%)
Concentrating on the road	9 (32%)
Not stated	9 (32%)

Drivers were asked to state what they thought the main two causes of injury in older passengers, one driver didn't respond and others selected just one option. Overall the main problem area for older passengers is standing waiting to get off the bus (Figure 17). Drivers were also asked to state what 2 bus manoeuvres had the potential to cause injury to older bus passengers, one driver did not respond.

The most frequently cited cause was sudden braking (24) and pulling in and out of stops were also a problem area (Figure 18).

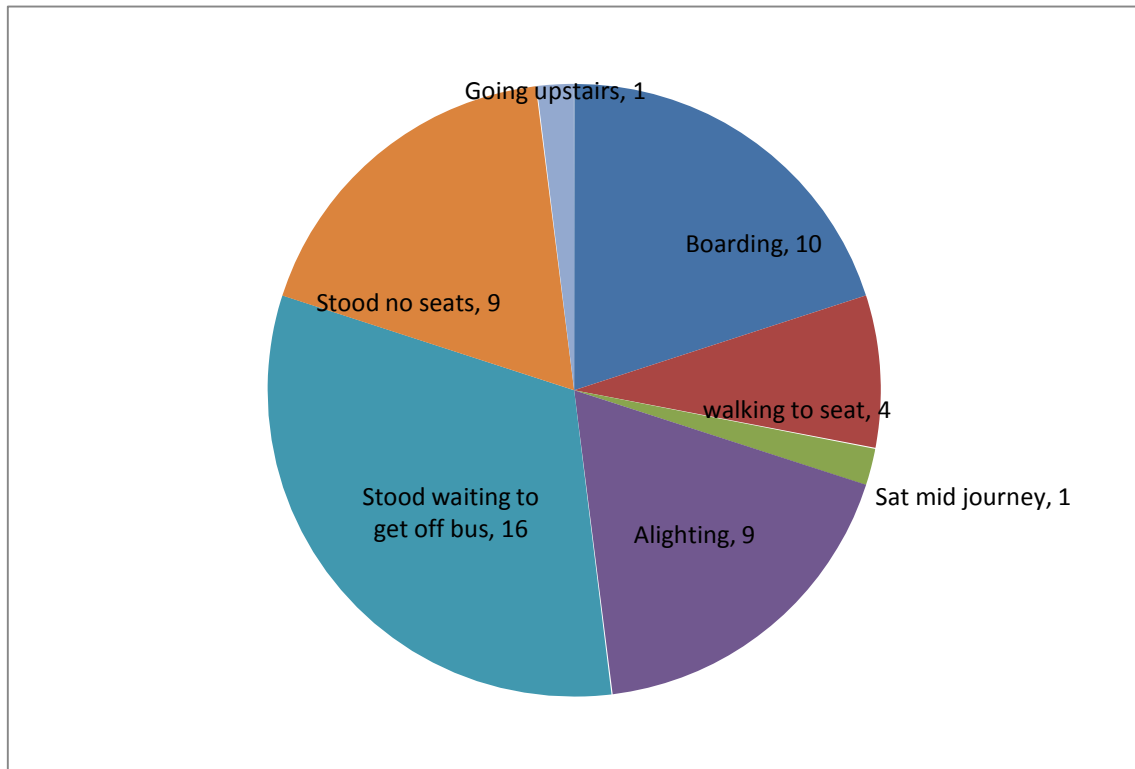


Figure 17 Main perceived injury risk locations of older users – bus driver's perspective

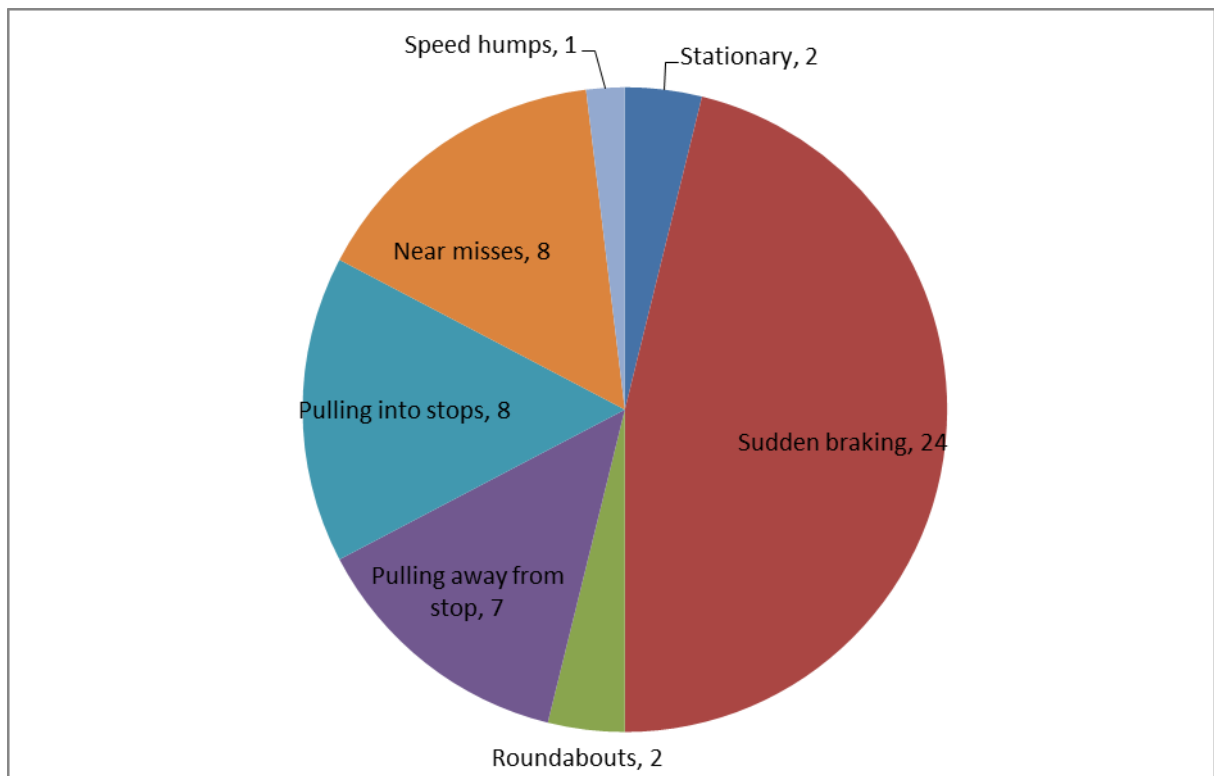


Figure 18 Main perceived injury causing bus manoeuvres for older users – bus driver's perspective

The drivers were also asked an optional question to consider what they thought could improve the safety of older passengers either structurally, as a driver and also what the passengers could do to help themselves. Seven drivers responded to the structural question and the main suggestions were more handrails in the pushchair area (3); padded handrails (2); handrails for side seats –nothing to hold onto there; seatbelts (1); rubber floor (1) and no standees (1).

Eight drivers offered their opinion on what they could do their responses were drive slowly in and out of stops, be more aware (1) and use interior mirror (2); let passengers sit down before driving off (3); softer braking (1); and drive nicely (1).

Lastly 14 drivers responded to the question what the older user could do to help themselves and all stated they should stay sat down until the bus had stopped (14) and also 1 added they should sit down quickly after boarding the bus.

Key Findings

- Very few drivers reported that older passengers had been injured on their buses whilst driving
- Higher numbers had experienced older passengers stumbling and near falls compared to actual falls on the bus
- For drivers the awareness of stumbles and near falls occurring on the buses was divided and seemed dependent on whether a passenger reported an incident rather than the driver observing it
- Most drivers report that passengers don't report the incidents to the drivers
- Passengers standing waiting to get off the bus is a main concern for the drivers in terms of injury causation
- Sudden braking of the bus is recognised as a potentially harmful bus manoeuvre

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EQ-5D

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Phase 2

Accident Protocol Development

During the stakeholder consultations and discussions with individual bus companies it was evident that there isn't a 'consistent' methodology for collecting data about injury causation on buses to promote injury prevention. The variation between even a few companies' data within this pilot study highlights the problem of different variables and different data definitions that cannot be linked into a single database. Consequently to develop a database requires a standard form that is not a burden to those collecting the data at source. Obviously the wider issue of maintaining, storing and analysing the data is beyond this study and acts only to highlight the gaps in the current data available and shows the potential of having the richer data to inform injury prevention. Figure 19 illustrates the steps considered in the development of the accident investigation protocol.

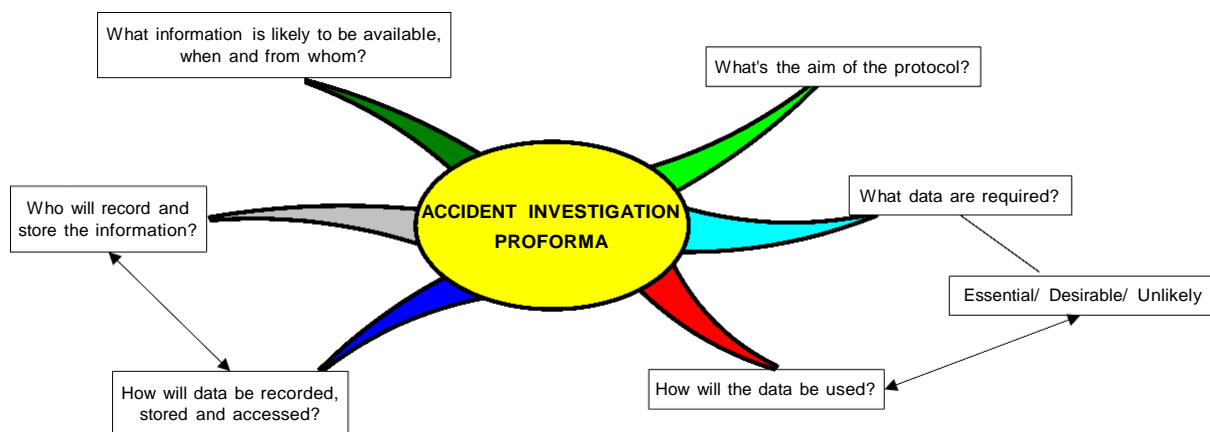


Figure 19 Mind- map steps in developing an accident protocol

Consultations were positive on the whole for the development of a national injury surveillance database that could ultimately be used to prevent injuries through:

- formulating risk assessment processes
- informing safety campaigns

- informing design changes on vehicles and assess the benefits of change
- feeding into driver training

Obviously there was some caution as the data would have to be anonymous and used for benefit and not competition between organisations. Further to this it was suggested that including bus stop and bus station incidents in such a database would have far more benefit in tackling injury prevention rather than focusing on the actual transport. The wider focus would incorporate any difficulties and incidents during 'access' to transport where problems at this point in a journey may deter public transport use.

In the wider context of accident investigation work fatal accidents tend to be examined in more detail than other severities because of the gravity of the situation. However in the reconstruction of such incidents there is pertinent data that can help examine the biomechanics of the person during the incident that is not always collected, furthermore, lesser severity incident investigations would benefit from similar pertinent data collection.

It was hoped that developing a standard accident protocol for slight, serious and fatal passenger incidents in the first instance would underpin any future accident protocol developments for the wider access areas such as bus stops and bus stations.

The study collaborated with a Collision Manager at one of the national bus companies and also with the Health and Safety Laboratory (HSL) to develop an accident protocol taking into consideration the needs of the stakeholders. The protocol was designed to be completed by the drivers or collision investigators and not to be too dissimilar to current data collection forms used by some bus companies. The emphasis on this protocol is the collection of 'extra' information that will help identify the root causes of injury in older public transport users. Variables added to the accident protocol form include what the passenger was doing at the time beyond the standard 'seated, alighting, boarding, standing' options; also expanded was the bus manoeuvre options but the main expansion was including more detail about the injury. Consideration was made for the needs of the stakeholders surveyed and where practical were included in the protocol. The reason for adding extra dimension to the accident protocol was to allow the data to be used in

modelling simulations of incidents to inform bus design in the future to prevent injuries happening on buses. However further data would be required to maximise the potential of using simulation modelling to full effect and as such recommended fields were added that could be collected after the incident at follow up with the passenger or coroner for fatalities. It is recognised that this is potentially beyond what could be collected and is seen as an 'ideal' to address injury causation and further having the added detail about the injuries becomes a more powerful injury surveillance database. There is an expectation that bus operator companies would collect the data either as an additional form or extracted from the current forms the bus operators have to complete for each incident. This is dependent on the existing procedures in place for individual bus operators. There are however added variables to enhance injury information and causation that would subsequently augment any modelling of incidents. Discussions with a collision manager were positive towards the form as the added variables wouldn't add any extra time to their completion and the benefit of the added information would help their own collision investigations.

The accident investigation protocol collects data under the following sections with the full version found in Appendix 6.

Section A: Contextual Information

Date, time, vehicle information, police attendance, ambulance attendance

Section B: Accident Details

Bus manoeuvre, passenger location and movement

Section C: Passenger details

Age, gender, height, mobility aids, luggage

Section D: Environmental conditions

Weather, lighting

Section E: Summary of the accident

Section F: Injury details

Severity, injury type, injury location, injury cause

Section G: Consequences of the accident

Hospital duration, medical treatment, public transport changes, coroner's report

Section H: Other useful information (to collect on follow up)

Passenger mobility and vision

Section I: Photograph requirements for incident modelling

Design Solutions

The Design Team at Loughborough University investigated the potential of using 3D computer modelling as part of a process of improving the safety of transport. The rationale is that the occurrence of an accident to a member of the travelling public may be digitally modelled, post-accident, to explore causality and potential design solutions. This report uses bus transport as a case study, and details a potential methodology moving from data capture at the scene of the accident, through digital modelling of the scene, exploration of the accident scenario using Digital Human Modelling (DHM) and analysis that may be used to inform design countermeasures to avoid future reoccurrence of the accident.

Method

The methodology adopted for the modelling activity was informed by the potential for the methodology to be adopted as part of a broader accident investigation. As such a number of factors should be considered, including:

- the time and disruption caused post-accident by the investigators collecting data and preventing the vehicle from continuing on its route
- the robustness of the method such that the relevant data can be captured to the required degree of accuracy, on the scene, and in a repeatable manner
- the capture of data that minimises the degree of post-processing required to create the relevant digital models
- the use of industry standard practices and tools where possible
- acceptable cost.

Data Capture and Setup

The case study accident scene consisted of the interior of a bus that was kindly accessed via the local Kinch depot; the bus shown in Figure 20 was a large 42 seat Optare Tempo variant. The layout of the vehicle includes a combined standard forward facing seating arrangement with a number of transversely mounted seats facing towards the centre of the bus (Figure

21). In addition the front six transverse seats are of the fold down type that when not in use provide space for wheelchairs and child pushchairs / buggies. This particular variant was selected following stakeholder consultations as there was a perceived problem with the fold down side seats and a known fatality in a similar variant bus (see case study 1).



Figure 20 Bus used for the modelling activity, a 42 seat Kinchbus No 12.

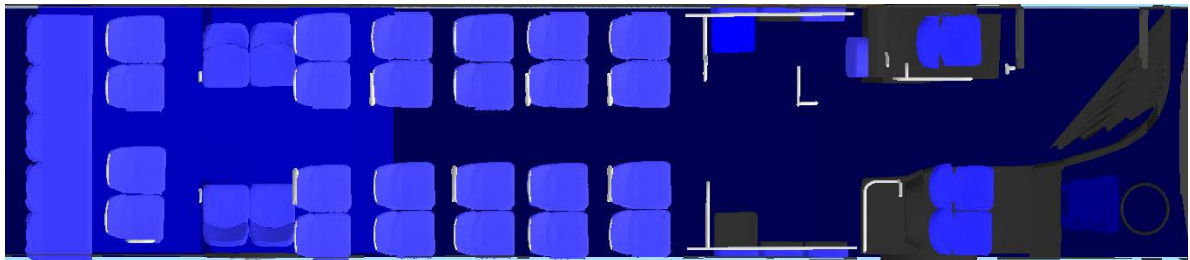


Figure 21 Internal layout of the bus used for the modelling activity, a 42 seat Kinchbus No 12.

The modelling activity would require a digital model of the interior of the bus. Due to the complexity of the vehicle interior the methodology needed to be suitable for capturing the geometry in a manageable way. Traditional approaches such as photographs and manual measures had a number of significant disadvantages, in that it would be difficult to define a protocol that could ensure a repeatable and robust collection of sufficient data to support the modelling activity. It was decided that a 3D approach was needed for capturing the 3D data.

Accident Scene Scanning

Where possible, perusal of the 3D CAD geometry from either the vehicle manufacturer or fitter would be the most efficient manner of obtaining the relevant data. However, this may not be available, or there may be other data at the scene such as obstacles due to passengers (e.g. bags, sticks and so on) that are not part of the design of the vehicle. Thus a possible approach is to employ 3D capture technologies. 3D scanning systems are available in a range of types, each with their own specific uses or advantages and disadvantages. The system selected for this research was the FARO LS 3D scene scanning system (FARO 2013). Figure 22 shows the scanning system located in the front of the bus to be modelled. The system consists of a scanning head mounted to a tripod. In addition, the system needs five calibrated white spheres to be placed around the scene in the line-of-sight of the scanner. The system can be transported in a medium size wheeled case containing the scanning head, spheres and an Apple iPod touch used as a control interface. The tripod is transported separately.



Figure 22 FARO 3D scene scanner located in the front of the bus.

The system works through the rotation of the scanning head 180 degrees over a period of approximately 60 seconds. A laser is projected from the head and used to record a 'point cloud' representing any solid surface in line-of-sight of the laser. Due to the limitations of line-of-sight, objects in the scan

environment can occlude relevant data. Thus, it is essential that any data capture protocol to be used at an accident scene ensures that appropriate scan locations are selected to form a full model. For the bus, four scans were taken at regular intervals along the length of the centre aisle. The white spheres are used to link multiple scans of a single scene. As the spheres are in a fixed location between scans, multiple scans can be combined to form one complete scan.

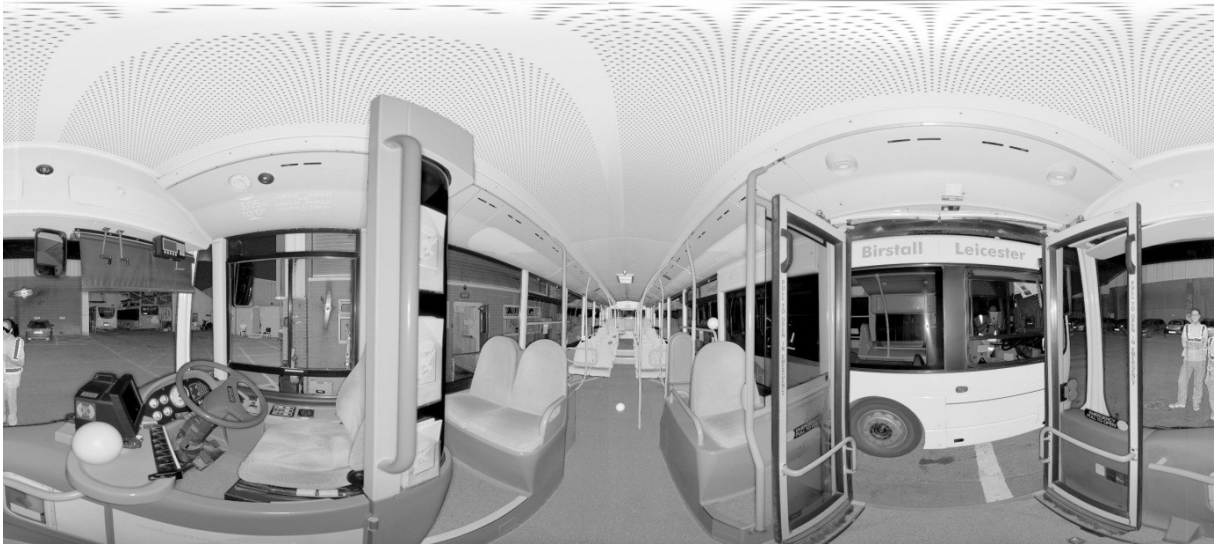


Figure 23 360 degree digital image from the first scan taken in the bus.

The results of a scan can be seen in Figure 23 and Figure 24. Figure 23 shows a 360 degree digital image of the field of view of the scan. The line-of-sight is clearly visible indicating how any occluded areas such as those behind the front row of seats would not be captured. Figure 24 shows the scan itself. As the laser is projected hundreds of metres the scanning process does capture a significant amount of unwanted data (noise) that must be removed during post-processing.

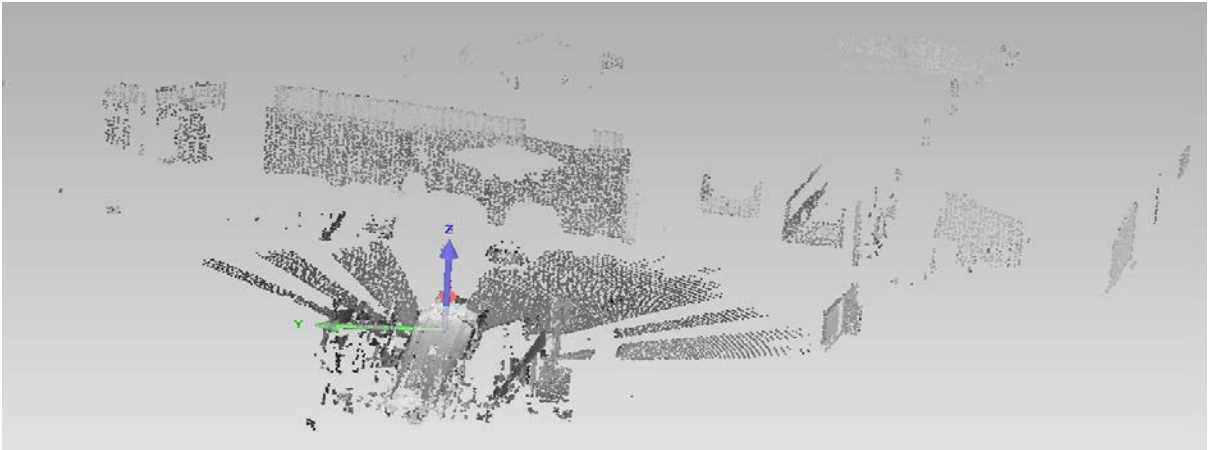


Figure 24 Scanned ‘point cloud’ resulting from a single scan of the bus.

Scan Processing

Figure 25 shows some of the detail captured during the scanning process. The scan consists of some very high resolution surfaces, such as the seat forms shown, and a large proportion of fragmented surfaces that provide only an indication of the surface type, as shown by the green bounded elements in the figure.

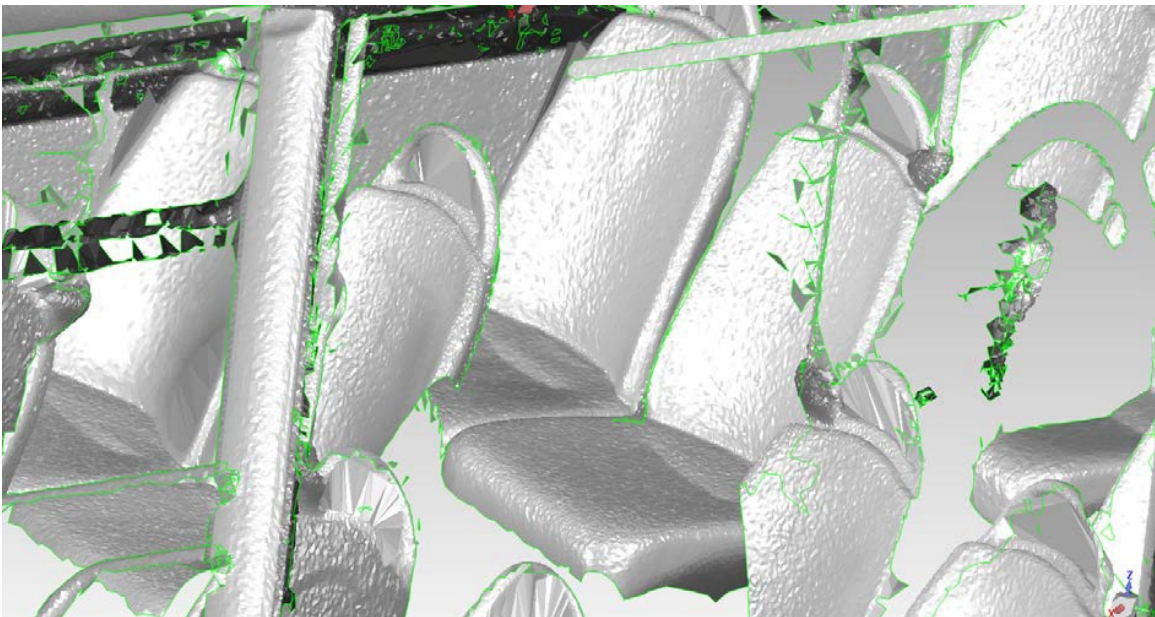


Figure 25 Close up of the scanned seat surfaces within the bus.

Due to the size and complexity of the scan data, Geomagic (3D Systems 2013) software was used to remove any unwanted noise, decimate the point cloud to reduce the complexity of the data and to tessellate the points into a triangular mesh surface. Next, the four scans were combined in the 3D modelling software Lightwave (Newtek 2013) to form a complete bus interior scan (Figure 26).

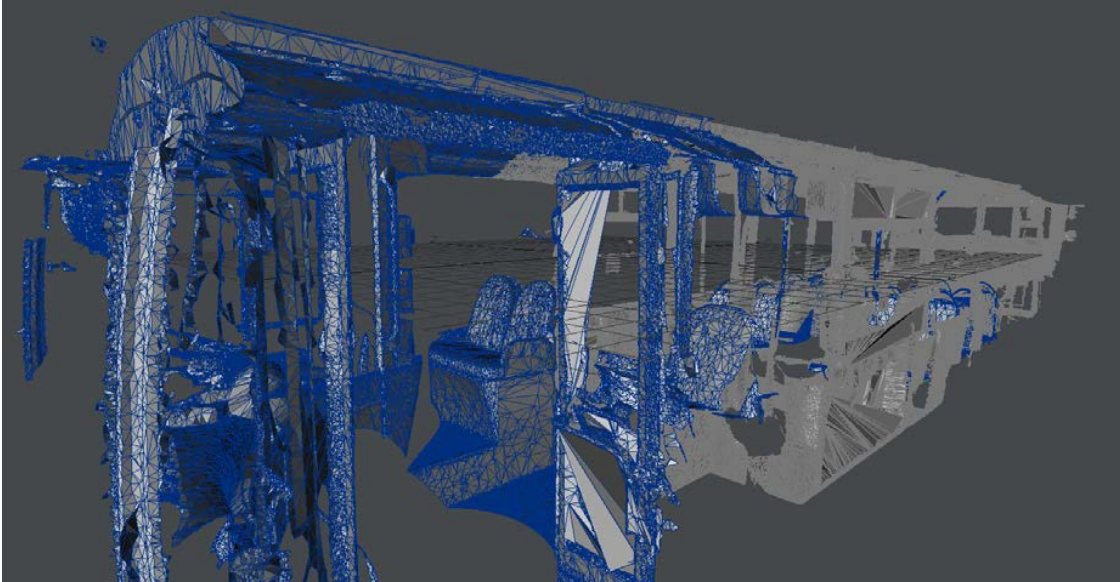


Figure 26 The combined bus scan data in Newtek Lightwave 3D.

Finally the scan data were used in two ways to form the final model. In areas of coherent surface data, such as the seats, the scan data were isolated and saved as individual elements directly (Figure 27). In areas where the data was incomplete, the available data were used as a 'guide' for the reconstruction of simple elements such as handles, rails, and fundamental structures such as the floor, walls etc.

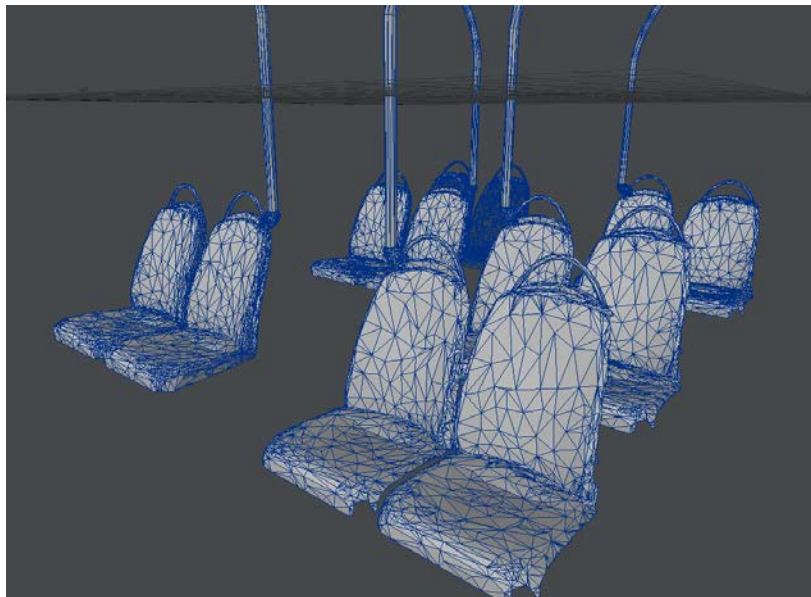


Figure 27 Model construction in Newtek Lightwave 3D, showing the seat surfaces and adjoining hand rails.

The post-processing required is potentially very time-consuming and so it was important to strike a balance between the necessary level of accuracy to support the analysis phase, and the complexity of the modelling. In many cases, relatively crude and / or simplified surfaces were used. However the 3D data would be more than adequate to support the analysis activity and whilst

the surfaces may be simple they are geometrically accurate. Once the model was complete in Lightwave 3D it was imported into the SAMMIE DHM system. Digital Human Modelling Setup

The availability of the DHM Digital Human Modelling system allowed the designers in the project to assess the feasibility of using the system for exploring the older bus passenger in various scenarios on a bus. It is not a dynamic crash system and therefore limited in its illustration of dynamic passenger interactions with the bus during a collision. However this study was not able to capture visual incidents of older passengers on buses being injured from any CCTV footage which would have allowed dynamic modelling to explore the biomechanics of injury. Therefore for this study the DHM system was considered to be a satisfactory method and of benefit because it allows for virtual humans to be created and their interaction with a digital environment to be assessed. The modelling of humans is highly configurable allowing individuals or representative populations to be created. The human model can be varied in size, shape, joint mobility and with access to the appropriate data such as the HADRIAN dataset people with disabilities can also be evaluated (Marshall et al. 2010). DHM systems also provide a number of analysis methods allowing reach and vision to be investigated. DHM tools therefore provide an accessible means of recreating and evaluating accident scenarios.

The DHM approach is not without its limitations. DHM tools typically support static evaluations of key-frame postures and tasks. However, accidents are invariably dynamic events and so there is a requirement for some hypothesis in the recreation of the accident event. Dynamic modelling technology is available; tools such as those used for crash simulation (e.g. Madymo, Tass International 2013) could be used to evaluate an accident in much greater detail and would be considered in future work. However, their accessibility and the complexity of the analyses, places them beyond the remit for this research at the present time. Taking a static approach still provides the potential to evaluate key design parameters that may prove to be causal factors in the accident, and this can provide inputs to potential design countermeasures.

Figure 28 and Figure 29 show the resulting setup of the model within the SAMMIE DHM system (Porter et al. 2004). The vehicle interior has

been accurately modelled from the scan data, including floor and wall surfaces, internal fitting such as seat and hand rails. The exterior has been approximated from photographs taken at the scene to mainly support visualisation. The bus has also been populated to provide a realistic case study environment and to provide the potential to explore the impact of passengers on accessibility, particularly to hand holds that may be obstructed by passengers seated or standing.



Figure 28 Bus modelled and populated in the SAMMIE DHM system.



Figure 29 Bus interior modelled and populated in the SAMMIE DHM system.

Postural Analysis

The methodology of the case study analysis focuses on the ability for a standing passenger to be able to hold on to the vehicle whilst traversing along the vehicle. As presented earlier accidents occur to both standing and seated passengers and passengers are at greatest risk when the vehicle moves off or comes to a stop e.g. whilst passengers are making their way to a seat, or whilst they are stood with a view to making their way to the front to alight. Whilst there are many complexities as to the causation of any particular accident in these conditions, it is reasonable for an analysis of the scene to explore the requirement for the passengers to be able to hold on and brace themselves against any acceleration or deceleration.

The dimensions of the older passenger were based on the police fatal case analysed earlier in the report and represents a 5th percentile UK female digital human model (1514mm stature), of slight frame with standard joint range of motion (mobility), see Figure 30. A small female provides a relatively extreme case in their ability to traverse along the vehicle whilst maintaining a hand hold due to having short arms. Clearly there are many more relevant human models that should be explored as part of a full post-accident analysis. In particular, human models should be considered that exhibit characteristics representative of the older population including reduced mobility or limited range of joint movement. The benefit of the DHM system is its versatility and rich anthropometric data source of various physical limitations and can incorporate them into the modelling. One type of impairment that is considered in this report is the impact of being encumbered. This was done through the human model holding a bag in one of their hands to represent the very typical occurrence of travelers travelling with shopping or other personal items such as a walking stick (Figure 31).

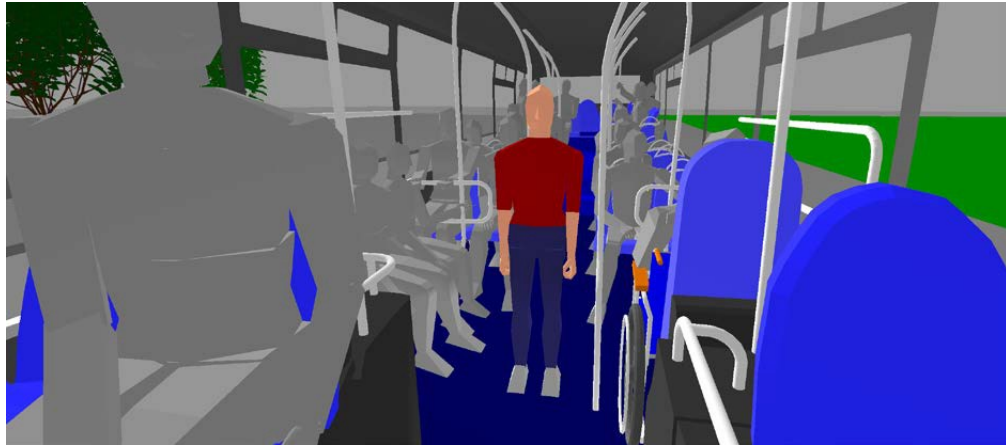


Figure 30 5th percentile UK Female digital human model (1514mm stature) within the bus

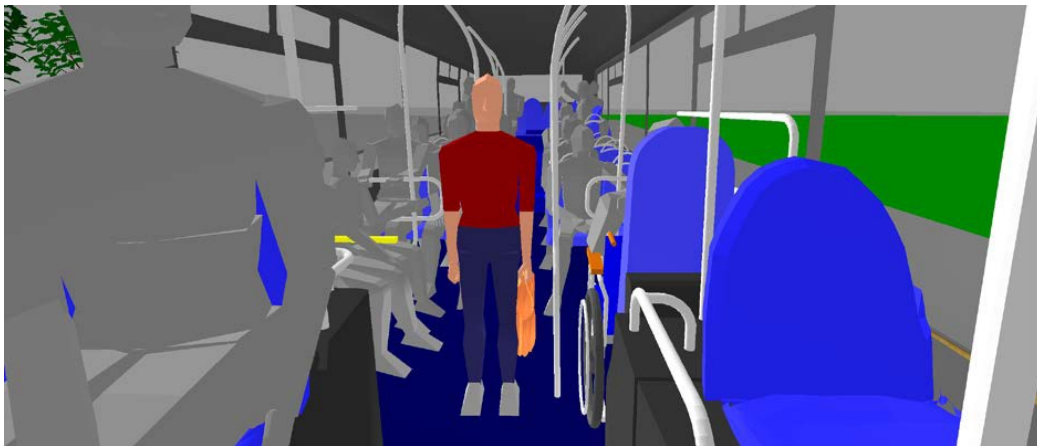


Figure 31 5th percentile UK Female digital human model (1514mm stature) holding a bag within the bus.

The analysis methodology involves the positioning and posturing of the digital human model, starting at the raised rear section of the vehicle as though they were initially seated at the very back, then moving forward to the front to alight. At each stage of the travel, the opportunity for the human model to hold onto at least one of the hand holds was explored. Where hand holds are out of reach the reach capability of the human model would be shown to give an indication of the extent to which the hand holds are out of reach. Wherever possible a constant grip would be maintained of a hand hold such that the human model would essentially always be holding on to at least one hand hold to give themselves some chance of bracing if required (Figure 32).

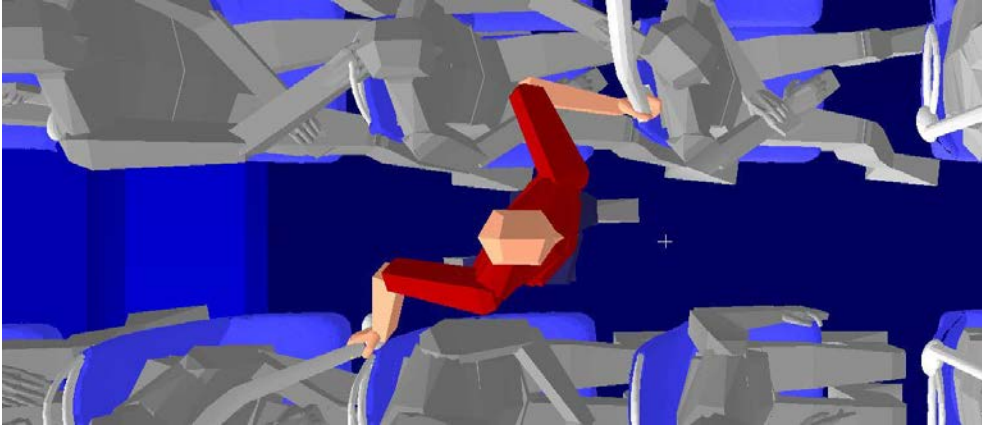


Figure 32 Human models would hold on to at least one hand hold within the vehicle whilst traversing

A secondary analysis will also be performed, evaluating the ability for a human model to brace whilst seated in the transverse seating area (Figure 33).



Figure 33 Human models seated in the transverse seating area

Results

The following results are the output from the modelling activity. A series of images taken from the SAMMIE DHM system illustrate the postures adopted by the passenger.

Traversing Front to Back Unencumbered

The following series of images show the possible postures for an unencumbered 5th percentile UK female traversing from the rear of the bus to the front attempting to maintain at least one hand hold at all times.

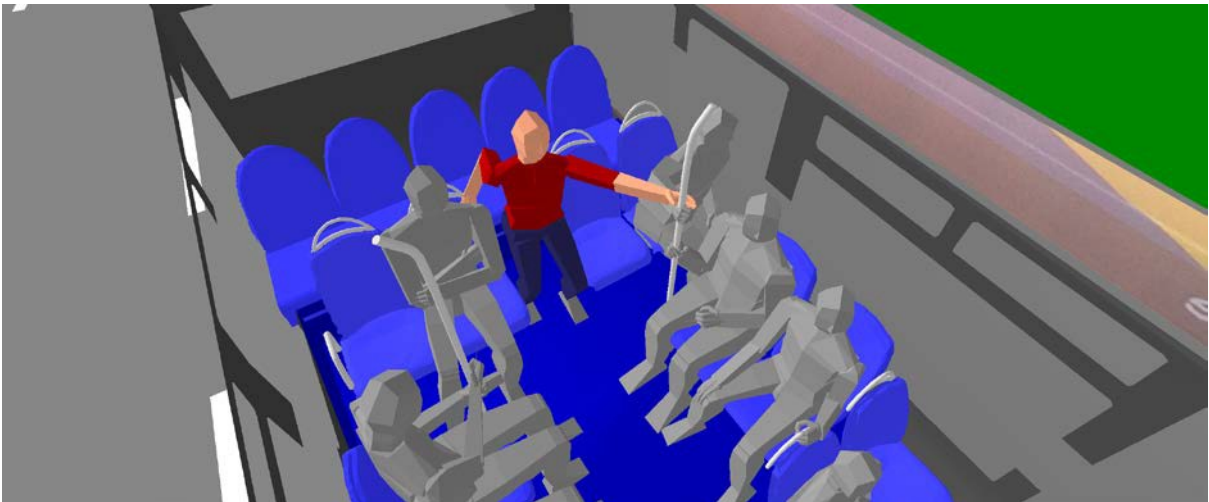


Figure 34 5th percentile UK Female moves from seated to standing at the very back of the bus and begins traverse forwards

After raising from one of the rear seats the handles on the back of the last but one row of seats would need to be used to move from a seated to standing posture. This grip could then be maintained whilst the passenger reached for the first left hand upright pole (Figure 34).

The passenger would then step forwards moving from a left hand forward posture to a right hand forward posture. This would release the back-of-seat handle with the right hand and reach for the next upright on the right (Figure 35 and Figure 36).



Figure 35 5th percentile UK Female moves forwards maintaining the left hand grip and reaching forwards with the right hand to the next upright.

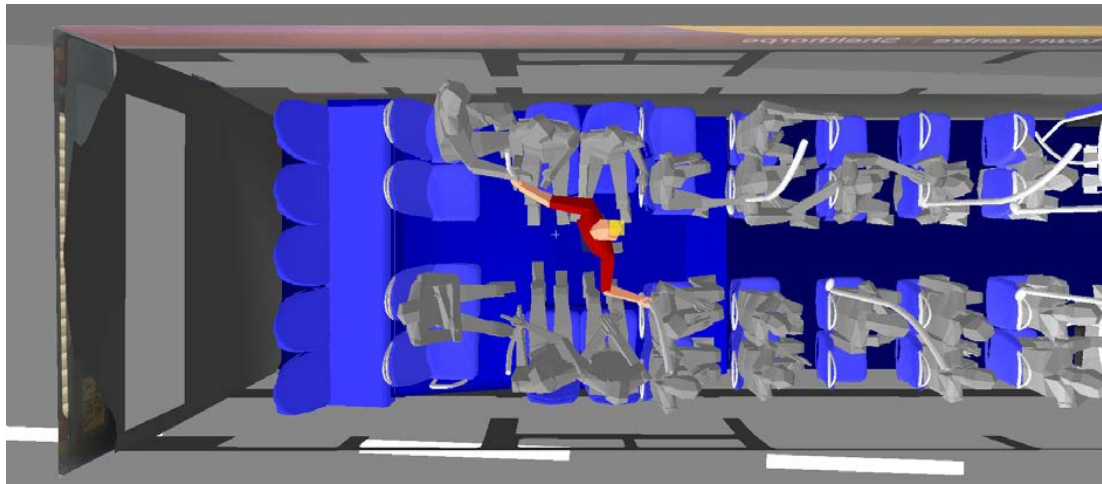


Figure 36 Plan view of the 5th percentile UK Female showing the left hand forward to right hand forward transition

The process is then repeated moving from right hand forward to left hand forward using the upright grips to reach the top of the steps (Figure 37 and Figure 38).



Figure 37 5th percentile UK Female moves to the top of the steps showing right hand forward to left hand forward transition.

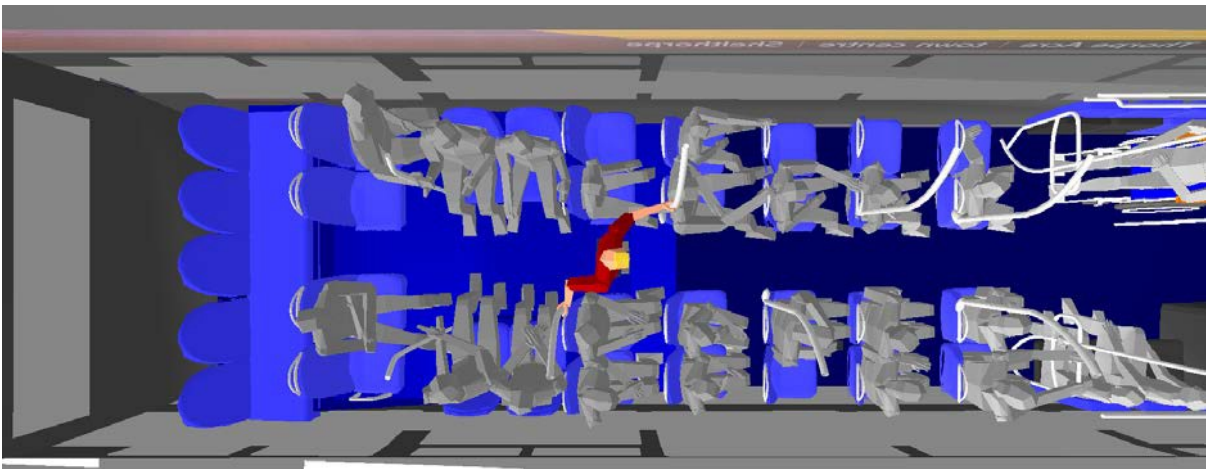


Figure 38 Plan view of the 5th percentile UK Female showing the right hand forward to left hand forward transition.

The steps can be descended whilst maintaining a grip of the left hand upright handle. However, seated passengers can make the grip quite awkward, particularly if the passengers are larger. It is likely that some people would let go in preference of inconveniencing another passenger (Figures 39 -41).



Figure 39 5th percentile UK Female steps down maintaining hold of the left hand upright.

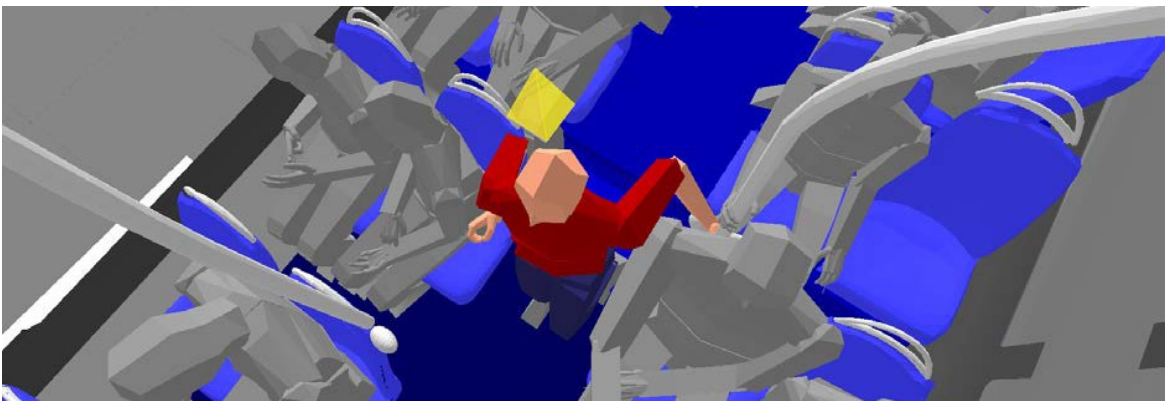


Figure 40 5th percentile UK Female steps down maintaining hold of the left hand upright.



Figure 41 5th percentile UK Female steps down maintaining hold of the left hand upright.

The passenger can then begin traversing forwards whilst alternately changing between left hand forwards to right hand forwards between successive upright handles (Figures 42-48).

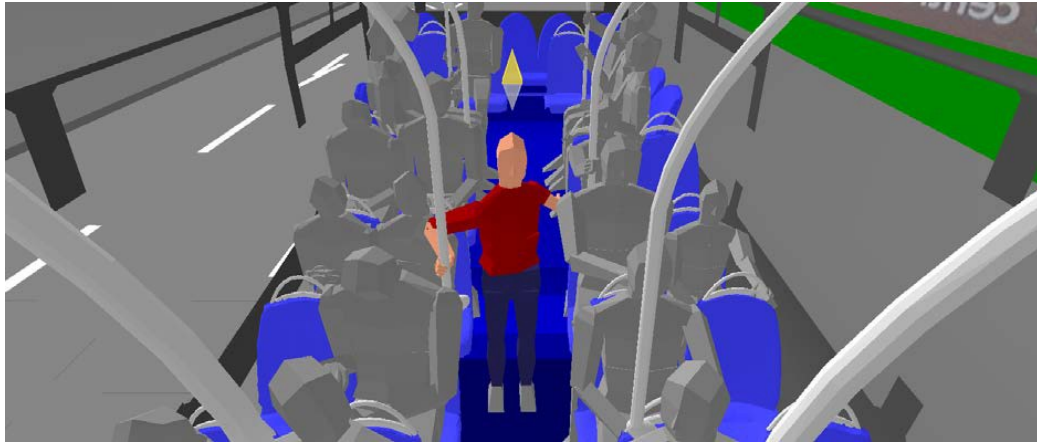


Figure 42 5th percentile UK Female moves forwards changing from left hand forwards to right hand forwards at the bottom of the steps.

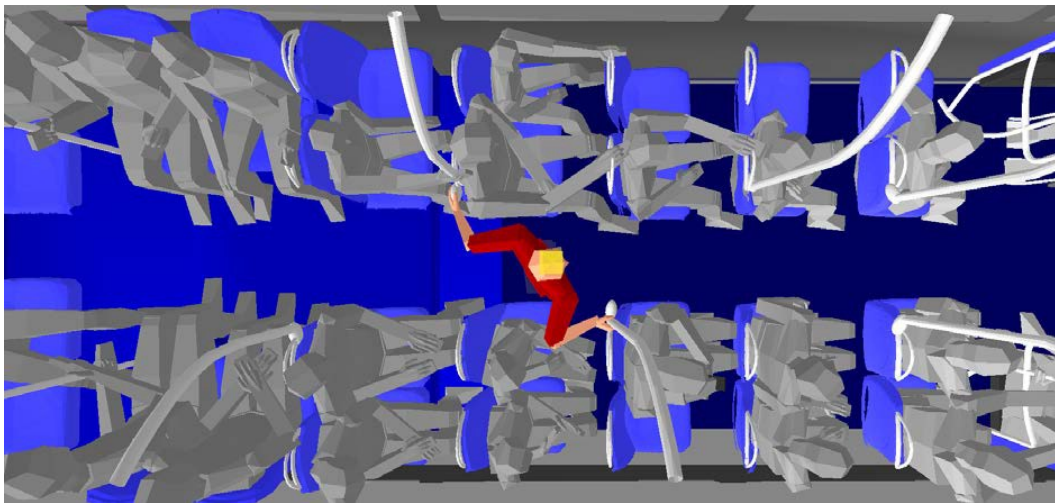


Figure 43 Plan view of the 5th percentile UK Female showing the left hand forward to right hand forward transition.

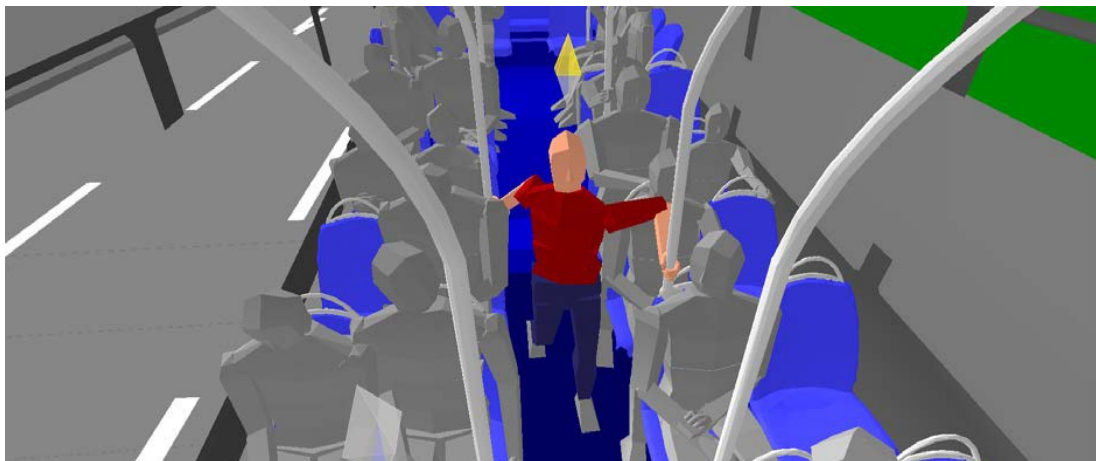


Figure 44 5th percentile UK Female moves forwards changing from right hand forwards to left hand forwards.

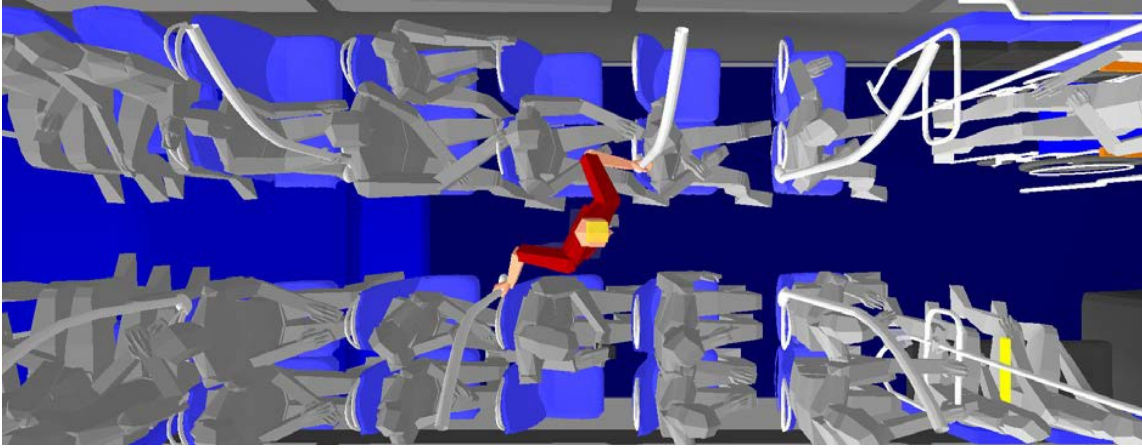


Figure 45 Plan view of the 5th percentile UK Female showing the right hand forward to left hand forward transition.

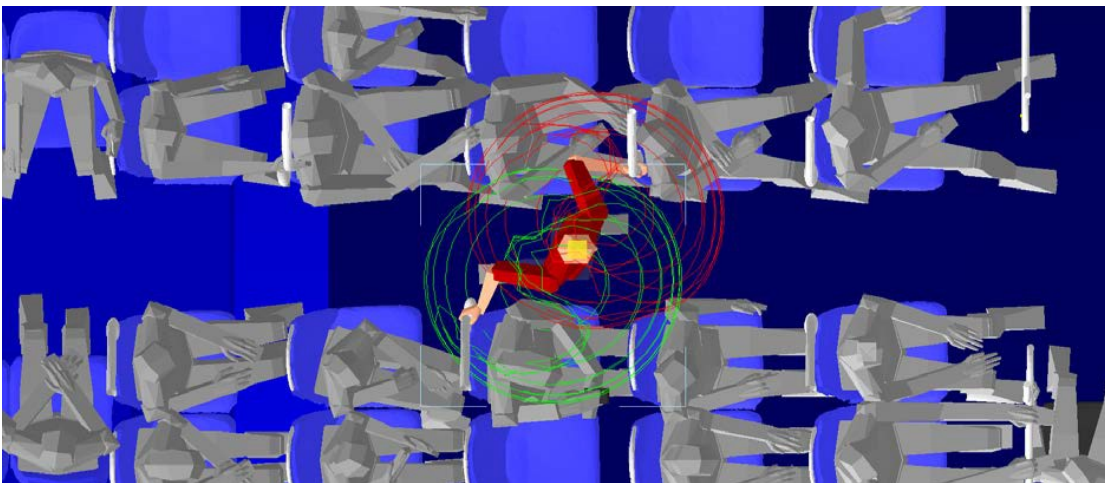


Figure 46 SAMMIE reach contours showing that alternate upright handles are well within reach of the unencumbered 5th percentile UK female.

Figure 46 shows 'reach contours' generated for the 5th 5ile UK female in the posture shown. The contours illustrate the reachable volume with a palm grip for the right and left arms. The contours highlight that alternate uprights are within reach for the passenger, as are the seat back handles if necessary.



Figure 47 5th percentile UK Female moves forwards changing from left hand forwards to right hand forwards.

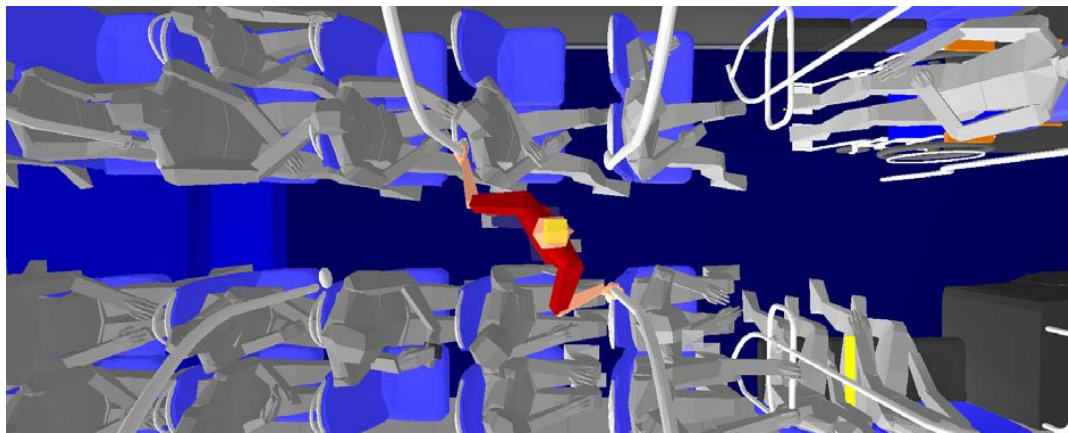


Figure 48 Plan view of the 5th percentile UK Female showing the left hand forward to right hand forward transition.

At the point shown in Figure 48 the passenger moves into the front area of the transverse seats. At this point the uprights become more unevenly spaced to avoid obstructions for wheelchair users and pushchairs.

Figure 49 and Figure 50 show how the next hand hold would have to be the curved tubing partitioning the transverse seats from the standard front facing seats. Whilst one handhold can be maintained at all times, at this point the left hand is now quite laterally displaced. This posture would make the handle more difficult to brace against during rapid acceleration or deceleration.



Figure 49 5th percentile UK Female moves forwards reaching to the laterally displaced curved handle with the left hand.

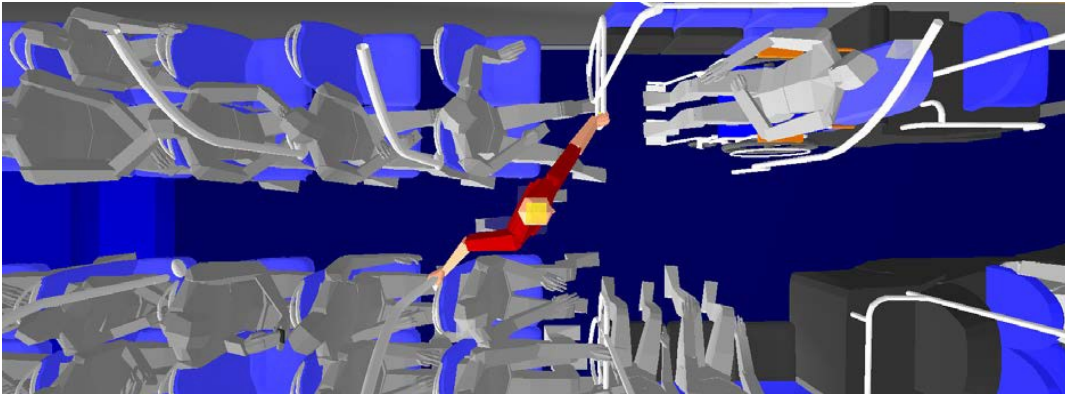


Figure 50 Plan view of the 5th percentile UK Female showing the left hand, laterally displaced, grip.

Once the passenger commits to holding onto the left hand curved handle and steps forward there is no convenient handle on the right hand side (Figure 51 and Figure 52). The next handle on the right is far out of reach. Figure 53 shows the reach contour of the right hand with a palm grip highlighting how far out of reach any right hand handles are. However, it also highlights that the passenger could reach the next left hand upright with their right hand.

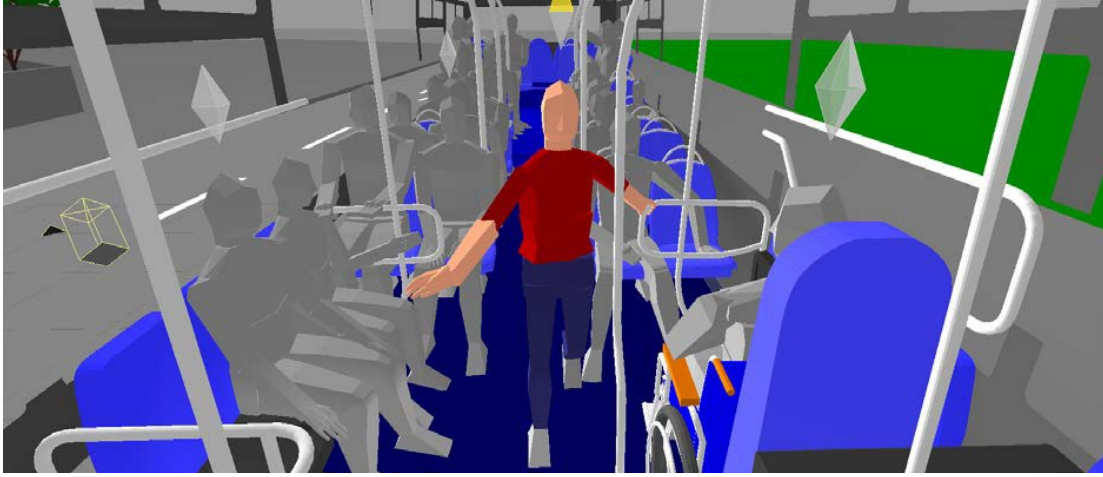


Figure 51 5th percentile UK Female moves forwards maintaining grip of the left hand handle but finds there is no conveniently placed right hand handle.

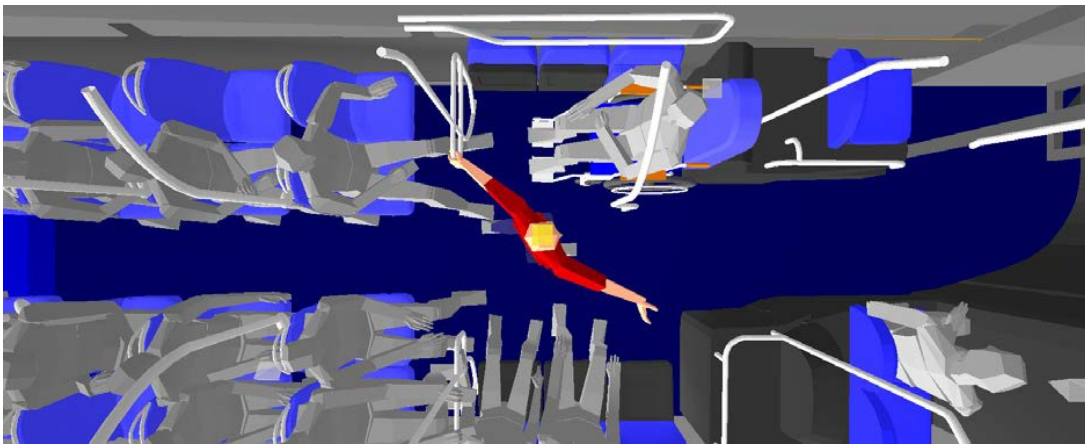


Figure 52 Plan view of the 5th percentile UK Female showing no conveniently located right hand grip.

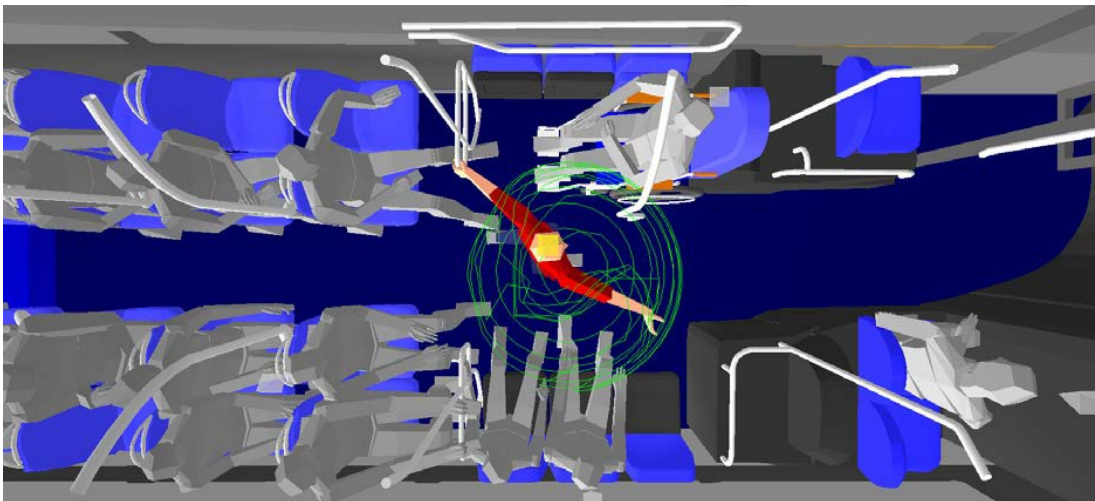


Figure 53 Reach contour for the 5th percentile UK Female confirming the lack of right hand handle, but also indicated the availability of the next left hand upright.

Figure 54 and Figure 55 show the posture required to move forward through this area, maintaining grip. Due to the lack of a suitable handhold to the right, the left hand upright could be gripped with the right hand.



Figure 54 5th percentile UK Female moves forwards gripping the next left hand upright with the right hand.

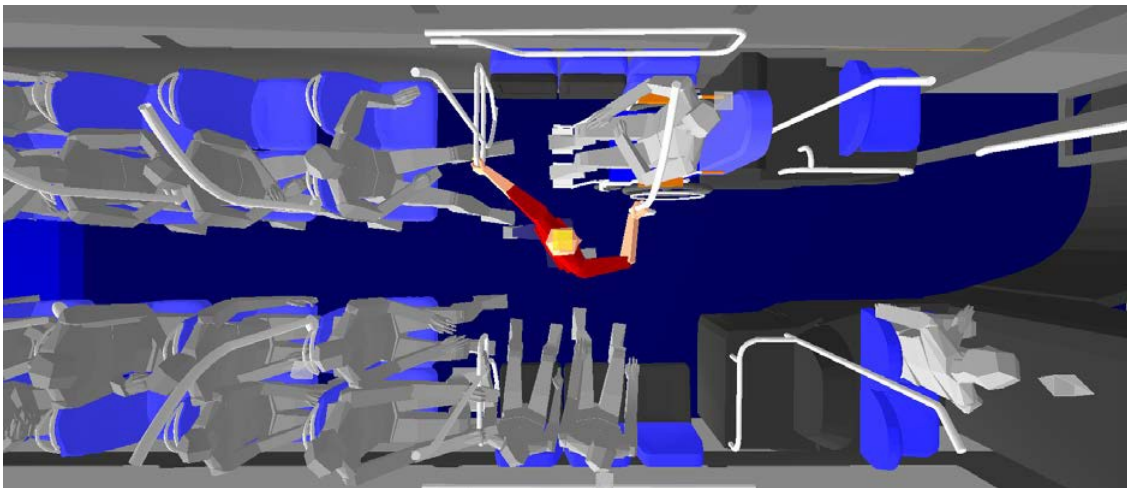


Figure 55 Plan view of the 5th percentile UK Female showing the grip of the two left hand handles.

Figures 56 and 57 show the posture required to move forward through this area, maintaining grip. Due to the lack of a suitable handhold to the right, and the use of a left hand side hand hold with the right hand, the same hand hold would need to be gripped with both hands to maintain at least one grip. This results in a double handed grip of the same upright.



Figure 56 5th percentile UK Female moves forwards resulting in a double handed grip of the left hand upright.

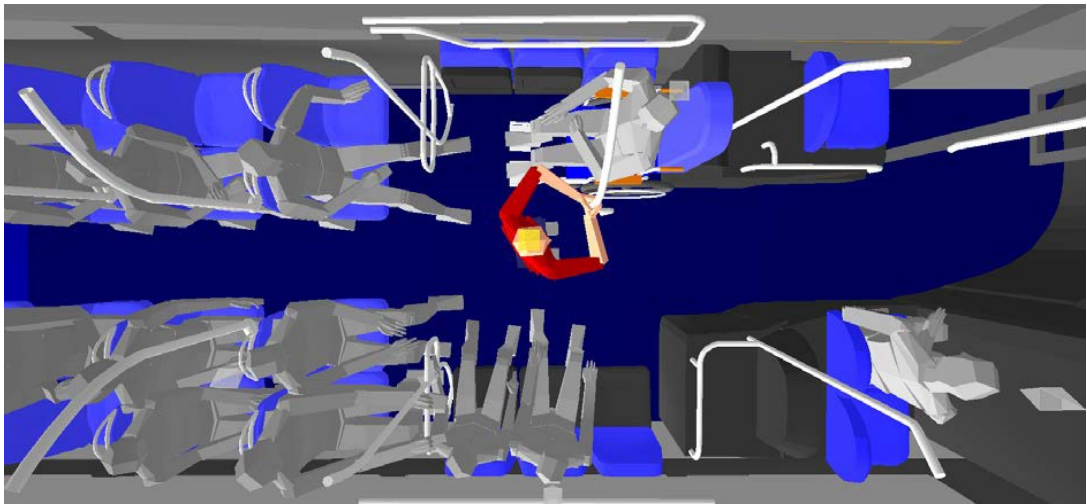


Figure 57 Plan view of the 5th percentile UK Female showing the double handed grip.

Beyond this area the alternating grip can be resumed reaching forward with the right hand to the next right hand upright (Figure 58 and Figure 61).



Figure 58 5th percentile UK Female moves forwards reaching to the next right hand upright.

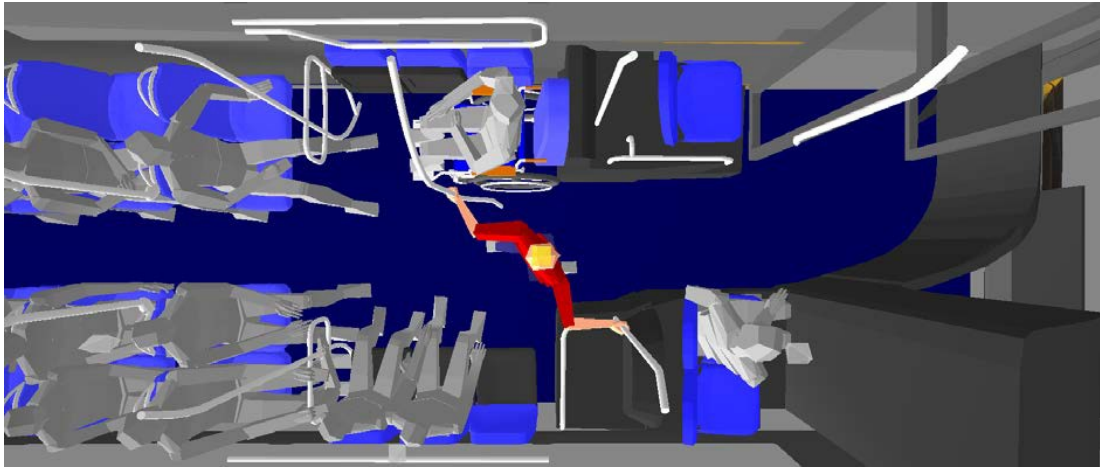


Figure 59 Plan view of the 5th percentile UK Female showing the right hand forward transition.

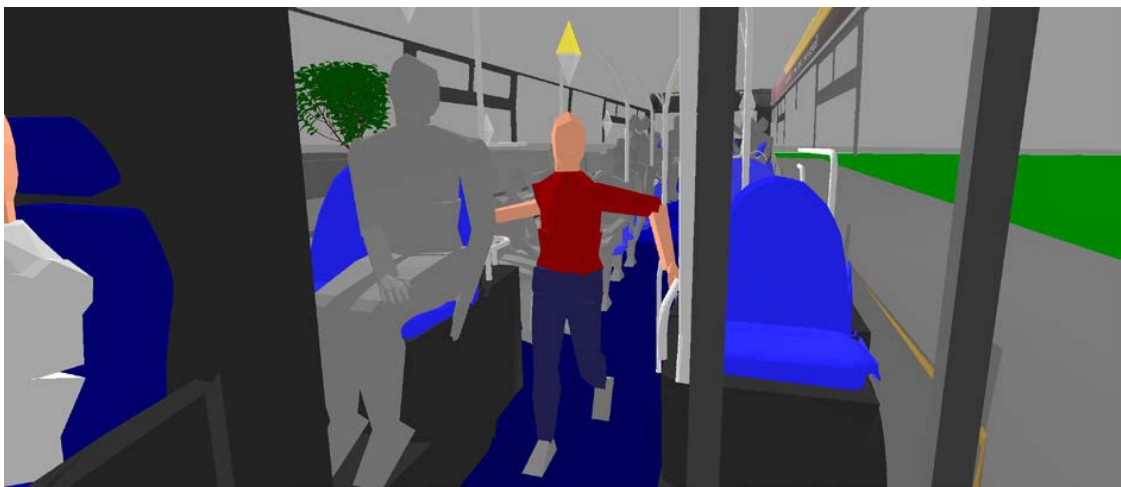


Figure 60 5th percentile UK Female moves forwards reaching to the next left hand horizontal handle on their way to the exit.

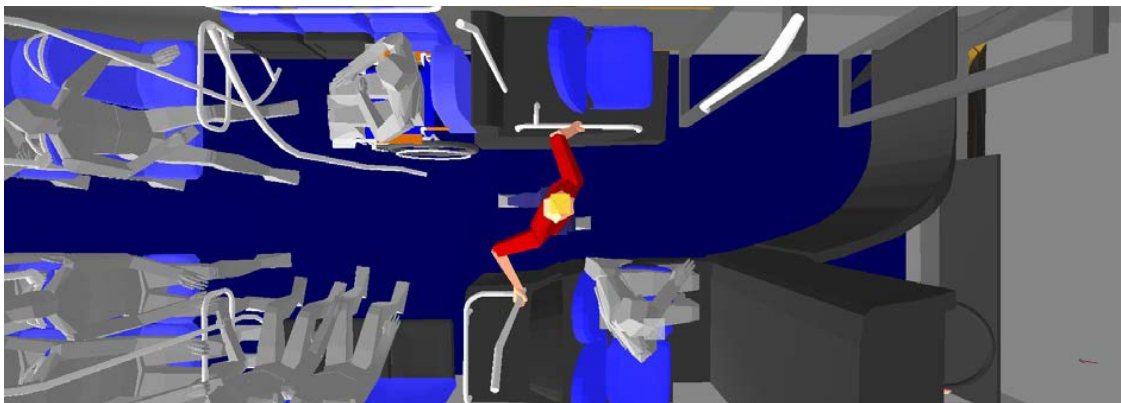


Figure 61 Plan view of the final transition before reaching the doors.

Adjacent to the front most seats the handles convert to a horizontal arrangement and provide the ability for a passenger to maintain grip and slid forwards until they reach the doors.

Traversing Front to Back Unencumbered – Summary

From the analysis it is clear that the main upright handles have been spaced to allow a hand to hand traversing arrangement for passengers. This allows grip to be maintained by at least one hand at all times. In some places this requires a relatively awkward posture such as stepping down the rear steps, or moving through the transverse seating area. In addition, other passengers may make actually gripping the hand holds awkward, though the upright handles are much less prone to this interference than the seat back handles. Overall unencumbered case presented here is a 'best' case scenario and does not include any potential hazards in the aisle that could restrict movement though the bus for example, shopping bags, pushchairs or other standing passengers. Further to this it is a static bus and does not reflect the difficulty that a person would have if needing to reach an upright handle quickly in the event of sudden braking or swerving manoeuvres.

Traversing Front to Back Encumbered

The following series of images show the possible postures for an encumbered 5th percentile UK female traversing from the rear of the bus to the front attempting to maintain at least one hand hold at all times. The encumbrance in this instance is a bag, held in one hand.

Figure 64 and Figure 65 show the 5th percentile UK female standing at the rear of the bus. The left hand is holding a bag, the right hand is holding the first right upright handle.



Figure 62 5th percentile UK Female stands at the rear of the bus, the left hand is carrying a bag, the right can grasp the first upright handle.

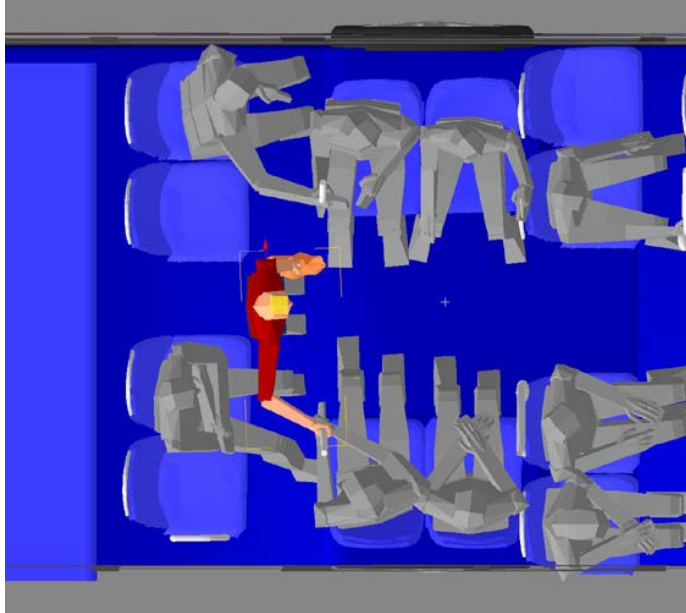


Figure 63 Plan view of the 5th percentile UK Female showing the first right hand grip.

Due to the encumbrance of carrying the bag it is clear that the alternating arm strategy of the unencumbered passenger is not possible without constantly changing hands with the bag. However, even if the bag was swapped from hand to hand the passenger would not be holding on during the swap. Figures 64 to 67 show the passenger moving forwards maintaining grip of the right hand upright for as long as possible before letting go and transferring to the next right hand upright. During the transfer the passenger has no support.

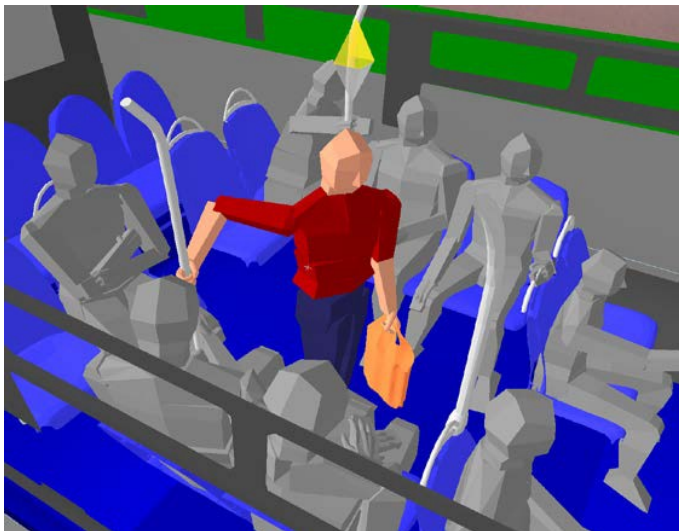


Figure 64 5th percentile UK Female moves forwards maintaining the right hand grip.

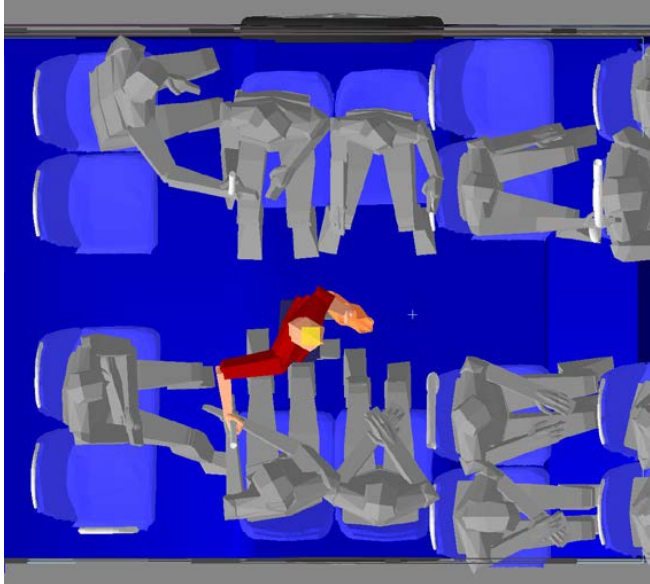


Figure 65 Plan view of the 5th percentile UK Female moving forwards maintaining the right hand grip.

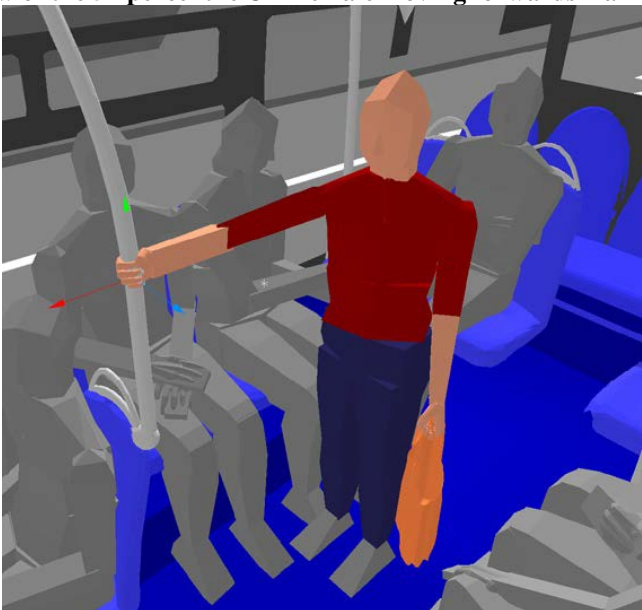


Figure 66 5th percentile UK Female reaches forwards after letting go of the first upright and grip the next right hand upright

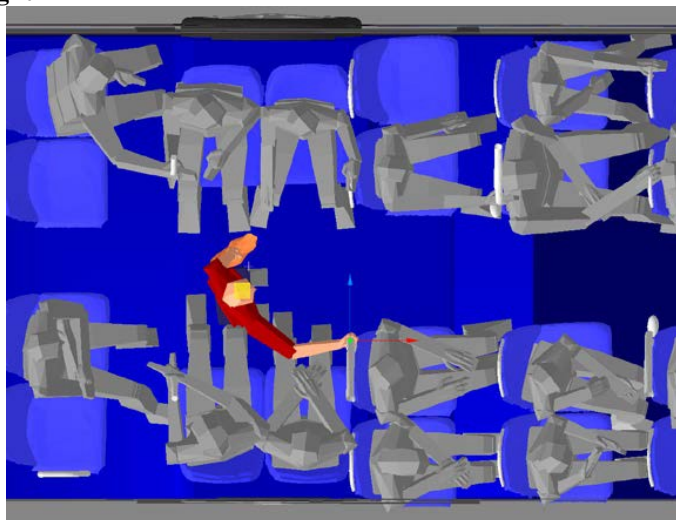


Figure 67 Plan view of the 5th percentile UK Female showing the next right hand grip.

The grip of the right hand upright can be maintained until the passenger reaches the top of the steps (Figure 68 and Figure 69).

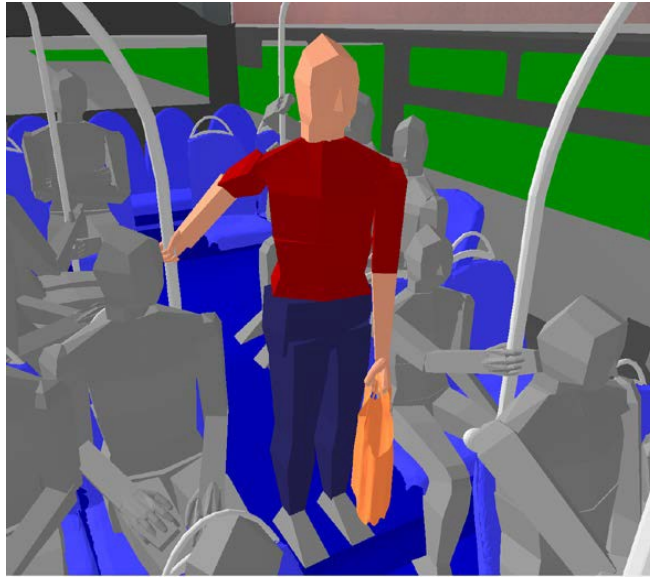


Figure 68 5th percentile UK Female reaches the top of the steps maintaining grip of right hand upright.

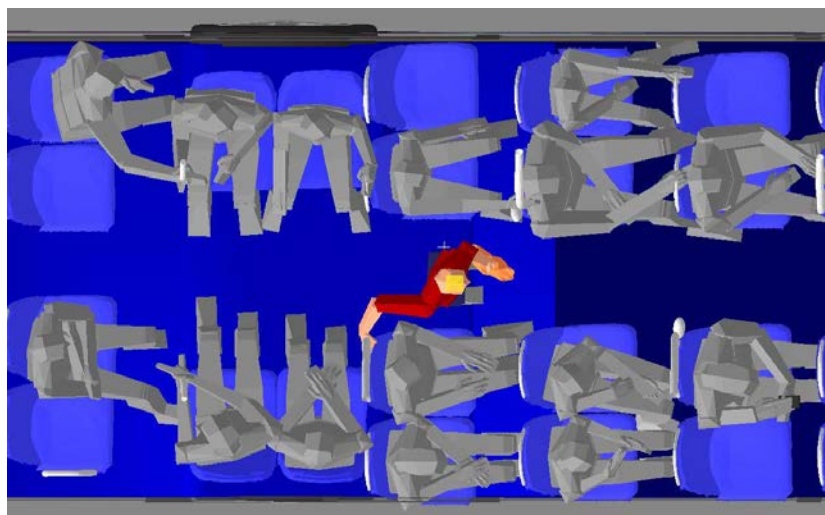


Figure 69 Plan view of the 5th percentile UK Female showing the posture at the top of the steps.

At the top of the steps the passenger finds themselves without an available right hand handhold. The next right hand upright is out of reach for an appropriate palm grip by 475mm (Figure 70 and Figure 71). The alternative of reaching for the grip on the seat back at the bottom of the steps is also out of reach by 235mm (Figure 72). Theoretically the seat back grip could be reached from the top of the steps though the passenger would have to bend down or crouch unrealistically in order to reach the handle.



Figure 70 5th percentile UK Female reaches forward with the right hand but the next upright is nearly 0.5m out of reach.

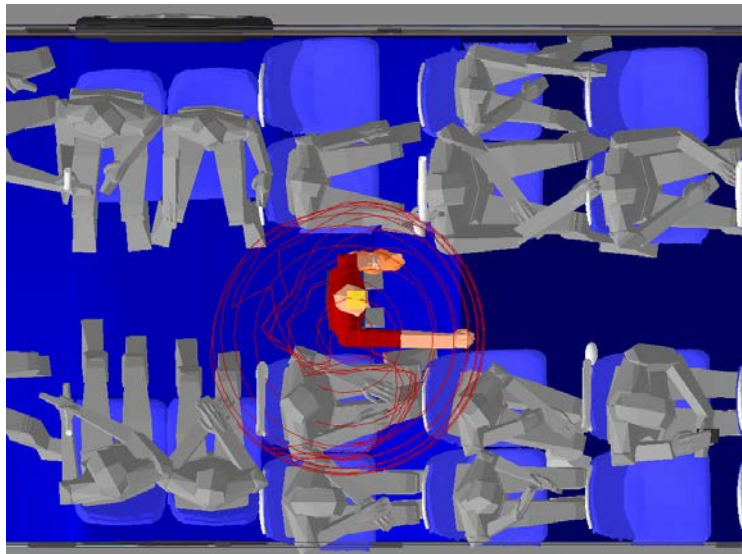


Figure 71 SAMMIE reach contours showing that the next right hand upright is well beyond the reach of the encumbered 5th percentile UK female.



Figure 72 5th percentile UK Female reaches downwards with the right hand but the next seat back handle is a little over 0.2m out of reach.

To move down the steps and maintain grip of at least one handle the passenger would need to swap hands with the bag from left to right hands. Having freed up the left hand the left hand upright could be held and used throughout the decent of the steps. Figures 73 though to 76 illustrate the decent of the steps whilst maintaining grip of the left hand upright.



Figure 73 5th percentile UK Female has to swap hands with the bag to reach the left hand upright.

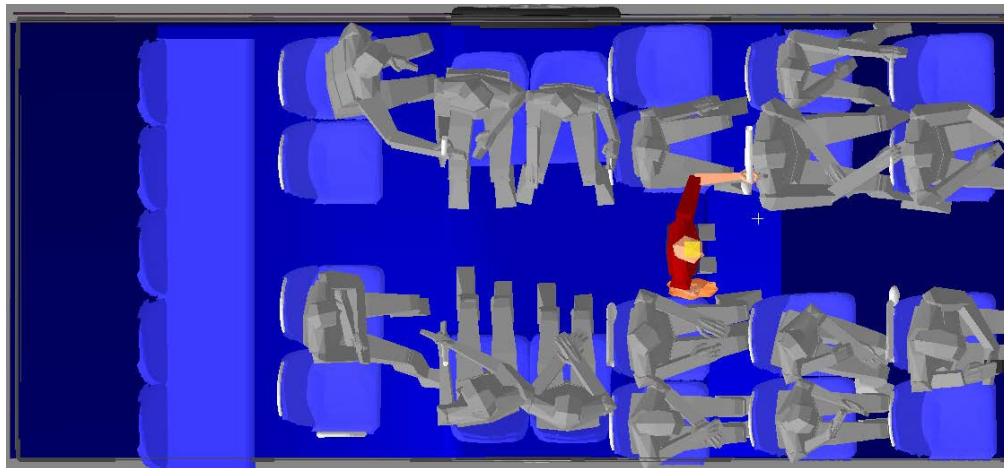


Figure 74 Plan view of the 5th percentile UK Female holding the left hand upright at the top of the steps.

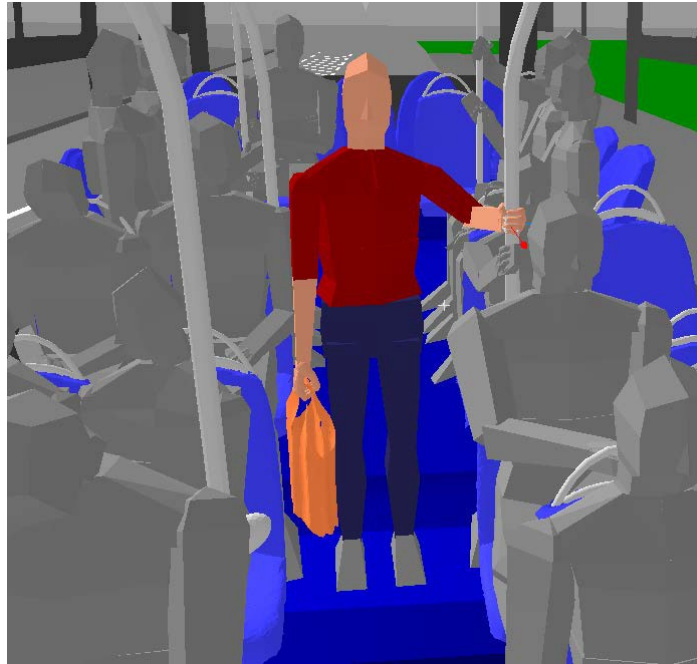


Figure 75 5th percentile UK Female maintaining grip of the left hand upright whilst descending the steps.

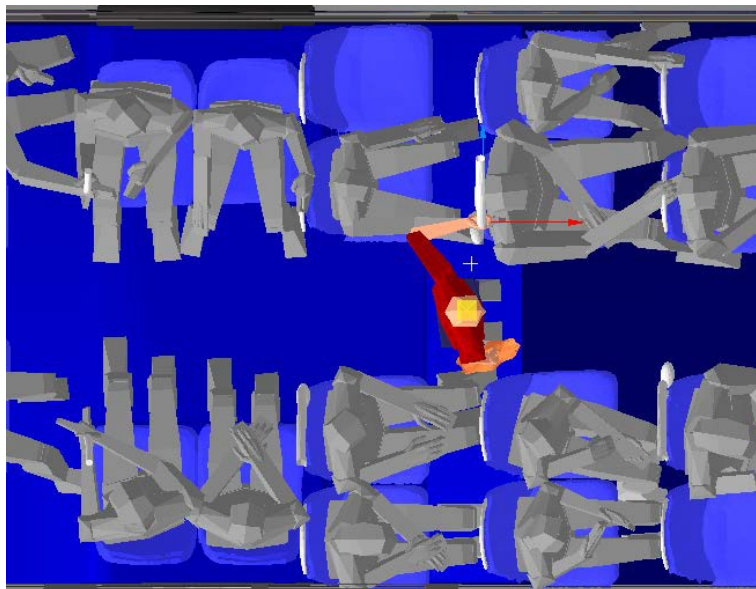


Figure 76 Plan view of the 5th percentile UK Female holding the left hand upright whilst descending the steps.

The postures of the passenger shown in Figure 77 and Figure 78 show the grip being maintained as the passenger moves forward. At this point the actual ability for the passenger to brace against any sudden acceleration or deceleration is limited and so whilst grip is maintained it is likely to have limited effectiveness.

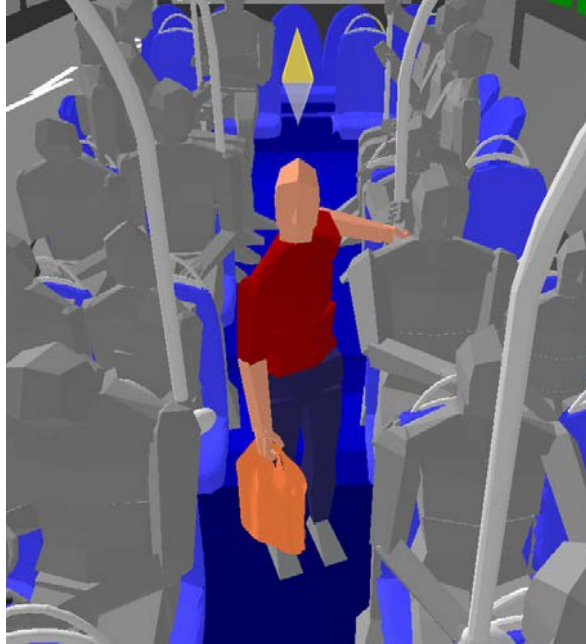


Figure 77 5th percentile UK Female maintaining grip of the left hand upright reaching the foot of the steps.

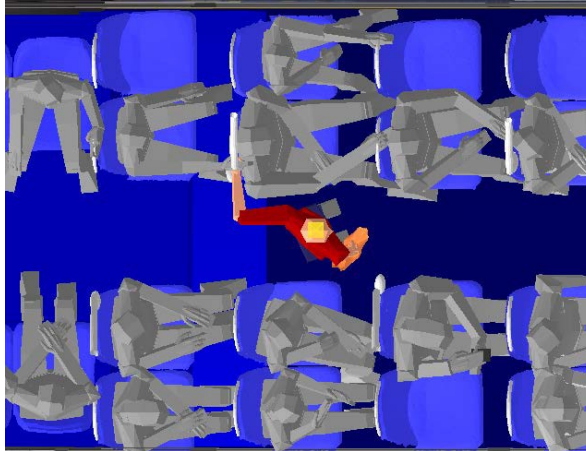


Figure 78 Plan view of the 5th percentile UK Female holding the left hand upright reaching the foot of the steps.

The following set of images (Figure 79 through to Figure 88) show a repeating pattern of the passenger maintaining grip of either a seat back handle or upright with their left hand. The passenger moves forward maintaining grip up to a point at which they then release their grip and grasp the next left hand handle. This can be done until the passenger reaches the front area with the transverse seats.

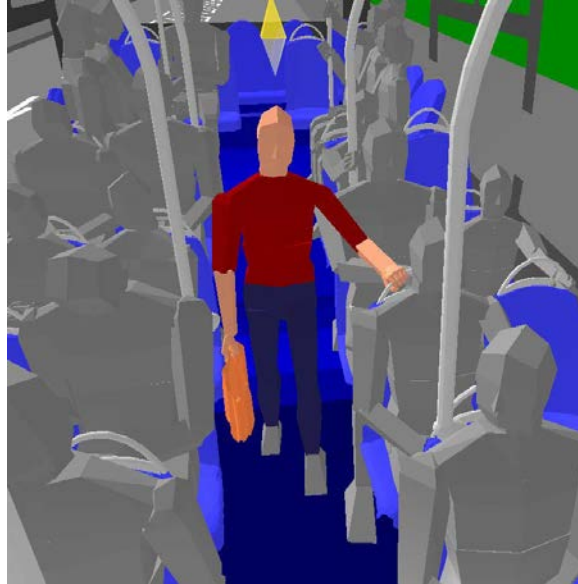


Figure 79 5th percentile UK Female releases grip to move to the next seat back handle with their left hand.

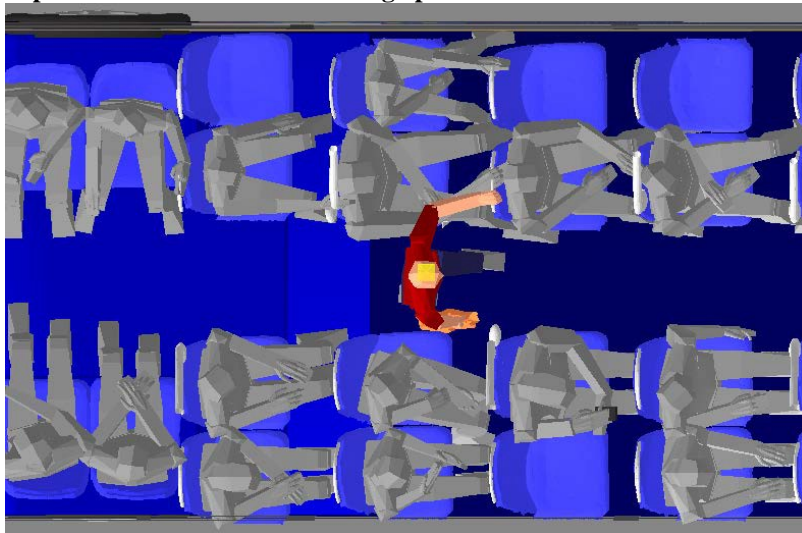


Figure 80 Plan view of the 5th percentile UK Female holding the next seat back handle.



Figure 81 5th percentile UK Female maintains grip of the left hand seat back to move forward.

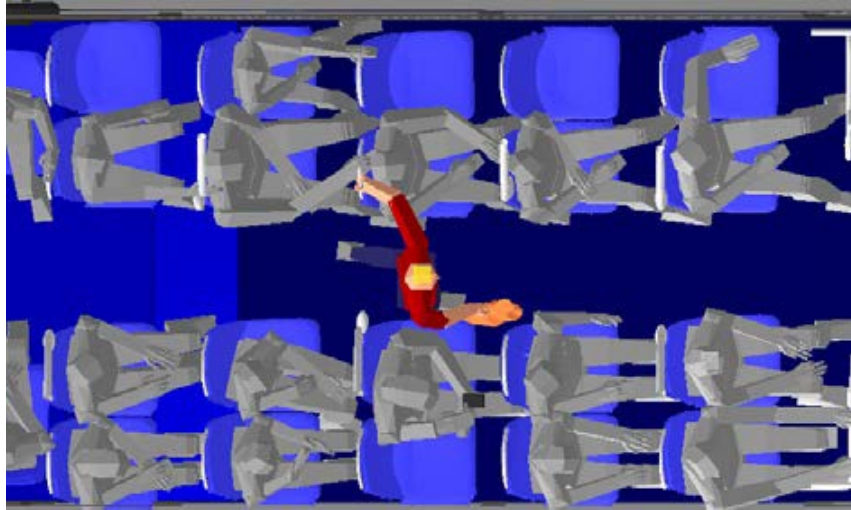


Figure 82 Plan view of the 5th percentile UK Female maintaining grip of the seat back whilst moving forwards.



Figure 83 5th percentile UK Female releases grip to move to the next left hand upright with their left hand.

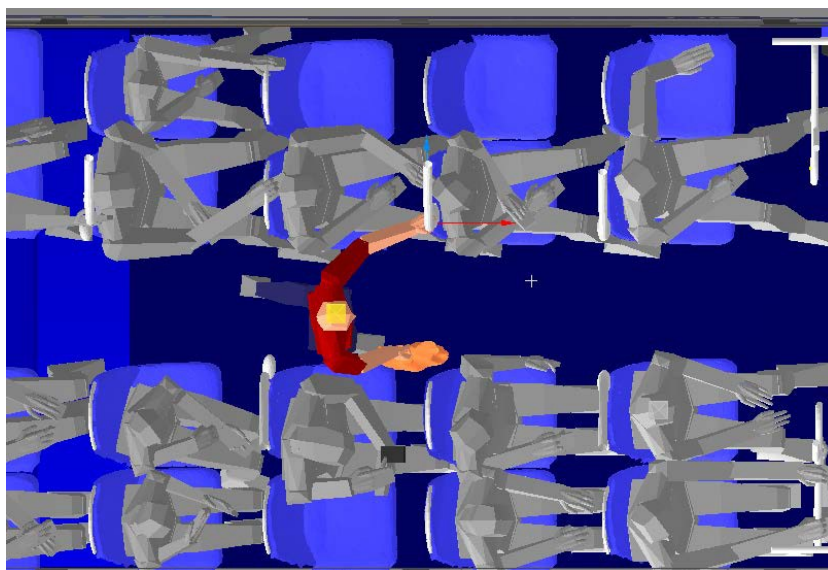


Figure 84 Plan view of the 5th percentile UK Female holding the next left hand upright with their left hand.



Figure 85 5th percentile UK Female maintains grip of the left hand upright to move forward.

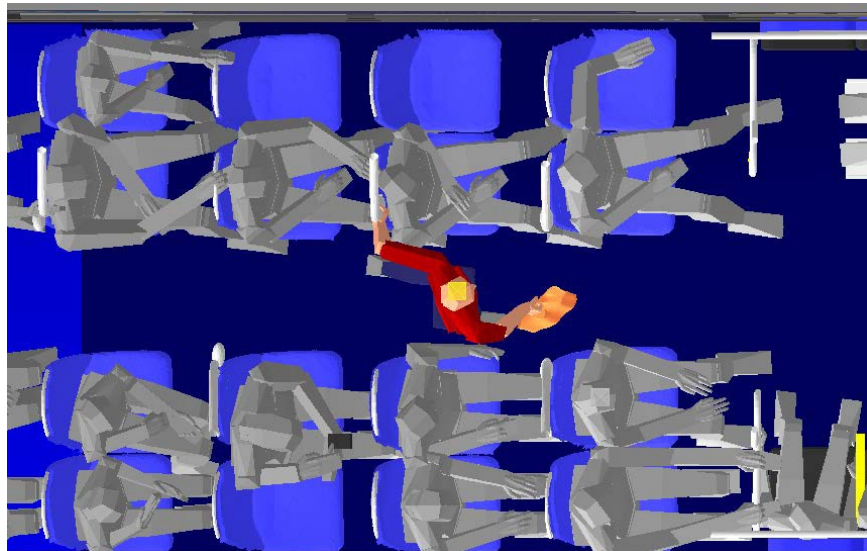


Figure 86 Plan view of the 5th percentile UK Female holding the left hand upright whilst moving forwards.

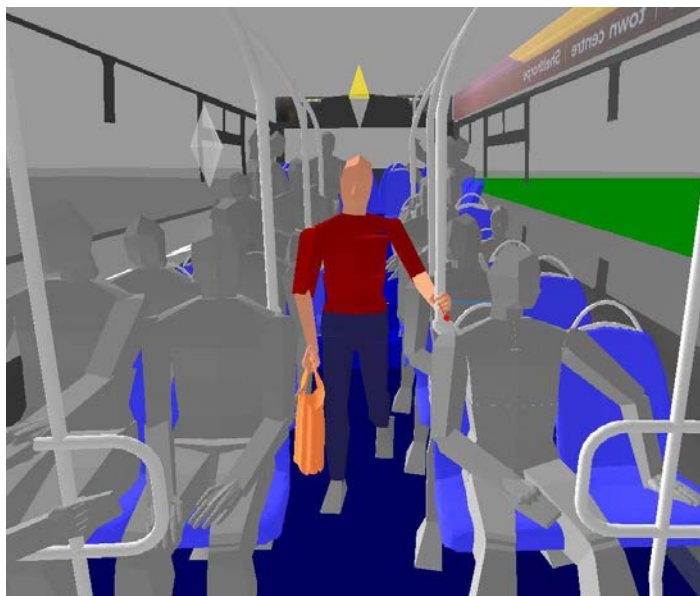


Figure 87 5th percentile UK Female releases grip to move to the next left hand upright with their left hand.

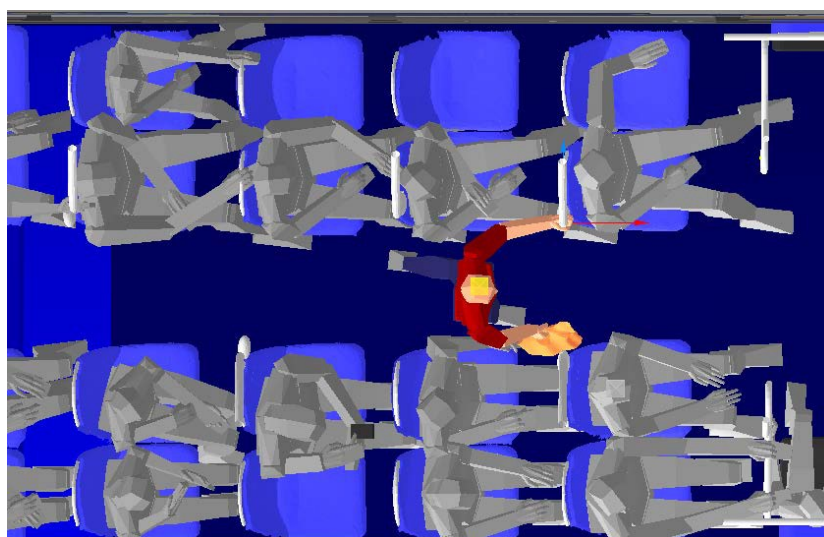


Figure 88 Plan view of the 5th percentile UK Female holding the next left hand upright with their left hand.

Moving into the area of the transverse seats the left hand upright can continued to be gripped as previously until eventually the grip has to be released and the left hand brought forward for the next hand hold (Figure 89 and Figure 90).

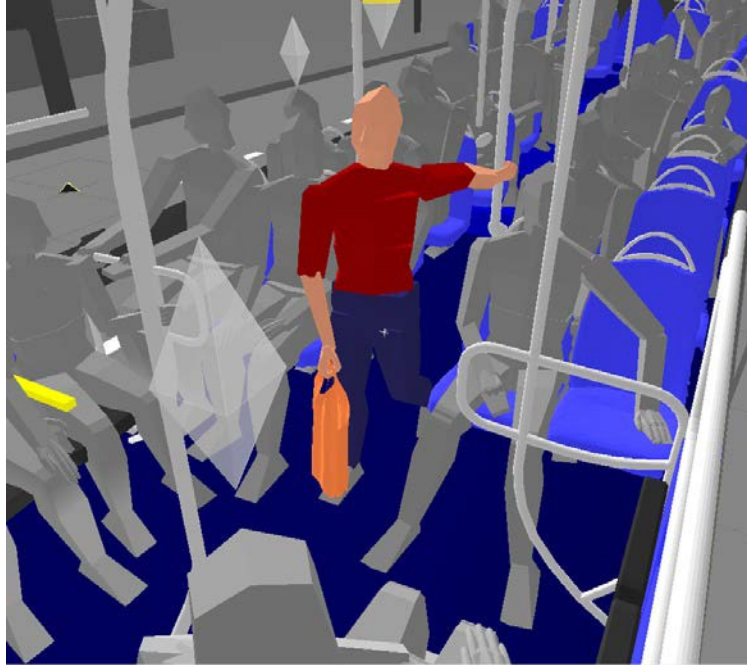


Figure 89 5th percentile UK Female maintains grip of the left hand upright to move forward to the transverse seating area.

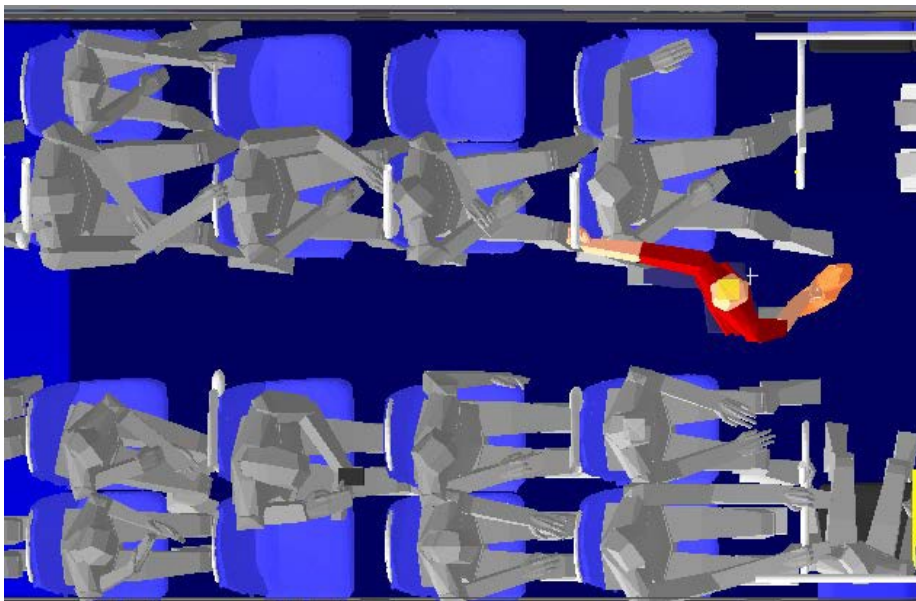


Figure 90 Plan view of the 5th percentile UK Female holding the left hand upright whilst moving forwards.

Figure 91 and Figure 92 show how the next hand hold would have to be the curved tubing partitioning the transverse seats from the standard front facing seats. At this point the left hand is now quite laterally displaced. As presented previously, this posture would make the handle more difficult to brace against during rapid acceleration or decelerations.



Figure 91 5th percentile UK Female moves forwards reaching to the laterally displaced curved handle with the left hand.

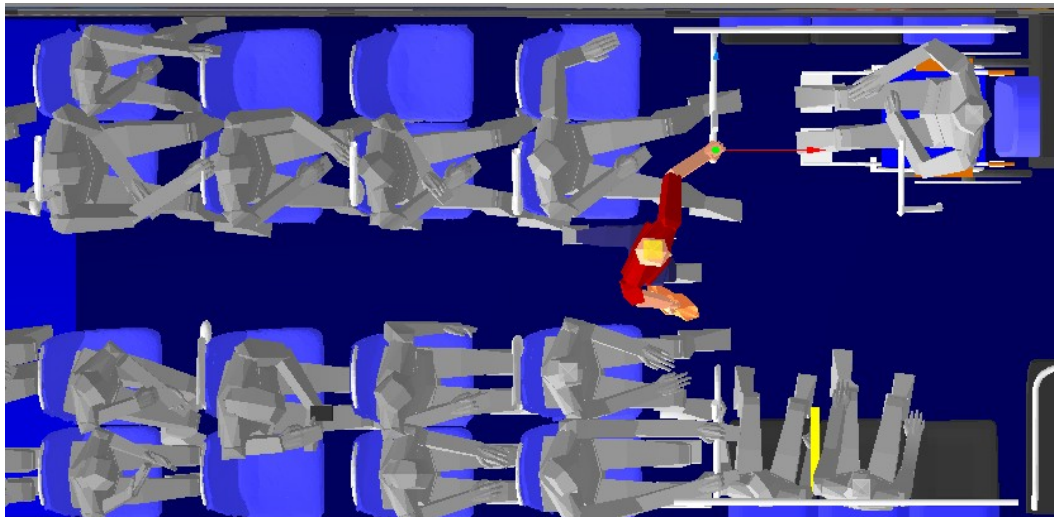


Figure 92 Plan view of the 5th percentile UK Female showing the left hand, laterally displaced, grip.

Moving through the transverse seating area Figure 93 through to Figure 98 show a now familiar pattern of the passenger being able to maintain grip for part of the traverse forwards until grip has to be released. There is then a period of time where no grip is possible for the passenger whilst they exchange one left hand grip to the next. In this instance the curved handle is released for the next left hand upright.



Figure 93 5th percentile UK Female maintains grip of the left hand curved handle to move forward through the transverse seating area.

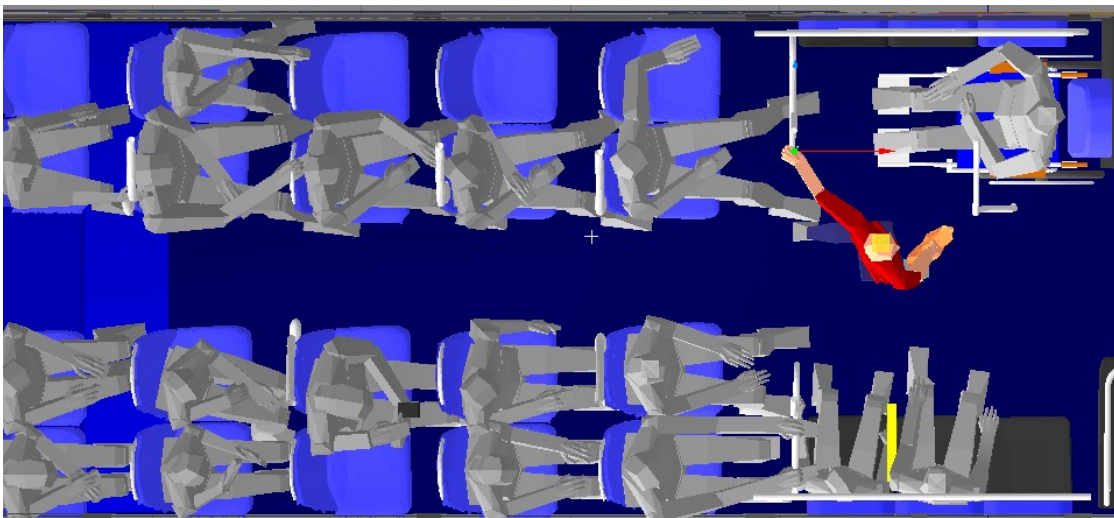


Figure 94 Plan view of the 5th percentile UK Female holding the left hand curved handle whilst moving forwards.

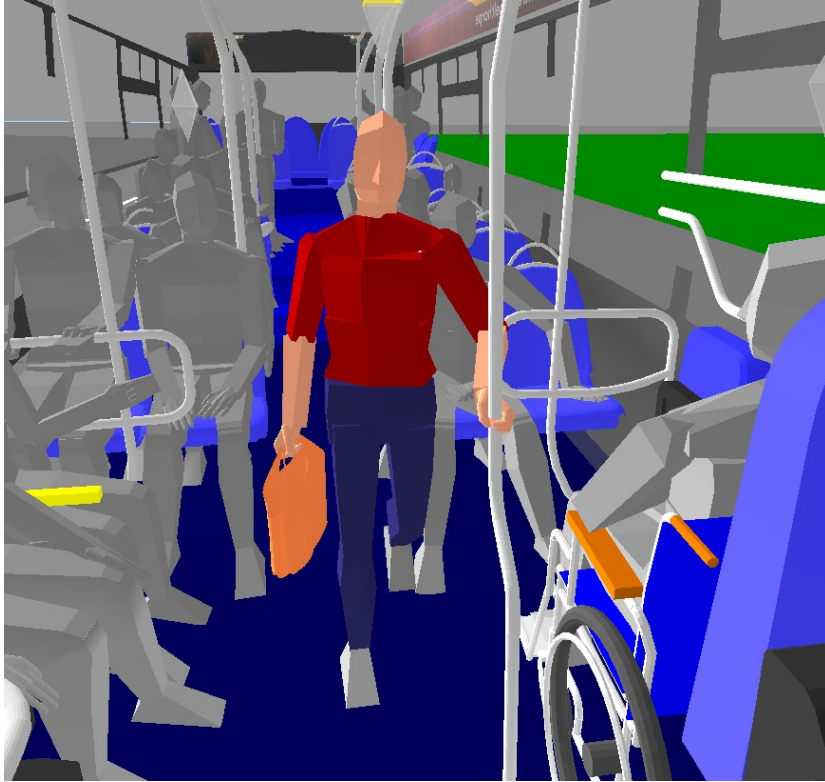


Figure 95 5th percentile UK Female moves forwards reaching to the next upright with the left hand.

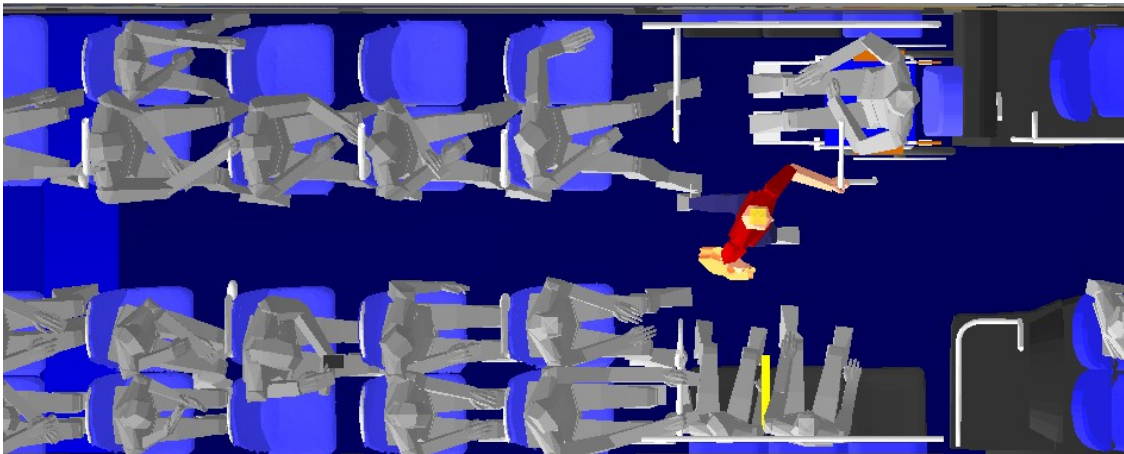


Figure 96 Plan view of the 5th percentile UK Female moving to the next left hand upright whilst moving forwards.

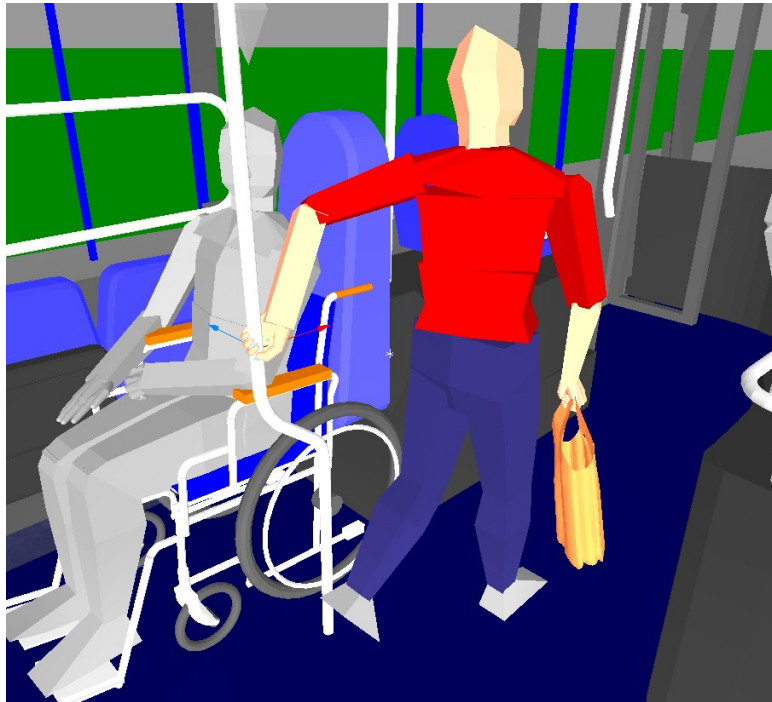


Figure 97 5th percentile UK Female maintains grip of the left hand upright to move forward past the transverse seating area.

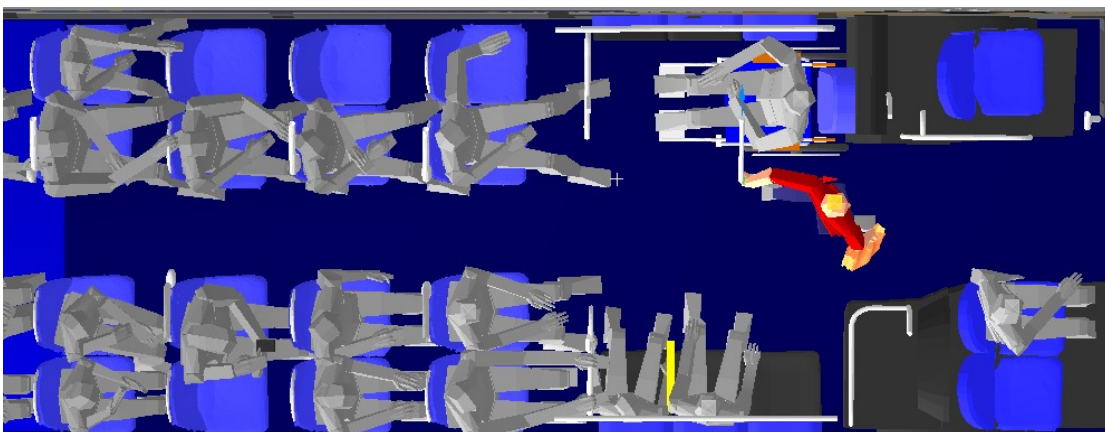


Figure 98 Plan view of the 5th percentile UK Female holding the left hand upright whilst moving forwards

Figure 99 and Figure 100 show the passenger reaching the horizontal handle, adjacent to the front row of seats. In many ways this is the ideal handle type for the encumbered passenger. The passenger can effectively slide one of their hands along the handle. Arguably grip is released during this time but the time to re-grip the handle is negligible compared to the swapping of hand holds seen previously.



Figure 99 5th percentile UK Female moves forwards reaching to the next left hand horizontal handle on their way to the exit.

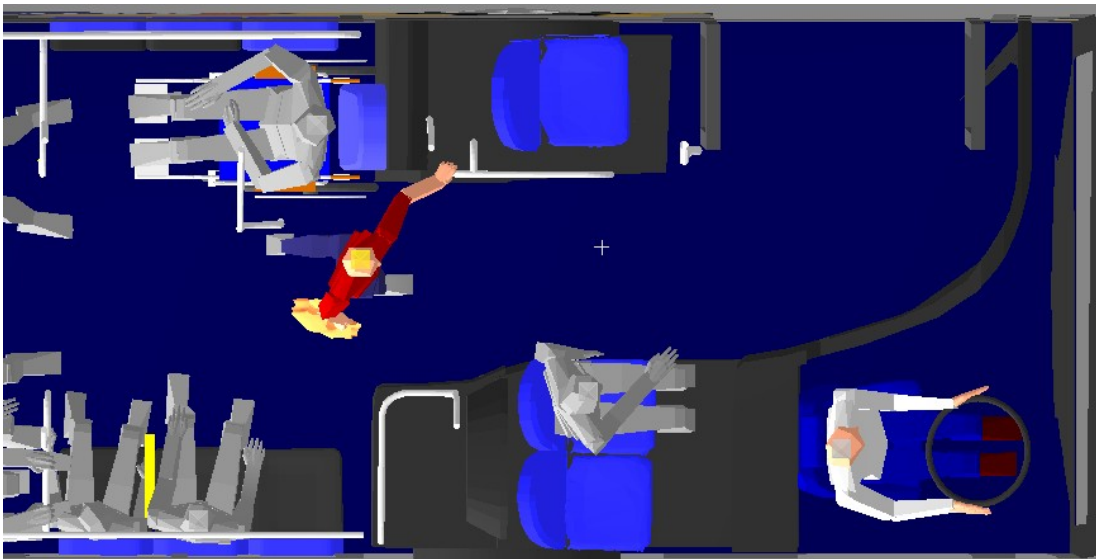


Figure 100 Plan view of the 5th percentile UK Female holding the left hand horizontal handle.

Figure 101 and Figure 102 show the final transition, of grip release and re-grip on the next hand hold. The final hold is the upright by the door used prior to alighting the vehicle.



Figure 101 5th percentile UK Female moves forwards reaching to the final, door, upright with the left hand.

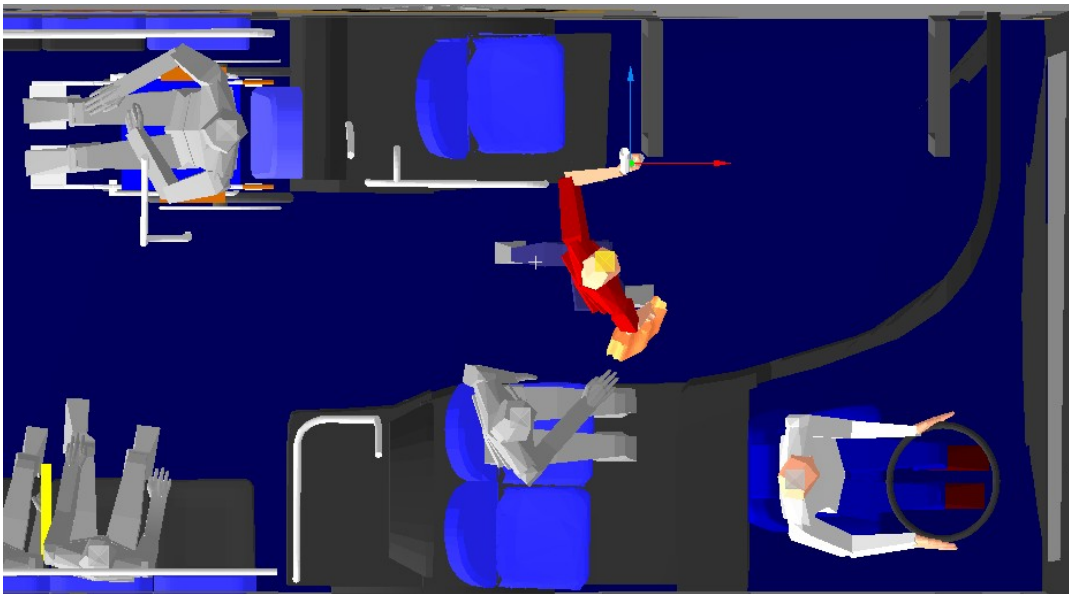


Figure 102 Plan view of the 5th percentile UK Female holding the final left hand upright.

Traversing Front to Back Encumbered – Summary

The analysis highlights that an encumbered passenger is at a significant disadvantage to the unencumbered passenger. Grip cannot be maintained by at least one hand at all times, and there are periods at regular intervals through the traverse from back to front where the passenger is not holding on and cannot brace against any external forces from the vehicle movement. As with the unencumbered analysis other passengers may

make gripping the hand holds awkward particularly where the seat back handles must be used.

Transverse Seating Evaluation

The following images show the limitations of the transverse seats for passengers seated in this area.

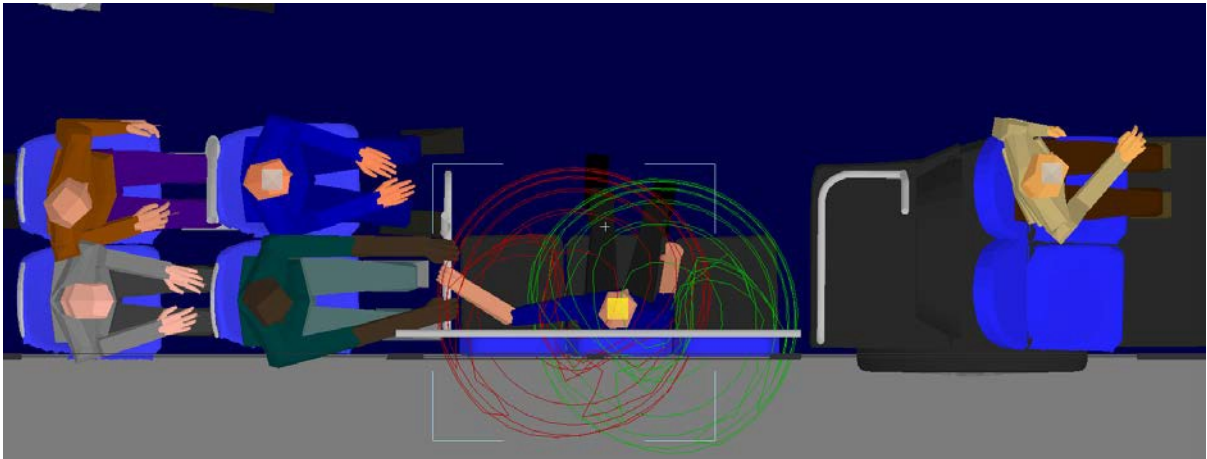


Figure 103 Plan view of 5th percentile UK Female seated in centre seat of transverse seating area.

Figure 103 shows the SAMMIE reach contours indicating that there are limited hand holds for a passenger seated in the centre seat of the transverse seating area. For passengers seated in either the left or right seats there are easily reached side hand holds. For the centrally seated passenger there is much less opportunity to brace themselves. If they are the only passenger in this area then it is just possible to reach to one of the side handles (Figure 104).

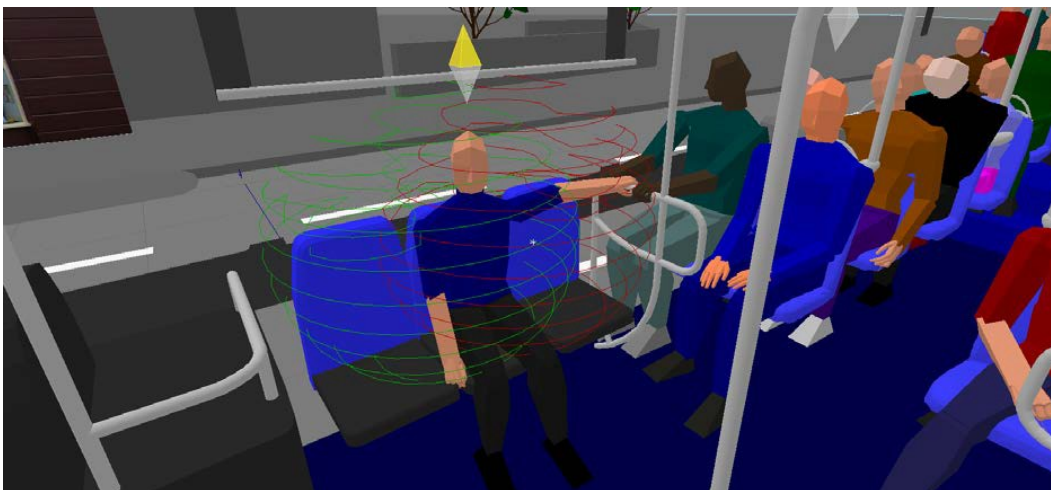


Figure 104 A centrally seated 5th percentile UK Female in the transverse seating area can just reach one of the side handles.

For passengers on the left hand side set of transverse seating (the area of the wheelchair space) there is no side handhold to the front of the vehicle (to the left of the seated passengers) but there is an additional upright hand hold to the front. However, the hand hold is quite a stretch for smaller passengers. Figure 104 and Figure 105 and Figure 106 show that the 5th percentile UK female would have to shuffle forward in the seat and lean forwards to use it as a hand hold.



Figure 105 The upright in front of the left hand transverse seats is not within easy reach of the seated passengers.

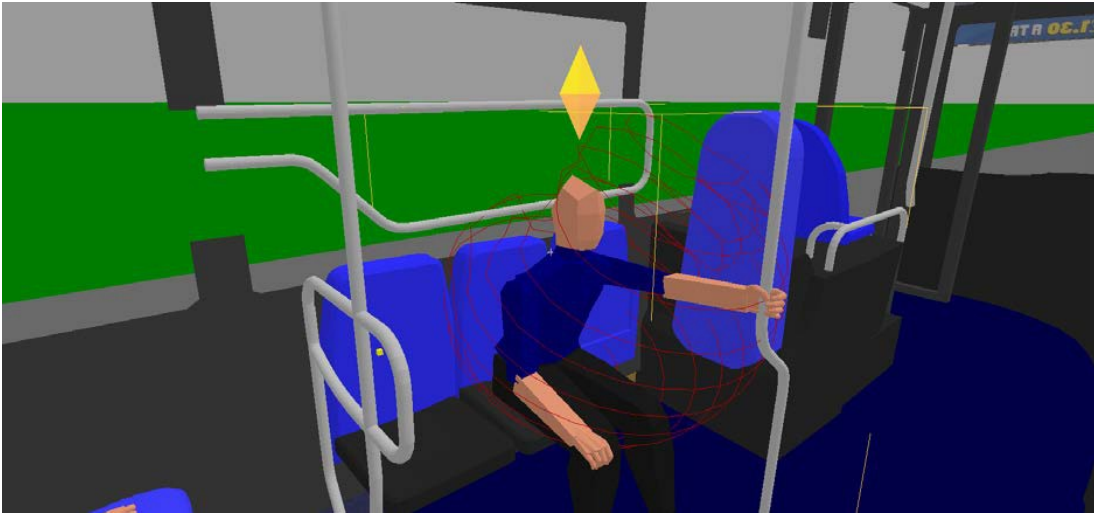


Figure 106 The upright can be reached by the 5th percentile UK Female if she sits forward on the seat and bends forwards.

For all passengers in this transverse seating area there is one potential issue concerning typical behaviour. Many seated passengers do not seem to think it necessary to hold on whilst the vehicle is in motion as they are seated. In addition, many passengers are encumbered with bags, sticks and the like and so unable to hold on. As such they may be very exposed to falling from the seats if they are not actively holding on whilst the vehicle is in motion. If all three seats are filled (see Figure 107) the passengers gain some bracing from each other due to the forces generally acting along the length of the bus, so each passenger can lean against one another. For a single passenger seated in the centre seat, or at one end with the force being in the opposite direction, e.g. in the rearmost seat during sharp braking, or in the front-most seat during hard acceleration there is little support.



Figure 107 Passengers filling all three of the transverse seats on one side of the vehicle.

Recommendations

The purpose of this report is not to provide actual recommendations to the issues identified. The data analysis highlighted a number of potential issues for older passengers whilst using a bus which the modelling activity exploited to illustrate potential difficulties and incident scenarios. The modelling activity also provides a means to explore potential countermeasures prior to testing via the vehicle manufacturers or fitters.

For example:

- The transverse seating area has a reduced availability of hand holds for passengers standing or traversing through this area. The modelling activity could be used to explore the addition of more upright handholds in this area and the potential of these to interfere with wheelchair and pushchair user needs in an attempt to provide a universal solution
- The seat back handholds are important but probably secondary for most passengers as the uprights provide improved, unobstructed access. The modelling activity could be used to explore the implication of providing redesigned seat back mounted handles to allow access that is unobstructed by other seated passengers
- The transverse seating provides reduced support for seated passengers. Particularly for single passengers in the rows of three seats, there is little bracing against forces from the vehicle motion. The modelling activity could be used to explore the opportunity for

fold-down arm rests in this area (see Figure 108 and Figure 109) or for the use of restraints



Figure 108 Passengers filling all three of the transverse seats on one side of the vehicle with fold down arm rests fitted.



Figure 109 A single passenger in the transverse seating area, braced by fold down arm rests.

Conclusion

The use of 3D modelling has been explored as part of a potential methodology for both analysing potential causality in an accident, and in the exploration of countermeasures to avoid any reoccurrence of an accident and associated injury to older bus-users. 3D scanning was employed using a FARO laser scanner to capture the interior of a bus to act as a case study of capturing accident scene data. The data were then post-processed and imported into the digital human modelling system SAMMIE to provide a virtual recreation of the vehicle. An existing DHM tool was employed for its ability to model a range of

humans and explore human – object interaction using industry standard tools and processes. Two main conditions were then evaluated: (1) using a single 5th percentile UK female human model traversing from the back to the front of the vehicle (unencumbered and encumbered with a bag); (2) passengers seated in the transverse seating area at the front of the bus. In both conditions there were a number of areas identified by the analysis that could be effectively explored further using 3D modelling, including the design and placement of hand holds throughout the vehicle and the inclusion of fold-down arm rests in the transverse seating area.

This report demonstrates the potential for 3D modelling activity to form a valuable part of accident investigation and to provide an evidence base to design changes in response to accidents. The process does provide additional overhead to any accident investigation and would require additional expertise. However, the time and costs involved need not be prohibitive particularly where the 3D scanning equipment is already available and used in accident scenario recreation. The greatest potential advantage of this technique is the ability to explore potential design changes, driven by an understanding of accidents that have occurred, in a digital environment before costs are committed through the implementation of changes to real vehicles.

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Cost-Benefit Analysis

Introduction

In justifying the need for implementation of new initiatives to improve safety, it is common to undertake a benefit, or a benefit-cost analysis, illustrating what the likely effectiveness is should a particular implementation strategy be adopted. These analyses can lead to more effective and strategic policies in Public Health, especially when they consider the long-term consequences as noted by Peters and Anderson (2012).

Government agencies in Public Transport typically call for Benefit-Cost-Analyses (BCA) as part of the preparation for introducing a new or modified regulation. This is claimed to be essential in terms of gaining industry and community support for a new safety intervention or countermeasure. Litman (2013) recently published a Best Practices Guidebook for evaluating public transit benefits and costs based on research conducted at the Victoria Transport Policy Institute in Canada. The Guidebook outlines a comprehensive framework for evaluating the full impact in terms of benefits and costs for transit improvements. The Guidebook notes the need for balancing the potential for quantified transit benefits against increases in costs of private or public amenity. Of particular importance is ensuring that injury benefits include both direct and indirect full social costs.

Background to Injury Costing

There are many different methods of assessing the impact of injury when conducting benefit-cost-analyses. The most accepted detailed approach involved assessing injury reductions in terms of anatomical trauma scoring systems such as the Abbreviated Injury Scale (AIS), the Injury Severity Score (ISS) or the International Classification of Disease (ICD-9 and ICD 10). Of these, AIS is probably the most common detailed measure of injury improvement (AAAM, 2011; Baker *et al*, 1974; Clarke Ragone and Greenwald, 2005). Injury costs have also been published, using more basic assessments such as the cost of a fatality, and a serious or minor injury by

various government sources. Often, these are the only available injury outcome criteria and can still be useful for computing BCAs. Injury costs have been shown to vary across countries. McMahon and Dahdah (2010) reported that the cost of a fatal injury (VOSL) in £2004 prices, varied from £2.2million in Austria to £0.97million in France. Further, the cost of a serious injury (hospitalisation) varied from £308,000 in Sweden to just £73,000 in Germany (see Table 38 below). They reported that in lower income countries, the cost of a statistical life (VOSL) was also found to be much lower (from as low as £5,000 in Vietnam £230,000 in Malaysia, and £329,000 in Latvia).

Table 38 Fatal and Serious injury data and costs (£2004) for several developed countries

Country	Fatalities	Serious Injuries	VOSL	VOSI	Serious Injuries /Fatalities	VOSI /VOSL	Method Used
Australia	1,634	22,000	1,029,740	223,110	13.	0.2	HC
Austria	73	6,7	2,242,266	265,350	9.3	0.1	WTP
Canada	2,936	17,830	1,028,086		6.1		HC
France	5,318	39,811	969,272	104,714	7.5	0.1	HC
Germany	5,842	80,801	973,427	73,112	13.	0.0	HC
Netherlands	98	11,018	1,513,067		11.		HC +
New Zealand	40	3,9	1,539,427	270,031	9.8	0.1	WTP
Sweden	44	4,0	1,724,730	307,736	9.1	0.1	WTP
United	3,221	31,130	1,384,463	155,563	9.7	0.1	WTP
Unites States	42,815	356,000	1,849,200	286,418	8.3	0.1	WTP

HC = Human Capital method; WTP = Willingness-To-Pay Method

It should also be noted that the costing methods in each of these countries also varied. In the developed countries, there was a mixture of Human Capital and Willingness to Pay methods employed, while the developing countries costs were primarily determined using Human Capital methods. More detail on these is discussed in the following section.

Current Cost Figures in UK

The latest costs of injury figures published by the Department for Transport are shown in Table 39 below for annual averages and in Table 40 for total accident costs (DfT, 2013).

Table 39 Average value of prevention by cost and road type (£2012) - (DfT, 2013)

Feature	Fatality	Serious Injury	Slight Injury	All Severity Average	Damage Only
Cost per casualty	1,703,822	191,462	14,760	50,698	-
Cost per accident	1,917,766	219,043	23,336	72,739	2,048
Urban roads	1,914,229	218,109	22,773	62,250	1,935
Rural roads	1,920,372	220,524	24,559	109,415	2,830
Motorways	1,924,341	229,358	27,857	74,471	2,720
All roads	1,917,766	219,043	23,336	72,739	2,048

Table 40 Total value of prevention by cost category and road type (£2012million) - (DfT, 2013)

Feature	Fatality	Serious Injury	Slight Injury	Damage Only	Total Costs
Casualty costs					
-Lost productivity	1,040	526	389	-	1,955
-Medical/ambulance	9	315	165	-	490
-Human costs	2,042	3,582	1,854	-	7,478
Total Casualty	3,091	4,423	2,408	0	9,923
Accident costs					
-Police costs	29	44	67	77	217
-Insurance/admin	1	4	15	124	143
-Property damage	19	108	381	4,332	4,840
Total Accident Costs	49	156	463	4,533	5,200
Total Costs	3,139	4,578	2,871	4,533	15,122
Urban roads	1,431	3,244	2,181	3,952	11,883
Rural roads	1,555	1,214	573	494	2,743
Motorways	153	120	116	87	496
All roads	3,139	4,578	2,871	4,533	15,122

BCA Methodologies

It should also be noted that while many Benefit-Cost-Analyses do not involve cost outcomes, those that do struggle to equate injury costs across countries as available figures tend to be developed for particular regions and may have little relevance outside that region. In the US, for example, injury costs tend to be rather high, given that they maintain a high level of private health cover and represent a relatively affluent society. In other countries such as UK and New Zealand, they prefer Willingness-To-Pay methods, rather than a Human Capital approach to costing injuries, that also give higher benefits but are also still not universally accepted as a legitimate costing model. Obviously, the higher the cost of injury, the higher is the Benefit-Cost-Ratio outcome.

Human Capital (HC)

The Human Capital approach has long been used for determining the cost of injury in transport studies. This “bottom-up” approach is the preferred method, adopted by many countries as a means of determining the benefits that will apply when assessing the need for a future invention or regulation to prevent or mitigate the effects of road crashes.

It is based on assessing the economic impact of fatal or survivable injuries to the individual or society and is an *ex post* approach, valuing these losses in current costs and then discounting the present value of the victims output for future values (McMahon and Dahdah, 2010). As these authors point out, the Human Capital method grossly underestimates the true value of preventing road crashes, as it often fails to allow for many indirect costs, such as pain and suffering and loss of quality of life. Wren and Barrell (2010) also pointed out that the method tends only to value tangible costs and understates the value of life for children and the older person who contribute less in terms of current earnings. It also misjudges loss of productivity values in countries where there is large unemployment as individuals who die in road crashes can often be replaced quickly and easily.

In spite of this, the Human Capital method is still the preferred method used by many, as it appears to have face-validity and appeals by its *building-block* approach. Financial and government treasury bodies, in particular, have confidence in the use of Human Capital methods, in contrast to the alternative “Willingness-To-Pay” method, although there are signs that this is slowly changing in these disciplines because of the low costs that are ascribed to preventing injuries.

Willingness-To-Pay (WTP)

The alternative challenge to the Human Capital method that is fast gaining subscription in injury prevention costing circles is the Willingness-To-Pay (WTP) approach. Philosophically, it seems a better approach as it applies values that people are prepared to pay to avoid injury (akin to a user-pays model). Its major challenge, however, is the means and limitations by which it goes about making these assessments.

WTP often uses revealed preference methods or gambling theory to arrive at its costing values. People are asked to put values on how much they are prepared to pay to avoid injury by comparing with a range of other

expenditures. Feldman (1994) described a series of approaches used in making these assessments, such as asking people what they are prepared to pay from their salaries to avoid dying in a road crash or insurance costs. He outlined mathematically, assessments using survival probabilities, or life and death indifference scenarios to help in making these WTP judgements. But herein is the challenge for Willingness-To-Pay: are people able to make accurate judgements of what they are prepared to pay in these circumstances? As Wren and Barrell (2010) pointed out, does a product safety margin really drive a purchase decision and do wage differentials really reflect an individual's knowledge of the real risk of injury? These issues are still hotly debated by various sectors in economics theory.

Net Present Value (Worth): Net Present Value (or Net Present Worth) is a metric commonly used by industries when making decisions about whether to invest in new product lines or alternative investment strategies. It balances the discounted costs and expected inflows from alternative decisions. With choices for spending limited funds, governments use NPV (NPW) in helping to prioritise their programs.

NPV was described by Lin and Nagalingam (2000) as the difference between the discounted sums of cash inflows and outflows. It compares the value of money today to the present value of money in the future, taking inflation and returns into account. NPV (NPW) measures the excess or shortfall of cash flows, in present value terms, above the cost of funds. If the NPV is greater than zero, it would be better to invest in the project than do nothing at all, but is also often assessed against alternative options with a higher NPV.

Undertaking a Benefit-Cost-Analysis: The OPTU pilot-study never intended to undertake a full "Benefit-Cost-Analysis" for each recommendation. Nevertheless, it was the intention to illustrate how a BCA could be undertaken on Older Road User injury countermeasures if required. To show what would be involved, the solution to overcoming injuries to older public transport users of having to sit in 'retracting' sideways facing seats by replacing these with forward or rearward facing seats is used as an exemplar technological in the BCA. In conducting a BCA, there are a series of steps required in computing the Benefit-Cost-Ratio (the relationship between the

individual benefit in fewer risk of injury and the unit cost in providing the replacement seats). Assessing the BCR involves a series of procedural steps:

- Device description and functionality
- Available data on pre-crash history
- Estimating possible injury savings
- Computing the overall community savings
- Computing the unit benefits (discounting and expected life)
- Economic cost of the device
- The Benefit-Cost-Ratio

These are discussed in more detail below.

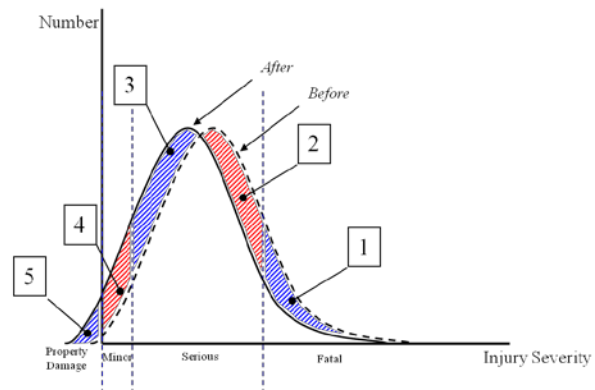
Device Functionality: It is important at the outset to fully describe the device and its functionality. In this case, it would be assumed to be similar to other fixed seats that are normally supplied in buses and trains that are perpendicular to the direction of travel as shown opposite. Further, it would be expected to meet the regulations for strength of attachment and load-bearing design capabilities for such seats in buses (5-10k Newtons force). Moreover sufficient spacing between seats and fitment of appropriate seat belts need to meet the current standards for public transit buses.

Proposed Perpendicular Seat Layout



Baseline Crash History: In computing the expected savings, it is necessary to have sufficient crash data on the extent of injury to older transport users from the current generation of seats. These data may be available from Stats 19 police reports (see earlier analyses presented) and/or supplemented with additional data from hospitals and other sources. This provides the before situation that is to be addressed by the design change proposed.

Estimating Injury Savings: This is usually the most difficult task associated with computing a BCA. In most cases, the solutions are new and untried and there is often little evidence available on the likely performance of the modification.



In estimating the likely benefits of a particular intervention, the researcher is looking for a shift in the injury distributions for fatal (1), serious and minor injury (2-4) affected by the change as shown opposite. When summed, these benefits reveal the likely savings for the measure assuming that all vehicles in the fleet have the device fitted immediately. In making these assessments, the investigator is forced to use several techniques to calculate at the shift. These include:

- Available evidence (earlier reports, test data, other information);
- crash reconstructions if in-depth data are available;
- Simulation and modelling occupant kinematics;
- On-road trials; and/or
- Expert judgments.

In the exemplar example, for instance, the available sources of information available would be comparisons of crash and injury outcomes by seating position (where available), computer modelling using occupant kinematic software to gauge the differences in movement and force using available injury assessment curves, and where appropriate, expert judgment.

Where there are no data available for making these assessments, the assessor is often called upon to use alternative methods. One approach that can be adopted calls for assembling a "panel of experts" to work through the likely effects of the technology in terms of which crashes are likely to be influenced by the technology and how road users are likely to respond to the new safety feature. These experts are usually selected because they have considerable experience in safety engineering and/or research and are well placed to make these judgments based on their specialized knowledge. Obviously, the more experienced, the more likely the assessment will be accurate, although there is always scope for misinterpretation and incorrect assumptions, especially in terms of driver responses to the technology.

It is fair to say that in making these judgments, the researcher is forced to make many assumptions about the likely injuries saved. These need to be thoroughly document and transparent so that should any future data become available, the original figures can be adjusted appropriately and a modified BCA can be made available (Fildes, Lahausse and Fitzharris 2009)

Community Benefits: Assuming it is possible to arrive at an overall expected benefit based on current and predicted future injury reductions and travel exposure, it is then possible to document the shift in terms of fatal, serious and minor injuries saved (i.e.: the number of older passengers whose injury is either mitigated or prevented entirely from the new seat positioning). After applying the relevant before and after injury costs, the total community financial benefits for the intervention can then be computed. It needs to be noted that in some cases, these changes may cause additional injury to others (more crowding in passageways for instance) involving injuries to younger passengers. In addition, where injuries are only mitigated, costs need to be adjusted taking into account the previous and predicted injury level costs. These adjustments will often reduce the overall community benefit of the intervention.

Equipment Costs: The final stage in computing the BCA is determining what the final economic cost (taxation free) will be for introducing the countermeasure, in this case, modifying the 'retracting' sideways facing seats to permanent forward or rearward facing seats. This would require purchasing new appropriate seating, less any saving from the sale of the side-facing units, and the fitment and associated bus modification costs required. If the fitment program is over an extended period, the future equipment cost over the life of the program will need to be adjusted. In this case, the seat and fitment costs can be simply costed as the seat design is well known and available. For other solutions, the costs may not be known and needs to be estimated also involving Original Equipment Manufacturers (OEMs). This can also introduce another source of possible variation to take account of in the computation.

Lifetime Benefits: It should be noted that the benefits accrue over several years so the savings will apply for the expected life of the transport unit. Moreover, the introduction of the countermeasure is likely to be a gradual

process as existing buses are modified and new buses are introduced with the vehicle fleet with the new feature. These processes need to be factored into the likely community benefit. Moreover, the savings today are likely to be less in future years as inflation and other increases take effect, so it is important to discount any future savings accordingly. Discount rates typically vary from a low of 2-3% up to 7% across countries, depending on government policies.

Computing the BCR: Armed with these benefit and cost figures, it is now possible to compute the likely Benefit-Cost-Ratio, commonly expressed as a 1:X ratio, and the Net Present Value figure. If the BCR, has an $X \geq 1$, then the intervention is judged to be cost effective; if below, not so. Beyond this, other considerations may come into account such as the level of NPV and the community's likely acceptance of the change, among other things. Given the degree of estimation associated with the BCR process, it is also normal to express these BCA findings across minimum and maximum values to cover all likely variations of relevance to the computation.

The limitations with the findings ultimately need to be clearly noted, involving the robustness of the injury reduction computations, data relevance issues, lifetime periods, discount rates and issues related to manufacture and fitment costs of the new seats.

Alternatives to BCA: In situations where it is difficult or even impossible to estimate the costs associated with particular intervention strategies, an alternative approach to a full BCA is to stop after showing what the community benefits are and what the costs would be to achieve a break- even BCR or one of a level required for acceptance of the need for intervention. In New Zealand, for instance, we understand that anything less than a BCR of 1:1.5 is generally considered not worthy of further consideration, given the possible cost variations associated with these estimates.

Cost Effectiveness Analysis (CEA) differs from benefit cost analysis (BCA) in that it expresses outcomes in natural units such as cases prevented or number of lives saved, not dollar values to the outcomes attributable to the program. Its advantages over BCA is that it requires less time and resources, is easier to understand, and some claim more readily suited to decision making (Centre for Disease Control - CDC 2013).

Another alternative approach noted by the CDC they refer to as cost-utility-

analysis (CUA) which is a specialized form of Cost Effectiveness Analysis in that it includes a quality-of-life component using health indices such as quality-adjusted life years (QALYs) and disability-adjusted life years (DALYs).

The Next Step: As noted earlier, it was not the intention of the pilot study to provide a full Benefit-Cost-Analysis for all recommendations that are provided in the report. Instead, an illustration was provided on how a BCA could be undertaken, using the exemplar recommendation of 'retracting' sideways facing seats with forward or rearward facing seats. Obviously, the next step in any ongoing research program in this area of reducing injuries to older people using public transport would be to undertake a comprehensive benefit-cost-analysis, a pure benefit analysis or either a CEA or CUA for at least the more promising countermeasure recommendations made in this report.

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Discussion and Conclusions

The literature identified a general lack of research relating to knowledge about the size and nature of the problem of injuries in older users of public transport. Most of the available published literature relating to bus designs was more than 10 years old whilst modern bus designs tend to be more inclusive for those passengers with mobility problems. Such designs have been made in conjunction with changes to corresponding infrastructure that can be found at the roadside (kerbs and bus stops) in order to ease the access onto the bus. Other concerns in the literature included the increased number of passengers who would have to stand following the introduction of new bus designs. However these design changes have not been reviewed in any detail to date. Furthermore, despite advances in bus designs, little detailed knowledge is available that examines all aspects of the injury within the sequence from injury causation to resultant outcomes. This last issue is especially important since how the aftermath of injury impacts on future travel plans, quality of life and social isolation and in the aetiology of depression amongst the 60+ age group have received scant regard.

Although the number of casualties attributed to bus and coach passengers is a small proportion of all road traffic casualties (2.7%) the 60+ age group is over represented in these national figures (8.5%). Furthermore, the actual 'total' number of injuries sustained by the 60+ users is largely an unknown factor. This is because a large number of incidents are dealt with by the bus operators themselves and therefore do not figure in national statistics. Even if the casualties attend hospital it is difficult to specifically identify bus passengers simply from hospital records. The total cost of the 60+ bus and coach casualties can only be calculated using the national data whereas the true total cost of injury should take bus operator data into account. For this reason, current estimates of costs are almost certainly grossly underestimated. Even if it were possible to include operator cost in the overall cost calculations, there is no way of taking into account the 'cost' of the impact of injury on social wellbeing and how travel patterns may be affected post-injury. This is one of the main issues that was identified in the feasibility study - the exposure of the 'hidden' bus and coach passenger incidents

because which do not appear in national figures. If this issue is disregarded, the general extent of the problem will remain grossly under-estimated. One problem in identifying the “hidden” extent of unreported injuries is the difficulty in obtaining data specifically relating to older public transport users. The available data did not allow for the analysts to discriminate on the basis of the casualty being a ‘bus passenger’ as most cases are recorded as RTA (road traffic accidents). Even if further details were available within the free text fields there were difficulties with data selection due to inaccuracies in the data or vague coding protocols with many incidents being recorded as ‘slip, trip or fall’ rather than ‘bus / coach passengers’. This latter category is consistent with the data from the bus operators who tended to classify the majority of the incidents they recorded as falls. If casualties attended hospital they would most probably be categorised as slip/trip/fall in the hospital records further exacerbating the difficulty of selecting this group of passengers for further analysis. However, it is recognised that the issue of falls in the older people is huge with 30% of the aged 65+ years having fallen at least once a year. Whilst there is much research relating to the issue of falls, there is little relating to falls on transport, yet if the cause of the fall can be controlled then the chances of injury can be lessened. (NICE guidelines June 2013)

National linked datasets provided a very valuable source for identifying road traffic injuries and were extremely useful in categorising the injury to specific body regions, determination of injury type and to some extent, determination of injury severity. However, the data provided in the linked databases was limited to the WHO ICD_10 categories and conversions to determine injury severity at the casualty level were therefore necessary using the Navarra algorithm developed by the European Centre for Injury Prevention (2006). The difficulty with this conversion was that many ICD_10 codes (18%) were not assigned a severity code often because the injury couldn’t be converted into an equivalent Abbreviated Injury Scale (AIS) code for severity calculations (AAAM 1998). However, what the data did offer was information about the passenger action(s) at the time of the incident even though there were only 4 available ‘action’ categories (standing, seated, alighting, boarding). Through analysis, it was possible to show that there were differences in body regions injured dependent on the respective action being carried out by the passenger. On the other hand, the data was not

sufficiently detailed to pinpoint the actual location of the passenger in relation to the bus layout at the time of the incident. Precise location of the passenger in respect of their actions would be a very useful aspect of data and would be potentially crucial for injury prevention research. For example, if it could be determined that that most injured standing passengers were near the front of the bus or the injured seated passengers were all in the first 2 rows, design change recommendations could focus on these locations rather than attempting wholesale changes throughout the bus interior.

The bus operator data identified the differences between the data that is collected and the variables are released to outside organisations. The data obtained for this study also further highlighted the gaps in injury information as many of the variables were incomplete particularly with regard to injury type. Importantly, and as explained earlier, it helped to identify the issue of hidden numbers of injured older users who do not appear in national datasets. However, accessing this data proved difficult as the bus companies were naturally reluctant to expose incident rates to their competition. A confounding issue with the bus operator data was that it could not be determined whether individual bus incident records could be matched to STATS-19 records (i.e. national data) so the true overall incident rate could not be established. Notably only 4% of the bus company data had 'collision details' recorded which might suggest that only 4% of the incidents are reported to the police which would in turn render the hidden injury rates as extremely high for the older public transport users. Conversely this may be a simplification of numbers and the true accuracy cannot in fact be derived from the collision data.

Also notable within the bus company data was the large number of older bus-users who did not attend hospital following the incidents that would therefore not appear in hospital statistics. This reinforces the difficulty of capturing data relating to ALL incidents as effectively the overall figures remain the domain of the bus operators and unless the operators are willing to share this data the true incident rate will remain unknown.

What was evident from the data available was the paucity of useful information to examine injury causation in older public transport passengers. This was often related to missing data within certain variables or perceived inaccuracy in for example alighting incidents whilst the bus was in mid-journey. Unspecific information as to passenger location was also a factor as

was the issue of useful injury data. A general lack of data makes it difficult to apply modelling principles to determine safety design interventions. The most detailed in-depth data was only available from the police accident records involving 'Fatal accident' cases which included CCTV photo stills, event timing and witness statements. This detailed information was hugely beneficial in that it allowed the researchers to determine where the passenger was sat, what baggage they had, their overall stature and the bus manoeuvring events that led up to the fall - all important factors required for modelling incidents to look at injury causation factors and potential prevention strategies. However it is impractical to assume that this amount of information should be collected as a routine activity after each 'serious' bus incident as it would potentially create a substantial disruption to traffic flow given the time that would be required for the completion of the investigation. A balance is therefore required to obtain the necessary data that can address the problem without contributing to the workload of the bus companies in addition to those incidents that are handled by the police. The accident protocol that was developed as an outcome for this study reviewed the data currently collected in STATS19, bus companies and stakeholder needs to identify a 'minimum' dataset that would allow for the study of injury causation and prevention.

Stakeholders consulted within this study all had links with bus operators but not all collected or accessed injury data even though it could have been a valuable tool for a number of reasons. The main uses for any injury database is considered to be evidence for developing policy and regulation, information for campaigns, in the development of new designs, for benchmarking and training purposes and for raising awareness. It was clear that there was some awareness of the differences between younger and older passengers and the increased risks of injury to older passengers was very evident within the data. However the source of this knowledge could have been attributed to experience or data figures but this was not identified. This was evident in the data that the older 'old' passengers were more likely to sustain serious injury, often fractures compared to the younger 'old' passengers.

The stakeholders also provided suggestions as to what data would be most valuable in a new injury database that could be used informatively in their work.

Having a database was seen as a positive tool by the stakeholders overall however there were concerns regarding confidentiality of competitor names and also concerns that the data would not be used to promote changes that could influence insurance payments or legal design requirements. The stakeholders considered an injury database as a valuable tool for further development of driver training programmes. They also thought that a database would be of benefit to the older bus-users in safety campaigns as the overriding aim of the stakeholders was reporting as being to ensure that older users continue to use public transport and that they are injury free whilst so-doing. This is particularly relevant as the bus network was perceived by older users as being more than a means of transport to conduct shopping - it was their gateway to social interaction and the freedom to escape the home whenever they wanted. For the majority, the bus was the only affordable means of transport and therefore social interaction therefore the free bus pass was the 'driver' to encourage them to get out and about. Most were pleased with the overall service that was offered to them; however there were some issues with access for a few of the older passengers in the focus groups.

The older users were themselves aware of some potential hazards on the bus - predominantly the need to sit quickly after boarding, not choosing the side seats (as they felt unsafe), the issue of obstacles in the aisles and the principle of staying seated until the bus stops before alighting. Despite this apparent awareness of hazards, when the older passengers were actually observed en route it was evident that staying seated until the bus stopped was definitely not the normal pattern of behaviour for them - thus increasing their potential risk of injury. Another typical behaviour involved the older bus-users seating themselves whenever possible as near to the front as they could thereby reducing the time spent walking to a seat before the bus moved off from the stops. It was also noted that in many cases, the drivers tended not to wait for the older passengers to sit down and none of the passengers asked for them to wait either. In contrast the survey of the bus drivers identified that they always waited or waited most of the time for the passengers to sit down before moving off. However the drivers themselves considered that the main problem was actually the older bus-users standing up and walking to the front of the bus and then waiting to get off even if they recognised that any sudden braking would cause potential injuries in

this situation. Realistically if it were possible to persuade the passengers to remain seated until the bus stops as a standard procedure it could help readily (and cost-effectively) prevent injurious situations.

Another issue that could further affect the incidence figures for this age group is the proportion of older bus-users who stated they do not report their injury or incident to the driver or bus-company. The bus-drivers concurred with this view and suggested that as a result, there would be many unreported events which would not manifest themselves in any incident statistics.

Overall the study identified that current existing databases do not cover all of the aspects required to examine injury prevention in detail from the passenger injury causation through to design countermeasure process. Huge swathes of data variables were incomplete and the comparisons of bus designs (good and bad) were not possible in the larger bus operator data as these variables were not available for analysis. There appears to be patterns in passenger behaviour that are more injurious than others including incidents and injuries that result from standing and seating. It is evident that falls in older passengers are indeed a problem but they cannot be addressed fully until the exact circumstances of the passenger injury and bus design are studied in combination to identify the general causes of the falls. What is evident from this study is that a lack of in-depth knowledge from the bus operators or national datasets makes the design and development of injury prevention interventions an extremely difficult task.

What was possible within this feasibility study was the modelling capability. In particular, this method could be used to reveal how potential areas of difficulty within the bus interior for encumbered passengers when they were traversing through the bus, particularly at the front section of the bus, adjacent to the wheelchair area. The modelling showed an ideal scenario of a lone passenger attempting to manoeuvre through the bus without having to compete for handrails. The modelling work also chose to use the option of utilising the wheelchair space with a wheelchair in situ. In real world scenarios this space is often filled with pushchairs which would force the older passenger to the opposite side of the bus adjacent to the flip down side seats where there is no convenient handrail. Further to this is the 'indent' of the handrails just before the first row of front facing seats which

may prove difficult to reach in the real world scenarios due to potential negotiation of obstacles such as feet and shopping bags.

Ideally the use of bus CCTV would help in the design assessment of bus interiors and could provide detailed real world evidence to help design injury prevention solutions in the future. Having the CCTV would help identify the details of

- What the passenger was doing at the time
- Where the passenger was on the bus
- Whether they were encumbered in anyway (luggage, obstacles)
- The immediate vicinity of the passenger and whether there were other factors involved (crowded bus, too many people holding the same handrail)
- Identify of the kinematics of the passenger – which could vary between acceleration/deceleration incidents

Access to CCTV was not granted by the bus operators for this feasibility study - however it is hoped by presenting our findings and what we are hoping to achieve with the data may go some way in alleviating any concerns that the research activity is attempting to lay the blame at the door of the operators. It is the design of the buses and the passenger interactions with these designs that are under scrutiny but without the incidence data (and CCTV) it will hinder the development of injury mitigation designs. CCTV data will improve the study's modelling capabilities allowing for the shift from static incident modelling to the dynamic modelling of bus incidents and further help target appropriate designs for injury countermeasure.

Findings from the study have been disseminated through meetings and presentations and the feedback has been positive with regard to further progress involving incorporation of wider issues including bus station accessibility and design and other aspects of general accessibility to public transport.

Recommendations for Future Work

This study has revealed several important aspects that are worthy of exploration in future studies. These are as follows;

- There is a need for an on-going national injury surveillance activity whose purpose is to collect data relating to accidents and incidents

on public transport. This could be related to activity in the area of general falls within the community as it is becoming clear that with an ageing population, the challenging problem of falls and falls-prevention will continue to increase. A future injury surveillance system should involve a co-operation between bus operators, manufacturers, the police and the Department for Transport

- The OPTU activity should continue on a larger scale with a design focus to explore interior layouts on buses. This will entail working in collaboration with bus operators, designers, stakeholders and other institutions.
- The OPTU activity should strive to expand its methodology and enhance the data collection systems. In particular, the need for CCTV data is evident in order to improve the modelling capabilities which should be extended to dynamic modelling of individual incidents involving serious/fatal injuries.
- The study methodology could be expanded to look at other vulnerable user-groups. These would include younger bus users and disabled bus-users. The issue of younger bus-users is as yet relatively under-explored but in many ways, current bus interior designs present challenges to younger users as well.
- The 'vulnerable group' to be studied in future research must include members of the travelling public who are affected by recognised ageing disorders including dementia. Bus-users affected by such disorders are clearly at risk when using public transport but their needs are not well understood within the service sector.
- The general issue of public transport use needs to be examined using a systems approach. This includes an evaluation of difficulties that certain user-groups have when using public transport and includes features such as accessibility to and from bus-stops, accessibility to bus-stations and studying injury risks with the bus-stations.
- There should be collaboration at wider level to study the problem – especially within the EU. There are a number of potential pan-European consortiums who could provide a substantial body of knowledge at a European level

APPENDICES

Appendix 1 Literature review search terms

Search terms for each database are shown below.

EMBASE

- 1 crash.mp.
- 2 collision.mp.
- 3 incident.mp.
- 4 accident/ or accident.mp.
- 5 1 or 2 or 3 or 4
- 6 bus.mp.
- 7 railway/
- 8 tram.mp.
- 9 coach.mp.
- 10 public transport.mp.
- 11 public transit.mp.
- 12 6 or 7 or 8 or 9 or 10 or 11
- 13 "traffic and transport"/
- 14 railroads.mp. or railway/
- 15 motor vehicle/
- 16 12 or 13 or 14 or 15
- 17 injury/ or injury.mp.
- 18 injury/
- 19 5 and 12 and 17

CINAHL plus

1. Accidents
2. Transportation
3. Railroads
4. Motor Vehicles
5. Trauma / wounds or Injuries
6. Railroads OR transportation OR motor vehicle
7. Accident AND Injury
8. Railroads OR transportation OR motor vehicle AND Accident AND Injury)

PUBMED

(((((bus[All Fields] OR train[All Fields]) OR coach[All Fields]) OR tram[All Fields]) OR ((public[All Fields] AND ("biological transport"[MeSH Terms] OR ("biological"[All Fields] AND "transport"[All Fields]) OR "biological transport"[All Fields] OR "transport"[All Fields])) OR (public[All Fields] AND transit[All Fields]))) AND (((("transportation"[MeSH Terms] OR "transportation"[All Fields]) OR ("railroads"[MeSH Terms] OR "railroads"[All Fields])) OR ("motor vehicles"[MeSH Terms] OR ("motor"[All Fields] AND "vehicles"[All Fields]) OR "motor vehicles"[All Fields]))) AND (((collision[All Fields] OR crash[All Fields]) OR incident[All Fields]) OR ("accidents"[MeSH Terms] OR "accidents"[All Fields] OR "accident"[All Fields]))) AND ("wounds and injuries"[MeSH Terms] OR

("wounds"[All Fields] AND "injuries"[All Fields]) OR "wounds and injuries"[All Fields] OR "injury"[All Fields])

WEB of SCIENCE

- #1 Topic=(crash)
- #2 Topic=(collision)
- #3 Topic=(incident)
- #4 Topic=(accident)
- #5 Topic=(bus)
- #6 Topic=(coach)
- #7 Topic=(train)
- #8 Topic=(tram)
- #9 Topic=(safety)
- #10 Topic=(road)
- #11 Topic=(injury)
- #12 Topic=(transportation)
- #13 Topic=(railroads)
- #14 Topic=(motor vehicles)
- #15 Topic=(public) AND Topic=(transport) OR Topic=(transit)
- #16 Topic=(trauma)
- #17 #16 OR #11
- #18 #4 OR #3 OR #2 OR #1
- #19 #15 OR #8 OR #7 OR #6 OR #5
- #20 #14 OR #13 OR #12
- #21 #20 AND #9
- 22 #21 AND #19 AND #18 AND #17

TRANSPORT RESEARCH INTERNATIONAL DOCUMENTATION (TRID)

("bus" OR "coach" OR "tram" OR "train") AND ("crash" OR "collision" OR "incident" OR "accident") AND ("injury" OR "trauma")

Older Public Transport Users

Appendix 2: Tables of studies included in the literature review

Table A1 Studies included in the review

Author	Year	Title	Journal	Volume	Issue	Page
Transport type: buses and/or coaches						
Leyland Vehicles Limited [19]	1980	Passenger problems in moving buses	Transport and Road Research Laboratory. Supplementary Report 520.			
nue Moller [16]	1982	Bus accidents	Journal of Traffic Medicine	10	4	59-62
Albrektsen [18]	1983	A casualty ward analysis of bus passenger accidents	Medicine, Science and the Law	23	2	102-105
Jovanis [12]	1991	Analysis of bus transit accidents: empirical, methodological and policy issues	Transportation Research Record		1322	17-28
Kendall [13]	1994	A review of injuries sustained by bus passengers	Journal of Accident and Emergency Medicine	11	1	57
Mabrook [15]	1994	Injuries sustained by passengers on buses	Journal of Accident and Emergency Medicine	11	3	209-210
Bachar [17]	1999	Injuries due to falls in urban buses: 100 consecutive cases	Harefuah	137	1-2	77-78
Kirk (a) [20]	2001	Bus and coach passenger casualties in non-collision incidents	Report, Vehicle Safety Research Centre, ICE Ergonomics, Loughborough University, UK			
Kirk (b) [21]	2003	Passenger casualties in non-collision incidents on buses and coaches in Great Britain	Report, Vehicle Safety Research Centre, ICE Ergonomics, Loughborough University, UK. Paper 296			

Older Public Transport Users

Author	Year	Title	Journal	Volume	Issue	Page
Transport type: buses and/or coaches						
Halpern [14]	2005	Non-collision injuries in public buses: a national survey of a neglected problem	Emergency Medicine Journal	22	2	108-110
Transport type: trains						
Morlok [23]	2004	Boarding and alighting injury experience with different station platform and car entranceway designs on US commuter railroads	Accident Analysis and Prevention	36	2	261-271
Daniel [25]	2009	Customer behaviour relative to gap between platform and train	Final Report submitted to New Jersey Institute of Technology, sponsored by New Jersey Department of Transportation and Federal Highway Administration, US Department of Transportation			24

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Table A2 Characteristics of included Studies

Author	Study design	Country	Participants	Transport	Outcomes
Transport type: buses and/or coaches					
Leyland Vehicles Limited [19]	Cross-sectional	UK	Passengers injured on public buses	Public buses	Injuries, mechanism of injury, risk factors for injury (age, sex, time of day, action at time of injury, objects struck by injured passengers)
nue Moller [16]	Cross-sectional	Denmark	Attendees at 2 EDs in Arhus	Public buses	Injuries, mechanism of injury, risk factors for injury (age, sex, time of day, month, action at time of injury, distraction at time of injury)
Albrektsen [18]	Cross-sectional	Denmark	Passengers who were injured on public buses in Copenhagen and attended one ED	Public bus	Injuries, risk factors for injury (age, sex, time of day, day of week, action at time of injury)
Jovanis [12]	Cross-sectional	USA	Passengers of one suburban bus company	Public buses	Injuries, risk factors for injury (time of day, month, weather and light conditions, location of injury, action at time of injury)
Kendall [13]	Cross-sectional	UK	Attendees at one ED in Leicester	Public buses	Injuries, mechanism of injury, risk factors for injury (action at time of injury)
Mabrook [15]	Cross-sectional	UK	Attendees at one ED in Surrey	Public buses	Injuries, mechanism of injury, risk factors for injury (age, sex)
Bachar [17]	Cross-sectional	Israel	Attendees at one ED in Israel	Public buses	Injuries, mechanism of injury, risk factors for injury (age, sex, month, time of day)
Kirk (a) [20]	Cross-sectional	UK	Passengers injured on buses and coaches on public highways in Great Britain	Buses and coaches with ≥ 17 seats	Injuries, mechanism of injury, risk factors for injury (age, sex, action at time of injury, road classification, design features of vehicles), plus bus use by gender

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Author	Study design	Country	Participants	Transport	Outcomes
Kirk (b) [21]	Cross-sectional	UK	Passengers injured on buses and coaches on public highways in Great Britain	Buses and coaches with ≥ 17 seats	Injuries, mechanism of injury, risk factors for injury (age, sex, action at time of injury, road classification, design features of vehicles), plus bus use by gender
Halpern [14]	Cross-sectional	Israel	Attendees at 6 emergency departments (EDs) in Israel (3 urban and 3 rural)	Urban and inter-city public buses	Injuries, mechanism of injury, risk factors for injury (age, sex, time of day, action at time of injury)
Transport type: trains					
Morlok [23]	Cross-sectional	USA	Passengers on US commuter railways	Public train	Injuries, mechanism of injury, risk factors for injury (platform level and entranceway type)
Daniel [25]	Cross-sectional	USA	Passengers injured on public transit rail network in New Jersey	Public train	Injuries, mechanism of injury, risk factors for injury (age, sex, month, time of day, action at time of injury, stations, distraction at time of injury)

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Table A3 Risk of bias in included studies

Author	Criteria for quality assessment checklist					
	Study design appropriate	Study sample representative	Control group acceptable	Quality of measurements and outcomes	Completeness	Distorting influences
Transport type: buses and/or coaches						
Leyland Vehicles Limited [19]	Yes	Bus passengers receiving injuries requiring hospital treatment on public buses operated by 30 British operators for 2 years, operating approximately 30,000 buses (approximately 60% of vehicles owned by bus operators in Great Britain)	Not applicable	Data collected by national survey. Unclear whether injury data was collected retrospectively or prospectively, or whether it relied on self-reports of injured passengers. Steps to ensure reproducibility and quality control not described.	Some missing data	Not applicable
nue Moller [16]	Yes	Bus passenger attenders at 2 EDs in Denmark	Not applicable	Steps to ensure reproducibility and quality control not described	Small amount of missing data	Not applicable
Albrektsen [18]	Yes	Attenders at one ED in Denmark who were passengers of the public transport company in Copenhagen. 76% were contacted at a later date for more information.	Not applicable	Steps to ensure reproducibility and quality control not described	Yes	Not applicable

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Author	Criteria for quality assessment checklist					
	Study design appropriate	Study sample representative	Control group acceptable	Quality of measurements and outcomes	Completeness	Distorting influences
Jovanis [12]	Yes	Participants were those with injuries reported by one public suburban bus company in the USA which operates bus services and contracts with other carriers. "Unreliable" and "questionable" accident reports were screened out, but unclear how this was undertaken and numbers not included in study as a result of this.	Not applicable	Authors report verifying the completeness of data but unclear what this process involved. Injury reports from bus operators and extent of under reporting not clear.	Authors report an "approximate" number of accidents. Amount of missing data unclear.	Not applicable
Kendall [13]	Yes	Participants comprised ED attenders at one UK hospital. Unclear if there were any non-respondents	Not applicable	Steps to ensure reproducibility and quality control not described	Data on circumstances of injury missing for 2 participants	Not applicable
Mabrook [15]	Yes	Participants comprised ED attenders at one UK hospital. Unclear if all ED attenders recruited to study and whether there were any non-respondents	Not applicable	Steps to ensure reproducibility and quality control not described	Yes	Not applicable
Bachar [17]	Yes	Consecutive bus passengers attending one ED in Israel	Not applicable	Steps to ensure reproducibility and quality control not described. Abstract only available	Unclear. Abstract only available	Unclear. Abstract only available

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Author	Criteria for quality assessment checklist					
	Study design appropriate	Study sample representative	Control group acceptable	Quality of measurements and outcomes	Completeness	Distorting influences
Kirk (a) [20]	Yes	Bus and coach passengers injured on public highways recorded in national road traffic accident data (STATS19), plus in depth case studies	Not applicable	Steps to ensure reproducibility and quality control not described. The definition of serious injury in STATS19 is broad and based on police officers assessment (see https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/48824/stats20-2011.pdf) so validity and reproducibility is unclear.	Yes	Changes in legislation regarding accessibility of vehicles for disabled travellers came into effect August 2000. Changes in legislation relating to conduct of drivers, inspectors, conductors and passengers came into effect October 2002. These changes may make some findings and recommendations out of date.

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Author	Criteria for quality assessment checklist					
	Study design appropriate	Study sample representative	Control group acceptable	Quality of measurements and outcomes	Completeness	Distorting influences
Kirk (b) [21]	Yes	Bus and coach passengers injured on public highways recorded in national road traffic accident data (STATS19), plus in depth case studies	Not applicable	Steps to ensure reproducibility and quality control not described. The definition of serious injury in STATS19 is broad and based on police officers assessment (see https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/48824/stats20-2011.pdf) so validity and reproducibility is unclear.	Yes	Changes in legislation regarding accessibility of vehicles for disabled travellers came into effect in August 2000. Changes in legislation relating to conduct of drivers, inspectors, conductors and passengers came into effect in October 2002. These changes may make some findings and recommendations out of date.
Halpern [14]	Yes	Participants comprised ED attenders from 6 hospitals in Israel in urban and rural settings. Unclear if all ED attenders recruited to study and whether there were any non-respondents	Not applicable	Steps to ensure reproducibility and quality control not described	Yes	Not applicable

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Author	Criteria for quality assessment checklist					
	Study design appropriate	Study sample representative	Control group acceptable	Quality of measurements and outcomes	Completeness	Distorting influences
Transport type: trains						
Morlok [23]	Yes	Participants comprised people reporting injuries to transit agencies across the USA. Transit agencies are required to report these data to receive federal funding.	Not applicable	Self-reported injuries so some under reporting may have occurred. Data from national dataset with mandatory reporting and standard definitions.	Yes	May have been changes in the propensity to self-report injuries over time
Daniel [25]	Yes	Participants comprised (a) people reporting injuries to NJ Transit rail network in USA. Transit agencies are required to report these data to receive federal funding, (b) passengers observed boarding and alighting trains and (c) gap measurements on NJ Transit Rail network on all tracks with high level platforms.	Not applicable	Self-reported injuries so some under reporting may have occurred.	Yes	May have been changes in the propensity to self-report injuries over time

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Table A4 Findings from included studies

Author	Findings
Transport type: buses and/or coaches	
Leyland Vehicles Limited [19]	<p>In 1976, 871 injured passengers (57%) were involved in non-collision events and 440 (29%) whilst the driver was taking action to avoid a collision. Of the non-collision events, 35% occurred whilst vehicle was stationary at bus stop and 65% whilst vehicle was moving.</p> <p>Age: <60 years=48%, ≥ 60 years=36%, unknown=16% Those aged 60 and over were significantly more likely to be injured in a non-collision event than those aged under 60.</p> <p>Gender: Female=73%, male=25%, unknown=2% Gender of bus passengers carried by the National Bus Company (reported from another uncited report): Female=69%, male=31%, with the proportion of males being approximately 40% in most industrialised towns that were sampled.</p> <p>Injury mechanism: Fall in bus=69%, falls to ground=14%, door entrapment=3%, alighting from moving bus=4%, attempting to board moving bus=3%, other=8%. Those aged ≥ 60s are significantly more likely to have injuries boarding buses, in the gangways when the bus was moving off and door entrapment injuries than the under 60s. No significant difference in alighting accidents by age group. No significant difference in door entrapment injuries by sex. Females were significantly more likely to have gangway injuries than males. Females ≥ 60 years of age were less likely to be involved in staircase accidents than those aged under 60 (statistical significance not reported). Males aged ≥60 were more likely to be injured in staircase incidents than females aged ≥60 (no figures or statistical significance reported).</p> <p>Bus stop accidents accounted for 96% of all accidents when bus was stationary. 75% of these accidents occurred on ground or in the platform area. 70% of ground accidents occurred whilst boarding (i.e. passengers fell of the bus whilst boarding). 71% of accidents in the platform area occurred whilst alighting (i.e. passengers fell within the bus whilst getting off).</p> <p>29% of non-collision accidents occurred when the bus was moving off and 19% occurred when the bus was stopping or slowing down.</p> <p>85% of the moving off accidents occurred when moving from a bus stop and 47% of these were caused to passengers who were still boarding whilst the bus moved off. Accelerating accidents accounted for 23% of gangway accidents, 83% of which were caused to passengers moving to their seats.</p> <p>37% of the slowing down accident occurred on the platform and most of these occurred to passengers waiting to alight. 24% of slowing down</p>

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Author	Findings
	<p>accidents occurred in gangways and 62% of these were to passengers moving down the gangway to alight. Staircase injuries represented a large proportion of moving-bus accelerating and decelerating injuries.</p> <p>Injury type: Cuts/grazes/bruises to head or neck=29%, cuts/grazes/bruises to arm or hand=11%, cuts/grazes/bruises to leg or foot=22%, cuts/grazes/bruises to other parts of body=9%, fractures to head or neck=0.5%, fractures to arm or hand=2%, fractures to leg or foot=3%, fractures to other parts of body=0.8%, amputations=0.2%, shock=14%, other injuries=8%.</p> <p>No important differences in injury type by age, except a lower incidence of shock in males under 60 and a slightly higher incidence of cuts, grazes or bruises to legs or feet to those ≥ 60. Cuts, grazes and bruises to head or neck were more common in gangway accidents and when entering or leaving seats. Cuts, grazes and bruises to legs and feet were more common in doorway and platform accidents. Fractures were most often reported for doorway and gangway accidents (statistical significance not reported).</p> <p>Objects struck by injured passengers: Road surface =22%, bus floor=22%, staircase steps=8%, platform floor=8%, platform steps=6%, seat back=5%</p> <p>Vehicle type: 2-door double deck buses had a significantly higher proportion of alighting accidents than single door double deck buses. Boarding and alighting accidents were significantly more common in rear open platform double deck buses than in single front door double deck buses. Falls on single front door buses most commonly occurred at bus stops, falls on rear platform buses most commonly occurred when the bus was moving off from a bus stop. Doorway accidents were significantly more common whilst the vehicle was moving in rear platform buses than in single front door buses. A significantly greater proportion of boarding and alighting injuries occur in intermediate floor buses than in low floor buses. More accidents occur on vehicles with doorway dividing stanchions and none or both doors fitted with diagonal handrails than buses doorway dividing stanchions but no diagonal handrails. (Statistical significance not reported). Gangway accidents are significantly more common with simple gangway designs (those with fewer gradient or level changes). Those aged ≥ 60 were over represented in injuries occurring in simple and complex gangways than in intermediate gangways. No significant difference was found in the proportion of injuries occurring in buses with 3 or fewer vertical stanchions compared to those with more.</p>
Nue Moller [16]	<p>183 injured bus passengers who reported 212 injuries were recruited over a 12 month period. 90% of injuries resulted from non-collision incidents and 10% from collisions.</p> <p>Age range: 3-88 years. Median age for women =58 years (6-88). Median age for men=28 years (3-84). Injured women were significantly older than injured men ($p<0.01$).</p>

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Author	Findings
	<p>Gender: Female =123 (67%). Male=60(33%). Significantly more women were injured than men ($p<0.01$).</p> <p>Month of injury: Most accidents recorded in January and May, with a lower rate of accidents in summer months (no figures reported).</p> <p>Day of injury: number of accidents increased over the week with highest number on Fridays and lower numbers at weekend (no figures reported).</p> <p>Time of day: 51% of injuries occurred in 2 time periods (9-11am and 3-5pm). Median age of passengers injured between 9-11am was 70 years (3-87) and 38.5 years (3-88) between 3-5pm.</p> <p>Passenger action at time of injury: Boarding=43 (24%), riding=85(46%), alighting=53(29%), unknown=2(1%) 124 (68%) of injured passengers had luggage in one or both hands at time of injury.</p> <p>Mechanism of injury: Injuries during boarding: Acceleration=16(37%), stumbling over steps when bus stationary=17(40%), doors closed too early trapping hands or causing falls=10(23%) Injuries during driving: Acceleration=22 (26%), deceleration=44(52%), constant velocity=14(16%), unknown=5(6%) Standing=58(68%), sitting=24(28%), unknown=3(4%) Median age of injured women (62 years (6-84)) was significantly higher than median age of injured men (29 years (3-82)) $p<0.01$. Injured standing passengers were significantly older than injured sitting passengers ($p<0.01$). Of injured standing passengers, women were significantly older than men ($p<0.01$). Injuries during alighting: Stumbling over steps when bus stationary=25(47%), doors closed too early=10(19%), stumbling caused by kerbstones or road works at bus stop and crowding during alighting=8(15%), acceleration before alighting completed=10(19%)</p> <p>Body part injured: Head and neck=42(20%), upper limb=49(23%), lower limb=91(43%), thorax and spine=19(9%), others=11(5%)</p> <p>Injury type: Sprains=108(51%), contusions and superficial wounds=48(23%), fractures and dislocations=39(18%), rupture of ligaments=12(6%), head injury=5(2%)</p> <p>Injury severity: Minor (AIS1)=112(61%), moderate(AIS2)=43(23%), serious(AIS3)=24(13%), severe(AIS4)=4(2%). No significant difference in action at time of injury and injury severity ($p=0.25$).</p>

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Author	Findings
Albrektsen [18]	<p>221 bus passengers (234 injuries) using the public transport company in Copenhagen attending the ED at Frederiksberg Hospital between 1st January 1980 and 31st December 1981. Only 6 passengers were injured in collision incidents (3%).</p> <p>Age:60% of participants were females aged over 60</p> <p>Gender: Male=42(19%), female=179(81%)</p> <p>Time of day: The highest number of injuries occurred at midday (figures not reported)</p> <p>Day of week:Significantly more injuries occurred on weekdays than weekends ($p<0.01$)</p> <p>Passenger action at time of injury: Boarding=18(8%), riding=138(62%), alighting=55(25%), unknown=10(5%). For those riding bus only, standing=114 (83%), sitting=19(14%), unknown=5(4%)</p> <p>Injury type: Fracture=51(22%), contusion=105(45%), wound=18(8%), haematoma=11(5%), abrasion=7(3%), concussion=9(4%), distortion=25(11%), luxation=1(0.5%), other=7(3%).</p> <p>Body part injured: (fractures only)Head=1(2%), trunk=14(27%), upper limb=22(43%), lower limb=14(27%)</p> <p>Outcome of injury:No further treatment=155(70%), admitted=31(14%) (Including one death related to the accident), out-patient=29(13%), referred to GP=6(3%)</p>

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Author	Findings
Jovanis [12]	<p>Reports from approximately 1800 accident reports, of which 11% (~200) were bus passengers injured in non-collision incidents.</p> <p>Time of day: 4 times of peak incidence: 6.00-8.30am and 3.30-7.00pm with a higher incidence and 11.00am and 2.00pm with a lower incidence, but still higher than during the rest of the day. The peaks at 11.00am and 2.00pm coincide with shift change times for drivers (no figures reported)</p> <p>Month: No apparent difference in injury frequency by month (no figures reported)</p> <p>Weather and light conditions: 75% injuries occurred in clear weather and 80% during daylight. (figures include collision and non-collision injuries)</p> <p>Location of injury: At intersections=80%, other locations=20%. More non-collision than collision injuries occur at stop signs. More than 65% of injuries occur on clear roads</p> <p>Passenger action at time of injury: Boarding=19%, alighting=36%, caught in doors=1%, seated=18%, moving around bus=16%, other=11% (adds up to more than 100% due to rounding and figures not reported)</p>
Kendall [13]	<p>46 injured bus passengers were recruited over a 12 month period.</p> <p>Injury mechanism for 13 non-collision incidents injuring 15 people: (no figures reported) more than half were standing passengers and one third of injuries occurred when bus halted suddenly.</p> <p>Body part injured: Head and face=21, Neck=7, Chest=5, Upper limb=5, Lower limb=5, Back=2</p>
Mabrook [15]	<p>30 injured bus passengers were recruited over a 4 month period. Unclear if all injuries occurred in non-collision incidents.</p> <p>Age: Mean = 56.8 (range 2-81 years)</p> <p>Gender: Female=21 (70%)</p> <p>Mechanism of injury: Bus braking whilst passengers waiting to alight=50%, bus moved off quickly after boarding=20%, bus braking suddenly whilst seated=30%.</p> <p>Injuries sustained: Fractures=11 (in 10 people), remaining injuries were mainly bruising.</p>

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Author	Findings
Bachar [7]	<p>Outcome of injury: 4 admissions</p> <p>100 passengers injured in non-collision incidents were recruited in 7 months from ED. 28% spinal injuries, 27% head, 25% chest; 1% died</p> <p>Age: Mean 55.6, SD 21.4 years; median 60 years, range 13-91 years</p> <p>Gender: Male=29%, female=71%</p> <p>Outcome of injury: 92% discharged home; 6% admitted, 2% (soldiers) sent for observation to military clinic</p> <p>Month of year: No significant difference (figures and p values not reported)</p> <p>Time of day: 58% injuries occurred during working hours, with peak incidence at 10.00</p> <p>Mechanism of injury: Falling whilst standing due to acceleration/deceleration/sudden turns was most common injury mechanism (figures not reported)</p>
Kirk (a) [20]	<p>Analysis of yearly average of 8774 passengers injured in bus and coach crashes on a public highway between 1994-1998 and recorded in national road accident data (STATS19), plus review of physical designs of bus fleet to identify how and why injuries occur.</p> <p>Age of passengers in non-collision events killed or seriously injured (KSI): The age at which the greatest number of killed or serious injuries (KSI) occur for males is 10-14 years and for females is 70-85+.</p> <p>Gender of passengers in non-collision events (KSI): Males KSI=28%, females=72%</p> <p>Injury mechanism for passengers (KSI): Non-collision=63%, front impact=24%, rear impact=4%, right side impact=4%, left side impact=6%.</p> <p>Action at time of injury for passengers in non-collision events (KSI): Boarding=11%, seated=43%, standing=28%, alighting=18%</p> <p>Likelihood of suffering a KSI injury: Not seated=10%, seated=6%</p> <p>42% of fatal injuries occurred when occupant was standing, boarding or alighting. Many resulted from a fall, slip or trip whilst standing,</p>

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Author	Findings
	<p>alighting or boarding (figures not reported). 84% of injuries to standing passengers occur in non-collision events and 38% of seated passenger injuries occur in non-collision events. Road classification: 0.2% of passenger injuries in non-collision events occur on roads with speed limit of limit of 0-20mph, 94% with limit of 30mph, 4% with limit of 40mph, 2% with limit of 50-70mph. Figures are very similar for KSI injuries.</p> <p>Bus use by gender (report from National Travel Survey): Women travel further on buses than men and make more local journeys, so women will have greater exposure to injuries that occur whilst standing, boarding and alighting than men. Overall it is estimated that women aged 16-59 years travel 47% further on local buses than men.</p>
Kirk (b) [21]	<p>Analysis of yearly average of 9100 passengers injured in bus and coach crashes on a public highway between 1999-2001 and recorded in national road accident data (STATS19), plus review of physical designs of bus fleet to identify how and why injuries occur (note this review is identical to that published in the earlier report and findings are not replicated here) and national travel survey figures on bus travel by age and gender are identical to those in Kirk's earlier report and are not replicated here.</p> <p>Age of passengers in non-collision events (KSI): The age at which the greatest number of killed or serious injuries (KSI) occur for males is 10-14 years and for females is 70-85+.</p> <p>Gender of passengers in non-collision events (KSI): Males KSI=26%, females=74%</p> <p>Injury mechanism for passengers (KSI): Non-collision=65%, front impact=22%, rear impact=3%, right side impact=4%, left side impact=6%.</p> <p>Action at time of injury for passengers in non-collision events (KSI): Boarding=9%, seated=44%, standing=30%, alighting=17%</p> <p>Likelihood of suffering a KSI injury: Not seated=8%, seated=4% 69% of fatal injuries occurred when occupant was standing, boarding or alighting. Many resulted from a fall, slip or trip whilst standing, alighting or boarding (figures not reported). 84% of injuries to standing passengers occur in non-collision events and 40% of seated passenger injuries occur in non-collision events.</p> <p>Road classification: 0.4% of passenger injuries in non-collision events occur on roads with speed limit of limit of 0-20mph, 93% with limit of 30mph, 4% with limit of 40mph, 2% with limit of 50-70mph. Figures are very similar for KSI injuries.</p>

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Author	Findings
Halpern [14]	<p>A total of 120 passengers injured in non-collision incidents on buses were recruited to the study between March and October 2000. 58% of participants were recruited from one urban ED in Tel Aviv</p> <p>Age range: 3-89 years; 67 (56%) aged ≥55; 24 (20%) aged ≥ 75</p> <p>Gender: Female = 86 (72%)</p> <p>Time of day: 05.00-12.00=53 (44%), 12.00-19.00=55 (46%), 19.00-23.00=12 (10%)</p> <p>Passenger action at time of injury: Standing =67 (56%), moving around bus =30 (25%), sitting=23 (19%)</p> <p>Mechanism of injury: Acceleration/deceleration=63 (51%), boarding/alighting=35 (29%), doors closing=6 (5%), bus swerving to make turn=9 (7%)</p> <p>Body part injured: Limbs=62 (33%), head=54(29%), spine=41(22%), chest=11(6%), pelvis=12(7%), abdomen=4(2%), skin=2(1%). Some people injured more than 1 body part)</p>
Transport type: trains	
Morlok [23]	<p>Number of passengers injured boarding/alighting: 1995=400, 1996=242, 1997=451, 1998=270, 1999=310, 2000=302</p> <p>Injuries per million passenger trips: 1995=1.2439, 1996=0.8008, 1997=1.2719, 1998=0.7153, 1999=0.7888, 2000=0.7478</p> <p>Mean (SD) injuries per million passenger trips by platform and entranceway type: High level platforms and remote controlled doors: 0.1528 (0.1397). Low level platforms and remote controlled doors: 0.9016 (1.0247). Mixed level platforms and manually operated doors: 2.4673 (1.5840) P<0.05</p> <p>Findings robust to excluding data from one rail system (METRA) classified as low level platforms and remote controlled doors which had one railway division with high level platforms and remote controlled doors.</p> <p>No significant difference found between 2 and 4 steps into railway carriages in low level platform and remote controlled doors systems by platform and entranceway type</p>

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Daniel [25]	<p>254 “gap” injuries and 766 “non-gap” injuries between 2005-2008 on the NJ Transit Rail network in USA. Non-gap injuries comprised 71% (2006, 2007), 76% (2008) and 83% (2005) of all injuries.</p> <p>Passenger gap injury rates/100,000,000 passenger miles: 2005=2.16, 2006=4.21, 2007=4.34, 2008=2.76 Passenger gap injury rates/100,000,000 passengers carried: 2005=56.7, 2006=105.6, 2007=110.6, 2008=75.0</p> <p>Age: Percentage of gap injuries by age group: 0-10 years=14.2%, 10-20=6.6%, 20-30=10.4%, 30-40=19.8%, 40-50=17.0%, 50-60=16.0%, >60=16.0% Percentage of non-gap injuries by age group: 0-10 years=3.2%, 10-20=2.5%, 20-30=12.7%, 30-40=13.1%, 40-50=21.6%, 50-60=24.7%, >60=22.3%</p> <p>Gender: 69% of gap injuries were women, 66% non-gap injuries were women</p> <p>Time of day: Percentage of gap injuries by time: 12am-7am=12.2%, 7am-10am=25.0%, 10am-3pm=15.8%, 3pm-7pm=37.8%, 7pm-12am=9.2% Percentage of non-gap injuries by time: 12am-7am=9.9%, 7am-10am=28.7%, 10am-3pm=18.0%, 3pm-7pm=34.3%, 7pm-12am=9.2% Gap injuries in women significantly more likely to occur during am and pm peak times (63.8% for women versus 39.4% for men)</p> <p>Month: Highest percentage of gap injuries occurred in October (12.2%), followed by June (10.7%) and December (10.2%). The highest percentage of non-gap injuries occurred in July (12.6%) Gap injuries in women significantly more likely to occur between October and December (33.8% for women versus 27.3% for men)</p> <p>Day of week: 78% of gap injuries and 87% of non-gap injuries occurred on weekdays. Gap injuries in women significantly more likely to occur on Thursdays (20.8% for women versus 18.6% for men)</p> <p>Action at time of injury: 66% of gap injuries occurred whilst boarding. There is little difference in gap injuries occurring whilst boarding or alighting at most times of the day. During the morning non-peak time (12am-7am) there is a higher percentage of gap injuries whilst boarding (15.6%) compared to alighting (5.9%). During the evening non-peak time (7pm-12am) there is a higher percentage of gap injuries whilst alighting (26.5%) than boarding (14.8%)</p>

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Author	Findings
	<p>A higher percentage of gap injuries whilst boarding occur at suburban stations between 10am-3pm (35%) compared to that for all NJ Transit Rail stations (21%)</p> <p>There are very small differences in the percentage of gap injuries occurring during boarding and alighting at age 30 and above. Women more likely to have gap injuries whilst boarding than men (70% for women versus 56% for men, significance not reported)</p> <p>The highest percentage of gap injuries occurring whilst boarding for women was from 10am-3pm (37% for women versus 22% for men). The highest percentage of gap injuries occurring whilst boarding for men was from 7pm-12am (28.1% for men versus 20.0% for women) (significance not reported).</p> <p>Women less likely to have gap injuries whilst alighting (29.1% for women versus 44.1% for men, significance not reported).</p> <p>The highest percentage of gap injuries occurring whilst alighting for women and men occurred during the period 7pm-12am (40.5% for women versus 38.5% for men, significance not reported)</p> <p>Rail stations: Newark Penn Station (n=28) and New York Penn Station (n=26) had the highest number of gap injuries. These stations also had the highest number of boarding and alighting passengers.</p> <p>Passenger observational surveys: observations of 681 passengers boarding and 531 alighting. 86% of boarding passengers were observed to be looking down and 76% of alighting passengers. For boarding passengers 86% of female passengers were observed to be looking down compared to 90% of male passengers. For alighting, 76% of female and 78% of male passengers were observed to be looking down. The most common distraction was carrying luggage (36% boarding and 20% of alighting passengers), followed by using mobile phone (7% boarding and 10% alighting passengers).</p> <p>Survey of large commuter railway networks: Data from Long Island Railroad on gap injuries from 1996-2006 shows slips, trips and falls are more common than gap injuries at all time points and a downward trend in the number and rate of injuries over the 11 year period.</p> <p>Measurement of gap widths: maximum gap at each station ranged from 6.6 to 24.5 inches. No relationship between maximum gap size and injury frequency or rate was found.</p>

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Table A5 Studies excluded from the review and reasons for exclusion

Author	Year	Title	Journal	Volume	Issue	Page	Reason
Schneider [22]	2010	Using in depth investigations to identify transportation safety issues for wheelchair seated occupants of motor vehicles	Medical Engineering and Physics	32	3	237-247	Transport
Cameron [26]	2001	Tram-related injuries in Sheffield	Injury, Int J Care Injured	32		275-277	Outcomes
Stephan [27]	2011	Distribution of transport injury and related risk behaviours in a large national cohort of Thai adults	Accident Analysis and Prevention	43		1062-1067	Participants
Parry [28]	2009	Road traffic accident fatalities: 1961-1986	J Clin Pathol	62		561-563	Transport
Cocks [29]	1987	Study of 100 patients injured by London underground trains 1981-6	BMJ	295		1527-1529	Transport
Richards [30]	1986	Broken necks in passengers in London taxi accidents	BMJ	292		1239	Study design
O'Donnell [31]	1996	Predicting the severity of motor vehicle accident injuries using models of ordered multiple choice	Accident Analysis and Prevention	28	6	739-753	Transport

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Author	Year	Title	Journal	Volume	Issue	Page	Reason
Jones [32]	1995	Emergency medical service accessibility and outcome from road traffic accidents	Public Health	109		169-177	Transport
Raffle [33]	1991	The cost of traffic casualties to the community	J Royal Soc Med	84		390-392	Study design
Jones [34]	2008	Geographical variations in mortality and morbidity from road traffic accidents in England and Wales	Health and Place	14		519-535	Transport
Pentland [35]	1986	Head injury in the elderly	Age and Ageing	15		193-202	Transport
Boucher [36]	1959	Accidents among old persons	Geriatrics	14		293-300	Study design
Huelke [37]	1995	Vertebral column injuries and lap-shoulder belts	The Journal of Trauma: Injury, infection and Critical Care	38	4	547-556	Transport
Panagiotidis [38]	2004	Ocular injuries secondary to motor vehicle accidents	European Journal of Ophthalmology	14	2	144-148	Transport
Giannoudis [39]	2007	Incidence and outcome of whiplash injury after multiple trauma	Spine	32	7	776-781	Transport
Nanda [40]	1992	Penetrating ocular injuries secondary to motor vehicle accidents	Ophthalmology	100	2	201-207	Transport
Fox [41]	1978	Fatal road traffic accidents Edinburgh 1972	Health Bulletin	36	6	313-317	Transport

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Author	Year	Title	Journal	Volume	Issue	Page	Reason
Dellinger [42]	2008	Fall injuries in older adults from an unusual source: entering and exiting a vehicle	JAGS	56		609-614	Transport
Zunjic [43]	2012	Research of injuries of passengers in city buses as a consequence of non-collision effects	Work	41		4943-4950	Participants
Keeley [44]	1990	Railroad injuries	Emergency Medical Services	19	6	28	Study design
Mitchell [45]	2001	Road safety of an ageing population	Conference proceedings, 9th International Conference on Mobility and Transport for Elderly and Disabled People. Warsaw, Poland			199-208	Study design
US Department of Transportation [46]	2004	Railroad safety statistics Final Report 2002	Report				Study design

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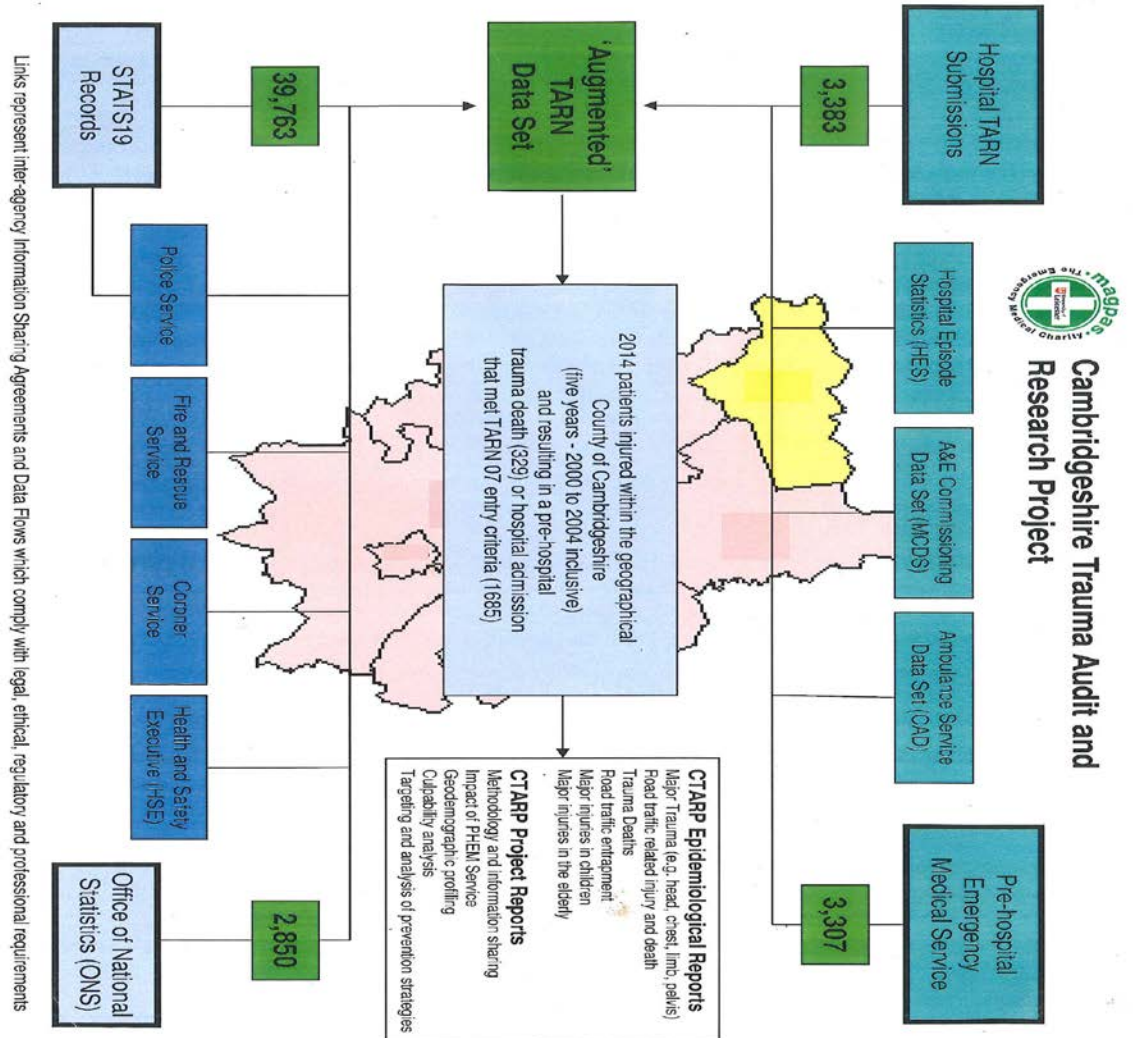
Author	Year	Title	Journal	Volume	Issue	Page	Reason
Frost [47]	2010	Retrospective review of adverse incidents involving passengers seated in wheeled mobility devices while traveling in large accessible transit vehicles	Medical Engineering and Physics	32		230-236	
Soares [48]	2012	Research of injuries of passengers in city buses as a consequence of non-collision effects	Work	41		4943-4950	Duplicate
Kaneko [49]	1992	Multiday driving patterns and motor carrier accident risk: a disaggregate analysis	Accident Analysis and Prevention	24	5	437-456	Participants
US Department of Transportation [50]	2000	Nebraska transportation profile	Report - Bureau of Transportation Statistics				Study Design
Department of the Environment [51]	2000	Compendium of research projects 2000	Report – Vehicle Standards and Engineering Research				Study Design
Bureau of Transportation Statistics [52]	2000	Table 2-15	Report				Study Design

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Author	Year	Title	Journal	Volume	Issue	Page	Reason
American Public Transport Association [53]	2000	Table 71	Report				Study Design
Graaf [54]	1997	The retention of balance: an exploratory study into the limits of acceleration the human body can withstand without losing equilibrium	Human Factors	39	1	111-118	Study Design
Scammell [55]	1987	The unrestrained coach passenger - an injury complex	Injury	18		1-4	Outcomes

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Appendix 3 CTARP



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Appendix 4 Monash Report

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Appendix 5: Stakeholder – survey monkey questionnaire

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Appendix 6 Accident protocol

Section A - Contextual information			
Date:		Time:	
Location on route:			
Operating Company:		Depot:	
Vehicle type/ model: e.g. Volvo B7RLE Wright Eclipse urban 69334		Fleet number:	
Registration number:			
Passenger Severity:	No injury	Minor	Major Fatal
Did ambulance attend?	Yes No	Did passenger attend hospital?	Yes No
Name of hospital:			
Did police attend?	Yes No	Were photos taken at the scene? **	Yes/ No / Don't know

** see photograph requirements (Section I)

Section B - Accident details					
What was the bus doing? (tick all that apply)					
Stationary	<input type="checkbox"/>	Normal driving	<input type="checkbox"/>	Sudden braking	<input type="checkbox"/>
Changing lanes	<input type="checkbox"/>	Reversing	<input type="checkbox"/>	Swerving to avoid collision	<input type="checkbox"/>
Moving away from a stop	<input type="checkbox"/>	Slowing down to pull into a stop	<input type="checkbox"/>	Turning	<input type="checkbox"/>
Overtaking	<input type="checkbox"/>	Roundabout	<input type="checkbox"/>	In a collision	<input type="checkbox"/>
Other <input type="checkbox"/> Please describe:					
Road type (e.g. A road, B road, city street)		Road speed limit		Approximate speed of bus at time of incident	
Other <input type="checkbox"/> Please describe:					
What was the passenger doing? (tick all that apply)					
Preparing to board	<input type="checkbox"/>	Boarding (stationary bus)	<input type="checkbox"/>	Alighting (stationary bus)	<input type="checkbox"/>
Sitting	<input type="checkbox"/>	Walking to a seat	<input type="checkbox"/>	Struck/ trapped by doors	<input type="checkbox"/>
Going upstairs	<input type="checkbox"/>	Coming downstairs	<input type="checkbox"/>	Standing mid-journey	<input type="checkbox"/>
Standing ready to alight	<input type="checkbox"/>	Other <input type="checkbox"/> Please describe:			
If seated, where was the passenger sitting?					
Forward facing high seats (behind driver)	<input type="checkbox"/>	Flip down side seats	<input type="checkbox"/>	Forward facing fixed seats	<input type="checkbox"/>
Fixed side seats	<input type="checkbox"/>	Other <input type="checkbox"/> Please describe:			

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Section C: Passenger details							
Age (if known)				Senior citizen bus pass		Yes / No	
Gender		M / F					
Adult passengers only Approximate height: (circle one)		Very short 5ft (1.5m) or less		Short 5ft (1.5m)		Average 5.5ft (1.67m)	
						Tall 6ft (1.8m) or more	
Was the passenger carrying any obvious luggage? (tick all that apply)				Yes / No			
Shopping bag	<input type="checkbox"/>	Handbag	<input type="checkbox"/>	Suit case	<input type="checkbox"/>		
Other	<input type="checkbox"/>	Please describe:					
Was the passenger using a mobility aid? (tick all that apply)				Yes / No			
Stick	<input type="checkbox"/>	Walker	<input type="checkbox"/>	Visual aid	<input type="checkbox"/>	Wheelchair	<input type="checkbox"/>
Other	<input type="checkbox"/>	Please describe:					
Section D: Environmental conditions							
Weather conditions that could have influenced grip							
Dry	<input type="checkbox"/>	Raining/ wet surface	<input type="checkbox"/>	Snow/ ice	<input type="checkbox"/>		
Other	<input type="checkbox"/>	Please describe:					
Lighting that could have influenced visibility when boarding the bus							
Daylight	<input type="checkbox"/>	Dark with street lights	<input type="checkbox"/>	Dark but no street lights	<input type="checkbox"/>		
Lighting that could have influenced visibility on the bus							
Internal lighting on and fully functional	<input type="checkbox"/>	Internal lighting reduced	<input type="checkbox"/>	Internal lighting off	<input type="checkbox"/>		
Obstacles that could have impeded passenger movement through bus?							
Pushchairs	<input type="checkbox"/>	Luggage	<input type="checkbox"/>	Wheelchair	<input type="checkbox"/>		
Other	<input type="checkbox"/>	Please state					
Section E: Brief summary of the accident							
Please be as specific as possible and include the cause of the accident (e.g. heavy braking to avoid collision) and how the injury occurred (e.g. the person slipped, tripped, fell, collided with something/ someone)							
What happened to the passenger							
Trip / slip but <u>no</u> fall	<input type="checkbox"/>	Fall from standing	<input type="checkbox"/>	Fall from seat	<input type="checkbox"/>		
Struck by object / person	<input type="checkbox"/>	Crash / collision	<input type="checkbox"/>				
Section F: Injury Details							

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Was the person injured		Yes / No				
If yes complete the information below						
Body Region Injured	Injury 1	Injury 2	Injury 3	Injury 4	Injury 5	Injury 6
Head, excludes face						
Face, excludes eye, includes ears						
Neck						
Chest						
Abdomen						
Lower back						
Pelvis						
Shoulder						
Upper arm						
Elbow						
Forearm						
Wrist						
Hand, includes fingers						
Hip						
Thigh						
Knee						
Lower leg						
Ankle						
Foot, includes toes						
Unspecified body region						
Injury Type	Injury 1	Injury 2	Injury 3	Injury 4	Injury 5	Injury 6
Sprain or strain						
Fracture						
Superficial – bruise, abrasion						
Open wound - laceration						
Injury to muscle or tendon						
Dislocation						
Intracranial injury (head)						
Crushing injury						
Injury to internal organ						
Eye injury						
Other specified injury- state what						
Injury of unspecified nature						
Contact cause for the injury	Injury 1	Injury 2	Injury 3	Injury 4	Injury 5	Injury 6
Floor						
Door						
Handrail						
Seat in front						
Stairs						
Steps – lower deck						
Other passenger						
Luggage						
Bus furniture e.g.–ticket machine						
Other – please state						

Section G – Consequences of the accident (if known or on follow up)

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Did you attend hospital?	Yes/ No
Did you attend your GP or other medical service? (walk-in centre)	Yes/ No
What injuries did you have?	
Were you admitted to hospital?	Yes/ no
If yes, for how long were you in hospital?	
What treatment did you receive? – e.g. operation, plaster of paris, dressings	
Did you need additional care after leaving hospital?	Yes/ no
What type of care did you need? – e.g. physiotherapy, home care	
For how long did you need this care?	
Do you still use public transport	Yes/ No
If no, why not?	
Any other information – please add	
Fatalities: Was the coroner's findings report received?	Yes / No
Was a post mortem received?	Yes / No

Section H – Other useful information (for follow up)

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The following information if it can be collected will allow for simulation modelling of incidents. The information will allow for mapping individuals capabilities to an existing database used for simulation studies at Loughborough University.

- With regard to your mobility around the home, are you:
 - ☐ Completely independent (can walk totally unaided)?
 - ☐ Independent (but may use stick, frame, etc.)?
 - ☐ Walk with help of one person (verbal or physical)?
 - ☐ Wheelchair independent?
 - ☐ Unable to move without assistance from another person?
- With regard to your mobility outside the home, are you:
 - ☐ Completely independent (can walk totally unaided)?
 - ☐ Independent (but may use stick, frame, etc.)?
 - ☐ Walk with help of one person (verbal or physical)?
 - ☐ Wheelchair independent?
 - ☐ Unable to move without assistance form another person?
- How far can you bend down?
 - ☐ Above knees
 - ☐ Knees
 - ☐ Between shins and knees
 - ☐ Floor
- Can you lie on the floor and get back up again?
 - ☐ Yes
 - ☐ No
- Can you reach to tie your shoelaces?
 - ☐ Yes
 - ☐ No
- Have you fallen over in the last year? (ask number of times)
 - ☐ Yes
 - ☐ No
- Can you reach out with either hand (shake hands)?
 - ☐ Yes
 - ☐ Neither
 - ☐ Only one
- Can you raise either arm above your head?
 - ☐ Yes
 - ☐ Neither
 - ☐ Only one
- Can you reach to turn bath/sink taps on with either hand?
 - ☐ Yes
 - ☐ Neither
 - ☐ Only one

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- Can you reach backwards with either hand?
 - ☐ Yes
 - ☐ Neither
 - ☐ Only one

- Which of these objects can you pick up and hold using either hand?
 - Mug of coffee
 - ☐ Yes
 - ☐ Neither
 - ☐ Only one
 - Pint of milk
 - ☐ Yes
 - ☐ Neither
 - ☐ Only one
 - 5lb bag of potatoes
 - ☐ Yes
 - ☐ Neither
 - ☐ Only one

- Which of these things can you do with either hand?
 - Turn cooker control knobs
 - ☐ Yes
 - ☐ Neither
 - ☐ Only one
 - Unscrew a jar
 - ☐ Yes
 - ☐ Neither
 - ☐ Only one
 - Turn the taps on and off
 - ☐ Yes
 - ☐ Neither
 - ☐ Only one
 - Pick up a small object (safety pin)
 - ☐ Yes
 - ☐ Neither
 - ☐ Only one
 - Use a pair of scissors
 - ☐ Yes
 - ☐ Neither
 - ☐ Only one

Which best describes the passengers' vision

- Able to see well enough to read ordinary newsprint and recognize a friend on the other side of the street, without glasses or contact lenses.

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- Able to see well enough to read ordinary newsprint and recognize a friend on the other side of the street, but with glasses.
- Able to read ordinary newsprint with or without glasses but unable to recognize a friend on the other side of the street, even with glasses.
- Able to recognize a friend on the other side of the street with or without glasses but unable to read ordinary newsprint, even with glasses.
- Unable to read ordinary newsprint and unable to recognize a friend on the other side of the street, even with glasses.
- Unable to see at all.

Section I – Photograph requirements for incident modelling

This is highly situation dependent but effectively there should be a set of images that describe the scene. The photographer should imagine the viewer of the photographs wanting to understand the environment encountered by the person who has suffered the accident from entry to the vehicle to the location of the accident;

- External images of front, rear and side of vehicle
- Images of the vehicle entrance(s) including any steps or stairs
- Images of the driving position from through the vehicle door
- Images of the walkway from the door to the location of the accident (multiple if required)
- Images **of** the location of the accident from as many angles as possible with a clear marker with a known scale (e.g. 30cm ruler) showing the location of the accident
- Images taken **from** (standing/sitting at) the location of the accident from as many angles as possible (aiming for a 360 degree field of view)
- Time of photos in relation to time of accident

[If this was being described in some sort of specification it would probably be useful to have examples of what we would consider an appropriate set of images.]