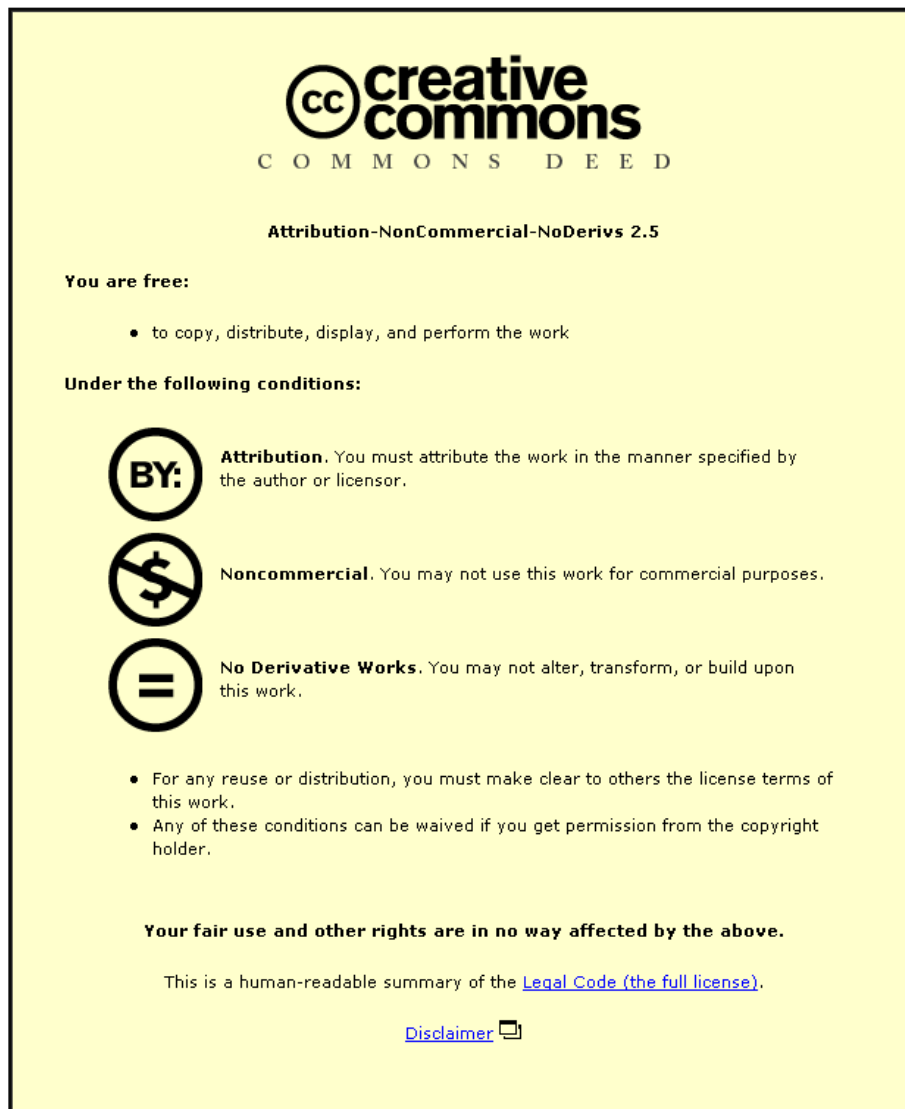


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**Causes and Consequences of Road Traffic Crashes in  
Dubai, United Arab Emirates and Strategies for Injury  
Reduction**

By

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for the award of  
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## **Abstract**

This thesis looked at traffic crashes in the emirate of Dubai in the United Arab Emirates (UAE) to establish the current situation in road safety and ways of improving it. A global overview of road safety literature revealed that standards of road safety vary widely by region. Key indicators like fatality rate and risk (Jacobs et al, 2000) were found to be higher in most neighbouring Gulf Cooperative Council (GCC) countries (10-25 fatalities/100,000 pop., 3-5 fatalities/10,000 motor vehicles) than in the best-performing Western countries (6 fatalities/100,000 pop., 1 fatality/10,000 motor vehicles).

Interventions and countermeasures to tackle specific road safety issues were reviewed from international studies. Countermeasures were chosen with consideration for the local situation in Dubai within the categories of Human, Environmental and Vehicle factors. Examples of selected measures include offending driver punishment (Human), Electronic Stability Control (Vehicle) and central barriers (Environment). These measures were mostly studied in different environments to those in Dubai so the aspect of knowledge transfer between areas of different cultural and environmental conditions was discussed.

Data from real world injury crashes (as collected by Dubai Police and the Roads & Transport Authority) over twelve years (1995 – 2006) were subject to macroanalysis in SPSS to identify the main issues over the past decade. 18,142 crashes involving 30,942 casualties and 48,960 vehicles were analysed at the outset. The following issues were among the main concerns:

- High proportion of fatal crashes out of all injury crashes (13.5% compared to 1.4% in the UK);
- Most fatal crashes involved a single vehicle hitting a pedestrian;
- Most injury crashes involved a single vehicle;
- Inconsiderate driving was the most common crash cause cited by the police.

Countermeasures found in the literature to counteract these problems were then suggested for application and the estimated savings from applying them were calculated. Savings were quantified as either reductions in casualties or injury crashes. Furthermore, cost savings for the calculated reductions were estimated using existing UK crash costs due to the scarcity of UAE crash cost estimates. Calculation of the estimated improvement in safety if these



countermeasures were applied retrospectively meant a reduction of 4,634 injury crashes and 1,555 casualties over the 12-year period with an estimated cost saving of approximately £368 million or 2.7 billion Dirhams.

To refine this method more detailed data on crashes were required and collected from the dedicated crash investigation team files in Dubai Police for 2006 and part of 2007. This new dataset (300 crashes) was put into a purpose-built database with over 140 fields and subject to microanalysis to more accurately match the problems and interventions. Six interventions were matched to individual cases in the database where they would have positively altered the outcome. This process was verified by independent crash experts and investigators. The benefits from these six countermeasures were then weighted to calculate the benefits for the whole crash population over a year. Examples of specific interventions included guardrails along the roadside; grade-separated crossing facilities for pedestrians; Electronic Stability Control and speed cameras. The estimated total reduction in crashes was 2,412 annually with calculated savings of £40 million or 280 million Dirhams.

This was the first time this geographical area was studied in such depth and detail to allow the calculation of benefits from interventions matched to known road safety issues. Various limitations were encountered such as the unavailability of GIS basemaps and the continuously changing infrastructure and population of Dubai. Numerous areas of further work were identified. Such work areas include hospital studies for collecting injury data to compare with police data; changing vehicle standards so that they are better suited to local crash types; the calculation of crash and injury costs based on local figures; vehicle fleet analysis for comparing different vehicle segments and exposure; and improved data collection and storage methods.

**Keywords: Crashes; Accidents; Traffic; Road Safety; UAE; Dubai; Strategy; Pedestrian Safety; Vehicle Safety; Speeding; Injury Prevention**



وَلَا تَقْتُلُوا أَنْفُسَكُمْ إِنَّ اللَّهَ كَانَ بِكُمْ رَحِيمًا

"Do not kill yourselves nor kill one another. Surely, Allah is Most Merciful to you" *Surah An-Nisa (4:29), The Holy Quran.*



*To the family who backed me all the way.*



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# **Chapter 1 Global Assessment of Road Traffic Injuries**

## ***1.1 Introduction***

Human beings have been mobile creatures since times ancient. Mobility is utilised for recreation, food gathering and hunting, avoiding danger and generally staying alive. Their modes of travel however have changed somewhat over the years as have the merits (and hazards) of different modes of travel. Humans were not equipped to travel unaided at speeds greater than 10 km/hr. The reaction times needed and the low tolerance to impact at higher speeds hinder the fast human being. This chapter presents the background to the challenge of counting and managing road traffic injuries around the world. It demonstrates different ways of measuring the damage caused by poor road safety both in economic and lost output measures.

## ***1.2 Human tolerance to injury***

Humans are mostly capable of reacting to dangers and changes in their surroundings in a timely manner and changing direction or speed of travel while walking to accommodate or avoid those dangers. This ability decreases as speed increases (generally above 5-10 km/h); even riding a bicycle can be challenging at speed. A car that goes at many times that speed is even more challenging to human tolerances.

“Travel hazards changed completely after the invention of the automobile in the second part of the 19<sup>th</sup> century. On July 3<sup>rd</sup> 1886 Carl Benz in Mannheim was the first person driving in public...The maximum velocity of this 3-wheel vehicle was 15 km/hr. Twenty years later the maximum vehicle speed increased already to close to 100 km/hr. Due to higher vehicle speeds, but more important due to the larger speed differences between various means of transport, the first traffic crashes occurred. The increasing motorisation generated mobility and consequently more people were exposed to risk.” (Wismans et al, 1994).

In the first half of the 20<sup>th</sup> century literature on the subject of road crashes and related studies was scarce (Mackay, 1965). In 1917 in North America Hugh De Haven survived a military aircraft crash (De Haven, 2000). This led him to develop an interest in morbidity and mortality from crashes and the human body's tolerance to impact. The other cadets involved in the crash did not



survive according to one narration of the story (Hess et al, 1982). The prevailing attitude at the time was:

“Flying was dangerous and the best way to prevent injuries was to stay on the ground.”\*

De Haven persisted, conducting a study of survival in falls from height (started in 1938) to prove that the fragile human body had more tolerance to severe deceleration than previously thought possible (De Haven, 1942). This was further proven by rocket-fired sled tests conducted by John Stapp on monkeys and subsequently on his own body (Stapp, 1957) that showed the human body could tolerate deceleration of 50g's for very brief periods of time (50 times the acceleration due to gravity). The work of these pioneers paved the way for understanding and managing injurious forces on the human body in future decades.

### ***1.3 Describing the problem of road safety on a global scale***

From the first recorded fatality due to a motor vehicle in New York on 13 September 1889 (Wagner et al, 1997) the number of people involved in motor crashes has increased enormously. One estimate puts the cumulative total of deaths due to road crashes up to 1997 at 25 million (Faith, 1997). In Europe and North America (UNECE countries – United Nations Economic Commission for Europe, see Appendix A) the number of people injured in road crashes in 2003 was around 5 million. The number killed in the same year was around 140,000 (UNECE, 2005).

The definition of a road fatality is not universal but one commonly used is that of the Convention of Road Traffic (UNECE, 1968) where a person dies from an injury suffered in a road crash within 30 days of the crash. This includes vehicle occupants as well as other road users like pedestrians and cyclists.

Global estimates of annual road fatalities for 1999 (Jacobs et al, 2000) by TRL for countries that record this data show at least half a million recorded fatalities occur annually on roads, even more if adjusted for under-reporting (table 1).

---

\* Words of De Haven's commanding officer when told that "luck could be changed by better engineering and design" (Horsch et al, 1991).



**Table 1: 1999 Minimum fatality estimates for countries with data**

	<i>1996 reported</i>	<i>1999 estimated</i>	<i>1999 inc. non-reporting estimates</i>
HMC	100,116	98,822	98,834
Africa	38,492	40,769	58,319
Central-Eastern Europe*	58,612	60,051	63,540
Asia-Pacific	204,379	226,663	228,405
Latin/Central America & Caribbean	58,484	61,318	64,700
Middle East	20,225	25,462	28,865
<b>Global</b>	<b>480,308</b>	<b>513,085</b>	<b>542,663</b>

\*Higher regional growth rate applied

Source: Jacobs et al, 2000

The following table shows global estimates made using an adjustment factor to bring the figures from countries without a 30-day-definition into line. One final adjustment was made for under-reporting with the factor estimated to affect 2-5 per cent of HMC figures and 25-50 per cent of LMCs though how this figure was arrived at is not explained in the study.

**Table 2: 1999 upper and lower fatality estimates and 30-day adjustment**

	<i>1999 inc. 30-day adjustment</i>	<i>1999 lower under-reporting estimate</i>	<i>1999 upper under-reporting estimate</i>
HMC	105,654	107,767	110,937
Africa	67,067	83,834	100,600
Central-Eastern Europe	73,071	91,339	109,607
Asia-Pacific	262,666	328,332	393,999
Latin/Central America & Caribbean	74,404	93,005	111,606
Middle East	33,194	41,492	49,790
<b>Global</b>	<b>616,056</b>	<b>745,769</b>	<b>876,539</b>

Source: Jacobs et al, 2000

The World Health Organisation (WHO) has a higher global estimate at 1.18 million in 1998 but this has come under scrutiny because in some cases it was based on less than ideal projections (Jacobs et al, 2000):

“...estimates for the entire region of sub-Saharan Africa were based only on South Africa which in turn represented only about 1 per cent of the region’s population (Cooper et al, 1998)”.

To put things in perspective the global estimate of deaths from all causes in 2001 was 56 million (Lopez et al, 2006) so road fatalities made up about 2.1% of the total every year (Peden et al, 2004). This is not a large percentage but this must not undermine the subject matter of this topic which still directly concerns millions of people. In the same year the number of people injured in



road trauma was estimated at 50 million (Peden et al, 2004). Those injured in road crashes suffer numerous after-effects from their experience both immediately after injury and later on in life. The impact on victims' quality of life has been the subject of extensive study (Barnes, 2006). Indirectly it affects far larger numbers. This appears in the literature to be the upper range of the global impact of road-related deaths as the global percentage works out at 1.3 – 1.5% using the more conservative TRL estimates.

#### **1.4 Global Burden of Disease (GBD) study**

The study in which the former estimate was made was part of a framework entitled the Global Burden of Disease (GBD) study which began with a publication in 1992 (World Bank, 1993) and with updated publications since then (Murray & Lopez, 1994 & 1996, 1997*a,b,c*; Lopez et al, 2006). Projected estimates continued to the year 2020 (Murray & Lopez, 1997*d*). Among the other important calculations which highlight how this problem may develop in the coming decades was a ranking of the leading causes of mortality worldwide in 1990, when road traffic crashes ranked 9<sup>th</sup> and in 2020 where the ranking is projected to rise to 6<sup>th</sup>. This may be attributed to a number of factors that relate to the LMCs in particular. A key factor is the expected rise in population in the increasingly prosperous economies of countries like China and India which leads to increased exposure to transport and the risks associated with it. Another important factor is the expected rise in the number of motor vehicles in use as economic development in these regions leads to motorised transport becoming more accessible to a larger section of the population. This increased use of motor vehicles will expose this larger section of the population to the risks associated with transport and road use. Another worrying estimate that takes into account the wider impact of traffic injuries on human life uses Disability-Adjusted Life Years or DALYs (Murray & Lopez, 1997*d*). DALYs are defined as the sum of the years of life lost due to premature mortality (YLL) in the population and the years lost due to disability (YLD) for incident cases of the health condition (WHO, 2006).

Estimates made by Murray & Lopez using DALYs showed that road deaths would be the 3<sup>rd</sup> leading cause of loss of these “life years” worldwide by 2020 and the 2<sup>nd</sup> if looking at developing regions only. The leading cause of life-



years lost was estimated to be ischaemic heart disease (that caused by low blood supply). These calculations make this subject a primary area of research and investigation.

#### **1.4.1 GBD shortcomings**

DALYs have been used in the GBD study since the start and have developed with it but the valuation protocols have changed over the years (Nord, 2002). The methodology used to assign weightings to different diseases have been criticised as flawed in their conception (Anand & Hanson, 1997). Some of the many assumptions which make the measure an estimate at best are life expectancy (80 years for males, 82.5 for females) which assumes that if health improves alone it will lead to this “maximum” value not taking into consideration other factors such as nutrition, wealth and economic activity. The calculated loss in earnings of a road crash victim who has become disabled will vary according to the life expectancy so the earnings for a 65-year life expectancy might be less than those for an 82-year life expectancy (Anand & Hanson, 1997). These factors combine to weaken the estimate and cast doubt on its accuracy.

### ***1.5 The multiple dimensions to the problem***

Every road traffic crash has many outcomes, not limited to the harm and injury caused, which will be discussed in the next section. There are associated costs and losses involved both direct and indirect. Direct costs include the costs of healthcare; rehabilitation; repairing infrastructure damage and repairing damage to the vehicles involved; while indirect costs include the value of lost earnings for survivors and those supported by them (Peden, 2004).

#### **1.5.1 High economic costs**

TRL estimates (Jacobs et al, 2000) of global economic costs for road traffic crashes range from 1% for developing countries to 1.5% in transitional countries to 2% in highly motorised countries as a percentage of Gross National Product (GNP). These estimates divided countries according to their level of “motorisation”. Motorisation was devised as a measure to differentiate the extent of motor vehicle use in a population. It was often measured by the



number of vehicles per population (normally vehicles/1,000 population). The Transport Research Laboratory (Jacobs & Aeron-Thomas, 2000) classified HMCs (Highly Motorised Countries) as those in North America, Australia, New Zealand, Japan and Western Europe. LMCs (Less Motorised Countries) were classed as those in the Middle East and North Africa (MENA); Latin/Central America and the Caribbean (LAC); Central and Eastern Europe (CEE); Asia/Pacific and Africa.

**Table 3: Road crash costs by region (US\$ billion)**

<i>Region</i>	<i>Regional GNP 1997</i>	<i>Estimated annual crash costs</i>	
		<i>GNP</i>	<i>Cost</i>
Africa	370	1%	3.7
Asia	2,454	1%	24.5
Latin America/Caribbean	1,890	1%	18.9
Middle East	495	1.5%	7.4
Central & Eastern Europe	659	1.5%	9.9
Sub total	5,615		64.5
Highly motorised countries	22,665	2%	453.3
<b>Total</b>			<b>517.8</b>

Source: Jacobs et al, 2000

Older literature mentions no less than six different methods for economic valuation of crashes (Hills & Jones-Lee, 1981). More recently three main costing methods were mentioned by Jacobs and others as suitable and relevant to road crashes. These may be broadly defined as (Jacobs et al, 2000):

- “(1) the ‘gross output’ or ‘human capital’ (HC) method (well suited to the objective of maximising the wealth of a country); and
- (2) The ‘willingness to pay’ (WTP) method (especially used for social welfare maximisation and for cost-benefit analyses).”
- (3) The “cost of restitution”, was mentioned by Krupp (Elvik, 1995) and is understood to mean the direct costs of a crash only.

TRL workers and the UK Department for Transport (DfT) favour the second approach where possible (DfT, 2007b) if the costs are intended to be used in cost benefit analysis. This was only available for HMCs. The first method is still used due to lack of empirical data for the second method in Asian and African countries for the estimates mentioned previously. Other studies deal with the subject of costing in more detail (Elvik, 1995 & TRL, 1995) and methods were expected to continue to change with the progress of time and



availability of data especially in developing countries. This presents a problem with the validity of comparisons between different regions if the costing method used is different. With current data availability it is not possible to unify the costing procedure and results. The cost figures used to estimate savings later on in the thesis are taken from UK costings which are in turn based on the Willingness To Pay method as mentioned earlier.

## ***1.6 Regional divisions and estimates of road crashes & injuries***

The World Bank divides the world into 8 regions (World Bank, 1993): sub-Saharan Africa; India; China; other Asia and islands; Latin America and the Caribbean; Middle Eastern crescent; formerly socialist economies of Europe; and established market economies (mainly OECD countries, Organisation for Economic Co-operation and Development). These were abbreviated in appendix A. For simplicity the data from two groups only will be reviewed according to the division of HMC/LMC.

Vital registration information (births and deaths) is recorded to varying degrees in these regions, and this forms the basis to forming the picture of the global impact of road-related deaths. According to the WHO (Mathers et al, 2005) only 115 countries collect this vital data. Out of these only 64 are considered to have complete data. Some developing countries with large populations employ sample registration techniques - like India and China - as representative of the whole population. This is due to the difficulty of implementing a complete registration system due to cost and lack of adequate staff training or supporting legislation. Overall there is a long way to go for many countries to implement vital registration systems to enable good data collection on mortality (Sibai, 2004).

### **1.6.1 Problems with global figures**

There are three main problems of difference and under-recording between country's figures mainly due to differences of definition. While 30 days after a crash is a typical cut-off for reporting a fatality some countries use other time periods like 24 hours, 3 days, 4 months and so on. The definition of a crash is another grey area as some countries do not report deaths at road works or



side streets so the numbers reported by the health authorities are more accurate (Jacobs et al, 2000). The final problem found by the TRL workers is that of updating and transferring records of fatality data especially in developing countries. This means the data might be altered or some significant portions might go missing in between the points where they are manually recorded and when finally inputted into the national system.

Campbell (Johnston et al, 1998) described the many complexities faced in international comparisons along with some crash rates that can be used as measures of severity:

1. Crashes per vehicle kilometre of exposure
2. Crashes per passenger kilometre of exposure
3. Crashes per hour of exposure
4. Crashes per number of trips
5. Crashes per number of participants
6. Crashes per population regardless of individual exposure, and
7. Fatal or injury crashes per total number of crashes.

### **1.6.2 Economic cost estimates in HMCs**

Elvik (1995) carried out an evaluation based on official country data for 20 HMCs and the costs of traffic crash fatalities varied greatly between countries (Table 4). The total costs were made up of three elements: direct costs, lost productive capacity and lost quality of life. Direct costs made up the smallest element of total costs (except for New Zealand where no figure was provided). The indirect costs of crashes made up the largest element of the economic valuations. Values of the quality of life lost were not available in a number of countries. The greatest total costs were found in Switzerland and the United States.

Estimates of road crash costs were collected from various sources reflecting the huge costs incurred. In the United States the estimated cost is US\$ 230.6 billion annually (Blincoe et al, 2002) while in the EU the cost is put at €180 billion (ETSC, 1997 & 2003).



**Table 4: Official economic valuation of a traffic crash fatality in 20 motorised countries in 1991. Norwegian currency\***

Country	Amount in million Norwegian kroner 1991			
	Lost productive capacity	Direct costs	Lost quality of life	Total costs
Australia	2.79	0.05	-	2.84
Austria	4.84	0.03	-	4.87
Belgium	3.13	0.03	0.12	3.28
Denmark	1.68	0.04	3.44	5.16
Finland	4.51	0.01	7.11	11.63
France	1.78	0.02	0.13	1.93
Germany	5.50	0.01	-	5.51
Great Britain	0.55	0.01	7.28	7.84
Japan	3.97	0.27	-	4.24
Netherlands	0.87	0.00	-	0.87
New Zealand	0.00	0.05	6.28	6.33
Norway	2.68	0.07	-	2.75
Portugal	1.85	0.00	-	1.85
Spain	0.93	0.00	0.48	1.41
Sweden	1.00	0.05	10.55	11.60
Switzerland	6.71	0.04	11.05	17.80
United States	3.82	0.94	12.80	17.56

- = This cost item is not included in national cost estimates.

\*Currency conversion factor, May 1994: 1US\$ = 0.139Kr

Source: Elvik, 1995

As a percentage of GNP in the UK they cost 0.5% and in Sweden 0.9% (often seen as the best-performing countries in that region in the field of road safety). In countries with a poorer road safety record they are notably higher like Italy at 2.8% and the USA at 2.0% (see table 5, Elvik, 2000).

### 1.6.3 Economic cost estimates in LMCs

In China, the “estimated annual economic cost of injury (*including traffic-related*) is equivalent to US\$12.5 billion, almost four times the total public health services budget of China” in 1998 (Zhou et al, 2003). In Saudi Arabia in the early 1980s the **daily** cost of traffic fatalities and their management was put at around on US\$1 million (Bener & Jadaan, 1992).



**Table 5: Recent crash cost estimates from LMCs**

<i>Country</i>	<i>Study year</i>	<i>Costing method</i>	<i>Percent GNP</i>	<i>Value US\$million (1997)</i>	<i>Source</i>
<i>LAC</i>					
Brazil	1997	HC	2.0%	15,681	IADB Review of Traffic Safety
<i>Asia</i>					
Vietnam	1998	HC	0.3%	72	Technical Note: Accident Costing
Bangladesh	1998	HC	0.5%	220	IDC Economics Working Paper Accident Costs
Thailand	1997	HC	2.3%	3,810	SWEROAD Road Safety Master Plan Report
Korea	1996	HC	2.6%	12,561	Elvik, 1999
Nepal	1996	HC	0.5%	24	Road Maintenance Component, TN Accident Costing 1996
Kerala, India	1993	HC	0.8%	-	Chand 'Cost of Road Accidents in India - reference to Kerala
Indonesia	1995	HC	-	691-958	Accident Costs in Indonesia: A Review June 1997 (Draft Copy), TRL/IRE
<i>Africa</i>					
KwaZulu Natal	1997	HC	4.5%	-	Kwazulu-Natal Road Traffic Safety Strategy (1996-2000)
Tanzania	1996	HC	1.3%	86	1996 Road Safety Programme Tanzania Ministry of Works
Zambia	1990	HC	2.3%	189	TOI Study
Malawi	1995	HC	<5.0%	106	SWK/Iberinsa Road Safety Study, 1997
<i>MENA</i>					
Egypt	1993	HC/CA	0.80%	577	Aly, 'Valuation of traffic accidents in Egypt'

Source: Jacobs et al, 2000

Key to table: HC: Human Capital. *LAC*: Latin American Countries. *MENA*: Middle East & North Africa.

## 1.7 Comparing fatality rate and fatality risk

Risk is a term that can take on different meanings depending on the context and purpose at hand (Fischhoff et al, 1984). One definition of risk in the traffic safety field is the possibility of an unwanted event (Elvik & Vaa, 2004). Two calculated measures that are often used to make comparisons between different regions easier are those of fatality risk and rate (Jacobs et al, 2000, Kopits & Cropper, 2003). There are different definitions of risk in the literature. In this research, when “fatality risk” is used it means the risk to the general population of dying in a road crash and is often measured in numbers per 100,000 units of population. Fatality rate on the other hand is the number of fatalities per 10,000 motor vehicles.

The term “motor vehicle” or MV is used to include motorised modes of transport such as saloon cars, buses, heavy goods vehicles and motorcycles (except where a certain type is excluded as shown at the foot of some tables). Exposure of the population to travel (Chapman, 1973; Elvik & Vaa, 2004) is another important element in consideration of such figures as risk changes with exposure. If there are two identical countries with an identical number of



MVs and every vehicle in country A undertakes 7 journeys a week of the same length, while every vehicle in country B undertakes 14 journeys a week then the exposure of the population to vehicles in country B is clearly greater all other things being equal.

**Table 6: 1974 Motorisation, fatality rates & risks in some highly motorised countries**

Country	Vehicles per 100,000 population	Road deaths per 100,000 population (Risk)	Road deaths per 10,000 vehicles (Rate)
Great Britain	32	13	4
Australia	47*	27	6*
Austria	31	33	11
Belgium	34	27	8
Canada	45	28	6
Denmark	33*	15	5*
Fed. Rep. Germany	33	24	7
Finland	28	18	7
France	42	28	7
German Dem. Rep.	31	13	4
Hungary	13	17	13
Irish Rep.	19	19	10
Italy	36	18	5
Japan	33	14	4
Luxembourg (1973)	41	31	8
Netherlands	41	19	6
New Zealand	49	22	5
Norway	30	13	4
Poland	10	15	15
Portugal	12*	28	24*
Spain (1973)	17	18	10
Sweden	35*	15	4*
Switzerland	41	21	5
United States of America	61	21	3

*\*figures exclude mopeds*

Source: DfT 1977

Table 6 shows the road safety situation using some key indicators in HMCs in 1974. The majority of countries have fatality risks between 13 and 30 (fatalities per 100,000 population) and fatality rates (fatalities per 10,000 MVs) show a greater variation ranging from 3 to 24. The highest reported motorisation at the time was found in Australia, Canada, New Zealand and the USA. The lowest motorisation was in Eastern European countries (Hungary and Poland). The fatality risk appears independent of motorisation levels with the lowest risk evident in Western and Northern Europe (Great Britain,



Germany and Norway) and Japan. Fatality rates were also lowest in those countries in addition to Sweden and the United States of America.

**Table 7: 2004 Motorisation, fatality rate & risk in some highly motorised countries**

Country	Motor vehicles per 1,000 population*	Road deaths per 100,000 population (Risk)	Road deaths per 10,000 vehicles* (Rate)
Australia	673	7.9	1.0
Austria	637	10.7	1.7
Belgium	583	11.2	1.9
Denmark	467	6.8	1.5
Finland	528	7.2	1.4
France	615	9.2	1.5
Germany	655	7.1	1.1
Hungary	327	12.8	3.9
Italy	745	9.7	1.3
Japan	636	6.7	1.0
Luxembourg	794	11.1	1.4
Netherlands	522	4.9	0.9
New Zealand	719	10.7	1.5
Norway	625	5.7	0.9
Poland	437	15.0	3.4
Portugal	510	12.3	2.4
Spain	614	11.0	1.8
Sweden	563	5.3	0.9
Switzerland	675	6.9	6.9
United Kingdom	552	5.6	1.0

\*Excluding mopeds

Source: DfT 2006b

Table 7 shows how the situation changed for a similar group of countries in 2004. Virtually all countries have reduced both fatality risk and rate (with the exception of Poland) in some cases to less than a quarter of the original figures while motorisation increased manifold. Before any comparison can be made it cannot be assumed that the 1974 and 2004 figures are directly comparable or contain the same types and range of errors or inaccuracies but they provide a general view of improvement over time. Early figures for fatalities in LMCs are even more difficult to come by and less likely to be accurate if the level of development of the nations they were gathered from is taken into account but more recent statistics are available as shown in table 8.

The variation between different countries is large and gives a worrying outlook for the future. If populous countries such as China and India were to reach the level of motorisation of HMCs without the single-digit fatality rate then the fatality rate may rise along with motorisation (as has been shown from the sample of countries in the previous two tables).



Projected estimates of fatalities using fixed effect models made by a World Bank funded study (Kopits & Cropper, 2003) based on economic growth

**Table 8: Motorisation, fatality rate & risk for selected years in some Less Motorised Countries (LMC's)**

Country	Motor vehicles per 1,000 population	Road deaths per 100,000 population (Risk)	Road deaths per 10,000 vehicles (Rate)
Bangladesh (1996)	3.8	1.7	44.5
China (1995)	22.5	5.9	26.1
India (1995)	31.2	6.3	20.3
Pakistan (1996)	18.4	3.2	17.4
Turkey (1996)	82.7	8.7	10.5
Albania (1996)	32.4	7.8	24.1
Bulgaria (1996)	296.5	12.1	4.1
Kazakhstan (1996)	81.5	16.6	20.4
Poland (1996)	291.3	16.5	5.7
Romania (1996)	139.2	12.6	9
Argentina (1996)	154.7	18.4	11.9
Brazil (1996)	161.6	16.7	10.3
Cuba (1996)	64.1	12.9	20.2
Mexico (1995)	142.8	3.6	2.6
Paraguay (1995)	51	2	3.9
Kenya (1993)	14.3	9.2	64.3
Malawi (1996)	5.6	10.9	193.2
Nigeria (1993)	12	7.8	65
Tanzania (1994)	4.6	5.1	111.4
Egypt (1994)	37.2	7.4	20
Iran (1995)	80.8	4.7	5.9
Saudi Arabia (1994)	151.9	21	13.9
Yemen (1996)	33.9	8	23.7

Source: Jacobs et al 2000

predicted a 66% increase in the global road death toll between 2000 and 2020. Most of the rise is expected to come from LMCs while HMCs are expected to witness a decrease in road deaths if the current trends continue and no drastic changes occur. This will likely mean a reversal of the current situation where the regions with the most MVs account for the least proportion of fatalities and those with the least MVs account for most of the fatalities worldwide. As car ownership levels rise in the previous LMCs and they join the HMC's group they will account for both the largest proportion of MVs and



fatalities worldwide which is a worrying prospect for all the parties involved in road safety.

The Middle-Eastern countries in the above table appear to show a large variation in fatality risk with Saudi Arabia leading in that respect. However Saudi Arabia also has the highest rate of motorisation of those countries so the fatality risk may be held down in the other countries by virtue of lower motorisation. This is shown in the fatality rate which is less dependent on motorisation because it is calculated using a fixed vehicle ratio (for every 10,000 vehicles). In that measure two of the three countries in that group apart from Saudi Arabia (Egypt and Yemen) have higher fatality rates than Saudi Arabia. Saudi Arabia is a key indicator because it is the largest country in the GCC (Gulf Cooperative Council which is made up of six neighbouring countries bordering the Arabian Gulf) both in population and area. The United Arab Emirates borders Saudi Arabia and shares many characteristics with that country – it is the focus of the next chapter.

## **1.8 Summary**

A basic introduction to the field of road and vehicle safety and the impact of the invention and increased use of motor vehicles on human injury worldwide was presented. From various studies conducted in different areas of the world the cost to humans (mainly in terms of casualties and fatalities) was shown to have increased significantly in the past 100 years. The cumulative total of road fatalities in the last century was estimated at 25 million (Faith, 1997). Estimated deaths related to road crashes in 1998 were estimated at 1.2 million worldwide (Jacobs et al, 2000). The concept of motorisation (ratio of vehicles per population unit) was introduced and a distinction was made between different geographical locations based on the level of motorisation (HMC v. LMC). The performance of these different regions in terms of road traffic injuries was evaluated based on commonly-used measures such as fatality rate and risk. Fatality risk was the probability of dying from a road crash as a member of the general population, calculated as a fatality per 100,000 people. Fatality rate described the rate of fatalities among motor vehicles as a fatality per 1,000 motor vehicles. HMCs generally have between



500 and 700 motor vehicles per 1,000 heads of population while LMCs have less than 300 motor vehicles per 1,000 people. Fatality risk for HMCs were found to be in the region of 6 to 12 deaths per 100,000 people. In LMCs the fatality risk at times reached 20 deaths per 100,000 people or more (assuming the data gathered was reliable which was difficult to establish in some cases). The economic costs of crashes were reviewed where available. In HMCs every fatality's calculated cost to the economy in 1991 (Elvik, 1995) ranged from \$6 million to \$126 million. As a percentage of GNP (without the estimated loss of quality of life) road crashes cost HMCs between 0.5 – 2.5% (Elvik, 2000). In LMCs the estimates were higher at between 2 – 4.5% (Jacobs et al, 2000).

Future predictions of the size of the problem are worrying to all observers and road users. In 2020 road crashes were predicted to become the 6<sup>th</sup> leading cause of mortality worldwide; in 1990 it was ranked 9<sup>th</sup> (Murray & Lopez, 1997*d*). This highlighted the need to deal with the problem immediately and continuously.



## **Chapter 2 The Road Safety Situation in Dubai, United Arab Emirates (UAE)**

### ***2.1 Introduction***

The emirate of Dubai in the United Arab Emirates (UAE) was the primary focus of this work. After defining the road safety problem on a global scale this section focuses the research to the area of interest and defines the questions that were the impetus for this work.

Research questions:

1. Is there a road safety problem in Dubai?
2. What is the nature of the problem and the main causes?
3. What can be done to overcome the road safety challenge with measures that have been effective elsewhere?
4. What is the magnitude of benefits that might be gained from applying these measures?

The development of road safety performance in many countries was reviewed in the previous chapter. Major countries in the Middle East region were shown to have adverse performance in road safety as shown by fatality rate and risk (Jacobs et al, 2000). The next step is to review the performance and situation of Dubai and the UAE in this context.

Since the formation of the UAE in 1971 the growth witnessed in Dubai has impacted every aspect of life there. Until the start of this study (2005) there had been significant growth in the population and with this an increase in the number of newly registered vehicles; the number of newly issued licenses and the number of traffic violations (DMSC, 2007a). This chapter describes the road safety scenario and how road safety is managed in the area. The few previous studies conducted will be used to present the problem at a basic level and demonstrate the novelty of the work undertaken in Dubai. The main stakeholders in this area will be introduced to indicate how complex the management of this issue is on the local (Dubai) and national (UAE) level. Regional data is presented to show the overall standard of road safety in neighbouring countries that share some of the climate and culture of the UAE.



The many rules and regulations that govern the use of motor vehicles will be translated from Arabic and reviewed to establish the extent and breadth of existing safety legislation. Safety regulations will be compared to international standards where possible to highlight differences where they exist. Finally recent and future proposed changes in regulations in Dubai and the UAE with a potential effect on crashes will be discussed.

## **2.2 Aims and intended outcomes of the study**

The overall aims and objectives of this research can be arrived at by posing the following questions first:

- ◆ How does Dubai compare to other nations in terms of casualty rates?
- ◆ What is the nature and circumstances of crashes in Dubai?
- ◆ What is the influence of enforcement?
- ◆ What is the influence of road infrastructure?
- ◆ What is the influence of demographics?
- ◆ What is the influence of driver education?
- ◆ What is the influence of time and work patterns?
- ◆ What is the influence of environmental conditions?

Once the above questions are addressed it will be easier to determine which further steps could be taken to improve the road safety situation. The worldwide scientific literature on countermeasures can then be selectively scanned and reviewed for suitable interventions according to the broad problem areas that were established.

In summary the main objectives and intended outcomes of the thesis are as follows:

- ◆ To assess – through the analysis of crash data – the main factors which influence the traffic casualty situation in Dubai thus establishing a baseline for future studies;
- ◆ To assess the suitability of countermeasure application - through international knowledge transfer - armed with the knowledge of what is already in use locally; and

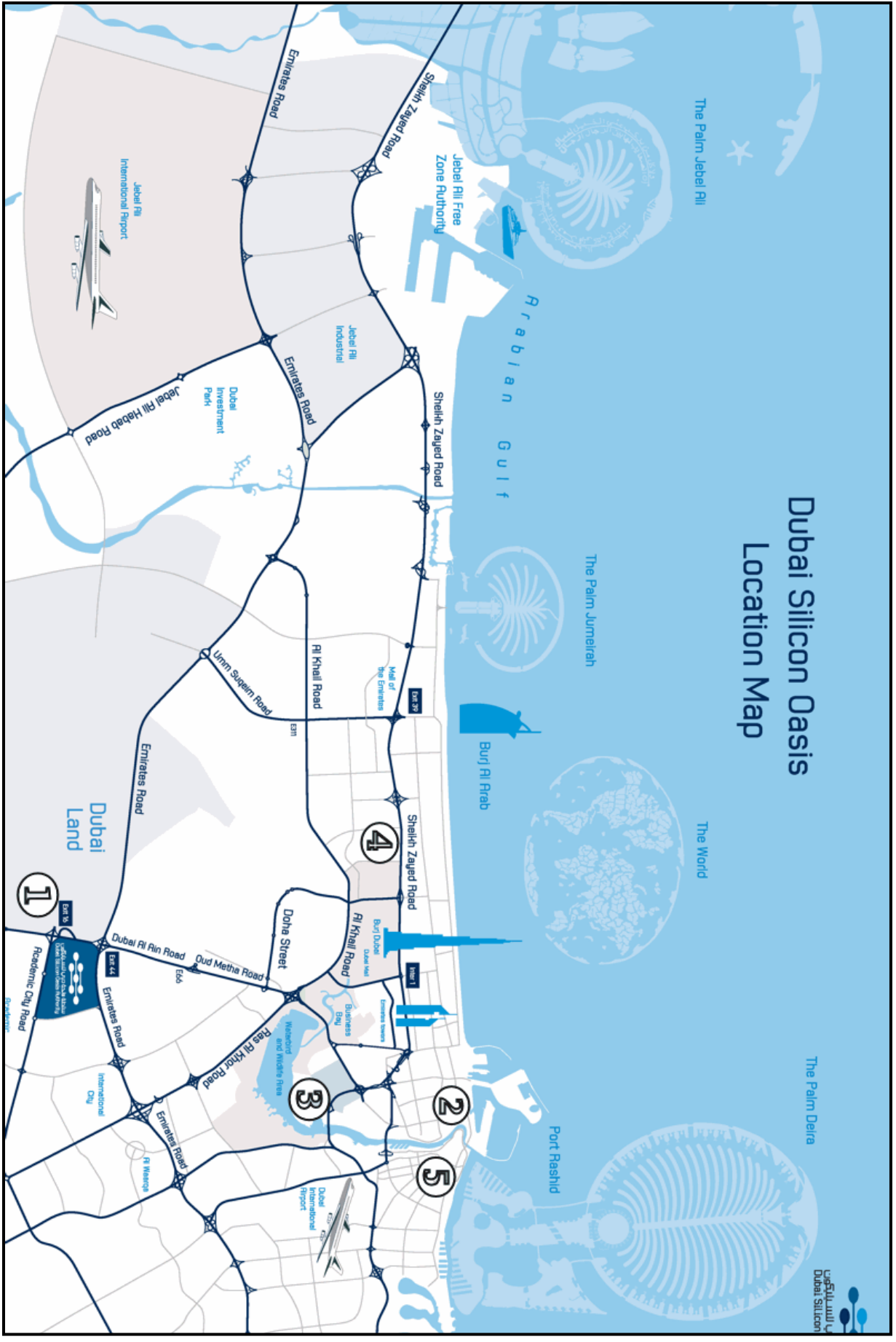


- ◆ To establish how reductions in casualties could be derived if the countermeasures suggested were applied.

### ***2.3 Background to the road safety situation***

To provide an adequate background to the subject of road safety in Dubai it is important to understand the geographical context in which it all takes place. The city of Dubai is part of an emirate by the same name, that itself is part of seven constituent emirates that make up the UAE. It lies on the coast of the Arabian Gulf and is covered by a significant road network. On the following page is an official map kindly provided by Dubai Silicon Oasis Authority, Government of Dubai (© 2010). It illustrates the layout of major roads and developments in the emirate. The numbers superimposed on the map (①-⑤) correspond to the locations of roads pictured in figures 1 to 5. Photographs of some of the main roads and road types in Dubai are included on the following pages. These are mentioned in more detail in the following chapters.









**Figure 1: Dubai – Al-Ain road highlighting the desert surroundings and central barrier with lighting in the middle of the road (Copyright AreJay, Wikimedia Commons, GDFL, Creative Commons Attribution 3.0 Unported licence: full text available at <http://creativecommons.org/licenses/by/3.0/deed.en>.)**



**Figure 2: A photograph showing a typical side street in the area known as Bur Dubai, where different traffic modes compete for space (Copyright by Perla, Picasa Web Albums).**





**Figure 3: A section of Sheikh Rashid Road, before the installation of a pedestrian fence between the two carriageways (Photographs provided courtesy of the Government of Dubai, Department of Tourism and Commerce Marketing - Copyright 2010).**



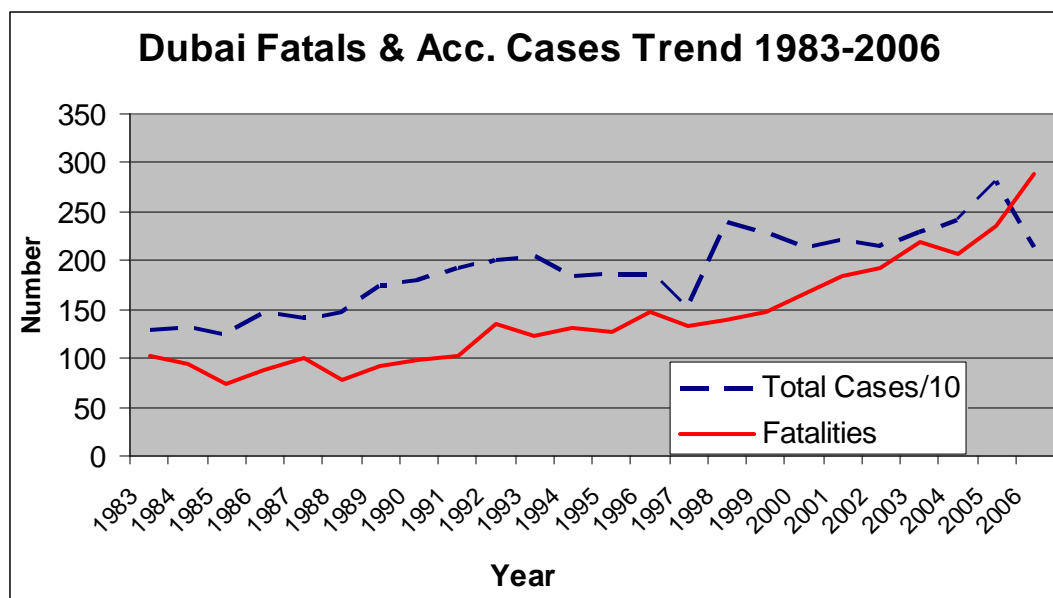
**Figure 4: The beginning of Sheikh Zayed Road (that ends at the border with Abu Dhabi emirate) showing one of the first air-conditioned pedestrian bridges spanning the full width of the highway (Photographs provided courtesy of the Government of Dubai, Department of Tourism and Commerce Marketing - Copyright 2010).**





**Figure 5: An aerial view of Dubai Creek that divides Deira (on the right) from Bur Dubai (on the left). Photographs provided courtesy of the Government of Dubai, Department of Tourism and Commerce Marketing - Copyright 2010.**

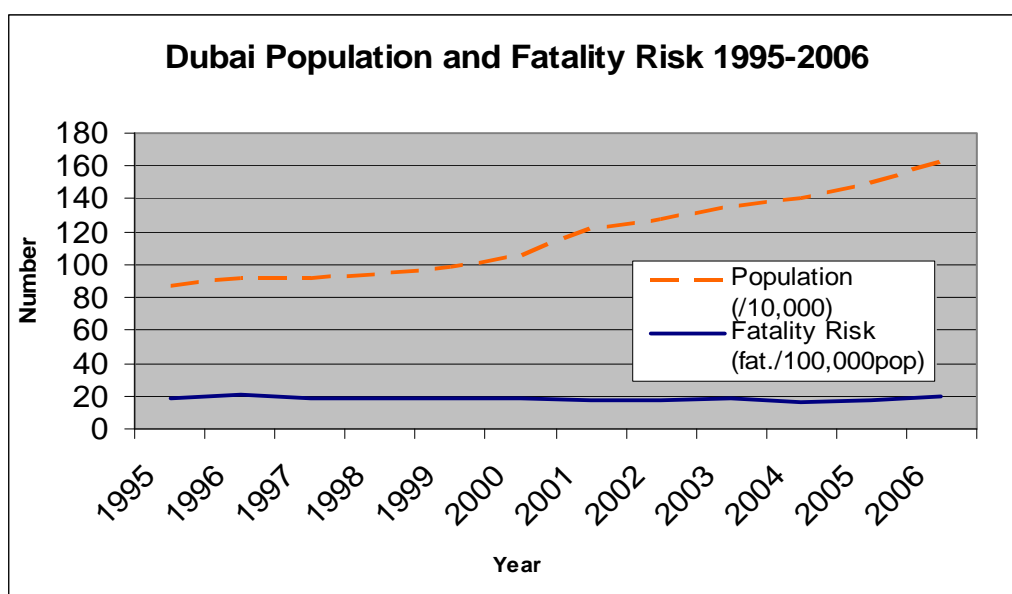
Records of traffic fatalities and injuries (from all crashes where at least one motor vehicle was involved) have been kept by Dubai Police since at least 1983 as shown in figure 6.



**Figure 6: Fatalities and total crash cases (injury & non-injury), historic trend. Source: Dubai Roads & Traffic Authority, Dubai Police.**



The casualty figures include car occupants, pedestrians, cyclists and motorcyclists. The motor vehicles involved in crashes are not limited to passenger cars, but include buses; trucks; motorcycles and other road-going motorised traffic. Though the total figures shown are not large compared to industrialised nations (the overall deaths per year were under 300) the rising trend is a source of worry for all the stakeholders in the area. To see the overall picture it is important to take into account population growth and the linked fatality risk (figure 7). While the population is increasing steadily the fatality risk has remained stable over the years at a value of ~20 per 100,000 people. This implies that there has been no increase in the risk of fatality. On the other hand the level at which it remains is still three times that of the best-performing HMCs like Sweden and the UK. This indicates that there is considerable scope for improvement. Studies by workers in the field (Al-Madani, 2000; Almubarak, 1998; Ashur, 2003; Bener & Alwash, 2002; Weddell & McDougall, 1981) have looked at the UAE road traffic situation (tables 9 & 10) especially in the last decade and have come to the conclusion that the UAE has a major problem. Road crashes were the cause of significant mortality and morbidity. Many recommendations have been made for improving the situation. These recommendations were broadly based around the four areas of education (including awareness and learning); engineering; enforcement and emergency and medical care.



**Figure 7: Population and Fatality Risk (deaths per 100,000 population), historic trend. Note 2006 population figures are preliminary. Source: Statistics Centre of Dubai; RTA.**



**Table 9: Registered Vehicles, Population, and Fatalities in the UAE (1990-2000)**

Year	Number of Registered Vehicles	Population in Thousands	Fatalities	Fatalities per 100,000 Population	Fatalities per 10,000 Vehicles
1990	303,284	1,844	394	21	13
1991	309,539	1,875	490	26	16
1992	344,855	2,062	510	25	15
1993	398,788	2,145	567	26	14
1994	442,700	2,230	600	27	14
1995	428,149	2,377	563	24	13
1996**	453,291	2,479	358	14	8
1997	463,891	2,624	619	23	13
1998	539,407	2,776	646	23	12
1999	575,929	2,938	661	22	11
2000	673,040	3,108	673	22	10
2001	745,000	3,167	803	25	11
2002	767,000	3,349	755	23	10
2003	792,000	3,551	873	25	11
2004	1,025,000	3,761	824	22	8
2005	1,073,000	4,106	830	20	8
2006	1,078,000	4,229	878	21	8

\*\* : Data does not include injuries and fatalities in Sharjah, Ajman, and Abu Dhabi city.

Sources: Ashur, 2003; Ministry of Economy, 2006; 2009.

A comparison of Dubai and the UAE (table 10) with some of the best-performing and worst-performing countries in road safety terms in the European Union (EU) shows the large differences between them while the levels of motorisation did not vary significantly.

**Table 10: Comparison of the UAE with some HMCs**

Country	Motor vehicles per 1,000 population	Fatalities per 100,000 population	Fatalities per 10,000 vehicles
UAE (2000)	217	21.7	10
UAE (Dubai only, 2005)	525	20.5	3.75
Greece (2003)	-	14.6	-
Portugal (2004)	510	12.3	2.4
United Kingdom (2004)	552	5.6	1.0
Sweden (2004)	563	5.3	0.9

Source: DfT, 2006b; Ashur, 2003; RTA 2006b; Ministry of Economy, 2005.

The sole source of traffic crash data in Dubai is the authorities responsible for building, maintaining and policing roads. It is imperative to know the source of this data and how it is collected before it is used with any confidence. Traffic crash management in the emirate of Dubai and in the UAE in general involves



a number of different stakeholders sometimes with overlapping responsibilities. In the case of Dubai, road design, construction and maintenance used to fall within the remit of the municipality until 2005 when a Roads and Transport Authority (RTA) was established. All traffic matters (aside from policing) were transferred to the authority. This included vehicle registration and licensing.

Crashes are first reported to the police who have a range of responses depending on the situation. A patrol car is often dispatched immediately followed soon thereafter by a road ambulance or air ambulance (especially for areas that are distant from the main trauma centre). A rescue vehicle may also be sent depending on the nature of the crash if there is a risk of trapped victims. Dubai police operates most of the above services and is often called to assist in incidents outside the emirate of Dubai in areas where the same resources might not be available. Road crash victims are exclusively transferred by Dubai Ambulance Services Centre. In extreme cases an air ambulance can be dispatched. One of four is always on duty all year round with the possibility of calling in more units as the need arises<sup>◇</sup>.

In 2006 a dedicated trauma centre (Interhealth Canada, 2009) was established at one of the main hospitals (Rashid Hospital Trauma Centre) to deal almost exclusively with trauma cases from vehicle crashes and similar cases and they deal with a large number of road crash victims. Dubai Civil Defence also operate a fleet of rescue vehicles and heavy equipment that can be used to free trapped passengers. They are always called in the case of a vehicle fire or spillage on the roadway. A police forensic team is also called if suspicious circumstances surround the incident. Vehicles involved in fires are often towed to the police forensic laboratory for further examination.

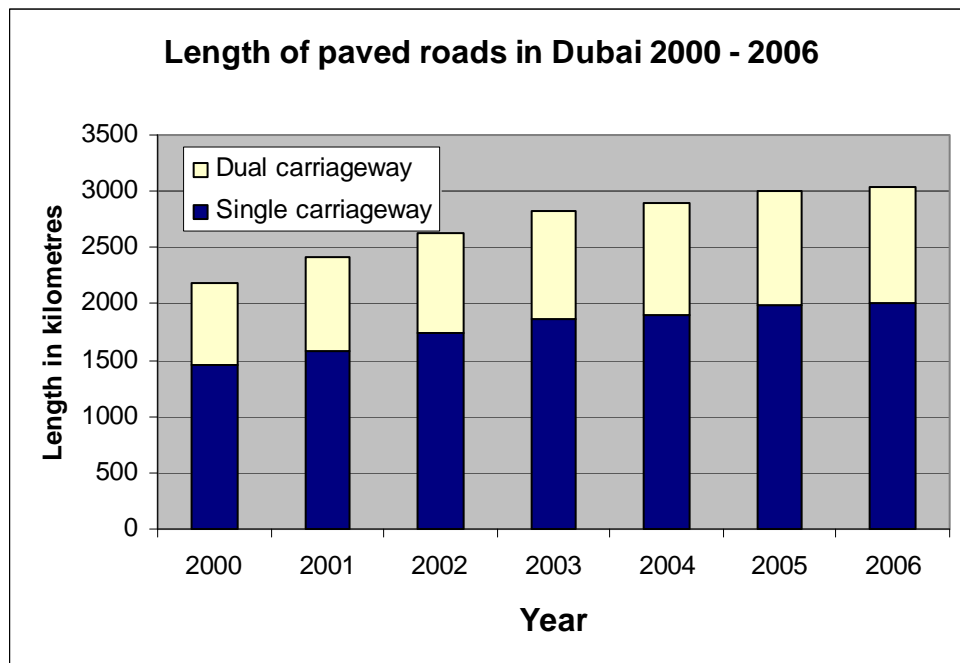
The growth witnessed in Dubai over the past few years has been remarkable. This can be measured by many variables; whether in the number of driving licences issued; or the number of motor vehicles licensed; or the number of residents or the number of dwellings that exist (DMSC, 2007a). A rapidly expanding country and economy is expected to see different trends in crash rates than a country with a shrinking economy or total net emigration.

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<sup>◇</sup> *Personal communication, Paramedics at Rashid Hospital, December 2007.*



Figure 8 shows an example of this growth expressed here in the length of paved roads being constructed over a period of six years. The total road network length has increased by almost 50% in six years in an effort to keep up with the increase in the number of vehicles registered and the growth of the city as a whole.



**Figure 8: Length of paved roads in Dubai, 2000 – 2006 (Source: DMSC, 2007b; 2008).**

Adding almost 900 kilometres of new roads in such a short time period is typical of the speed of development taking place in Dubai. Other growth indicators show first time vehicle registrations to have increased by 37.1% in 2005 and a 32.7% increase in new driving licences issued for the same year (DMSC, 2007a).

## **2.4 Road safety studies on the UAE**

### **2.4.1 Introduction**

To establish the novelty of this research topic in this part of the world it was necessary to outline what previous work has been done in the subject area and where it was carried out along with a brief overview of the results obtained. This will also serve to avoid duplication in effort. An extensive literature review showed very few completed and published works of scientific research existed on this topic in Dubai. Published studies will be reviewed after the unpublished works are reviewed.



## **2.4.2 Unpublished studies**

Two independent studies were conducted in recent times by researchers on the topic of road safety in the UAE one from 1998 and the other from 2002. Almubarak (1998) from the Department of Civil and Transportation Engineering at Napier University in Scotland reviewed and compiled the data for crashes in 1990 – 1992 for all of the UAE and from 1989 – 1990 for the city of Abu Dhabi. Some of the main findings are listed below:

- The main study area of urban Abu Dhabi possesses an adverse road safety record
- Particular problems highlighted were child and pedestrian casualties
- Some cost estimates were made, which showed the economic cost of crashes to be around 1.5% of the UAE GDP (1991 figures)
- Some significance was found in relationships between vehicle registrations and fatalities using statistical tests (T-test) for the study area
- Using a development of the “innocent victim” concept to measure crash involvement. Those under 21 years of age and UAE nationals were found to be over-involved while Asian nationality groups and taxi drivers were found to be under-involved.
- Ramadan (Muslim holy month of fasting from food and water) and summer months showed different crash rates (higher in Ramadan, lower in summer – although this may even out when Ramadan falls in the late summer). Accident Involvement Ratio (AIR = percentage of accidents to percentage of traffic flow) peaked at the time of sunset (just before breaking the fast) and during working hours (0800 – 1300) and from 0300 to 0500.

The fasting month of Ramadan (when able and healthy Muslims abstain from food and water during daylight hours) has been the focus of some studies in the past due to the perceived increase in fatigue and tiredness due to fasting (Rashed, 1992). Research in a multi-cultural area of London showed increased attendance to the Accident & Emergency department of a major hospital for Muslims during Ramadan when compared to non-Muslims (Langford et al, 1994). It would be safe to assume a number of these attendances relate to motor vehicle injury. This directly relates to the UAE because it is a majority-Muslim country where the adult population practises fasting regularly.

The accuracy and comprehensiveness of the supplied crash data might not be as complete as the records suggest because it is unlikely that all crashes



in the years of study were actually reported to the police or the insurance companies whose data was used for cost estimates. The problem of underreporting with crash data is widely known and acknowledged in most countries of the world (WHO, 1975; Mufti, 1983; Ofusu et al, 1988; Bener et al, 1992; Jacobs & Aeron-Thomas, 2000). It has also been studied in depth by the Department for Transport in the UK (DfT, 2006a).

The author cites the lack of a no-claims-bonus system by insurers in the UAE as an incentive to claim for all crashes while in reality there are other reasons that might prevent a claim from reaching insurance companies. Such reasons are the avoidance of hassle if only minor damage is involved or the belief (ethical or otherwise) in the non-validity of the insurance system as a whole. Also the data collected from federal authorities might not be the same as that submitted to them by the local police forces especially before the dawn of electronic mass communications and the internet. These factors combined mean there might be other explanations for observations but it is impossible to stand on all the possible reasons without expending an enormous amount of effort in addition to what was done already.

Haj Ahmed (2002) from the UAE University's Faculty of Medicine and Health Sciences conducted studies on the medical and economic impact of road crashes in the UAE at the University of Abertay Dundee. The data used was collected from the federal security and health authorities. Some of the main findings were:

- The total economic costs calculated using Human Capital and Willingness To Pay methods were found to be 2-3% of the UAE GDP (1995).
- The total economic cost of crashes in 1995 was approximately \$1bn (AED3.8bn) while every minor injury cost AED50,000 (~£7,000), and fatalities cost AED7.5m (~£1m) each.
- Drivers between 18 – 40 years old were most involved in fatalities.
- From 1985 – 1995 crashes per population and per vehicle declined in the UAE while the severity of injury and rate of death in a crash increased.
- Seat belt effectiveness was studied from hospital admissions. An estimated 62% reduction in costs of crashes could have been achieved in 1995 if every occupant involved in a crash that year had used a seat belt.



The sources of data for most of the above work were similar to the first studies in that they are secondary, collated by central authorities from various sources and thus suffer from the same shortcomings and limited coverage. Both works illustrate the limited extent and accessibility of data in this field and are a good primer for anyone planning research work in the area. However the need for in-depth injury and crash data is undoubtedly clear (Almubarak, 1998; Haj Ahmed, 2002) because it allows an accurate depiction of the road and vehicle safety situation and continuous monitoring and analysis of the situation with time along with the assessment of remedial measures.

### **2.4.3 Published papers and journal articles**

A small number of published studies examining the UAE and the regional situation with regards to traffic safety were found and reviewed. These studies most often targeted specific issues that are seen as significant like the influence of a high percentage of 4x4s in the vehicle fleet or mobile phone and seat belt use or driver comprehension of road signs.

Studies of seat belt use from police crash data will only reveal usage rates for those involved in crashes which might not reflect the actual driving population due to differences in risk-taking behaviour or habits. Nevertheless they can provide an indicator of usage levels and the effectiveness of seat belts in reducing injury severity. Seat belt use for front occupants was made compulsory, and enforced, across the UAE in January 1999. This provided an excellent opportunity to study the effect of this measure on crashes and injuries. A study on Dubai police data at the period before and after implementation (Abdalla, 2005) found that fatalities and serious injuries were significantly reduced and that fatalities among unbelted casualties are more than twice those among belted casualties. Another study (El-Sadig et al, 2004) in the oasis city of Al-Ain, 150km south-east of Dubai, using hospital admissions of road casualties found that minor injuries increased in the post-implementation stage. "Moderate to fatal" injuries declined significantly during this stage (54% to 17%) as did the number of days spent in hospital for survivors.



Bener (Bener et al, 2006) also looked at hospital admissions from road crashes in the city of Al-Ain using a questionnaire filled in by doctors and hospital staff assessing the injuries according to the Abbreviated Injury Scale-1990 revision classification (Association for the Advancement of Automotive Medicine, 1990). Their findings indicated the involvement of a 4x4 (four-wheel-drive or sport-utility vehicle) in almost half the crashes and found that most of the injured were pedestrians and young drivers. Such vehicles are common as a second or even first car in the UAE due to the extensive desert terrain and they are used on family outings and the “school run” due to their increased load and passenger-carrying capacity compared to smaller cars as UAE families tend to be large (in 1995 the average household size in the UAE was 5.3 members; Ministry of Economy, 2007).

A case study of highway capacity, level of service and traffic crashes (Ashur et al, 2005) found young drivers in the downtown section of Abu Dhabi city (capital of the UAE) most responsible for crashes. The most prominent crash type was the “chain crash” (front-to-back crashes from following too close to the vehicle in front) and the most common crash cause was reckless driving. However this study had some coverage omissions (due to road works on an important road in the area) as well as a lack of accurate geographical matching of crash locations (due to the non-coding of precise locations using Geographical Information Systems).

Studies of drivers’ comprehension of road signs and the relationship between comprehension and safety (as measured by factors like crash involvement or frequency of speed citations) brought up interesting results. Bi-lingual road signs might be the norm in some countries but are not universally used, hence some drivers might be bewildered by some of the combinations of road signs found in Dubai. One study based on a questionnaire survey (Al-Madani, 2000) of drivers in the GCC (Gulf Cooperation Council) states of Bahrain, Qatar and the UAE completed by 2,820 drivers showed that drivers with more experience tend to comprehend signs better though this had little influence on their crash involvement. However seat belt usage increased with the understanding of posted signs. A later study (Al-Madani & Al-Janahi, 2002) on a wider scale (4,774 respondents) covering five GCC countries found that



only around 55-56% of drivers correctly identified warning and regulatory signs. Factors that affected this comprehension rate were age, gender, education and income while marital status was not seen to have an effect. Drivers that were young, female and with a low level of education and income were less likely to comprehend the signs than drivers that are older, male and with higher levels of education and income. Another interesting find was that European and American drivers are significantly better than Arab and Asian drivers in sign comprehension. This difference is difficult to put down to either culture or educational driver training and licensing background (from different countries) without further study.



**Figure 9: Example of a road sign from the UAE by a shopping mall, indicating a speed bump that also serves as a pedestrian crossing.**





Figure 10: Example of a road sign gantry on Sheikh Zayed Road in Dubai illustrating the amount of information and symbols that may confront a new driver (Copyright by Sawfun, Picasa Web Albums).

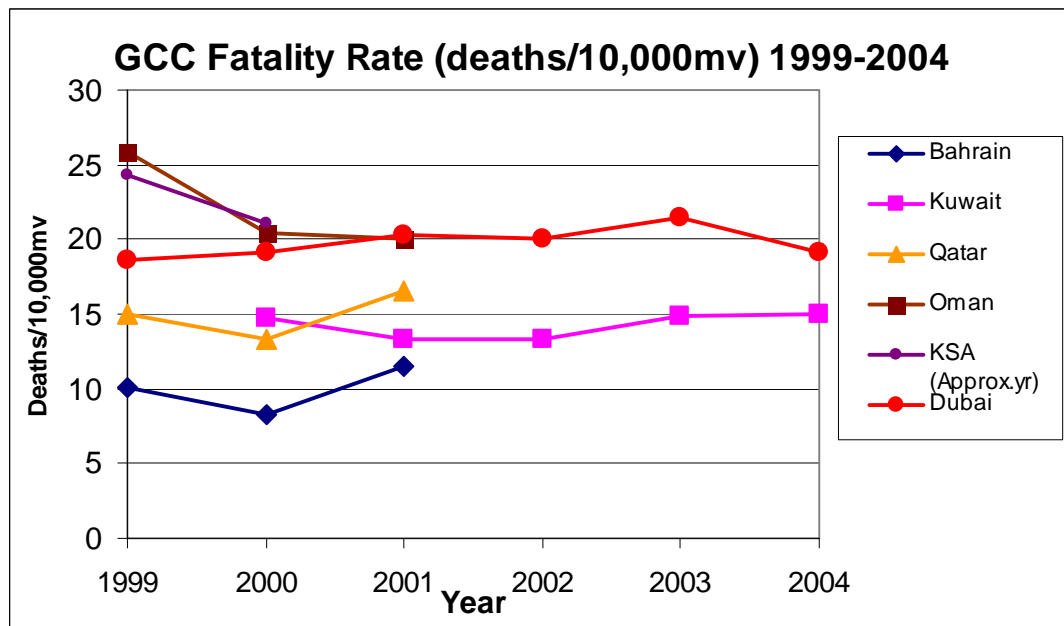
The self-reported use of mobile phones while driving (for drivers involved in a crash) was studied in Qatar (Bener et al, 2005). Most GCC countries have laws banning the hand-held use of mobiles while driving though enforcement does not appear to be very strict. The Qatari study found significant use of mobile phones amongst drivers and a large number of calls were received while driving (on average, 4.28 per day). Similar cultural attitudes are likely to prevail amongst neighbouring countries, where it is seen as acceptable to use a mobile phone while driving. Yet a third of the respondents favoured laws banning the use of any mobile phone equipment while driving. In Dubai in 2006 mobile phone penetration was fairly high at 2.2m lines for 1.4m residents (DMSC, 2007c) but the extent of the problem has not yet been studied in depth.

## 2.5 Road safety in the regional context

Neighbouring countries that share similar geographic and cultural identities are useful for the comparison of key data where it is available. In this case data from each of the neighbouring countries was not readily available or



published however some sporadic figures from the GCC Information Centre Statistical Department allowed the plots in figure 11 and 12 to be made.



**Figure 11: Fatality rate for available GCC country data. Note: Saudi Arabia (KSA) use the Hijri calendar so years were matched as closely as possible to the Gregorian calendar (Source: The Cooperation Council for the Arab states of the Gulf (GCC), 2005).**

From the data available it appears that Qatar, Kuwait and Bahrain fare better than Dubai in both indicators, while Oman is worse off and Saudi Arabia is not far off the Dubai levels. It must be stated that the reporting and recording of crash data varies significantly between regions as does the population density. The small island state of Bahrain is home to about 750,000 inhabitants while Saudi Arabia with its vast desert areas is home to over 23 million people (Cooperative Council for the Arab States of the Gulf (GCC), 2005).



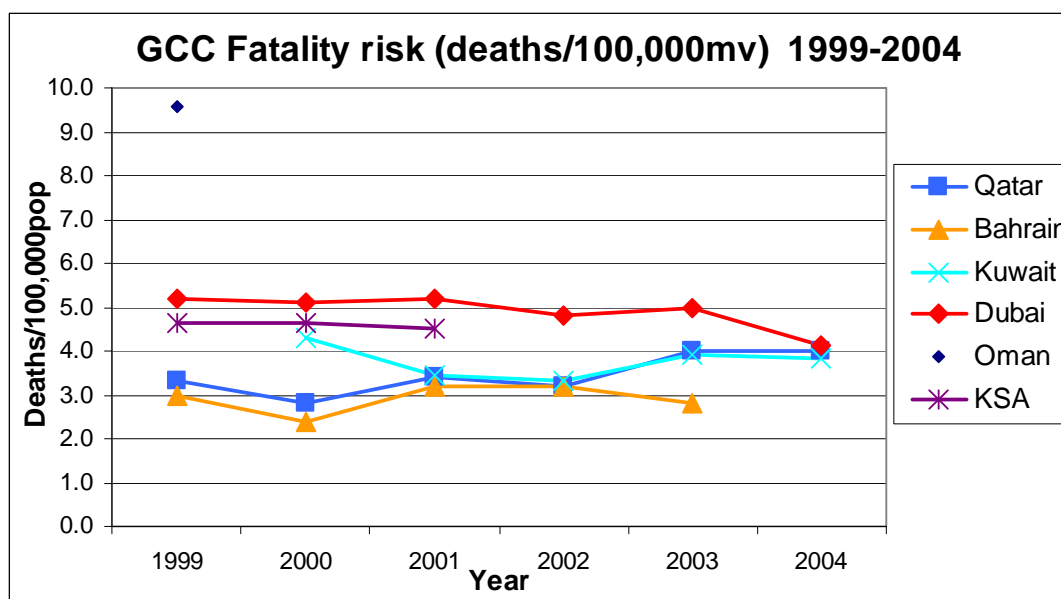


Figure 12: Fatality risk for available GCC countries (Source: The Cooperation Council for the Arab states of the Gulf (GCC), 2005).

## 2.6 Overview of some local and national stakeholders in road safety

Responsibility for and monitoring of road safety involves a large number of government organisations and executive bodies. The division of responsibility is not always clearly defined or addressed in any existing publication but all bodies were in agreement upon the joint nature of responsibility for this key aspect of the transport system. The key stakeholders for road safety are outlined over the next few pages to show how they relate to the problem and to outline later where they might be involved in any recommended solutions.

### 2.6.1 UAE Ministry of Interior

The Ministry of Interior is the Federal body responsible for legislation and policing at the highest level in the country. The Ministry oversees the police forces in the seven Emirates and is linked directly to those in Abu Dhabi and some of the Northern Emirates while the Dubai Police force retains some level of independence. However the Ministry retains a close working relationship between all the parties involved in policing. The major police forces (Abu Dhabi, Dubai and some from the Northern Emirates) predate the establishment of the federation of the UAE in 1971 hence a large degree of independence is maintained in day to day affairs. Federal laws apply to all the



Emirates but they may be supplemented by local orders and regulations that are Emirate-specific.

The governing traffic laws (No. 21 of 1995 and No. 12 of 2007) were issued by the council of Ministers based upon the recommendations of the various police forces and Ministry submissions.

### **2.6.2 Emirates Authority for Standardization & Metrology (ESMA)**

ESMA was established in 2001, and is the Federal body in charge of standards, metrology and certification in the UAE. It works in close collaboration with the GCC-SO (Gulf Cooperative Council Standards Organisation) in adopting standards for the Gulf region. Vehicle standards for crashworthiness and safety specifications are set by ESMA, and all vehicles legally imported and sold in the country must be certified according to these specifications.

### **2.6.3 The Executive Council – Dubai**

TEC (The Executive Council) is the chief government office in Dubai that oversees the various local departments and sets performance standards and continuously monitors these departments to make sure they keep pace with the developments of the Emirate as a whole. The council is made up of representatives of all the local departments (Police; Roads & Transport Authority; Municipality; Courts; etc) and meets once a week and is headed by the Crown-Prince of Dubai.

### **2.6.4 Dubai Police**

Dubai Police was established by a local decree in 1956 and is one of the first local police forces in the region. It is administratively divided into 12 geographic regions each with a police station or outpost. Responsibility for policing the roads and monitoring drivers and issuing fines mostly falls within the remit of the police. Responsibility for vehicle registration and driver licensing falls with the RTA.



### **2.6.5 Dubai Health Authority (DHA)**

The DHA was established in 2007 by a local decree by the Ruler of Dubai, to oversee the healthcare sector in the Emirate. It will gradually replace the former Department of Health & Medical Services with a number of independent centres according to specialisation. It is the main body responsible for the provision and regulation of healthcare in the city through a number of hospitals and health centres and the only provider of emergency medical services in the Emirate. The primary trauma centre is run by the authority at Rashid Hospital and is currently managed by a Canadian health services consultancy (InterHealth Canada, 2009). Most casualties of road crashes are referred to this trauma centre.

### **2.6.6 Roads and Transport Authority (RTA)**

The RTA was set up by a local decree in 2005 to take responsibility for the development and maintenance of roads in Dubai along with public transport and vehicle and driver licensing (departments that were previously with the police or municipality). It is divided into a number of agencies according to specialty, mainly the Traffic & Roads; Marine; Public Transport; Rail and Taxi agencies. Traffic safety is one of the main responsibilities of the RTA, along with the other stakeholders mentioned in this section.

### **2.6.7 Dubai Public Prosecution**

The Public Prosecution (PP) department is responsible for the prosecution of offenders in road crashes where there is loss of life, injury, or property damage. The traffic prosecution section is positioned within Dubai Police Traffic Department. They maintain a close working relationship and try to improve road safety through securing suitable punishment for offenders in serious crashes according to the law, so that they may set an example to others and act as a deterrent. They also liaise with the police and RTA on issues that become apparent through prosecution like blackspots or recurring patterns of crashes.



### **2.6.8 Dubai Centre for Ambulance Services**

The ambulance service in Dubai was initially provided by the police and health authorities but an independent centre has been recently setup to unify the emergency response where casualties are involved. It is based in close proximity to the Dubai Police control room and operations are run through their own control room in close cooperation with other emergency service providers. A total of about 100 ambulances are positioned at strategic locations around the Emirate including a number of quick-response motorcycle paramedics and four Dubai Police Airwing helicopters to provide evacuation cover for any type of emergency that may arise. The average response time is about 8 minutes<sup>◇</sup>.

### **2.6.9 Media**

Media in the UAE and Dubai is predominantly state-owned and operated. A small number of private or internationally-owned operations run alongside the local press. Newspapers, television and radio stations contribute in reporting on major traffic incidents and almost all casualty crashes which serves to inform the population of the road safety situation on a regular basis. Also some of the stakeholders grant frequent interviews to the press to update them on projects, plans, statistics and rule-making. Sometimes campaigns are run by local television channels to highlight serious crashes with graphic images to serve as a deterrent to potential offenders.

### **2.6.10 Dubai Municipality**

The municipality has responsibility for licensing the construction of buildings and dwellings and maintaining public parks and irrigation. They used to have responsibility for roads before the RTA was established. They also have a Geographic Information Systems (GIS) Centre responsible for mapping in Dubai. The regularly-updated map is provided by the GIS Centre to most government departments (RTA and the police being two key users) for multiple purposes; from planning of new projects to plotting out existing trends (of pedestrian fatalities for instance).

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<sup>◇</sup> *Personal communication, Paramedics at Rashid Hospital, December 2007.*



### 2.6.11 National Transport Authority

This was set up in 2006 and headquartered in Abu Dhabi to oversee marine and land transport (National Transport Authority, 2009). It is the central body concerned with the registration of marine vessels bearing the UAE flag. It is also concerned with proposing laws and regulations governing transport in the UAE while liaising with local and neighbouring bodies. The NTA also advises on joining various international treaties related to the different transport modes.

## 2.7 Vehicle safety standards in the UAE & GCC

ESMA hold a number of vehicle-safety-related standards for products used in the UAE. These standards were mostly shared with the Gulf Standards Organisation (GSO) using the same number. Table 11 lists the relevant standards.

**Table 11: Motor Vehicle Safety-Related Standards in the UAE**

Name of Standard	UAE Standard No.
Motor Vehicles: Methods of Testing Passenger Cars Impact Strength Part 1: Frontal Impact	36
Motor Vehicles: Methods of Testing Passenger Cars Impact Strength Part 2: Moving Barrier Rear Impact	37
Motor Vehicles: Methods of Testing Passenger Cars Impact Strength Part 3: Side Impact	38
Motor Vehicles: Methods of Testing Passenger Cars Impact Strength Part 4: Roof Strength	39
Motor Vehicles: Passenger Car Impact Strength	40
Motor Vehicles: Front and Rear Exterior Protection Devices for Passenger Cars (Bumpers etc) and its Methods of Test	41
Motor Vehicles: General Requirements	42/2003
Motor Vehicles: Conformity Certificates	48
Motor Vehicles - Methods of Testing of Safety Belt	96
Motor Vehicles - Safety Belts	97
Motor Vehicles - Conformity Certificates for Vehicles Manufactured in Multi-Stages	153
Road Vehicles - Safety Glasses - Test Methods for Optical Properties	684
Motor Vehicles - Safety Glass – Mechanical Test	1007
Motor Vehicle - Head Lamps Safety Requirements.	1503
Motor Vehicles - Head Restraints and Its Method of Testing	1598
Motor Vehicles - Speed Limiters - Part 2: Technical Requirements U. A. E. STANDARD	1625
Motor Vehicles - Speed Limiters - Part 3: Methods of Test	1626
Motor Vehicles –Laminated Safety Glass	1677



A review of the standards alongside United States Federal Motor Vehicle Safety Standards (FMVSS) revealed some similarity in limits and specifications. For example, frontal crash test speed and permissible rearward displacement of the steering column in UAE Standard 40 were identical to the parameters set out in FMVSS 208 (NHTSA, 2003). It was expected for a new regulatory agency to adopt existing standards that are met by a large number of product suppliers (in this case, automotive manufacturers) rather than go to the prohibitive cost of developing its own new standards. However this necessitates the constant monitoring of leading global standards to update local standards accordingly – but only when the global standards are compatible with the local culture and environment.

## **2.8 Vehicle technical regulations in the UAE**

The UAE traffic law of 1995 (Dubai Courts, 2006) describes in chapter 3, section 2, items 34 and 35, the technical specifications that vehicles must meet as follows (*translation from the original Arabic provided by the author*):

“No mechanical vehicle may be used on the road unless it is mechanically sound and equipped, as a minimum, with the following:

1. A solid, functional steering wheel that is easy to turn.
2. Two independent, effective braking systems, or one effective system that is operated by two independent means, one of which is capable of stopping the vehicle surely and quickly if the other should fail.
3. Suitable alerting device capable of giving an auditory warning when needed.
4. Front-mounted mirror such that it gives the driver a view of the road behind.
5. Windscreen made of a transparent material that does not distort vision and does not shatter into sharp pieces upon breakage.
6. A motorised device to wipe the glass when needed.
7. A seat belt, used, fitted and described according to regulations.
8. A device to prevent pollution and reduce exhaust noise.
9. Speedometer.
10. An inflated spare tyre fit for purpose.
11. Fire extinguisher (fit for use) for buses and vehicles and tankers used to transport flammable liquids.

This may be extended to other vehicles as directed by the law.

Motorised cycles are excluded from rules 5, 6, 7 and 10. Every mechanical vehicle must be equipped with lighting devices clearly fixed to the vehicle, that show the width of the vehicle, and they may not be obscured or rendered inoperative by any



part of the vehicle or the load it carries, and an indicator of the direction of travel of the vehicle. Trailers must be equipped with rear and side lights that show the length of the trailer. Motorised cycles must be equipped with a main light to illuminate the road ahead at night, and another at the back, and any side cars must be additionally equipped with two side lights at the front and at the back. Normal cycles must be equipped with a main light at the front and a red light and red reflector at the back. The carriage must be equipped with enough light to alert other road users of its presence at night.”

## **2.9 Driver regulations in the UAE**

Chapter 1, section 1, item 10 of the UAE traffic law (Dubai Courts, 2006) describes the obligations of the vehicle driver as follows (*translation provided by the author*):

1. “To remain on the near side of the right edge of the road in relation to the direction of vehicle travel (*the UAE population drives on the right side of the road, opposite to the UK*).
2. To ensure sufficient vision in front when attempting to overtake a vehicle or person or animal or obstruction, and to indicate the intention to overtake and alert others that will be overtaken using alerting signals, and ensuring they respond to the alert.
3. To remain at the right edge of the road to allow other priority traffic to pass.
4. To take necessary precautions before turning in a side road, or curve or junction or crossroads, and to give the necessary signal for changing the path of travel, and ensuring it is possible to turn without putting other road users in danger.
5. Not to overtake another vehicle in the same carriageway except from the left side, unless the vehicle moved to the left to turn into a road on the left, after the driver of the other vehicle has given the correct signal, and provided there is enough space allowing the overtake without danger.
6. Not to drive while under the influence of wine or any another alcoholic substance or drug, or other similar substance.
7. Not to drive while exhausted to a degree that affects vehicle control.
8. To reduce speed, or stop when necessary, to allow another vehicle in front that has indicated to turn left or right, to do so.
9. Not to endanger pedestrians, and to stop when necessary, to avoid annoying or injuring any road user.
10. Not to exceed the maximum speed permitted on the road, while taking into account the surrounding conditions and weather and vehicle and other safety considerations.



11. Not to cause any clear damage to the surface of the paved road, while not contradicting the federal law no. 8 of 1986 (*relating to permitted axle weights on paved roads*).
12. Not to reverse without checking if the road is clear, and only by the distance necessary for protection or turning in the road.
13. To follow the signs given by a police officer that is directing traffic.
14. To use the vehicle's indicator when turning, depending on the direction of turn, whether left or right.
15. To illuminate the vehicle between sunset and sunrise and when necessary, by that which alerts others to its presence."

Additional obligations apply to drivers of vehicles that carry passengers (taxis, buses, etc) and heavy vehicles. A brief comparison of some of the key differences in traffic-related legislation is made in the following table.

**Table 12: Examples of some key differences in traffic-related legislation and practice between the UAE and UK.**

Dubai (UAE)	UK
Seat belt legislation for front seat occupants	Seat belt legislation for front and rear seat occupants and children
Penalty points for licences not introduced until 2008	Penalty points in use for some time
Penalty points expire after one calendar year	Penalty points expire after 4 to 11 years depending on offence
Annual mechanical roadworthiness test required for all vehicles older than two years	Annual mechanical roadworthiness test required for all vehicles older than three years
Highest permitted speeds (on highways) of 120 kph (75 mph)	Highest permitted speeds (on highways) of 112 kph (70 mph)
Alcohol breath testing on the roadside generally not in use	Alcohol breath testing on the roadside in widespread use

## ***2.10 Recent changes in traffic legislation and policing***

### **2.10.1 Changes in Dubai**

Some changes were related to the emirate of Dubai only as policing and law enforcement may differ slightly from one emirate to another according to local



laws and orders that may supplement federal laws. Subjects covered by these changes in legislation and policing include toll roads, speed limiters and speed camera use.

#### **2.10.1.1 Toll roads and speed limiters**

The situation in Dubai is changing on an almost daily basis as authorities in charge of roads, policing and regulation explore different methods to tackle the problems they face in managing traffic on the roads. The most recent changes at the time of writing (that might affect the incidence and severity of crashes) were the announcement of the start date for the first road toll ever in the region; the introduction of a minimum speed limit on major highways; and the installation of speed limiters on certain vehicle categories.

The road toll system (called “Salik”, an Arabic word for “uncongested”) was introduced on 1 July 2007 at Al-Garhood bridge at the rate of 4 Dirhams (the local UAE currency, abbreviated AED) per crossing, up to a maximum of AED24 per day per car (~£3.30 at April 2007 exchange rates). All vehicles crossing the toll gates will have to be equipped with a Radio Frequency Identification (RFID) sticker to collect payment and avoid being fined (Ahmed, 2007b). Toll roads may have an effect on safety as they affect exposure. In Norway (Elvik & Vaa, 2004) it was found that toll ring roads had a lower number of injury crashes than roads in other towns, but only marginally so with an average reduction of -5%. Also because tolls are often implemented on congested roads, the likely change in congestion might subsequently affect the safety of these roads. Shefer and Rietveld (1997) argue that a positive effect of congestion is a reduction in fatalities as the opportunities for speeding decrease. Hence if the new road toll results in lower congestion and possibly faster traffic in some areas of Dubai, it might also affect safety (negatively).

A minimum speed limit of 60km/h was introduced in April 2007 on the main highways in Dubai to try and minimize the speed difference between different vehicles and thus improve traffic flow and lessen the severity and occurrence of crashes. Speed limiters (set at 120km/h) have become mandatory on taxis earlier in the year and there are plans to make them compulsory on “safari”



vehicles or those used for taking tourist parties off-road after the involvement of one of those vehicles in a fatal crash early in 2007. Fifteen-passenger minibuses have also come under scrutiny due to their involvement in some high profile crashes.

#### **2.10.1.2 Speed camera use**

In 2007, 193 enforcement cameras of different types (termed “radars” locally) were operational on the streets of Dubai, including 97 fixed speed cameras, 74 red-light cameras, 16 mobile speed cameras, and 6 shoulder enforcement cameras (to detect abuse of the emergency lane). In 2008, 287 new devices were brought into operation consisting of 174 fixed speed cameras, 184 red light cameras, 15 mobile speed cameras and 14 radar guns (Almutairi, 2008).

#### **2.10.2 Changes in the UAE**

Federal legislation changes in the UAE after the commencement of this research in 2005 that were related to road safety include an amended traffic law and restrictions on vehicle registration according to age. Federal laws apply to all emirates in addition to any local laws and regulations.

##### **2.10.2.1 Traffic law amendment 2007**

The law no. 12 of 2007 (in force on 1/3/2008; Abu Dhabi Police, 2008) amends some of the statutes of the 1995 law. The main change was an introduction of a penalty points system whereby if 24 points are accumulated in a year the licence is suspended for 6 months and not returned until the driver passes a driver rehabilitation test at an approved institution. If the 24 points are accumulated again within the prescribed period then the licence is withdrawn and the driver may not reapply until a year has passed since the withdrawal.

The other major amendment was to the table of fines (many have been raised with the speeding fines made proportional to the extent of speeding) and the association of penalty points with certain violations. Vehicle detention has also been extended to cover more offences with the most severe being the detention of heavy goods vehicles for up to 60 days (for dangerous overtaking manoeuvres) and for a month if the driver is found guilty of causing a rollover



of his or another vehicle or jumping a red light. These punitive measures are in addition to a heavy fine (AED 3,000, ~£430) and licence suspension for a year (Abu Dhabi Police, 2008).

#### **2.10.2.2 Vehicle registration restrictions – 2008-2010**

In an effort to reduce the volume of traffic by limiting the number of vehicles registered the Interior Ministry's Traffic department announced a number of initiatives (Emirates News Agency, 2008). The first deals with vehicle emissions putting more stringent limits on the emission of Carbon Monoxide, Hydrocarbons and Nitrogen Oxides. The second deals with the import and registration of older vehicles. From January 2009 no light vehicles older than 5 years or heavy vehicles older than 7 years may be imported with the exception of classic cars that pass all the required tests. Also from December 2008 all vehicles over 20 years old will not be renewed or registered. This maximum age will be reduced to 15 years in January 2010. The transfer of registration (hence sale) of vehicles above 10 years of age will also be prohibited for vehicles intended for use inside the UAE. All this will contribute to reducing the number of old vehicles on the road if applied according to the schedule suggested.

### **2.11 Summary**

This chapter provided the background to the road safety scene in Dubai. The main research questions in the work were defined. The broad aims and objectives of the study were outlined along with the expected outcomes.

Road safety in the emirate of Dubai and the UAE was reviewed from aggregate data in the context of the high rate of growth being experienced in most sectors (the past decade saw the population and number of fatalities double). Comparisons of the road safety situation using common indicators such as fatality rates and fatality risks were made with different countries in the region and the world. These comparisons showed a large potential for improvement in the road safety scene in Dubai. The way that road crashes are managed in Dubai was shown to involve multiple parties from the police, health authority, roads authority and civil defence. The different public and private bodies that affect road safety and policing were numerous. Examples



were the Ministry of Interior; Dubai Police; Public Prosecution; Rashid Hospital; Ambulance Services and the Media.

Rule-making involved both local (emirate-level) and federal (UAE-wide) legislation and both applied in Dubai. Existing legislation that related to vehicle regulations and crash testing as well as rules of the road and driver licensing and punishment was translated and presented. Vehicle crash-testing standards were found to have some commonality with US standards. Existing legislation was dynamic and stricter rules for vehicle age and offending driver punishment were proposed for application. These rule changes were expected to lower the average vehicle age and increase fines for driving offences. Policing and enforcement were being strengthened through automatic enforcement technologies such as fixed and mobile speed cameras.

Previous research in this field from surrounding regions was presented to show pre-existing concern about this area and the common challenges faced by other researchers. The little data found indicated slightly better performance in road safety in the past by Qatar, Kuwait and Bahrain while Saudi Arabia had similar levels to the UAE. Oman appeared to fare worse compared to neighbouring countries.

This overview of the situation in Dubai gave enough background information to form a clear picture of the situation as it stood at the time of writing. This is important as it allows a better understanding of the context of the work and the extent of the differences that exist between Dubai and cities around the world in Africa, Europe and America. There is no substitute for ground-work and site visits for familiarisation with the situation and environment. It is however possible to gain some understanding through a snapshot as provided in this chapter.



## **Chapter 3 Literature Review – Safety Interventions to Reduce Crashes**

### ***3.1 Introduction***

This chapter will provide the necessary background of technical knowledge on which a major part of the research is constructed. The description of safety interventions to reduce crashes and consequential casualties abound in literature; Elvik & Vaa (2004) in their handbook of measures list no less than 124 safety interventions that have been the subject of scientific study in the past fifty years. To ensure the effectiveness of countermeasures that are selected for consideration in Dubai, their prior deployment in other areas of the world must have been documented along with their measured effectiveness. Only documents from scholarly sources (mostly peer-reviewed) that follow sound test principles were selected. Other sources (such as newspapers) were used to convey the reality of the local situation in Dubai and the UAE where little scientific literature exists to date.

Studies in the field of road and vehicle safety were rare in the first half of the twentieth century and for some time afterwards (Mackay, 1965). The paved roads used by motor vehicles have only been around so long. As such the history of safety studies is mostly recent. Other countries have made progress in tackling the road safety challenge in various ways. Most of these countries created data collection projects to collate continuous data on road safety to monitor the situation and discover the main problem areas. The background to the major worldwide data sets and reasons for their creation will be reviewed here along with the status of data collection in Dubai.

The international transfer of knowledge in this field will be reviewed from earlier studies and publications. The culture and environment of the UAE in general and Dubai in particular may make it difficult to carry interventions across borders without considering the effect of these factors. Finally, published studies that describe countermeasures considered relevant to Dubai crashes will be reviewed according to their area of influence (human, vehicle or environment).



### **3.2 *How other countries manage road safety: real-world data***

Remedies for road safety problems should be arrived at like remedies for medical problems; first the problem must be diagnosed and defined. A trial-and-error approach might occasionally achieve some positive results. In the real world such approaches abound due to the scarcity of resources. Ideally the most fruitful approach is that built on a solid foundation of information. In the road safety field this is provided by crash data and the related collection and interpretation of that data.

The need for data exists for a number of reasons, first as an integral part of problem definition and then as a means to monitor the situation and develop solutions that work in the real world (Thomas et al, 2003). Safety policy needs to be based on real world data if it is to be effective in improving safety.

#### **3.2.1 Existing examples of data collection and crash data sets**

In most regions containing HMCs a system for collecting data across a large area (whether nationwide or continent-wide) is already in place or in the process of being developed. The United States National Highway Traffic Safety Administration (NHTSA) began a study in 1988 called the National Automotive Sampling System (NASS) General Estimates System (GES) (NHTSA, 2001). This study collects data from police reports of crashes throughout the USA in a sample that is nationally representative. The Fatality Analysis Reporting System (FARS) is also run by NHTSA and has been in operation since 1975. It collects data from the fatal crashes that occur in 50 states, the District of Columbia and Puerto Rico including police reports, driver licence records, vehicle registration files, state highway department records and vital statistics from medical examiner's and coroner's reports (Finkelstein, 1982).

In Europe the CARE project (Community database on Accidents on the Roads in Europe) started gathering disaggregated data from the individual countries' data sets, keeping their respective definitions, for fatal and injury crashes only since 1993 (European Commission, 2007). A more recent development in Europe is the European Road Safety Observatory (ERSO) a tool designed to inform concerned parties (particularly policy makers) on road safety through data collection and dissemination (SafetyNet, 2007a). ERSO



was a deliverable of the SafetyNet project which was tasked with establishing the framework for the creation of such an observatory (SafetyNet, 2007b).

In the UK one of the first large-scale crash studies known as CCIS (Cooperative Crash Injury Study) was established in 1983 “bringing together Birmingham and Loughborough Universities, the TRL, the DfT and various car manufacturers” (Mackay et al, 1985, in Welsh et al, 2006). It was a retrospective study covering vehicles less than seven years old at the time of the crash, that were sufficiently damaged to require towing away from the scene of the crash. CCIS uses a stratified sampling criterion along the lines of the UK government’s classifications (100% of fatal crashes, 80% of serious and 10-15% of slight injury crashes) which results in a sample bias towards more serious crashes (Welsh et al, 2006). More recently an On-The-Spot (OTS) crash study was started in 2000 to put experienced accident researchers at the scene of the crash immediately after it occurs (often along with the emergency services) to enable the collection of vital data that is likely to disappear from the scene after the emergency services are done clearing up (Hill & Cuerden, 2005).

On a broader level an aggregated database (with unified fields and definitions) was created by the OECD (Organisation for Economic Co-operation and Development) called IRTAD (International Road Traffic and Accident Database) collecting around 500 fields of data on crashes occurring in OECD member countries since 1988 (IRTAD, 2007). Member countries include most of Europe, the USA, New Zealand, Australia and Japan (see Appendix A for full list).

### **3.2.2 The different levels of data collected**

As outlined in the previous examples data is collected in various systems to different levels of complexity, detail and accuracy. The main levels of crash data are broadly divided into three segments; base, intermediate and in-depth as outlined in table 13.



**Table 13: Levels of data, sources and functions (based on Sabey, 1990)**

Level	Main source of data	Functions
Base level	Traffic police accident reports National road transport statistics	To assess accident situations (who, where, when, what) To examine trends in traffic volume, risks and accidents, make forecasts To evaluate the effects of legislation and other countermeasures
Intermediate level	As above, plus: Observation at sites Additional evidence from witnesses Judicial reports	To identify and diagnose hazardous road locations (where, how, what) To reconstruct accidents and determine their useful countermeasures
In-Depth level	As above, plus: Interviews with road users involved Clinical assessment of injuries Technical inspection of damage	To assess accident causes & mechanisms To study accident & injury prevention measures To further knowledge on vehicle safety, human tolerance & mechanism of injury To monitor the effectiveness of specific legislation & legislative measures
Specialist level	As above, plus: On-the-scene attendance and data gathering of time-sensitive data	Some or all of the above To aid monitoring the effect of developments and innovations in safety under real-world conditions.

Base level data is thought to exist in most countries but it can only serve limited functionality in assessing the general state of affairs for traffic safety and the extent of the problem. Intermediate level data is available less widely and normally for more serious crashes that are associated with litigation or where there might be large sums of money being paid out in compensation. In-depth data is typically only collected for more advanced uses such as assessing crash causation and injury causation mechanisms and how the vehicle-human-environment systems interact with each other. Ideally this level of data is the most desirable from a research point of view but even this level of data collection is often constrained by practical considerations such as cost and privacy issues. In-depth data collection will normally involve the interaction with personal data such as names and addresses especially if questionnaires are used to supplement the data sources available. Medical



and injury information is another very useful data source but access to medical files is reluctantly granted in most cases as they are considered the personal property of the patient and must be treated sensitively and ethically. Most crash studies are first approved by an ethical board before collecting personal data to ensure the integrity of the data collection and storage process.

### **3.3 *Data functions and usage***

As outlined previously in table 12 base-level data is of limited functionality compared to more in-depth data. However it is still an important starting point for assessing the general traffic safety situation and to examine the trends in crashes and casualties and to evaluate the effects of any external factors on the situation such as a change in legislation that affects motoring. The data collected from Dubai will be used to perform basic trend-spotting for general crash numbers and their variation with time. The few external factors that might affect the numbers have been taken into account and before-after comparisons were used to show whether these factors (e.g. weekend change, seat belt law) have had any effect on crashes. The analysis of the available data is used to answer the questions set out in the second chapter (aims and objectives) about the nature and circumstances of crashes and their severity and the influence of various factors on road safety.

### **3.4 *Status of data collection in Dubai and the UAE***

The UAE has since its establishment in 1971 come a long way in a fairly short time. Prosperity such as that experienced today was unheard of in the 1970s but with the discovery of oil in the neighbouring emirate of Abu Dhabi (the largest by area, covering about 80% of the UAE) in the early 1960s and consequently in Dubai (and natural gas in Sharjah) the level of income (and expenditure) began to rise and motor vehicle ownership began to spread amongst the population.

Dubai police started collecting base-level crash data using a self-developed form in 1983. This form underwent many updates with the current version being adopted in 2002. It has been submitted to the Ministry of Interior (the body responsible for policing at the federal level) for implementation nation-



wide (Dubai Police, 2005). The department formerly responsible for road safety and traffic engineering in Dubai Police developed an electronic data input system running on Microsoft (MS) Access software which allowed the input of the crash form data from any computer terminal connected to the Dubai Police network.

### ***3.5 Assessing the benefits of countermeasures***

The effectiveness of countermeasures may be measured in two terms, either a reduction in crashes or injuries resulting from crashes or a reduction in the monetary costs associated with crashes (or preferably both). These measurements of effectiveness will be derived from previous studies conducted on the countermeasures in other parts of the world while making the broad assumption that a similar level of effectiveness will be seen if they were applied in a different context. Reasons why these assumptions might not hold true will be expanded upon in the chapters on countermeasures and discussion.

The suggestion of countermeasures that will be made for application in Dubai will be based on the known level of effectiveness of each countermeasure. The priority and ordering of these measures will be made according to their projected effect on the ground in Dubai. The greater the effect of the countermeasure on road safety (in other words the greater the expected improvement in safety) the higher the ranking or priority that will be assigned to that countermeasure in the overall list of measures. Countermeasures that are already in use in Dubai or the UAE in a simplified form may be recommended again as there might be some alterations to be made in their application that can make them effective in Dubai as they have been effective elsewhere.

### ***3.6 International knowledge transfer***

The presence of knowledge in one place and the application of this knowledge are two different matters. In corporate culture it has been shown that different departments within the same organisation might possess valuable knowledge assets but these will often not be used by other



departments for numerous reasons (Szulanski, 2000). One of the main reasons behind this lack of knowledge use is the “stickiness” of the knowledge transfer process. Stickiness is defined as the difficulty experienced in the process of knowledge transfer (Szulanski, 1996; von Hippel, 1994; as cited in Szulanski, 2000). If stickiness is to be found within departments of the same organisation then it is more likely to be found on a larger scale in countries separated by borders or great distances with differences in language, tradition and culture.

The same problem applies to the measures of road safety. The presence of other measures that can solve a particular problem might not be known. If the presence of a measure is known then the method of application or implementation of that measure might not be available. Many barriers can be found to the transfer of such knowledge but fortunately the propriety of knowledge (intellectual property) does not normally stand in the way of such transfer. It is understandable when a technology company might want to protect an innovative process from discovery by competitors for fear of losing market advantage or a competitive edge. However if a local council was successful in improving road safety through some innovative process then it is more likely that the council will want to advertise and spread the knowledge of their achievement through every possible channel.

### **3.6.1 Early efforts at international knowledge transfer in road safety**

It is natural that the countries with more experience of the motor car and the problems faced by its use will tend to think of solutions earlier than countries without significant motorisation. Early work in this field was conducted (Jacobs, 1986) by the Transport Research Laboratory in the UK in the year 1972 when a team of researchers was formed under the Overseas Unit to help what was known as third-world countries in this area. The objective of this team was to undertake research to establish the nature and extent of the road safety problem and to assess the long term effectiveness of remedial measures. The team was better placed to do this than many LMCs because at that time the UK had some experience of dealing with traffic safety issues with some success (Jacobs & Sayer, 1983). This success was measured as a



decrease in the crash rate (in terms of vehicle kilometres travelled) and the number of people killed and injured in crashes at the time but this change took place gradually over a number of decades.

### ***3.7 The steps to improving road safety***

The description of the objectives of the TRL team and others provide a template for deriving the steps necessary for knowledge transfer in this field to a different country or region (Elvik & Vaa, 2004; Jacobs & Baguley, 1995). First the current situation must be measured and analysed to establish a point from which progress can be measured (the baseline). This must of course be done while considering the nuances of the local situation such as the availability and extent of data recording and reliability. This will also allow a rudimentary understanding of the traffic safety situation in any particular place. This must also include (if possible) the analysis of crash rates and trends and their variation with time and identifying the presence of any unusual peaks or anomalies.

The second step is the adoption of safety measures or at least the assessment of the suitability of measures that may improve the situation if they were adopted. In this step, knowledge transfer comes into play, for it would be a daunting task if every measure had to be proven to work beyond doubt in every new location on earth before adoption. This part of the task is made easier with the increased motorisation of the world as more and more regions face traffic safety issues and may develop new effective measures to deal with them.

The third and final stage of the process would be to measure the effect of the road safety measures to see whether their application has been successful and if not, to try and find out why. When this is not possible due to practical constraints an attempt can still be made to measure the effects of countermeasures based on earlier experience with the same measures or based on knowledge of how the countermeasures work (Jacobs & Baguley, 1995). For example if seat belts are not currently used by the majority of the motoring population and a lot of drivers are ejected out of the vehicle in crashes and it is known that seat belts can prevent ejection then it is



reasonable to assume that ejections will decrease in at least some crashes once seat belt wearing increases. If the number of crashes involving ejection is known and a time-series of data is available from previous years then the improvement in that respect can be quantified by projecting the expected numbers with and without the intervention in place.

It is somewhat misleading to call the third stage final as this process is iterative and as some problems are solved others typically come up and some solutions might become outdated with time or the problem might develop immunity to certain countermeasures. Some measures might work well in one area but might need some fine-tuning and adjustment to work in other areas, other measures might be exhausted soon after introduction or the problem that they treat might go away due to other factors.

### ***3.8 Knowledge transfer and road safety***

The rapid globalisation that has taken place around the world in the last few years has allowed the sharing of experience and best-practice in many fields of science and technology. What would have taken one country twenty years to develop might be adopted by another country in five years once the complexity of the process is understood and the errors and mistakes that were made are not repeated. This can be seen as a distinct advantage to those that produce the best results or most workable methods of solving a problem as the adoption of their solution will save the repetition of effort thus saving valuable time and resources.

As the wealth of nations increased so did their growth (Barro, 1996). As shown in previous chapters high motorisation was generally observed in richer countries (based on GDP). The problems that come along with high motorisation were also experienced by these countries first and thus dealt with earlier. In developing countries, road safety has been a focus of international development agencies (Dinh-Zarr, 2008) as this problem erodes significant resources that could otherwise be better employed for the development of nations. It makes sense to share such life-saving knowledge and experience in the quest for human development and the improved quality of life. The transfer of knowledge between nations should allow the



contraction of time and effort in achieving a good standard of road safety. Studying the problem in detail allows the focussing of efforts on key issues rather than following a haphazard approach to solutions which will waste precious resources that can be employed elsewhere in the nation-building exercise.

### ***3.9 Socio-cultural differences and their effect on road safety***

Research has hinted at a relation between the culture of a country (as represented by values and religion) and the level of road safety observed there. Comparisons between the fatality risks (deaths/100,000 inhabitants) in 15 countries in Western Europe (Melinder, 2007) showed that wealthy Catholic Christian countries had less crashes than poorer non-Catholic countries when comparing two periods (1989-1991 and 1997-1999). However wealthy Catholic countries (e.g. Austria & Belgium) seemed to have more crashes than similar wealthy non-Catholic countries (e.g. Sweden & United Kingdom). This may be further expanded to other regions or countries to see if it still applies and shows that there are many ways of understanding or explaining differences in safety between countries.

This is of interest because the social and cultural conditions prevalent in the GCC are unlike those in any other region of the world. The natural inhabitants of the land for centuries were Arab Bedouins (Bener & Crundall, 2005) whose occupations were based on two main activities, either land-based herding and farming (where possible near oases and wells) or sea-based fishing and pearling. The discovery of oil in the area starting with Bahrain in the early parts of the twentieth century (Gause, 1994) led to the increase in material wealth which was accompanied by rapid development (Davidson, 2006). The larger area of Arabia and neighbouring ancient Syria, Yemen and Africa is historically known as the origin of major faiths and cultures. The people who descended from such origins tend to be resistant to change, especially when fast-paced, as are all established tribes and communities (depending on the approach followed to implementing change). The combination of ancient tradition and considerable wealth combined with a relatively small population resulted in a combination of factors peculiar to this part of the world.



### ***3.10 Countermeasures to improve safety***

Various solutions to traffic safety have been devised according to the local context of every region. Some of the solutions are markedly similar because they deal with similar problems. The purpose of the literature review is to canvass solutions that may be relevant to the Dubai situation from around the world. These particular measures will be appraised later on for their calculated effectiveness on the subset of crashes that they relate to. This assumes they will have the same effectiveness when applied to the local context in Dubai. This permits building on existing knowledge and avoiding reinvention of the wheel.

As the problem's global dimensions have been presented and the extent of the problem affects a large number of people there have been some efforts to address this problem and treat the perceived causes of crashes and injuries since the dawn of the "motor age". The improvement of road safety normally results from a two-stage process firstly involving the identification and measurement of the problem and its extent and secondly attempting a remedy to the problem by a suitable countermeasure designed for that purpose. A simple example of this process is the seat belt which was suggested by a Frenchman, M. Gustave-Désiré Leveau, to help keep occupants in motor vehicles and to whom a French patent (331,926) was granted as early as 1903 (Wismans et al, 1994). His effort stemmed out of the desire to keep his family from being thrown out of the vehicle in the event of a crash (Eckermann, 2001). The effect of the use of seat belts on a large scale was illustrated by the experience of the UK with seat belt legislation. After introduction of the seat belt law for front-seat occupants of vehicles in the UK in 1983 it was shown that usage went up to 90%, and morbidity and mortality figures for vehicle occupants went down by ~25% (Mackay, 1985).

The Handbook of Road Safety Measures (Elvik & Vaa, 2004) lists 124 countermeasures and previous studies conducted on them with some analysis of use and effectiveness.



The large volume included studies as long as they:

“...provide at least one numerical estimate of the effect of a road safety measure, or provide information that can be used to derive such an estimate and state the number of crashes on which the estimate of effect is based.”

A road safety measure is defined as a device, program or tool whose sole or main purpose is to improve road safety (Elvik & Vaa, 2004). There is no consensus on the definition of improvement but it can be interpreted from any one of a number of indicators like: a reduction in the total number of fatalities; reduced injuries; reduced number of crashes; less serious crashes (in both senses – less of the serious crash variety and crashes of a lower severity); or an improvement in the rate of any of the above provided it is *statistically significant*.

Some countermeasures are highly effective in certain environments (e.g. studded tyres in severe winters) but not applicable in others (e.g. desert environment with no snow at any time of the year). Measures were divided into three broad sections as defined in Haddon’s matrix (Haddon, 1983) which attempted to simplify the traffic safety problem by classifying the factors involved according to phase (figure 13).

		Factors			
Phases		Humans	Vehicles	Physical env.	Socio-econ. env.
	Pre-crash				
	Crash				
	Post-crash				
	Losses	Damage to people	Damage to vehicles	Damage to physical env.	Damage to society

**Figure 13: Illustration of Haddon’s Matrix (Haddon, 1983).**

The exhaustive listing of every single countermeasure employed or developed to improve road safety is not a task that is feasible in the time-frame of this work so a selection of measures was made based on their relevance to the area of study and their effectiveness (as proven in previous research).

### **3.11 Human factors in crashes**

The human element has been present in road safety since the beginning from the “design and build” stages of the automobile to operating and servicing it.



There is some overlap between these factors and vehicle factors, for instance in the build quality of a vehicle where manual labour is still used; the comfort of workers and ergonomic design of tools contributes to improved vehicle quality. Most human factors issues concern the person in control of the vehicle namely the driver and the behaviours they adopt, exhibit and undertake (Lewin, 1982; cited in Bener et al, 2005). For example road user distraction is one major consideration in road safety affecting a driver talking on a mobile phone. Mobile phone use by drivers has been linked to increased crash risk (Redelmeier & Tibshirani, 1997; cited in Bener et al, 2005). Whereas the traditional attitude was that programs of behavioural change are of little effectiveness this is no longer the case (Evans, 1991; Oxley et al, 2004). In one of the most ambitious safety strategies adopted in the world – Sweden's Vision Zero (Tingvall, 1998) – it was explicitly stated that responsibility for safety in the transport system is jointly held between the different stakeholders of the road transport system. Road user error is by far the most common crash cause or contributory factor. In the UK in 2007 (DfT, 2008) the top 10 contributory factors reported for crashes were exclusively human-related with no mention of mechanical or road failures.

### **3.11.1 School driver education as a pre-driving safety measure**

Young driver education has attracted some attention at government level in many motorised countries. While this measure might appear fool-proof, studies of crash involvement with teenagers who enrol in such schemes have sometimes been controversial. One of the largest studies in this area conducted by Stock and others (Stock et al, 1983) recruited over 16,000 high school students in DeKalb county, Georgia, USA, recording their "licensure, violation, and crash experience" (Lund et al, 1986). The initial study was designed to evaluate the relationship between driver education and the crash involvement of teenage drivers due to previous research showing negative rather than positive effects of young driver education (Mayhew & Simpson, 2002). The results showed that teenage drivers who underwent driver education at school got their licence earlier than those students who did not. However the control students were more exposed to driving than their counterparts. The re-analysis conducted on the same data later (Lund et al,



1986), came to the conclusion that driver education courses at this level do not decrease crashes and violations among young drivers as a group. Instead it showed that the availability of driver education stimulates younger drivers to get licensed earlier which in turn leads to their involvement in more crashes and violations. The cautious recommendation from this study is not to count on young driver education as a safety tool for improving crash rates in this segment of drivers but rather that it be viewed as a method for teaching basic driving skills (Lund et al, 1986).

A review of studies on this topic was conducted by Vernick and co-workers (Vernick et al, 1999) that concluded:

“...In the absence of evidence that driver education reduces crash involvement rates for young persons, schools and communities should consider other ways to reduce motor vehicle-related deaths in this population, such as graduated licensing.”

In the UK a program of education in schools that was run by the Driving Standards Agency (DSA), the agency responsible for administering driving tests, based on the road safety strategy of the British Government (DfT, 2000) came under criticism for not being evidence-based or rather being based on insufficient evidence (Achara et al, 2001). The program consisted of an education package, the main component of which was a 50-minute presentation made to classes of 16-18 year-olds by driving examiners. The evidence took the form of surveys that showed an improved attitude of students after undergoing the DSA presentations but no monitoring of the crash involvement of the same students once they qualified.

In the USA (Hotz et al, 2004a; b) an education program called WalkSafe for primary schools proved effective in improving pedestrian crossing behaviour after a one-year trial in Miami-Dade County, Florida. In Melbourne, Australia (Congiu et al, 2008), a training package for educating school children was developed to improve road crossing behaviour. The performance of students improved when tested immediately after undergoing the training and one month later.

### **3.11.2 Road user training and its effect on safety**

Training and qualification of drivers for licensing to operate a motor vehicle is a standard procedure followed in most countries around the world. The level of training however is not uniform. The effect of training and testing of drivers



may be measured by before/after studies when licensing laws were introduced or by studies conducted when there is a change in legislation. The effectiveness of driver education as a measure for improving road safety is disputed in India and other Less Motorised Countries (Mohan & Tiwari, 1998; Mohan, 2003). The argument is that perceived low standards of driver education should not be criticised before studying the causes of crashes as the driving environment is significantly different to more motorised countries. Other studies emphasise the difference in driving habits and vehicle usage between low-income countries and much of the West. For example, in Kenya (Nantulya & Reich, 2002) the majority of road user fatalities belong to the pedestrian category while in the USA drivers make up the largest group of road fatalities. Also in Vietnam motorcyclists were involved in 62% of motor crashes (*ibid.*) which is far higher than the involvement rate of motorcyclists in the UK for example (8.7% - DfT, 2006*b*). Driver education and training were found not to reduce motor crashes by most evidential evaluation of them (Vernick et al, 1999; Mayhew & Simpson, 1996; Roberts et al, 2001; *in* O'Neill & Mohan, 2002) however they continue to be suggested as remedies to problems in road safety.

The education and behaviour of other road users (such as motorcyclists) seem to be influenced only by legislation – at least in the already motorised countries – as suggested by one study (O'Neill & Mohan, 2002). They argue that laws requiring compliance with helmet use for instance are complied with due to the high risk of detection, while in areas where the risk of detection is perceived to be low, legislation might not have any positive effect. Pedestrian behaviour has been reviewed in the literature in high income countries (Duperrex et al, 2002). Most of the studies related to younger road users. Though some behavioural changes were found in road-crossing, the effect of these changes on pedestrian injury in crashes was not known.

### **3.11.3 Professional driver training and the effect on crash involvement and driver behaviour**

Professional driver education and training, or that given to qualified drivers is another measure that is used by some organisations and countries in the hope that it improves the safety of drivers. The majority of studies on this



subject show post-qualification training to be an ineffective measure in reducing crash involvement as the effects of practical training to handle emergency situations are short-lived (Christie, 2001) unless practised frequently. Examples of these situations are skids (loss of traction or movement of the car in a lateral direction) and under- and over-steer (where the vehicle veers off the intended path of a curve, either overshooting it or heading towards the centre of the curve radius). Christie conducted an extensive literature review of the subject covering Australia and other motorised countries, discussing many reasons why driver training might not be effective as follows:

- False assumptions about driver deficiencies and the merits of training
- Asking too much of driver training in crash reduction terms
- Driving emergencies and crashes are rare events.

The question of cost is also factored in the conclusion to Christie's work as training of this type is time-consuming and hence expensive and it might be the case that this diverts funds from other areas more in need of attention (that may have a better track record of improving safety). No studies were found that speak of near-misses (a crash that was narrowly avoided) which might also be used as a measure of the success (or not) of driver training probably due to the difficulty in accurately measuring and recording such events before and after training.

Studies using driving simulators (Dorn & Barker, 2005) that compared trained drivers (police drivers from two urban UK police forces) with non-police drivers of a similar age group and driving experience found that the police drivers tend to exhibit safer behaviour in some scenarios (like slowing down more in the presence of pedestrians and positioning the car more centrally and consistently on the road for better views ahead). This might reinforce the idea that this type of skill training needs continuous practice as all the police drivers drove daily and covered significant annual mileages in both their work and commute.



#### **3.11.4 Driving age limit and crash risk effect**

In a review of US data it was found that the age of the driver has an effect on the level of threat to other road users (Evans, 1991) with an increase in age corresponding to a decreased threat. This cannot be attributed to age alone as driving exposure is also reduced with increased age according to the same study. This naturally leads to the assumption that a limit on licensing younger drivers will reduce this threat. However this does not take into account that older drivers if newly licensed will be similarly disadvantaged by inexperience as younger drivers are. Research from Norway (Elvik & Vaa, 2004) shows a peak in the risk of driver involvement in injury crashes at ages 18-19 which bottoms out at ages 45-54 then again peaks at age 75+. A similar trend is seen in the US (Massie et al, 1995). In Canada surveys of drivers of different ages by telephone (n~10,000) found younger drivers (16-24) more likely to engage in risky driving and to have a higher crash and violation rate (Jonah, 1990).

Very few studies were found of the effect of raising or lowering the driving age (at the lower end of the scale) aside from two; one which found an increase in the number of crashes and fatalities when lowering the minimum driving age from 18 to 16 in Quebec, Canada in 1962 (Gaudry, 1987) and the other in Denmark showed a decrease in moped injury crashes of 15-year-olds when the age limit was raised from 15 to 16 years in 1980 (Engel & Krogsgård-Thomsen, 1989). No upper age limits have been found in existence for driving licences (Elvik & Vaa, 2004).

#### **3.11.5 Driving tests and crash risks**

To determine the suitability and safety of a driver to get behind the wheel a test is the established norm for ensuring that a certain standard of driving ability is attained before joining the driving population. Assessing the effect of this test is difficult because a before-after study would need to be done at the introduction of the test and most countries with a significant driving population have had a test for a long time. The methodological problems with testing the effectiveness of this measure on improving safety are acknowledged in a review of related studies (Elvik & Vaa, 2004).



Tests often consist of two parts: a written theory test and a practical test. The effect of theory tests on crash involvement is not evident in studies according to Elvik nor is there a difference between driving school instruction and family/friends instruction (Elvik & Vaa, 2004). Practical test outcomes are affected by the length of the test as found when comparing the mistakes made by drivers after 30 and 90 minutes of an examination (Fazakerley & Downing, 1980; cited in Elvik & Vaa, 2004) with mistakes increasing with an extended test time as would be expected. A study of the differences in crash involvement, over three years, of drivers that pass or fail an advanced driving test show a significant reduction in crashes for subjects that pass the test (Hoinville et al, 1972; cited in Elvik & Vaa, 2004). This is what international studies have found. There appears to be no published data on the effectiveness of the driving test standard in Dubai.

### **3.11.6 Offending driver punishment's effect on crashes and re-offending**

Driver punishment, most often through fines and suspension of licences, and less often through detainment and prison sentences has been used as a tool with some effect on crashes. The experience of Brazil (Poli de Figueiredo et al, 2001) showed that a new traffic code introduced in 1998 (which included an increase in fines and a penalty scoring system) led to a 21.3% reduction in crashes and a reduction in hospital emergency room admissions from road crashes by 33.2% over the 12 months after implementation of the law. Possible confounding factors can be the increase in speed limits on many roads and a reduction (over the same period) of tickets issued by 49.5%. This shows a case where deterrence theory by punishment appears to hold true but the same was not found for unlicensed drivers from a study in Brisbane, Australia (Watson, 2004). Unlicensed drivers caught by the police in a metropolitan area and interviewed on the frequency of their unlicensed driving and their intention to drive unlicensed in the future seem to be undeterred by the fines and punishment unless there is a high chance of apprehension and a severe enough fine imposed (*ibid.*).



One study (Lawpoolsri et al, 2007) found the risk of re-offending to be high for drivers in Maryland, USA suggesting that deterrence was no longer effective for repeat offenders. Some reasons suggested for this are the size of the penalty or the type of driver committing the offence and it should be noted that drivers that do get cited for offences are expected to be only a small percentage of the total “offending” driver population that are detected by the police (Elvik & Vaa, 2004). In some countries in Europe fines increase with the level of speeding and the number of previous convictions (Delhay, 2006). Delhay goes on to develop a model that can infer the driver type from their offending history in order to base the “optimal” fine structure on the probability of detection as well as the strength of relationship between driver type and the record of convictions held by the authorities. The average estimate of reduction in all crashes (injury and non-injury) based on a number of studies on driver punishment is 10% (Elvik & Vaa, 2004).

### 3.12 Vehicle factors in crashes

The invention of the motor vehicle has had a great effect on the speed and efficiency of transport in the last century. It also has a great effect on the involvement and survivability of a crash for all the parties involved whether they are motor vehicle occupants or other road users.

Traffic accident solutions		
Prevention Strategy	Aims	Example of involvement factors
Prevent the accident occurring <i>Primary Safety</i>	• Improve driver behaviour	<i>Alcohol, speed</i>
	• Improve road design	<i>Crash barriers, guardrails</i>
	• Improve vehicles	<i>Handling, braking</i>
Prevent the injuries occurring <i>Secondary Safety</i>	• Reduce forces on road users	<i>Restraints, structure</i>
Reduce injury consequences <i>Tertiary Safety</i>	• Medical treatment	<i>Rescue, paramedics, emergency medicine</i>

Figure 14: Stages of safety in treating crashes (Thomas, 2006a).



Crash safety is generally divided into three sections, before (also known as the primary or active stage), during (also known as passive or secondary) and after the event (tertiary stage) as illustrated in figure 14.

### **3.12.1 Active vehicle safety measures**

For vehicle safety the measures activated in the pre-crash stage to try and avoid the crash occurring are often described as “Active” safety measures and these include vehicle stability control, anti-lock braking systems (ABS), electronic brake assist (EBA) and many others like anti-whiplash devices. Future developments in active safety technologies promise further advances in crash avoidance including pedestrian detection, lane change assistance and advanced vehicle communications (Schulze et al, 2008).

#### **3.12.1.1 Electronic Stability Control (ESC) and crashes**

The control of vehicle dynamics by monitoring the rate of turn around the vertical axis (yaw) and rate of roll and lateral acceleration and subsequent intervention through selective braking of individual wheels and/or power reduction to the driven wheels was introduced into the mass market in the late 1990s (Weekes et al, 2009). It came under various names depending on the supplier/manufacturer, from ESC, to ESP (electronic stability program), DSC (dynamic-) and VSC (vehicle-stability control) to name a few. These advanced systems were designed to intervene when the vehicle begins to lose control and thus could be used to prevent crashes that result from loss of control as many single-vehicle crashes do. The effectiveness of these systems has been evaluated in the USA and in Europe, with varying results mostly positive (Farmer, 2004; Kreiss et al, 2005; Lie et al, 2005) especially in low-friction situations. Thomas (2006*b*) in a study of crash involvement risks for cars in Great Britain with electronic stability control systems found a greater effectiveness of ESC in wet or icy conditions (reductions of 34% and 53%, respectively) and for fatal and serious injury crashes (19% reduction). 4x4's and large luxury vehicles of a popular Japanese brand were the focus of a study in the USA that found a 52.6% reduction in single-vehicle crash rates (Bahouth, 2005). In Japan (Aga & Okada, 2003) a study of three models of one brand of vehicle showed a reduction of approximately 50% in the casualty



rate for severe single-car-crashes. The casualty rate was described as “casualties per vehicles in use per year”. There were indications in 2007 of the possibility of passing legislation to make such electronic controls standard on all cars for sale in the EU (Anonymous, 2007).

### **3.12.2 Passive vehicle safety measures**

Measures that help deal with the crash during the event are known as passive (or secondary) safety measures. Such measures include deformation zones in vehicle structures, airbags, restraints (seat belts) and head rests.

#### **3.12.2.1 Seat belt wearing and legislation**

Seat belts have been fitted to vehicles for at least half a century since the first application by Nash in the USA in 1949 (Wagner et al, 1997). Seatbelt legislation followed soon after first requiring manufacturers to fit the devices in cars (first recorded in Wisconsin, 1962) then requiring vehicle occupants to wear them (in the Australian state of Victoria, 1970; Wagner et al, 1997). Nash discontinued offering the contraption when it found little use hence the need for legislation both for vehicle manufacturers and users. User legislation worldwide generally takes two forms either primary or secondary enforcement laws. Primary enforcement makes it possible to stop a vehicle and issue a ticket solely for failing to wear a seat belt whereas secondary laws allow a ticket to be issued for not wearing a seat belt only if the vehicle was first stopped for another offence (Rivara et al, 1999). Studies comparing the effectiveness of both types of enforcement suggest that primary enforcement is more effective, though secondary enforcement is almost exclusively present within the USA (Rivara et al, 1999).

The number of countries with mandatory seat belt wearing laws stood at 40 in 1990 (Evans, 1991). Studies from countries such as Sweden, Denmark, France, New Zealand, Germany, Canada and the Irish Republic report a decrease in fatalities after introduction of the law but to varying degrees (*ibid.*). Doubt has been cast on the effectiveness of seat belt legislation suggesting that risk compensation has not been taken into account and any improvement in injury outcomes for car occupants are offset by worse outcomes for other road users (Adams, 1982 & 1994). This was challenged by



research from other geographical areas (Lund & Zador, 1984). Another major factor in the argument is that the data from the first region to apply the measure (the Australian state of Victoria) is not significant enough and data from other regions is not conclusive. Additionally where large estimates of improvement were made they were later revised as in the UK (from 1000 life “savings” in 1983 to 200 in 1986; Adams, 1994). The smaller-than-expected improvement might also have been affected by an increase in the exposure of unbelted occupants with time because some seat belt wearers will gradually stop wearing them. Therefore before and after studies cannot hope to control for all other factors besides the seat belt legislation. More recent estimates of mandatory seat belt use benefits show the probability of being killed is reduced by 40-50% by wearing a seat belt for front seat occupants, and by ~25% for rear seat occupants (Elvik & Vaa, 2004). Seat belt use in itself was not found to be universally effective as the benefit gained by users depends on many factors like posture, size and biomechanic characteristics (Mackay et al, 1998).

#### **3.12.2.2 Vehicle crashworthiness and consumer testing**

The outcome of a crash (for occupant injury) can be significantly altered by the crashworthiness of the vehicle involved. Crashworthiness is a measure of how well a vehicle performs in a crash mainly in terms of occupant protection and passenger cell integrity. “Consumer” crash testing (by a “neutral” third party rather than the vehicle manufacturer) was first conducted in 1987 by NHTSA (National Highway Traffic and Safety Administration) in America (Wagner et al, 1997) and soon other countries followed. This has been the predominant form of testing for crashworthiness until the introduction of high-powered computers and simulation programs that have taken over from physical crash testing to some extent. Some vehicle manufacturers have voluntarily been testing vehicles before then as witnessed by Ford building their first crash test facility in 1954 (*ibid.*) and Mercedes-Benz testing all their vehicles with an off-set barrier since 1978 (Kallina & Justen, 1994).

The trends of injury severity in traffic crashes (increasing injuries of slight severity and decreasing serious injuries) were suggested as proof of the effectiveness of improved crashworthiness (Elvik & Vaa, 2004). A number of



measures within crashworthiness were reviewed (*ibid.*) like collapsible steering columns (to prevent the steering being thrust into the driver upon frontal deformation), laminated window glazing (to prevent occupant ejection, or injury from flying glass), energy-absorbing instrument panels and head rests (to prevent whiplash and extreme head/neck travel). The overall effect was found to be positive (a reduction in the number of people injured) except for some instances of head rests increasing fatal injuries in rear-end crashes. Nowadays the design of most vehicles has been optimised to perform well in consumer crash tests (known often as NCAP for New Car Assessment Program, in the USA, and EuroNCAP in Europe) as witnessed by the large number of cars obtaining the maximum star-rating (five stars out of five). However the question of compatibility is a major worry for car-to-car impacts (Zeidler & Knöchelmann, 1998) as vehicle structures designed to perform well in a standardised barrier impact will behave differently with a crash partner that is significantly different in mass and stiffness. Also increased rigidity of the structure puts more pressure on the occupant restraint systems and might lead to increased loads on the occupants that can lead to more injuries especially for more vulnerable vehicle occupants with lower biomechanical limits (such as older drivers with lower bone density and strength).

This is not to say that NCAP programs – and other passive safety developments – have not been effective in improving injury outcomes in crashes. In a comparison of injury outcomes of car to car impacts published in 2000 cars with a 3 or 4 star Euro NCAP rating were found to be approximately 30% safer than cars with a 2 star rating or cars that have not been rated yet (Lie & Tingvall, 2000). An earlier study on US NCAP tested cars compared the US NCAP scores for head injury, chest acceleration and femur (thigh-bone) loading with real world crashes of the same model cars. Real world crashes were selected where a car with a good US NCAP score collided with a car of similar weight but with a poor score and it found that drivers of the car with a better NCAP score had a 15 – 25% lower risk of fatal injury (Kahane et al, 1994). In the UK (Welsh et al, 2007) vehicles of different ages were compared (before and after regulations for side impact came into play) and it was found that the post-regulation vehicles did see improved injury outcomes



for passengers compared to pre-regulation vehicles. The outcomes improved in particular for front occupants on the struck-side of the vehicle, however serious head and chest injuries continued to present a threat to life in post-regulatory vehicles. The main contacts for head injuries were external objects (e.g. other vehicles) while the side door was the main contact for chest injuries (Welsh et al, 2007).

Pedestrian test methods were developed for frontal vehicle structures to minimise the risk to pedestrians hit in crashes (British Standards Institution, 2002). More recent European regulations (Directive 2003/102/EC) will come in force in two stages, beginning in 2005 (European Communities, 2009a;b). These regulations include a test of the bonnet using a head form to measure compliance with test limits (Kerkeling et al, 2005). More detailed tests using both a head form (for the bonnet) and leg form impactor (for the bumper leading edge) were introduced by Euro NCAP and incorporated into the overall score of a vehicle (Euro NCAP, 2009). This will make it more difficult for vehicles to achieve a high star rating without offering good pedestrian protection. Vehicle and system manufacturers realised a problem existed with vulnerable road users and have tried to develop systems that aid the driver in detecting and avoiding pedestrians (Moxey et al, 2006). The system goes one step further in deploying a device to reduce the severity of the impact on the pedestrian. Such systems hold promise for introduction in future automobiles.

### ***3.13 Environmental factors in crashes***

All factors related to the environment around the vehicle and user are classified here (socio-economic, physical, regulatory) except as expressly related to the vehicle and driver as those were covered in the previous section.

#### **3.13.1 Exposure control, as applied to reduce crash risk**

The concept of exposure has been discussed in relation to road safety for at least half a century (de Silva, 1938) and attempts to define it have been made. One early definition was “the number or relative danger of the hazards he (the driver) encounters” (de Silva, 1942). Haight (1973) describes it as being analogous to exposure to disease and says that measures for exposure can be “distance travelled, or the time travelled, or a product of these by the



density of traffic encountered, or by the speed of that traffic". He continues to mention the common measure used for large areas and often, national policy which is a gross estimate of the amount of road travel done. It is an estimate at best due to the difficulty in measuring, to any degree of accuracy, the travel patterns of a whole nation. Fuel consumption has often been used as an indicative measure as it is assumed to be proportional to the amount of motor vehicle use. However fuel consumption will indicate both moving and stationary MV use with the engine on (like when stopped in traffic jams or at traffic lights or to run ancillaries like heating or cooling). Induced exposure is that exposure based solely on crash involvement and not the whole (non-crash-involved) population (Haight, 1973).

The control of exposure is seen as an obvious way to control crashes as the absence or reduction of traffic and traffic activity should directly influence the probability of involvement in a crash. Studies in Nordic countries show that a large part of the systematic variation in crash counts can be explained by changes in exposure measured through fuel consumption (Elvik & Vaa, 2004). In Canada estimates based on driver surveys suggested that "apparent differences in crash risk per kilometre" can be explained by differences in "driving speed and environment" and that exposure time rather than distance is better at explaining the differences between populations and areas (Chipman et al, 1993). These results, however, are only suggested and not endorsed as there is a large margin for error with surveys that ask for estimates of driving distance and time and are not measured precisely (for example using electronic tracking devices). Studies in Scandinavia using Poisson regression methods (Fridstrøm et al, 1995) explain variation in small crash counts (such as those for fatalities) by "randomness" whereas exposure is found to be a more probable explanation for injury crashes (to a degree that the relationship between the two is claimed to be almost proportional). The study goes one step further in consigning 80-90% of observable variation in the figures studied to changes in randomness and exposure. This leads to the conclusion that the greatest reductions in crashes can be achieved through drastic reductions in traffic volume though it is unclear to what extent this holds true and if there is a reversal point. This is supported by observations in very crowded urban areas that suggest that the increase in traffic there (and



the corresponding slow-down in speeds) results in an improvement in safety (Shefer & Rietveld, 1997). This phenomenon needs further study to confirm if it applies in different geographical areas and with traffic of different composition (for example different ratio of pedestrians or cyclists to motorised vehicles).

### **3.13.2 Police patrol effectiveness in reducing traffic offences and crashes**

Police patrols in marked cars are one way of enforcing adherence to traffic regulations, especially speed limits. Although the effect of the patrol is limited to only the immediate vicinity, as the car travels the effect is spread over a greater area. The change in driver behaviour is often called the halo effect and is measured as the distance before and after an enforcement site (Fildes & Lee, 1993; Zaal, 1994). The principle of deterrence to poor behaviour (Homel, 1988 cited in Zaal, 1994) is that poor behaviour can be modified by making people fearful of the consequences of committing illegal acts. In relation to crime, a study in Minneapolis, USA (Koper, 1995) found that patrol stops of 11-15 minutes produce an optimum effect in securing the area (and preventing further incidents) but no studies of a similar effect by highly-visible stationary patrols on driver's adherence to road laws have been found. The largest study of patrol effectiveness (one city of 120,000 inhabitants covering a period of 3.5 years) specifically looked at drink-driving enforcement (Voas & Hause, 1987) through patrols in the evenings of weekends. It found that the patrols had a measurable effect on crashes during night-time, first reducing weekend night-time crashes (during the first six months) then the weeknight crashes fell as well. However the two cannot be tied conclusively as patrols were not changed during weeknights. The major drawback to this method is the limited long-term possibilities for traffic safety as the effect subsided six months after funding was terminated.

The effect of enforcement on seat belt wearing and speeding was studied in many countries and reported in extensive literature reviews (Fildes & Lee, 1993; Zaal, 1994). Enforcement (when combined with legislation) can raise compliance with seat belt wearing but the level of improvement is dependent upon numerous factors like the levels of enforcement and publicity involved



(Makinen & Hagenzieker, 1991, as cited in Zaal, 1994). A difference was found between behavioural changes from enforcement strategies using visible (marked) and non-visible (unmarked) police cars by Galizio, Jackson and Steele (1979, cited in Fildes & Lee, 1993) with unmarked cars having no effect on speeds. Marked police cars on the other hand had a significant speed reducing effect. The type of police strategy used may be customised to the type of offence targeted (Sanderson & Cameron, 1982, cited in Fildes & Lee, 1993). Fixed offences such as driving with no insurance were most suited to visible enforcement as the driver was unable to change his behaviour in time to avoid detection. Transient offences such as speeding were better detected by non-visible enforcement (Sanderson & Cameron, 1982) as the driver would not alter his behaviour on seeing an unmarked police car.

Though enforcement and legislation are important factors in improving driver behaviour and compliance with the law, other non-enforcement factors have also been suggested to complement enforcement (Zaal, 1994). Such factors include educational and promotional programs as well as the effect of habitation (when seat belt wearing becomes a habit) after continuous use. The reasons behind the non-use of seat belts were investigated and drivers were found to fall within one of four categories (Landry, 1991, as cited in Zaal, 1994):

- Drivers who wear seat belts on the basis of improved safety.
- Drivers who wear seat belts in response to compulsory legislative requirements.
- Drivers who respond to enforcement and the threat of punishment.
- Drivers who do not wear seat belts regardless of any other factors.

These factors are important in tailoring the enforcement or legislative activities to the different driver types depending on their prevalence in the driver population. However in many countries enforcement is not actively pursued (Zaal, 1994) and actual apprehension rates for seat belt violations are very low (1%, Campbell & Campbell, 1986). This places the emphasis for compliance with the individual road user (Zaal, 1994). In the absence of enforcement, road user behaviour may deteriorate significantly as was seen in Finland during a police strike when serious speeding offences increased



considerably (Makinen, 1988 cited in Fildes & Lee, 1993). The overall seat belt use of vehicle occupants in Finland over thirty years (ETSC, 1996, cited in Peden et al, 2004) showed that legislation had a temporary effect on usage levels when not accompanied by fines, publicity and enforcement.

### **3.13.3 Blood alcohol concentration legislation and the effect on injury crashes**

Legislation to regulate drink-driving involves either an outright ban on the practice or a certain blood alcohol concentration above which driving is banned. The former exists in the UAE and similar countries where drinking alcohol in itself is seen as a societal and cultural taboo while the latter is used in Europe, Canada and Australia (Voas et al, 2000) where drinking alcohol is more a societal norm. Elvik & Vaa (2004) in a meta-analysis (see Appendix A for explanation) of 18 studies on the subject found that general legislation banning drink-driving gives a 26% reduction in the number of fatal crashes while reducing permitted blood alcohol concentrations is also effective but to a lesser degree. Legislation appears to be most effective immediately after enactment with the effect diminishing over time (Ross, 1988).

### **3.13.4 Drink-driving enforcement's effect on offenders**

The enforcement of drink-driving laws and limits is the logical step after legislation, and can have a substantial effect on the rate of offence, as seen in the work of some researchers. In a meta-analysis of 26 studies of drink-driving enforcement the effectiveness of this measure was found to be a 9% reduction in the number of fatal crashes and 7% for injury crashes (Elvik & Vaa, 2004). The effects of enforcement in the UK are detailed in a study commissioned by the Home Office (Riley, 1991). The findings of that study show that drivers in areas of high enforcement are less likely to drink and drive though this survey study relies on self-reporting and as such the results might not be entirely representative.

In Australia random breath testing (RBT) of drivers to verify blood alcohol concentration has been in use in some areas since 1982. One study (Homel, 1988) showed a 36% decline in alcohol-related fatalities over five years in the Australian state of New South Wales related to RBT. The legislation was launched with considerable momentum (Homel, 1990) with the recruitment of



200 new highway patrolmen especially for the task of breath testing and nearly one million breath tests carried out in the first year. This equated to approximately one test for every three license holders. This shows the dramatic effect legislation can have when supported by high profile and strict enforcement.

### **3.13.5 Speed limits and their effect on actual speeds and crashes**

The setting of appropriate speeds and enforcing them can be an important factor in the frequency of crashes, particularly fatal ones. Early work on the subject of speed and crash involvement in the UK (in the counties of Berkshire and Buckinghamshire) found that drivers deviating from the average speed (whether higher or lower) have higher crash rates than other drivers (Munden, 1967). This was corroborated by a study in Tyne and Wear (Aljanahi et al, 1999). Other studies in the Kingdom of Bahrain found evidence of an association between mean speed and the crash rate (*ibid.*) and work in Ghana found that the 'speed factor' accounted for over half the crashes in two years (Afukaar, 2003) as reported by the police. Most studies that looked at the effect of speed reductions compared the imposition of speed limits where none existed before and the reduction of speeds in the higher speed ranges (e.g. 120km/h to 100km/h). Few studies looked at reductions in the lower ranges (Elvik & Vaa, 2004). The effect of reducing speed limits is almost always positive at least when the reduction is reflected in the actual driving speed (when drivers abide by the law). Experiments on Finnish roads in the 1960's and 1970's (Salusjärvi, 1981) found that actual speeds correlated with speed limit restrictions and there was a direct correlation between speeds and crash numbers (higher speeds result in more crashes and vice versa). Estimates by the European Transport Safety Council (ETSC, 1995) claim that a 5km/hr reduction in average speeds could save over 11,000 deaths and 180,000 injury crashes every year in the EU. A review of studies on speed and safety mostly in the USA (Wilmot & Khanal, 1999) found no statistical link between speed and crash incidence but a significant link between speed and crash severity was found. In the UK early work on real-world pedestrian crashes (Ashton & Mackay, 1979; Ashton, 1982) found that most crashes (>95%) occurred at lower speeds (less than 50 km/hr). Most crashes with



pedestrians where the vehicle was travelling at below 25 km/hr resulted in minor injuries to pedestrians. Impacts speeds over 30 km/hr resulted in non-minor injuries. Pedestrians were most likely to be killed by impacts at speeds above 55 km/hr. This was based on the vehicle fleet of the time which was very different to cars on the road today. These results may no longer be valid for modern car fleets. Later reviews of literature found that fatalities occurred at slightly higher impact speeds (Neal-Sturgess et al, 2002) suggesting vehicle design improvements positively affected outcomes.

#### **3.13.6 Automatic speed enforcement devices and their effect on speed**

The enforcement of speed limits by authorities is a labour-intensive affair with a typical cycle (of speed checking by radar, then stopping a vehicle, then issuing the driver with a citation and completing the necessary paperwork) taking approximately 0.91 person-hours per citation in the Netherlands (Wilmot & Khanal, 1999). With a speed camera the figure is 0.02 person-hours. Also the chances of being apprehended for speeding are fairly low even with high levels of traditional enforcement (Elvik & Vaa, 2004). Thus the automation of this task will save valuable traffic officer time and enable the processing of more citations but at the expense of high maintenance and capital equipment costs as speed cameras are fairly expensive. Speed cameras are designed to detect traffic violations (speeding) and identify the vehicle or driver automatically (Elvik & Vaa, 2004). Systems started off using analogue photography where films had to be manually replaced but nowadays digital cameras have been deployed that simplify the task of storing large amounts of information digitally and retrieving it quickly. Cameras provide a solution to bring speeding vehicles to account because the photographic evidence is used in association with existing laws to issue a fine or legal proceedings against the vehicle owner or registered keeper. In some areas (Sweden & Germany) this is made difficult because legislation does not allow the issue of a fine to a vehicle or vehicle owner but only to a driver. The experience of studies performed in a number of countries (Pilkington & Kinra, 2005) shows some positive effect of the measure. In Queensland, Australia the application of an overt (not disguised) marked speed camera van in areas



within an approved speed camera zone was studied over a number of years (Newstead & Cameron, 2003). These zones were determined by a local road safety manual put together by the roads and policing authorities (Queensland Transport, 2000). Reductions of around 45% in fatal crashes were found in areas within 2km of the speed camera sites with associated reductions in hospitalisation and lesser-severity crashes.

The average reduction in injury crashes calculated from a multitude of studies due to speed cameras is 17% (Elvik & Vaa, 2004). The effect of automatic enforcement on average speeds also appears to be time-limited as shown from a short-term study in the UK (Holland & Conner, 1996) while research in Kuwait shows that drivers show disregard for the speed limit after a number of years from camera installation as the fixed location becomes well-known and the phenomenon of speeding outside (immediately before and after) the camera zone is also observed (Koushki & Hasan, 2000). The distance-halo effect was also observed by a later study in Queensland, Australia (Champness et al, 2005) which found that a 6kph reduction in mean speed occurred due to speed camera deployment. However all effects of deployment disappeared about 1,500m beyond the speed camera location.

### **3.13.7 Central barriers, guardrails and crash cushions as roadside safety devices**

The installation of a barrier at the edge of the road where there is a danger to the vehicle from running off the road (due to a drop in elevation or an obstacle or a combination of both) and the installation of a barrier between lanes of traffic travelling in opposite directions can prevent the worst outcome (injury) and limit the damage that happens when a driver loses control for any reason. Damaging obstacles that might be present off the side of the road include lamp posts, utility posts, rocks, trees and bodies of water (rivers, streams, etc.). Crash barriers might be located at sites where such obstacles cannot be positioned a safe distance back from the kerb. A study of road barriers in Willow Creek, California, spanning 17 years (7 before and 10 after barrier installation) looked at the fatalities from vehicles going over embankments on a 161km stretch of road. Regression analysis showed that 21 fatalities were predicted over the ten year period following installation. However no fatalities



at all occurred at the new installation sites, averaging a reduction of 2 per year (Short & Robertson, 1998). In a review of related research from a number of countries but predominantly the USA (Elvik & Vaa, 2004) most studies on the subject found a positive effect in reducing injury except that the installation of barriers in the median of highways resulted in an increase in non-injury crashes (with a reduction in injuries). The average reduction from installing a guardrail along the embankment of a road was 47% for any injury crashes (*ibid.*).

On highways the separation of opposing traffic is particularly important due to the high speeds involved and the great potential for damage from just one vehicle crossing over into opposing traffic (Elvik & Vaa, 2004). One type of guardrail (concrete) appears to increase the probability of injury as opposed to metal rails most likely due to the more brittle deformation of concrete as opposed to steel. The average reduction in injury crashes from installing a median guardrail on multi-lane divided highways was found to be 30% for all injury crashes (Elvik & Vaa, 2004).

The Australian experience (Corben et al, 1997) of treating a large number of blackspots with various measures found the following showed statistically reliable ( $p < 0.05$ ) improvements in before-after counts:

- Changes to horizontal road geometry (reduced casualty crashes by 44%)
- Large-scale shoulder sealing (reduced casualty crashes by 32%).

This is a developing field with new barriers undergoing development and regulation (in the form of industry standards and crash testing certification) is catching up. New types of barriers are expected to come to market in the future allowing more research to be carried out to better understand their usefulness.

### **3.13.8 Speed-reducing devices (speed humps and rumble strips)**

Devices such as speed humps (alternatively termed bumps) and rumble strips are used on roads to alert drivers to a possible hazard ahead or road feature that might require slowing down and paying more attention (like a roundabout, pedestrian crossing or junction). Such vertical deflections are used as engineering measures to slow drivers down (Schlabach, 1997). These



devices are now widespread as a method for traffic calming. Higher speeds have been associated with more severe pedestrian injuries from a study in the USA in the late 1970s (Pitt et al, 1990) and 1990s (Gårder, 2004; Kim et al, 2008) so reducing speeds is desirable especially in a pedestrian environment. Speed humps were first tested for public use in the UK in the early 1970s (Watts, 1973). Their use in urban settings has obvious advantages due to the proximity of pedestrians and other vulnerable road users but their use on main roads and arterial highways can be detrimental to traffic flow (Al-Omari & Al-Masaeid, 2002) especially where no code of use exists as is expected to be the case in most LMCs. Their use as part of a wider measure of pedestrian-friendly zones (that includes road design elements and signage to slow down drivers) has been reported as effective in reducing injury crashes, speed and traffic in the Netherlands. Similar results were found in Germany in a study of six cities albeit with a rise in non-injury crashes coupled with a decrease in injuries (Schlabach, 1997). However most of those studies were before-after studies that might show different results if they were conducted over longer timescales or larger areas to detect any shift in crash location. Such devices were also part of a wider program of pedestrian safety measures considered for application in Victoria, Australia (Corben & Duarte, 2006).

Studies in Vancouver, Canada (Zein et al, 1997) in four urban locations show a benefit of traffic calming measures (speed bumps combined with other measures like traffic restrictions, one-way streets and mini-roundabouts) in reducing crash insurance claim costs. However the study is not exclusive to speed humps and focused more on financial costs rather than human injury costs, being sponsored by an insurance company.

Rumble strips (thin strips of plastic or asphalt laid at decreasing intervals to induce a “rumbling” sensation in vehicles travelling over them) have been shown to reduce crashes and vehicle speeds when used across the whole roadway especially in front of intersections (Fontaine & Carlson, 2001; Elvik & Vaa, 2004). Rumble strips applied as thin strips at the road shoulder to mark the edge of the carriageway (and hence alert drivers when they start to leave the carriageway) also appear to have been used successfully to reduce



crashes especially single-vehicle road-departure crashes (Griffith, 1999; Elvik & Vaa, 2004; Persaud et al, 2004).

### **3.13.9 Measures for protecting pedestrians**

Measures designed to protect pedestrians from involvement with other traffic (namely motorised) are numerous and have come a long way since the days of red-flag-waving when a man with a red flag was supposed to run ahead of a car to alert other road users (DfT, 2004). Pedestrian crossings are one of the prime measures to protect pedestrians and provide them with safe passage across roads and they are of many types. Comparisons of different types have shown little difference between them in crash rates (Zaidel & Hocherman, 1987). Crossings have been shown to reduce crashes by numerous studies (Reading et al, 1995; Elvik & Vaa, 2004) but the safest types of crossings remain those that separate the two different types of traffic completely by elevation either above motor vehicles (overhead by-pass or bridge) or below (underpass). In Dubai the first solution has been applied to the most dangerous road (Sheikh Zayed Road) but due to the cost and complexity and the length of the road only a few have been built. In Abu Dhabi the second solution is favoured as the wide inner-city roads (3 lanes each direction) are notoriously difficult for pedestrians to cross, especially with little attention paid to pedestrian priority by drivers at zebra crossings. The effectiveness of grade-separated crossing facilities for pedestrians in reducing injury crashes is quite high at 82% (Elvik & Vaa, 2004) for all crashes where pedestrians attempt crossing the road.

Pedestrianised zones (where MVs are not allowed, except for deliveries) are another measure which can be considered in busy market areas and streets. From studies conducted in Scandinavian countries and the UK (Elvik & Vaa, 2004) the effect of pedestrian streets is always a reduction in crashes however there is a slight indication of increased crashes in adjoining streets that are not pedestrian-only.

Australian work on the area of pedestrian safety in areas of high pedestrian activity in Victoria (Corben & Diamantopoulou, 1996; Corben & Duarte, 2006) showed a need for paying attention to a number of priority issues when considering countermeasures. These include vulnerable pedestrian groups;



locational preferences for crossing; crossing width and complexity; vehicle speeds and pedestrian level of service. Pedestrian level of service may be simplistically described as the degree of accommodation of pedestrian traffic within the transport system (Dixon, 1996). The countermeasures considered by researchers in Victoria (Corben & Duarte, 2006) included traffic control measures like speed zoning and signs as well as physical measures (gateway treatment; different carriageway pavement; rumble strips; roundabouts; carriageway/lane narrowing and medians). Most of the measures are self explanatory with the possible exception of gateway treatment. This refers to erecting a kind of outpost or symbolic structure at the entrance to an area of high pedestrian use (like a large sign or canopy) to differentiate it from the area preceding it thus highlighting the change in the mix of road users.

#### **3.13.10 Light conditions, illumination & weather conditions**

Lighting conditions were considered in a number of studies when looking at pedestrian safety with a variety of results. The severity of pedestrian crashes in rural Connecticut (Zajac & Ivan, 2003) was not found to be influenced by daylight, illumination or weather conditions. In Austria children were more commonly injured in crashes in the afternoon and early evening (Mayr et al, 2003) while most site conditions were described as sunny and dry (63.1%). In the US Pitt et al (1990) used the data from the Pedestrian Injury Causation Study to focus on child injuries and it was found that the lowest injury severities occurred at noon and immediately after while the most severe injuries occurred early in the morning with the late afternoon taking a significant share of severe injuries. The morning period might account for more severe injuries due to driver tiredness and child pedestrians going to school. The increased severity of injury in the afternoon in both studies might be explained by increased fatigue by both drivers and child pedestrians returning from school at the end of the working day. Also the low angle of the sun in winter months might contribute to poor visibility conditions in some geographical areas.

#### **3.13.11 Intelligent Transport Systems (ITS) in relation to safety**

The advancement in communications technology and computing power combined with the reduced cost of electronic displays and data transmission



and the advance in vehicle weight, speed, and traffic density detection have all contributed to the development of what is known as Intelligent Transport Systems or ITS. The careful application of these technologies is said to make the transport system, as a whole, safer, more secure and efficient with a reduced environmental impact (Sayeg & Charles, 2005). The effect of the adoption of ITS on road safety is difficult to quantify as the system can include so many factors. Controlling for all of them is virtually impossible and there is no known situation where a road system is closed to use, “converted” to ITS, then re-opened and assessed thereafter. ITS measures can be applied individually or simultaneously and reviews of specific aspects of ITS have been found in previous work.

The technology for voluntary and forced speed limiting devices in vehicles has been around for some time and research on the topic has included both simulation and real-world trials (Brookhuis & de Waard, 1999). Field studies in three European countries (the Netherlands, Spain and Sweden) indicated a good level of effectiveness in free driving conditions (Varhelyi & Mäkinen, 2001). However negative behavioural effects were found such as slightly increased travel times and increased driver stress and frustration. One method of implementing speed limiting devices in a vehicle involves using an “active” accelerator pedal that resists being pushed further to break the speed limit in a specific area (Varhelyi, 2002). A large-scale trial in Sweden in 2000-2002 found some acceptability of the usefulness of the system by drivers, however the majority of drivers preferred not to keep the system at the end of the trials (Adell & Varhelyi, 2008). The negative perceptions towards the device might be affected by factors such as technical malfunctions and increased emotional pressure during driving. Other technologies that have already been implemented in production cars are variations of adaptive cruise control that measures the distance to the vehicle ahead and maintains it at a driver-set limit. Manufacturers have various names for the systems. Some common names (Zou, 2001) are Distronic (Mercedes), Radar Cruise Control (Toyota), and Preview Distance Control (Mitsubishi).

Variable message signs (VMS) are road side or overhead signs with messages that can be tailored to conditions and changed dynamically as



conditions change either automatically or manually. Drivers might be more responsive to a dynamic sign rather than a fixed one that might not be applicable or accurate all the time. Elvik & Vaa (2004) found a number of studies covering the measure that show a significant reduction in the number of crashes after deployment. Many were criticised for not controlling for regression-to-the-mean and for being at crash blackspots which increases the perceived effectiveness as opposed to a randomly-chosen location. The overall effect of this new technology does not appear proven, but the novelty of approach and the driver-empowerment with knowledge might be sufficient in improving the conditions of roads, especially during inclement weather and crash conditions. Ideally a well-executed ITS would alert drivers to delays on roads ahead in sufficient time to allow them to choose (or even suggest to them) a different route that is less congested. In extreme weather conditions like fog or ice, the dynamic alert might be more convincing to drivers than a static sign that is present all year round.

A review commissioned by the Royal Automobile Club of Victoria, Australia (RACV) suggested a number of measures that had the potential to decrease injuries and fatalities by 10% like incident management systems, motorway control systems, urban traffic control and automated speed enforcement (reviewed earlier). The potential of current and future ITS applications to reduce crashes is emphasised and development of these systems must always take place with an eye on the overall safety effect on the road transport system (Regan et al, 2001).

### ***3.14 Post-crash safety measures***

The final stage of a traffic crash comes once the event is over and the process of rescue of the victims and recovery of the vehicles commences. Traffic management around the vicinity of the crash is key to avoid further crashes. International studies have shown that crash fatalities were potentially preventable where death occurs before arrival at hospital (Mock et al, 1997; Hussain & Redmond, 1994 *in* Peden et al, 2004). In comparing different countries, it appears that deaths tend to occur more frequently in low and



middle-income countries before arrival at hospital, when compared to higher-income countries (Mock et al, 1998 *in* Peden et al, 2004).

Post-crash care can be viewed in terms of a chain made up of the following links (Buylaert, 1999 *in* Peden et al, 2004):

- Actions or self-help at the scene of the crash
- Access to an emergency medical system
- Help by emergency rescue services
- Pre-hospital medical care provision
- Hospital trauma care
- Rehabilitative psychosocial care.

These measures were not considered within the scope of this study.

### **3.15 Summary**

This chapter reviewed methods of road safety management and problem solving from various regions around the world. Most methods were based on data analysis which emphasised the importance of collecting data. Major ongoing data collection projects related to crashes were found and described in the USA (NASS) and Europe (CARE, IRTAD and ERSO). Three general levels of detailed data were collected: base, intermediate and in-depth. Each detail level was useful for a particular purpose with the most functional level being the in-depth data (Sabey, 1990). This level was also the most difficult to collect due to the extent of information needed from various sources (hospitals, road users, etc). Base-level data was found to exist in Dubai. Collection of this data was started by the police in 1983.

Knowledge transfer in general was a process that does not always happen within the same organisation let alone across different countries (Szulanski, 2000). Knowledge transfer as related to road safety has been described in past work (Jacobs, 1986) so the methods were not entirely new. These methods of approaching the problem consist of three steps of which knowledge transfer is a key component of the central step. The process begins with problem identification through on-the-ground work to establish what data is available and what it covers and how reliable it is. Once this is



done this data (which is most often of the base-level) is analysed to identify the problems and classify them along with the causes if possible. The second key step consists of measuring up the problems identified with countermeasures that can be used to remedy them. Knowledge transfer is involved at this stage to identify the best countermeasures and the method of implementation. The third step was the measurement of the effect of a safety measure introduction or adoption and this can be done either directly where possible or by estimation or extrapolation of existing data on use and effectiveness.

One example of this process that was found in previous work involves one of the most famous road safety countermeasures: the seat belt. In Dubai and the UAE seat belt use was not mandatory for front seat occupants of motor vehicles until January 1999. A before-after study was conducted from police data in Dubai (Abdalla, 2005) that showed a significant reduction in fatal and serious injury for vehicle occupants as a result of increased seat belt use after the new law came in force. In this case the direct effect of seatbelt use (on injuries) was measured after the countermeasure was applied and compared with the injury record before the enforcement of the law. The result was in accordance to previous research on seat belts which showed the success of this model of traffic safety problem treatment.

This is the process that should be followed when any new measure is introduced be it pedestrian crossings, bridges, red light cameras or mobile and stationary speed cameras. International knowledge transfer allows the selection of appropriate countermeasures after key problem areas are identified. Once that is done the deployment of the countermeasure should be followed by monitoring and appraisal as described in the previous example. This thesis is mainly concerned with the identification of problems and matching them with countermeasures. Further work in the future needs to be carried out for evaluation and appraisal.

The effect of development and environment on road safety scenarios was described. Increased wealth generally led to increased growth (Barro, 1996). Motorisation followed not long after. International development agencies targeted road safety in some of their work in developing countries due to the



scale of the problem there (Dinh-Zarr, 2008). Religion and values may have an effect on the level of road safety (Melinder, 2007). Rapid increase in the material wealth of the Gulf nations created a somewhat unique situation both in terms of economy and development (Davidson, 2006; Gause, 1994).

The final part of the chapter was a global overview of some of the main traffic safety interventions. This revealed a wealth of data on a whole range of safety-improving countermeasures which have been useful in many areas of the world and that might be effective if used in areas where they are not currently in use. The number of measures is far too large for an exhaustive survey – that would require a separate volume on its own – so measures were chosen based on their level of effectiveness as shown from previously published academic studies. Most of the studies of countermeasures were found from highly motorised regions. As the thesis only deals with the problems found in Dubai (according to the data analysis in following chapters) most countermeasures that do not relate directly to the main problems were excluded even if they were highly effective in another context. Differences in climate, road environment and culture were among the factors that led to the exclusion of some measures.

Measures were divided into three general sections (table 14) according to what factor they dealt with. The three sections were used to group factors according to what area they act on or relate to under the headings of Human, Vehicle and Environmental factors.

Further divisions were made within the different sections along the lines of passive and active safety according to the effect of the countermeasure and whether it was injury-preventing (passive safety) or crash-preventing (active safety). Examples of measures within the Human factors section were driver education; school education and professional driver training. Factors that concern the vehicle were the fitment of Electronic Stability Control; seat belts; and vehicle crashworthiness. Environmental factors that were reviewed include exposure control; enforcement and central barriers and crash cushions.



**Table 14: Division of literature reviewed measures**

No.	Chapter Section	Factor	Measure
1	3.11.1.1	Human	School education (pre-driving)
2	3.11.1.2	Human	Professional driver training & the effect on crash involvement and driver behaviour
3	3.11.2	Human	Driving age limit
4	3.11.3	Human	Driving tests
5	3.11.4	Human	Offending driver punishment
6	3.12.1.1	Vehicle	Electronic Stability Control
7	3.12.2.1	Vehicle	Seat belt wearing and legislation
8	3.12.2.2	Vehicle	Vehicle crashworthiness & consumer testing
9	3.13.1	Environmental	Exposure control
10	3.13.2	Environmental	Police patrol effectiveness
11	3.13.3	Environmental	Blood alcohol concentration legislation
12	3.13.4	Environmental	Drink-driving enforcement
13	3.13.5	Environmental	Speed limits
14	3.13.6	Environmental	Automatic speed enforcement devices
15	3.13.7	Environmental	Central barriers, guardrails & crash cushions
16	3.13.8	Environmental	Speed-reducing devices (speed humps & rumble strips)
17	3.13.9	Environmental	Measures for protecting pedestrians
18	3.13.10	Environmental	Light conditions, illumination & weather conditions
19	3.13.11	Environmental	Intelligent Transport Systems (ITS)



## **Chapter 4 Methodology**

### ***4.1 Introduction***

#### **4.1.1 Data sources and types**

Data was needed to explore the causes of road crashes and their subsequent effects on road users (mainly in injury terms) before remedies could be suggested. A large sample of injury crash cases was taken from crashes known to the police traffic department and roads authority in Dubai. This sample represented the majority of crashes that occurred on the roads due to reasons highlighted in later chapters. At first the base-level data was looked at in the macroscopic sense – that is in a general manner to garner an initial diagnosis of the situation from past years. This was performed with data that encompassed twelve years of all reported injury crashes in the population. Secondly the situation was looked at in more depth (microscopically) to focus on the main problem areas but due to the greater depth, the date range of data coverage had to be reduced. Thus the microscopic analysis focused on the year 2006 and the first three months of 2007. The second sample contained more detailed data on serious and fatal crashes investigated by a dedicated team at the police. This sample's relation to the overall crash population was demonstrated by weighting the different crash severities to those known from the overall crashes of 2006 (from the macroanalysis). Cost estimates for crashes were used from the UK Department for Transport (DfT, 2007b) which adopted the “willingness to pay” method in calculating the potential savings from the prevention of accidents.

#### **4.1.2 Benefits of microscopic data view**

The micro-level analysis served to verify the findings of the macroanalysis (to check if they still apply to the latest available data at a more detailed level) and to establish whether the preventative measures already suggested correlate with suspected crash causes. With more in-depth data available this allowed more assertive matching of countermeasures to crash types.

In addition more details that were not available from base data were collected and presented. Data that showed similar trends to those found in



macroanalysis were not reviewed in the results to avoid repetition and to allow for the presentation of new findings. Weighting of the data from the sample of in-depth crashes was possible because the whole population of reported injury crashes was recorded in the first part of the analysis so any projected benefits of countermeasures can also be weighted to the whole crash population (of the year under study).

#### **4.1.3 Process of estimating possible improvements**

Countermeasures for improving safety were matched as closely as possible to the top crash causes in the sample. With the known estimated effectiveness of measures from previous studies it was possible to make best estimates of safety improvement as reviewed in the literature.

### ***4.2 Crash data collection process in Dubai and the UAE***

Policing in Dubai is divided into 12 geographical areas (see next figure) and each area deals with crashes occurring in their division. The areas are: Airport (covering Dubai International), Alhabab, Bur Dubai, Al Rifaa, Hatta, Alfuqaa, Al Muraqabat, Nayef, Ports (dealing with the sea ports of Rashid and Jebel Ali), Al Qusais, Al Rashidiyya and Jabal Ali. When a crash notification is received by the police command and control room it dispatches a police patrol from those operating in the area and contacts the necessary emergency services if needed. The attending officer fills in a crash report form (Appendix B) and if the crash is severe or involves some ambiguity the technical crash investigation division is called in (by the Public Prosecution). The technical investigation division is a small division within the traffic department made up of crash investigators trained in reconstruction techniques. They are on call 24 hours a day and collect data from the scene using an additional form and their own photographs as well as taking appropriate measurements needed to reconstruct the crash on computer reconstruction programs which they have been trained to use. These include PC Crash (DSD, 2009) and Vista (Visual Statement, 2009). Detailed reports and reconstructions are used for court cases or to establish liability in the case of fatal crashes.

After a crash occurs and the attending police officer returns to his respective station, the statement of the incident is filed electronically. The crash form is



forwarded to the road safety section where an analyst inputs the data into the MS Access database and validates entries during this process. A software program called GeoMedia by Intergraph Corporation (Limp & Harmon, 1998) is used to locate the crash on a digital base-map of Dubai which is tied to the crash file using location coordinates. This in turn allows the display of crashes of any selected criteria on a map.

This can be used to inform policy in such matters as locating speed cameras (generally called “radars” in the UAE). Once the electronic statement is filed at the receiving station this is used by the analyst to clear up any mis-coding.



**Figure 15: Map showing the main Dubai Policing Regions (RTA, 2006a).**

Hospital data is also supplied for injured individuals. This is added on to the file once received to assess the degree of injury (fatal, serious, moderate or slight). The system as described has been running since approximately 2004. Most of this data was known to exist at the commencement of the study via numerous field visits to the general directorate of Traffic, Dubai Police. Contact was established with the different personnel to introduce the study to the police and to ascertain what crash data might be made available for study and how it could be delivered along with the possibility of accessing any of the archived data from past years.



### **4.3 Data description**

#### **4.3.1 Base-level data for macroanalysis**

Initially the data for all fatal crashes of the past year (2005) was requested. After obtaining the permission of senior management the data was granted in electronic format (on USB flash memory disk) for all 2005 fatal crash cases but each case contained the crash form data only (see appendix B) with no personal or injury details. After conducting some analysis on the given cases (around 211 cases with 236 fatalities) it was clear that further data was needed to understand crash causation and to be of use in describing the long-term trends and analysing the problems of the past few years. A larger sample size would make statistical analysis more significant.

In the year 2005 a major change had taken place in the government departments responsible for the roads in Dubai. The Roads and Transport Authority (RTA) was established in November 2005 to take over all responsibility for road and infrastructure design, construction and maintenance, and vehicle and driver licensing. Certain departments were transferred from Dubai Police namely the safety and road engineering section. Most of the new RTA was made up of departments formerly managed by Dubai Municipality (DM). This meant all of the crash data was now jointly kept by the RTA and Police. Contact was established with the relevant departments in the new organisation but this task was made difficult because of the sudden birth of the RTA. A lot of areas of responsibility remained in between the Police and RTA while the finer details were sorted out.

Eventually and with the move to the new headquarters (and associated equipment moving) completed the crash data input was resumed and field visits were again conducted to find the transferred personnel from the Police and find out the new responsibilities now assigned to them. As familiarity was gained with the fatal crash dataset of 2005 further attempts to expand it were made in 2006. These efforts culminated in a much larger and improved dataset from the new RTA now covering a 12-year series (1995 to 2006 inclusive) and including all fatal, injury and property damage crashes with basic injury records (degree of injury). The authorities regularly use the data to produce annual reports and inform the decision-making process but this



was the first time that this data had been exclusively analysed from an academic viewpoint.

### 4.3.2 In-depth data for microanalysis

To better understand the in-depth data that was available an example of the crash files that were the source of this data are illustrated from a sample anonymised case on the following few pages. The main sources of information were the police control room summary, the formal case reports (submitted to the Public Prosecution or the police station requesting the investigation), the scene plan drawings and photographs of the location, vehicles and victims involved and any relevant features of the surroundings. If the case involved a fatality then the coroner's report was often attached detailing the injuries and apparent cause of death.

POLICE HQ DUBAI  
General Investigation Department

القيادة العامة لشرطة دبي  
الإدارة العامة للتحريات والمباحث الجنائية  
مركز شرطة بر دبي

بلاغ دالم

٢٠٠٦

١/١ : الصفحة

٢٠٠٧

مركز شرطة

التاريخ :

تسجيل ملخصات / الموجز

٢٠٠٦ : التاريخ

الجهة : القيادة العامة لشرطة دبي / الإدارة العامة للتحريات والمباحث الجنائية / مركز شرطة بر دبي

وفاة

إصابة شخص

حادثة صدم حاجز

حادثي وعمود انارة وتدهور السيارة

في حوالي الساعة

دقيقة من مساء يوم

الموافق

٢٠٠٦م ورد بلاغ من العمليات مفاده

عنوان البلاغ اعلاه على شارع

على

كما حضر الى نفس المكان مساعد مسلوب

والنقيب

ومن لجنة السير

والوكيل

والذي اكتفى بإجراءات الشرطة

خلال الكشف والمعابنة انصح بان الخطأ من سائق السيارة رقم

٢٠٠٦م عائدة ملكيتها

من نوع

فاطرة ثقيلة اللون ابيض فضي برتقالي الانتهاء

الجنسية العمر

سنة يعمل بمهنة

لدى

ونتيجة السوق

سيرة على منحى الجسر الامر الذى ادى لفقدان السيطرة على معود سيطرة وانحرافه الى

جهة اليسار وصدمة الحاجز الحديدي والمثبت على الجانب الجسر ومن ثم التدهور وصدمة عمود الانارة وسقوط الحاوية من على

السيارة على بعد ٥/٤ متر ومن جراء الحادث

باصابات بليغة على اثرها فارق الحياة فى نفس المكان كما اصيب

شخص اخر كان برفقته يدعى

الجنسية العمر

سنة عنوانه هاتف

باصابات

متوسطة نقل على اثرها الى مستشفى راشد ولازال قيد العلاج حتى تكوين البلاغ

هذا ولحققت اضرار بليغة فى السيارة فى جميع

اجزائها مع الحاوية كما لحقت اضرار متوسطة فى عمود الانارة واضرار فى الحاجز الحديدي بطول ٢٥/٨ متر وعليه تم نقل

الجثمان الى مستشفى راشد ومن ثم الى الطب الشرعي تمهيدا لتسليمها لقوينة وعليه اتخذت كافة الاجراءات اللازمة للعلم

Figure 16: Example of police control room summary report. *Translation: At approximately A hours B minutes on the evening of X day a report was received that at the street mentioned above a crash had occurred. Officers A & B attended the scene as did officer C from traffic investigation. The representative of the prosecutor was satisfied with the actions of the police. After investigation it transpired that the error was from the driver of vehicle A (named) belonging to (named entity) due to his losing control while driving on the exit ramp and veering to the left where the vehicle impacted the steel barrier then rolled over and struck a lamp post and the container fell off the back of the trailer (a distance of X metres). Due to the crash the driver was*



severely injured and succumbed to his injuries while a passenger with him (details supplied) suffered medium injuries and was transferred to hospital. Severe damage was suffered by the vehicle in all parts as well as the container while the lamp post suffered medium damage and the steel barrier was damaged (length 25m). The driver's body was taken to hospital and then to the coroner to prepare for handing over to the family of the deceased and all the required actions were taken.



Figure 17: Examples of photographs from a case.

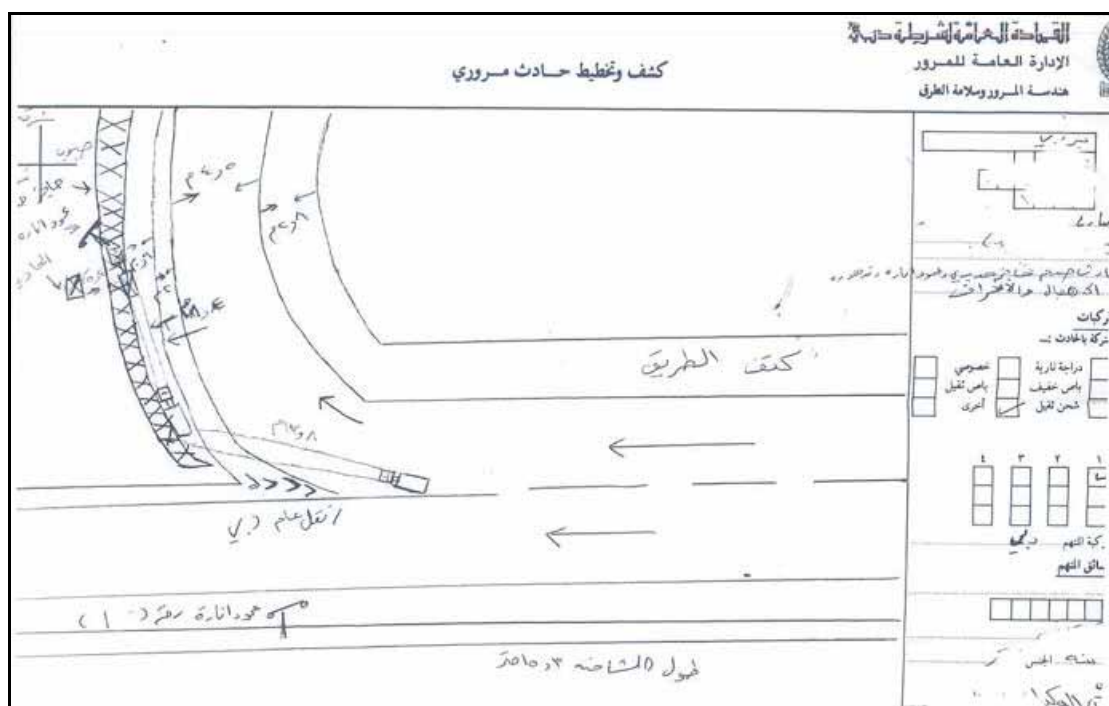


Figure 18: Example of scene plan drawing for a crash case.





**Dubai Police General H. Q.**      **القيادة العامة لشرطة دبي**

الإدارة العامة للمرور  
إدارة هندسة المرور وسلامة الطرق  
القسم الفني لحوادث السير

التاريخ : ١٤٢٦ هـ  
الموافق : ٢٠٠٦ م

المرجع :  
  
المحترم

**السيد / رئيس نيابة السير و المرور**  
السلام عليكم ورحمة الله وبركاته ...

**الموضوع : القضية رقم ٢٠٠٦ / جنح ومخالفات المرور**

بالإشارة إلى كتابكم رقم ..... بتاريخ ٢٠٠٦ م والخاص بحادث انحراف وتدهور شاحنة في منطقة اختصاص مركز شرطة بر دبي ، نود إعلام سيادتكم أنه بعد الانتقال والاطلاع على ملف القضية تبين الآتي :

تاريخ الحادث	٢٠٠٦ م الموافق ليوم
وقت الحادث	حوالي الساعة مساء
مكان الحادث	شارع
نوع الحادث	حادث انحراف وتدهور شاحنة
القائم بمعاينة مكان الحادث	الملازم / + الوكيل /
معد التقرير	الملازم /

بيانات المركبة	
رقم المركبة	
لون اللوحة (الرمز)	
مصدر وصنف اللوحة	نقل عام
لون المركبة	
نوع المركبة	
المسار	
الجنسية والمهنة	

الهاتف : ٢٢٢٢٢٢٢ / ٢٢٢٢٢٢٢ - ١١٩٢ - دبي - الإمارات العربية المتحدة  
Tel 04-2292222 / 2692222, P.O.Box : 1493 Dubai , United Arab Emirates  
www.dubai.police.gov.ae الموقع الرسمي للقيادة العامة لشرطة دبي على شبكة الإنترنت .  
البريد الإلكتروني للقيادة العامة لشرطة دبي على شبكة الإنترنت . mail@dubai.police.gov.ae

Figure 19: Extract from formal police case report.

## 4.4 Data adaptation

### 4.4.1 Base-level data description

As the original data was supplied in MS Access database format, a dedicated statistical analysis package was needed to perform the sorting, validating and mathematical work on the data. The Statistical Package for Social Sciences (SPSS Inc, 2006) was used for most of the data analysis along with Microsoft Excel when the required graphs were not easily produced in SPSS.



Training sessions on the use of SPSS were attended and numerous online and printed manuals and tutorials were consulted to achieve competency in use of the package for this purpose. In addition, regular consultation with VSRC staff more experienced in using the package were held.

The first step was to create the necessary programming commands, or 'syntax', for importing the files and converting them into SPSS format. This was needed to convert most of the fields (that were numeric) into the equivalent text value based on the translation of the original crash form from the Arabic language. Most syntax files used for this purpose are attached in Appendix C. Some problems were faced in importing data that contained missing values as was the case when a data field was only recently introduced (in the 2002 form revision, for example) and this had a significant effect on skewing the data and distorting the picture. A prime example of this was in the crash causation field where alcohol intoxication is listed as a cause. Analysis for all 12 years showed that as an infrequent causation but further investigation revealed that coding for alcohol intoxication was only performed in the years 1999 and 2004-2006. When the year 2006 was taken separately alcohol intoxication was the second leading cause of crashes, which was a more accurate reflection of this problem than that found by analysing all 12 years of data. More details are provided in the relevant chapter and the data analysis was conducted with this factor always in mind. This required an iterative process of filtering certain data out before conducting analyses of specific factors to avoid distortion by outside factors (like missing values in certain years).

#### **4.4.2 Base level data adaptation and processing**

The extended (12-year) data was supplied in three main tables; (i) a crash case file; (ii) an injury file and (iii) a driver/vehicle file. These were linked together by a relationship created in MS Access. These files were then merged in SPSS with some variables from different tables as some key variables (time, date) were not available in all the tables. Casualty-level analysis was performed using syntax adapted from existing experience in the VSRC (Vehicle Safety Research Centre, Loughborough University, UK) that was used for merging large data sets in the past. The files included non-injury



cases that went to court (due to property damage) so the analysis required the separation of these non-injury cases to concentrate on injury-producing crashes. The total number of cases supplied and their divisions were outlined in the following table. These were collected over a 12-year period and included all crashes reported in the jurisdiction of Dubai Police.

**Table 15: Description of file types and numbers in database**

<b>File type</b>	Vehicle/driver	Casualty	Crash file
<b>Total files</b>	48,960	30,942	26,067
<b>Injury files</b>	29,856 (61%)	30,942 (100%)	18,142 (70%)

The personal data on injuries sustained by the individuals involved in these 18,142 cases was later combined from the same sources for a total of 30,942 casualties. The vehicle/driver files contained 48,960 cases as most crashes involved more than one driver. Not all cases (especially from the end of 2006) might have made it into the files due to delays with receiving hospital records and filing statements by the police so the 2006 injury figures might not be complete.

The analysis of the provided variables (that were more or less complete and understood) of gender, nationality, age and degree of injury provides further detailed information related to the injured parties rather than the crash cases as a whole. This analysis permitted the highlighting of major trends and issues to arrive at the underlying problems that were present in many of the injury crashes. Many of these problems were common to more motorised countries with a better safety record (and have been covered in previous research as seen in the literature review) so the methods used to solve these problems were then evaluated with an eye on the local context and what might affect applicability in Dubai. If extenuating factors related to specific countermeasures were encountered that rendered them unsuitable for the Dubai situation then they were excluded. A prime example of this is the countermeasure of fitting studded tyres in winter (Elvik & Vaa, 2004). This may be beneficial in Scandinavian winters with extremely low temperatures but would be pointless if applied in a hot desert climate. Ideally a calculation of safety improvement or the reduction of casualty figures or severity was the intended outcome. In many cases the countermeasure effectiveness is not as



simple to calculate but in no case was a countermeasure suggested when it was thought that it might lead to a reduction in safety. Monitoring will provide the ultimate vindication. An example of where a countermeasure might have the opposite effect is introducing a zebra crossing to a frequent pedestrian crossing location (in a driving environment where drivers do not generally yield to pedestrians). This might lead to giving pedestrians more confidence to cross thus increasing their exposure to harm.

#### **4.4.2.1 Missing values in base-level data and under-reporting**

Missing values were encountered with a number of variables including speed limit, road layout, and site proximity to landmarks among others. Adjustments for this were made in the coding before analysis by setting missing value parameters for every variable in SPSS so missing values can be listed as independent categories (as seen for variables such as “central reservations and lane separation” and “number of lines or type of junction”). Details on the key variable names and properties used in the crash case files (excluding the casualty and vehicle/driver files) are shown in table 16 and in the section on limitations. Some fields that were not used included LINK; NODE; NORTH; EAST as they did not contain any information. These were probably used to describe the location of cases. These indicated the type of road involved and geographical coordinates but the relevant data for these fields were not supplied.

Under-reporting of crashes is a frequently reported problem with police figures as explained in Chapter 1 (DfT, 2006a). Some medical sources in the UK (e.g. Gill et al, 2006) attribute the fall in injury crashes as reported by police data, to less reporting rather than improved road safety. This is because the figures do not match up when comparing police and hospital records for road traffic crashes in general.

In Dubai the data was assumed to contain most of the injury crashes that occur there with very little under-reporting due to laws that prevent the repair of any MV by a garage unless accompanied by a police crash report and strict penalties for violators (Abdalla, 2005; El-Sadig et al, 2002). It is likely that any injury-producing crash will involve some vehicle damage.



<b>Table 16: Variable names &amp; types in the crash case file along with encountered missing values</b>			
<b>Name in database</b>	<b>Description</b>	<b>Type (from SPSS)</b>	<b>Comment</b>
DATE	Date of occurrence	Date	
TIME	Time of crash occurrence	Numeric	
NUMBERVEH	No. of vehicles involved	Numeric	
NOOPERINJ	No. of persons injured	Numeric	
DEGINJ	Degree of injury (fatal, serious, etc)	Numeric	
LOCATION	Location of crash	String	
CAUSE	Crash causation as listed by the police	Numeric	
TYPE	Crash type (see figure 36)	Numeric	
SPDLIMIT	Speed limit on road	Numeric	1833 unknown/invalid
SITECOND	Number of lanes/type of junction	Numeric	4 missing, 1036 unspecified
SITENRTO	Site proximity to (landmark etc)	Numeric	5057 missing, 7251 unspecified
CNTRESV	Central reservation/barrier type	Numeric	5254 missing
LIGHT	Lighting conditions	Numeric	3 missing
TCONTROL	Traffic markings and signs	String	1060 missing
WEATHER	Weather condition	Numeric	9 missing, 22 unspecified
RDSURF	Road surface condition	String	13 missing, 134 unspecified

#### **4.4.3 In-depth data adaptation and processing**

To analyse the in-depth data a new database was created based on the information held by the crash investigation section at Dubai Police Traffic Department for which access was granted exclusively for the purposes of this research. The new database was required to contain all the relevant data available in the Arabic reports, so that it was easily analysable and retrievable. The existing files were digitally archived in PDF and printed form, written almost entirely in the Arabic language. This required the extraction of relevant details followed by translation and input into an SPSS (SPSS Inc, 2006) database created specifically for the task taking into consideration the outcomes required. This database had to allow for the preventative measures (based on possible countermeasures) to be easily input and subsequently ranked according to frequency of occurrence, to highlight the most commonly-occurring measures.

A number of new fields were introduced that were not included in the original files but that could be deduced from the existing crash description or photos. Such an example was the daylight conditions that were assigned to one of



three variables: daytime, night-time, or dusk/dawn (half an hour after dusk, and half an hour before sunrise).

The new database enabled the matching of crash causation with reasonable certainty to suitable preventative measures for the most serious and common crashes. After this was done for all the crashes in the database a few preventative measures stood out because they were assigned to a large number of crashes and were not currently in extensive use in Dubai. Hence they would not be redundant. Such measures formed the basis for suggesting improvements to the existing safety standards and strategy in Dubai.

Key elements like crash mechanism and crash causation were assessed according to a study of all the data available on the crash, including photographs, scene plans, witness statements and the technical report of the investigation team along with discussions with members of the team who attended where possible.

#### **4.4.3.1 Preventative measures validation**

The preventative measures that were likely to positively affect each crash case were selected based on gaining a thorough understanding of all the data available on each case from the police electronic files and hard copy. Anything that needed clarification was discussed with the police investigators while collecting the data (as they worked in the same office). In many cases at least one investigator remembered the details of the case and could shed more light on the subject. After this was done a sample of 10 cases of various types was shown to crash investigation experts to test the validity of the preventative measures assigned by the researcher as compared to the experienced crash investigators and reconstructionists.

#### **4.4.3.2 Crash investigator experience**

The seven subjects who were used for the validation all had many years of experience in crash investigation and/or research mostly in the UK with some of them having investigated crashes internationally. More detail on their experience is provided in table 17.



**Table 17: Crash investigator experience and characteristics**

<b>No.</b>	<b>Organisation</b>	<b>Gender</b>	<b>Age group</b>	<b>Level of experience</b>	<b>Training &amp; qualifications</b>
1	Loughborough University	M	40-50	Crash investigation in UK, Australia, & UAE. Management of relevant projects in European countries to harmonised protocols for 20 years	PhD in crash safety
2	Loughborough University	M	40-50	Involvement with real-world crashes (investigation; analysis) for 20 years in UK, US & Germany	PhD in crash safety
3	Loughborough University	M	40-50	Full-time OTS investigator (9 years), CCIS investigator (9 years)	AITS MITAI DipASM LCGI MAIRSO HGV Class 1
4	Loughborough University	M	25-35	Full-time OTS investigator (5 years)	AITS
5	Loughborough University	M	25-35	Full-time OTS & European SafetyNet investigator (4 years)	AITS ITAI affiliate; Road safety audit training for highway appraisals
6	Loughborough University	M	25-35	Full-time OTS investigator (3 years) and data collection & management	AITS



No.	Organisation	Gender	Age group	Level of experience	Training & qualifications
7	Nottinghamshire Police	M	35-45	Police traffic patrol & crash investigation (15 years) and OTS police officer (5 years)	AITS; Road Safety Audit Forensic Light Bulb Examination Experience of various software (Total Station GPS; PC Crash; PenMap & FX3 CAD) Police advanced driver

Note: CCIS= Cooperative Crash Investigation Study; OTS=On-the-Spot crash study; AITS= Accident Investigation Training Services course in Forensic Collision Investigation; MITAI= Member of the Institute of Traffic Accident Investigators; DipASM= Diploma in Road Safety Management & Accident Investigation; LCGI= Licentiate ship; MAIRSO= Member of the Association of Industrial Road Safety Officers; HGV Class 1= Heavy Goods Vehicle class 1 licence.

Most experts were actively involved in crash investigation as part of their job description. A number had completed training and courses in investigation and reconstruction. However, the majority had never been to the UAE and hence would not have witnessed the road environment first hand so it is acknowledged that in some cases the crash scenario itself might not have been easily imaginable.

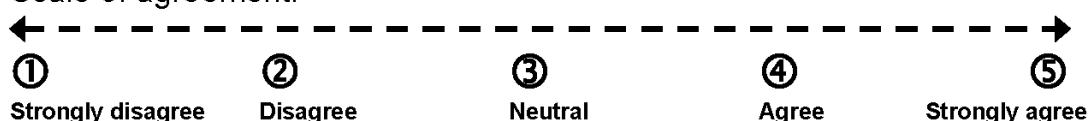
#### 4.4.3.3 Questionnaire style

The 10 cases were presented with most of the information available to the researcher (but not all of it) as some of the files in Dubai were not copied in order to avoid any possible data protection issues. Thus the experts could achieve some understanding of the crash scenario but without the important component of local knowledge of the areas involved.



The following scale was used to rank each factor entered by the researcher with a brief explanation:

Scale of agreement:



The experts were taken through the case summaries and photographs one by one taking time to process the information before filling a form assessing the factors related to each case. The results were anonymously analysed to show the extent of agreement with the researcher's assessment.

#### 4.4.3.4 Vehicle size and segment classification

Vehicle exposure data (traffic counts or number of registered vehicles of each type, or millions of kilometres travelled) was not available for the purposes of this study despite several attempts to gain access to traffic counters data. Instead manufacturer's sales data was kindly provided by Auto Strategies International who specialise in the field of collecting and marketing this data internationally from their base in the United States.

The data provided was new vehicle sales for the whole UAE market so it was assumed that the Dubai market is similar in proportion as it makes up a sizeable share of vehicles in the national market. It was also assumed that new vehicle sales reflected the composition of the whole fleet, as the biggest-selling vehicles will make up the biggest proportion of the existing fleet. Only the overall number of registered vehicles in Dubai was found in the public domain (Al-Theeb, 2008a) and that corresponded to 853,827 in 2007, and 739,547 in 2006 the main year for microscopic analysis.

**Table 18: Vehicle size categories**

Category	Example
Cars	Toyota Corolla
Sport Utility/4x4	BMW X5
Trucks	Mercedes Actros
Buses	Scania Bus
Pickups	Mitsubishi Fuso Canter
Others	Ex. Large utility van

Vehicle make and model information provided from the database was used to assign vehicles to their relevant size and body type categories in a simplified



classification based on the Auto Strategies classification (Auto Strategies International, 2008) to enable direct comparison of a vehicle model's dominance in crashes to that vehicle's standing in the whole market.

#### ***4.5 The necessity of in-depth data***

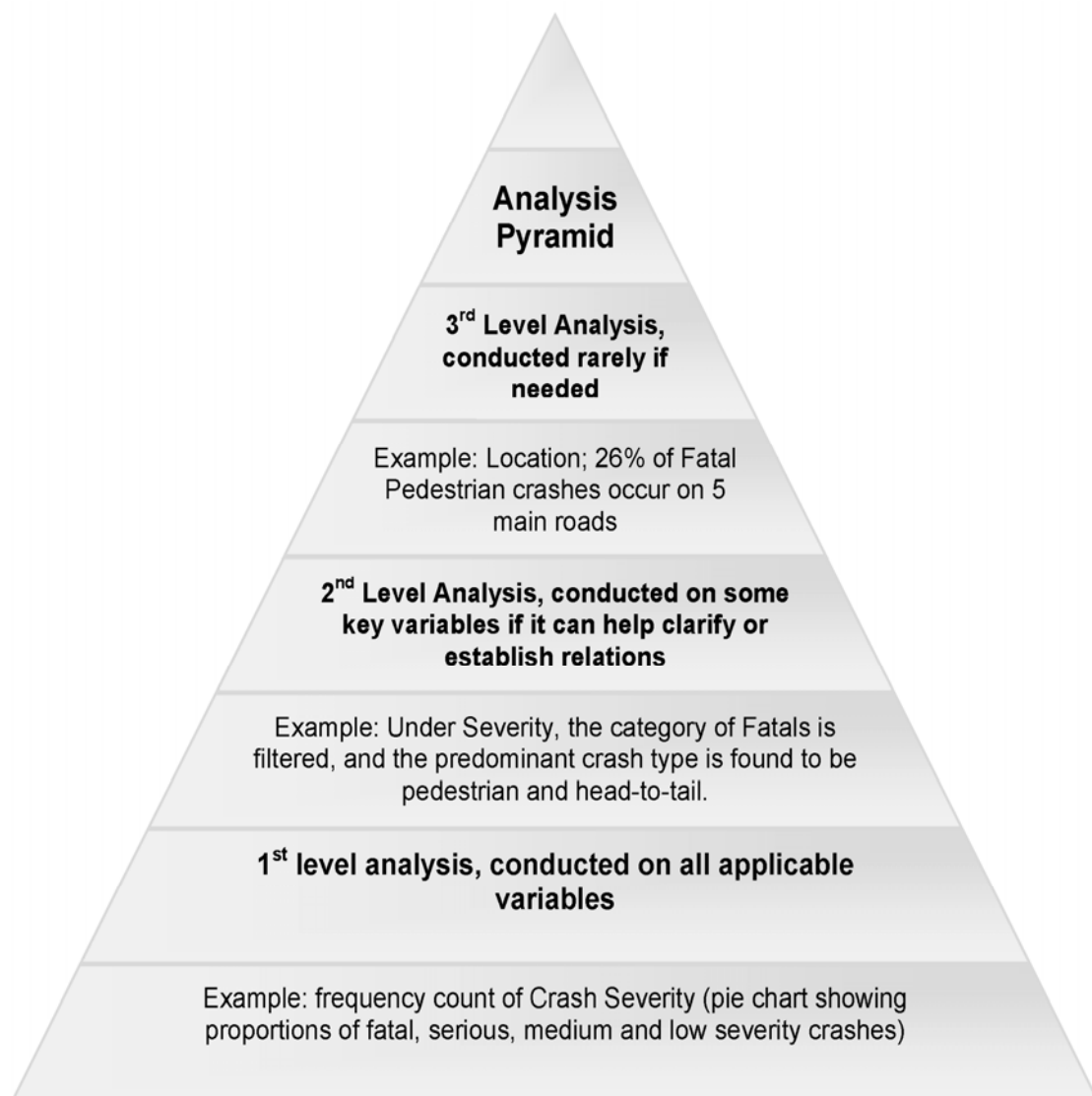
The macroanalysis of base data allowed the characterisation of injury crashes reported by the authorities according to numerous fields including time of occurrence and causes. The causes and mechanisms of crashes could not be further analysed or verified due to the limited volume of information supplied for every crash. For microanalysis, though the number of crashes analysed was much smaller, the volume of information supplied and reviewed for every crash was significantly higher than for the base data. This meant that crash causes, mechanisms, scene descriptions and court evidence could all be used to verify the crash report data. With this in-depth knowledge the countermeasures and interventions were more accurately matched to injury crashes and their effectiveness in the prevalent conditions could be established with greater accuracy.

#### ***4.6 Approach and methods to analysis***

##### **4.6.1 Macroanalysis of base data**

The three main tables of data (crash, injury, and driver/vehicle tables) were initially dealt with separately for analysis. The variables within these tables were individually assessed through frequency counts and comparison with





**Figure 20: Pyramid clarifying data analysis levels used**

other countries where appropriate to discover unusual traits and highlight problematic trends (first-level analysis). For every variable further tests were conducted with the categories of these variables if it was found that this could assist in understanding the crash situations encountered (second-level). For example, the initial analysis of crash severity reveals the proportion of each crash severity evident in the sample (fatal, serious, etc). Following this, the fatal category was subjected to more scrutiny as the type of fatal crashes was analysed (for example: Which is the most frequent fatal crash type? What time periods are fatal crashes concentrated in?) For a few select variables third-level analysis was conducted if this could support or negate the severity of particular problems. For example, for crashes with a reported fatal severity that involved pedestrians, what was the most frequent location(s)?



#### **4.6.2 Microanalysis of in-depth data**

For serious crashes or when there is a significant dispute over blame a special court looks into the matter (a dedicated traffic court, situated in premises next to the Traffic Department). It is this court that often requires a technical report into the crash from the Crash Investigation Team at Dubai Police. This report normally included estimates of crash speeds and probable crash scenarios when conflicting statements are made by witnesses to ascertain from the evidence what the most likely interaction was between the different parties. Sometimes police stations ask the investigation team for a report into a crash of ambiguous circumstances. In this case a report will also be made on the crash using the station's photographs and scene plan. The investigation team may make their own plans depending on how long ago the crash occurred and whether or not any of the team members attended the scene.

This data was collected for the whole year of 2006 and the first three months of 2007 with a total of 300 cases reviewed. The data was input into a new database created specifically for this purpose in SPSS (SPSS Inc, 2006) with around 150 fields. The data input was canvassed from the various sources of information mentioned earlier in this chapter. As this data set contained more variables from different sources it contributed to a more in-depth picture of each crash. These data fields included many new variables that were not available for the base-level database. Such variables include vehicle types and registration; visual obstruction presence; vehicle direction of travel; estimated impact speed; crash mechanism (separate from crash causation) and many others.

Minor discrepancies were found within the reviewed data between the filed court reports and the event summary from the emergency call centre. When this occurred, the data from the emergency call centre was chosen as advised by the officers who author the reports. The accuracy of the data entered was validated, where possible, by secondary means (e.g. day of week can be double-checked from the date).

The table of suggested preventative measures and their estimated effectiveness was carefully put together by looking at the countermeasures



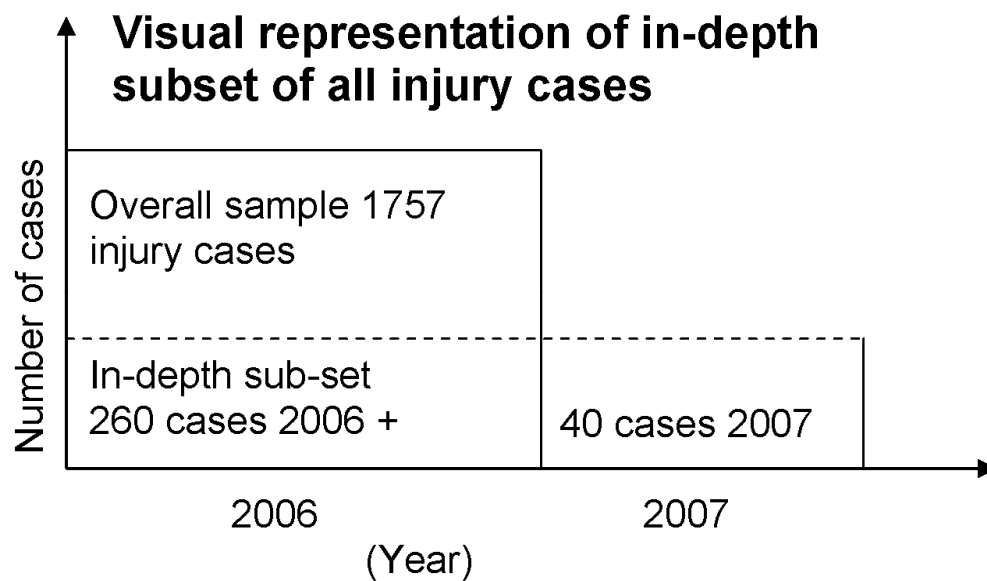
from the base-level data then selecting all the cases that may apply from the in-depth sample (using the preventative measures that were derived and validated by expert opinion). Then every case was filtered by type to see whether it was a suitable candidate for the chosen countermeasure. For example 46 crashes were listed with a preventative measure of “central barriers, guardrails & crash cushions”, however these represent a number of different interventions. The crashes were narrowed down to match one measure whose effectiveness is known from previous studies (e.g. Elvik & Vaa, 2004), either “guardrails along the roadside” or “median guardrail on multi-lane divided highway”. Each of these measures has an estimated percentage reduction for fatal injuries so that was then applied to the selected crashes to derive the expected reduction for this sample. This was then weighted to represent all the crashes of that year to arrive at an overall effectiveness of that particular intervention. This weighting is performed according to severity as serious and fatal crashes are over-represented in the sample so each severity is given a different weight (as explained in the next section).

When a countermeasure’s effectiveness was only found for the whole crash population (including non-injury crashes) or for a particular crash sub-type (like fatal crashes) then the estimates were adjusted based on the cost and prevalence of that type only. Key examples of this were offending driver punishment which had a measured effectiveness on all crashes – injury and damage-only, as well as ESP/stability control which had a measured effectiveness on fatal crashes only.

#### ***4.7 In-depth sample’s representation of the whole population***

The in-depth sample (January 2006 – March 2007) contained only 300 cases (240 in 2006 and 60 in the first quarter of 2007) whereas the number of all injurious crashes from January to December 2006 amounted to 1757 according to the base-level data collected earlier (figure 21).





**Figure 21: Graphical representation of the sub-set of in-depth cases in relation to the overall injury cases reported to the police.**

It is important to note here that the final data from the RTA for 2006 actually showed 1,812 injury crashes in that year which probably includes cases that were still being processed when the base-level data was collected from the RTA. To find out how representative the data from the in-depth sample was of all the injury crashes in that year the different severities of crashes were compared. It was found that the in-depth sample can be weighted to be representative of the overall population by dividing the number of cases of a specific severity in the whole population of crashes by the number of crashes of that severity in the in-depth sample. For example, 259 fatal crashes were reported in total in 2006 while only 166 were found in the in-depth sample. By dividing 259 over 166, a factor of 1.56 is obtained. To find out how many fatal cases occurred in the general population for every case in the sample, it is enough to multiply the number of cases (in the sample) by 1.56. This was useful in later stages when preventative measures were estimated to “prevent” a certain number of in-depth cases and this “prevention” was then weighted to represent the effect on the whole crash population. The results of these weight calculations are shown in table 19. This basic weighting method was used due to the absence of more detail in the base data set. There was no sampling system used by the in-depth crash team to select cases for investigation. Instead, selection was made based on a number of factors such



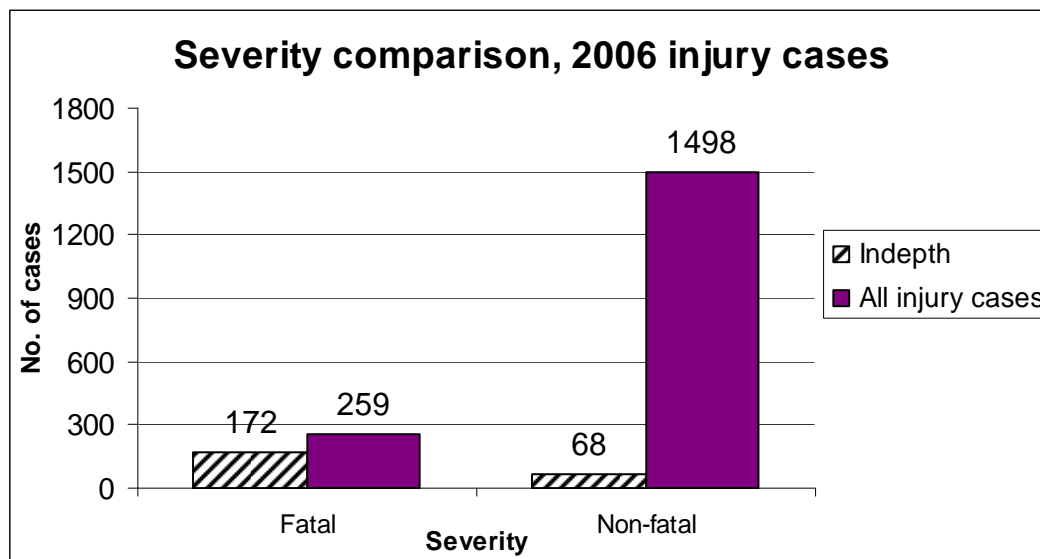
as court orders; police station requests; and unusual or severe crashes. This process resulted in more serious crashes being investigated and thus included in the in-depth database when compared to the overall cases reported in the year.

**Table 19: Weighting microscopic sample to population**

Severity	Cases in sample	Overall 2006 sample	Weighting factor
Fatal	166	259	1.56
Serious	23	155	6.74
Medium	23	600	26.1
Slight	8	743	92.9

The severity of crashes was taken from the base study sample. As the sample was collected earlier on in the work, it did not contain all the cases in the in-depth sample for 2006 as they were still being processed by the Dubai authorities (with a difference of 12 cases). Thus the severity of those 12 cases was not available so the weighting was based on the cases with known severity and is only approximate.

The overall difference in severity between the two studies is better illustrated in the following figures based on reported severity.



**Figure 22: Severity comparison for all 2006 injury cases.**



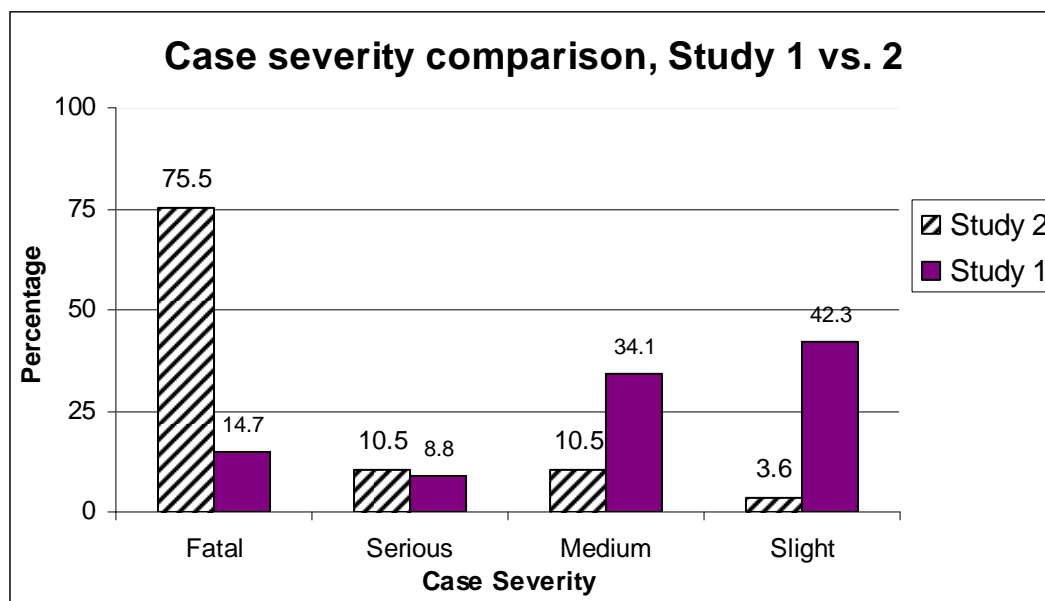


Figure 23: Severity comparison of studies 1 & 2 by reported police severity.

## 4.8 Estimating the effects of inaction

Using the available population data and a road safety performance guide that has remained constant over the years (fatality risk or fatality rate) it was possible to estimate the fatality or casualty situation for the coming years based on the growth seen in previous years and assuming that nothing is done. Factoring the projected crash savings into the estimated figures it can be shown how the traffic safety situation can be significantly altered if the countermeasures suggested were applied.

## 4.9 Limitations

### 4.9.1 Macro-level data and analysis

The crash forms kindly provided by Dubai Police show a number of fields of data that were not supplied but that would provide very useful insights into crash or injury causation especially if compared with other values (like comparing injury severity with seat belt use). In some cases these fields were completed but the confidence in their accuracy was low due to limited understanding of how they were coded. The key fields include: seat belt use, tyre condition, vehicle classification (type), year of manufacture and vehicle make. Other data was also supplied but contained many cases of uncoded variables (where there is an option to choose “other” as an option, and “other” was not supplied; a case in point is the field describing crash proximity to local



feature). Review of such data revealed “other” as the most frequent occurrence which was not useful in adding to the understanding of crashes. If these fields could be obtained they would add another dimension to understanding the problem. Some of the variables that contained missing or unspecified variables were explained by the RTA as being due to changes in database structure over the years which is natural as the database evolves. This useful feedback was received from the RTA following a presentation on the macroanalysis results to the staff concerned in Dubai as soon as the results were available. Between 1995 and 1997 the data collection media was different so when the old data was migrated to the new database the mapping of some variables was not complete resulting in a number of missing or unspecified values.

Further data that was supplied with the files but not used in this study included GIS (Geographical Information System) data that pin-pointed the location of a crash in XY coordinates. Efforts were made to import the data into software that could read it (ArcGIS was found to be installed on computer labs in the University campus). Despite numerous consultations with postgraduate researchers that had used such data before the efforts to locate crashes on a map of Dubai to try and visualise black spots and trends with different crash types did not succeed fully.

#### **4.9.2 Limitations with micro-level data and analysis**

Some limitations to the usefulness of the in-depth data were related to driver experience: the driver licensing date is useful for determining the experience of a driver, except in a few cases where the driving date is misleading. The system of licensing dictates a 2-year probational period (with annual renewal) after which a licence is granted with a validity of 10 years. In some cases if a licence is granted for 1 year only this was difficult to code in the database. In addition the licence issue date is not always representative of experience as the driver might have driven for many years outside Dubai before getting a Dubai licence.

Some variables that were collected in-depth were not analysed due to the limited projected usefulness of such analysis for the purposes of this work. Such variables include the report authoring date, which is useful to measure



the time between a crash occurring and the report being submitted, but it is subject to many other variables (like the workload level and the date of request of the report which can be any time from immediately after the crash to a few months after). This makes it a possible performance indicator for the efficiency of the investigation team but this is not a focus of this research.

The issuing authority of licences was mostly Dubai Police. Some instances of cases with no issue date were explained by deceased or injured drivers that did not present a licence or who did not hold a valid UAE licence. Since January 2008 licences were formally issued by the RTA instead of the Police. Ideally a database built from data collected by investigators trained to a similar (known) standard would be desirable but this is also outside the scope of the work.

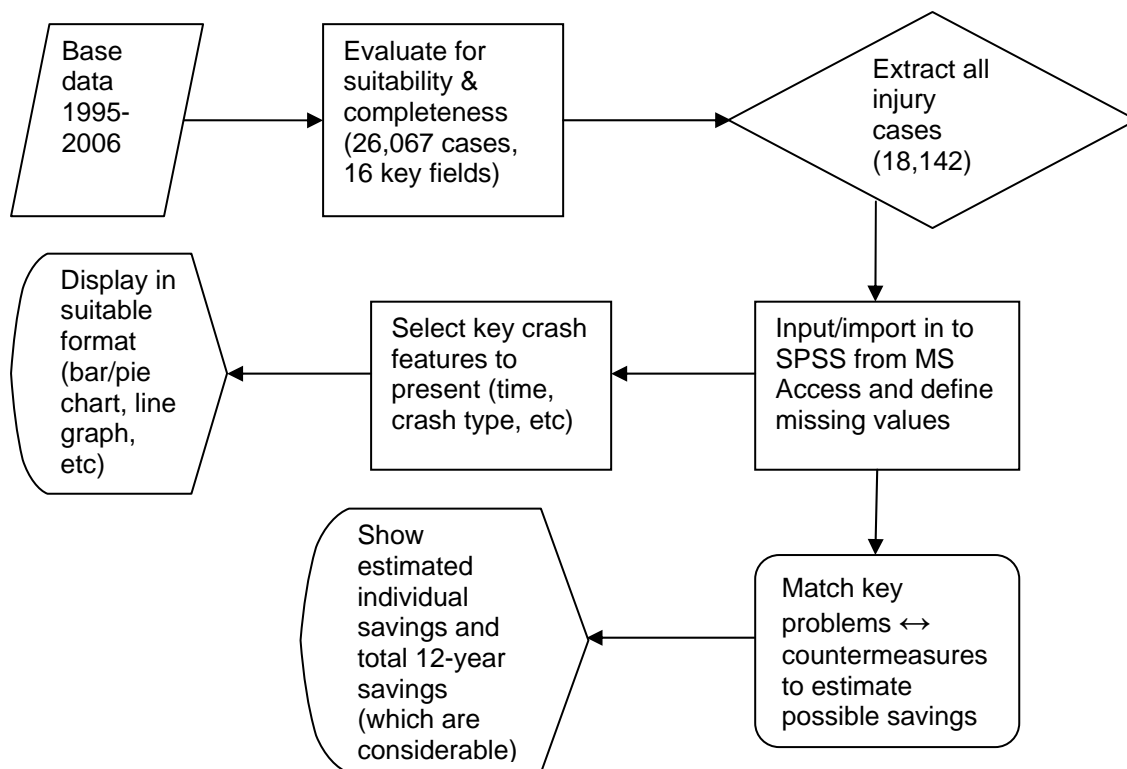
A lot of insight on the safety and involvement of different road users could be derived if this data was included along with injury levels. More information on vulnerable road users (pedestrians both young and old, drivers/occupants of small stature, cyclists, etc) could highlight the extent of their involvement and safety in the transport system compared to other users and other countries.

#### ***4.10 Summary***

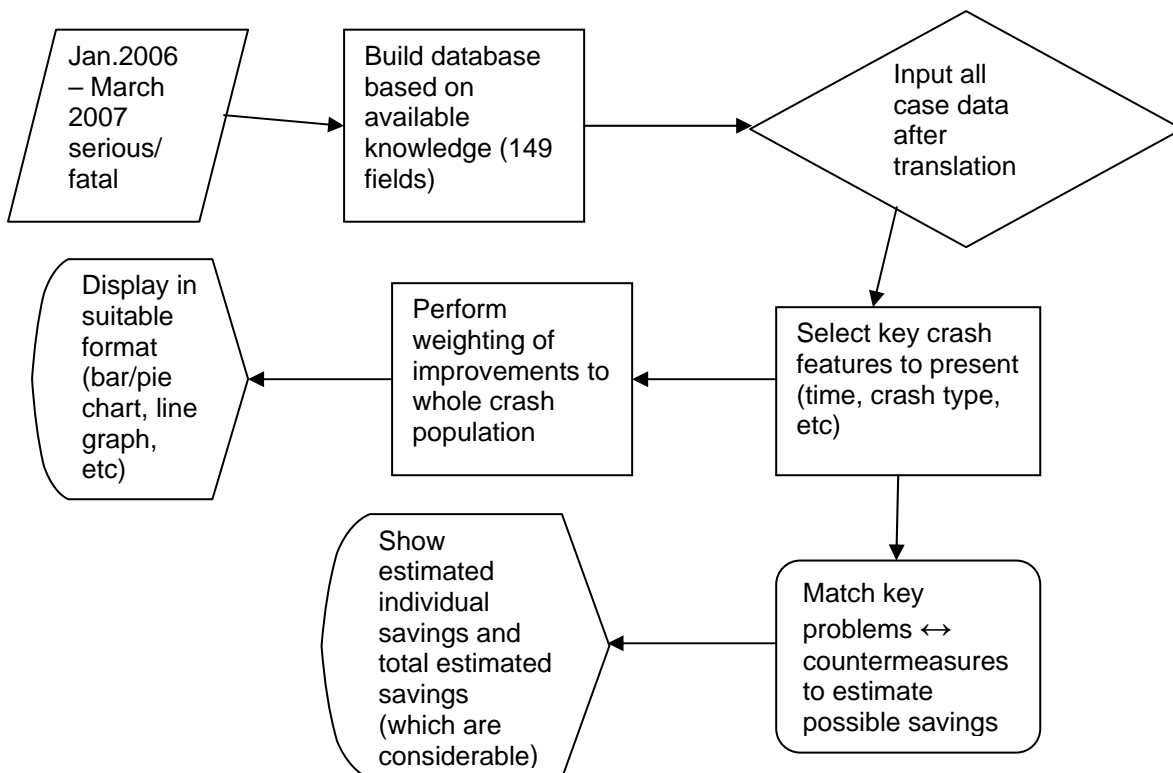
The collection and storage of crash data by the authorities in Dubai was described in some detail. This was based on observations of the author and numerous field visits to the Police and Road Authorities. A technical crash investigation division exists within the traffic police department that investigates crashes in more depth when required to do so by the Public Prosecutor or another police station or when there are unusual circumstances. They keep their own independent records of these investigations.

The following flowchart illustrates some of the key steps in data collection and processing undertaken as part of this research.





**Figure 24: Macro-analysis flowchart**



**Figure 25: Micro-analysis flowchart (300 cases)**



Initial data collection began with all the fatal crashes from one year (2005). This paved the way for collection of the complete twelve-year series of reported injury crashes held by the police and RTA containing basic injury-level information. In this way previously unanalysed data was obtained, then converted, translated and modified for original statistical analysis, taking care not to mis-interpret data due to missing or time-sensitive entries.

Further data of more depth was then collected for microanalysis. This included (in addition to the police report forms) formal case reports for court cases, scene plan drawings, photographs and the occasional coroner's report. This additional depth meant not as many cases could be collected because the level of detail was so great.

The base-level data used in macroanalysis was supplied in MS Access databases which required importing into MS Excel and SPSS for descriptive statistics and analysis. A total of 18,142 crash circumstance files were available along with 30,942 casualty files and 29,856 vehicle/driver files.

The given variables were reviewed using various methods (frequency counts, pie charts, bar and line graphs, etc) appropriate to the categories and nature of variables. This served to highlight major trends and issues like peak crash times and the top reported causes. Countermeasures were matched to major problem areas where they were not currently in use and were likely to be highly effective. The effectiveness of these countermeasures (as found in previous studies in the literature review) was used to calculate estimates of the expected benefits. Benefits were quantified in terms of crash or casualty reduction and financial savings. The total economic savings for a year and for the whole study period (twelve years) was calculated to quantify the immense gains achievable by the transfer of knowledge in this area.

The in-depth data collected for microanalysis was input on a custom-made SPSS database with as much relevant information as possible. This was piloted using a small number of cases to ensure the database made use of as much information available as possible. The sources of information (in addition to those in the base-level data) were formal court reports by a dedicated investigation team at Dubai police, scene plans, incident summaries from the police control room, photographs, witness statements and the occasional interview with an investigator who attended the crash. This



better understanding of crashes meant specific interventions could be used to address the most pressing issues as highlighted from the descriptive analysis of this data. The increased depth of data collected was used to assign up to eighteen preventative measures in one of three categories (human, vehicle and environment) to every individual case according to the available information. This procedure was verified for accuracy by having experienced crash investigators assess the factors independently. The choice of preventative measures was then narrowed down according to the most prevalent measures that applied to the greatest number of cases. These measures were then used as the basis for calculating expected benefits with greater accuracy as they were matched to individual cases then weighted to the overall population of crashes in one year.

The microscopic view provided by in-depth data broadly followed the analysis process for macroscopic data but avoided the repetition of similar results so only new information was reviewed. Specific interventions were matched to problems with better accuracy due to the greater level of detailed information available on the crashes. These interventions were chosen from the broad spectrum of countermeasure areas as used in the macroscopic study. The benefits of these interventions were again calculated for the given sample and for the whole population of crashes by weighting of crashes according to severity.

Projections of the future trends of road fatalities were made. They show what the situation might be like in a few years if the status quo was maintained and no new interventions or countermeasures were implemented.



## Chapter 5 Results: Analysis of vehicle crash data

### 5.1.1 Introduction: Macroscopic review of Dubai base-level data

Base-level data from cases of traffic crash reports from Dubai authorities for all available injury and fatal cases that occurred between 1 January 1995 and 31 December 2006 inclusive was reviewed. In-depth data from 2006 and 2007 crashes was reviewed in the next section. The results of the review as described in the methodology section are presented next. The results were presented according to the order of analysis performed which was normally according to the order of variables in the database.

### 5.1.2 Crashes by severity, day, time and date

#### 5.1.2.1 Crash severity

The severity of a crash in Dubai was recorded as one of four ratings according to the degree of injury of the most severely injured person involved. Medium severity is not used in the UK annual publication “Road Casualties Great Britain” which means some of the crashes recorded as slight and serious in the UK would belong to the Medium category as used in Dubai. This might explain the large difference in the percentage of slight-severity crashes between the two.

The most common type of injury crash rating was “slight” and the most rare injury crashes were “serious” ones (table 20). Differences in the definition and classification of crash severities between Dubai and the UK mean that these categories are not compatible with each other. However the differences are still of sufficient size to contrast the two regions in terms of the severity of road traffic crashes. One major difference is that a fatal crash in Dubai is recorded for a death that happens up to four months after the event (RTA, 2006a) while in the UK a 30-day definition is used.

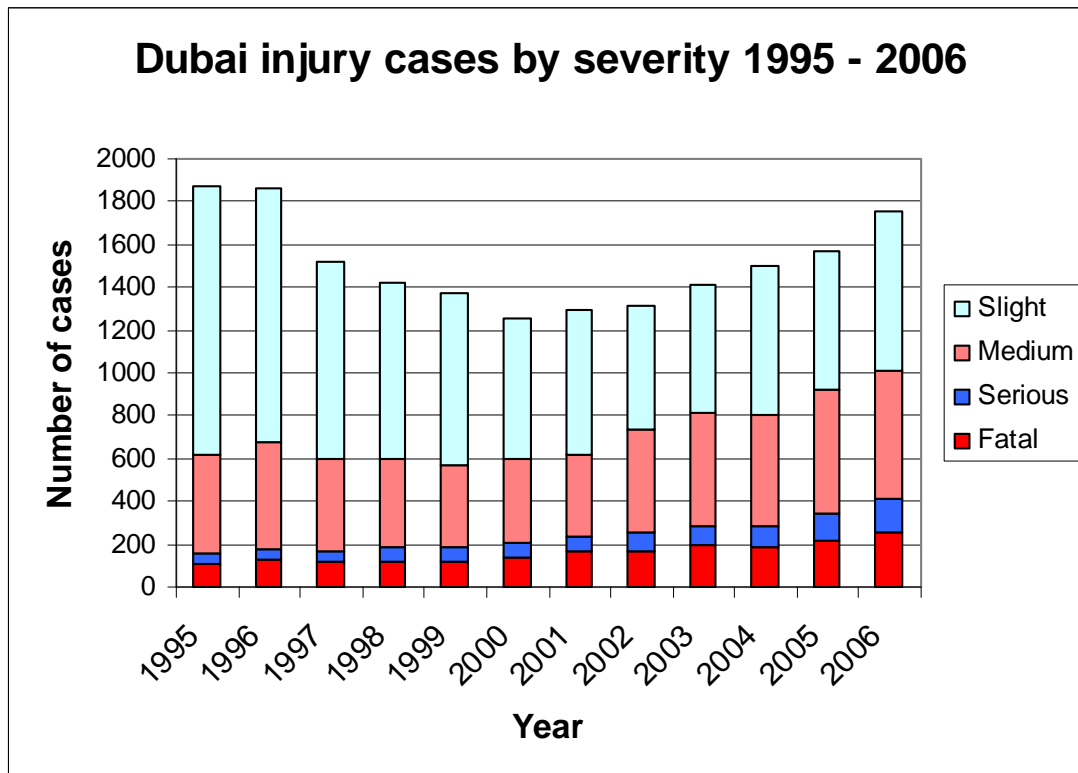
**Table 20: Crash severity, Dubai v. UK (2005)**

Crash severity	Dubai	Percent	UK*	Percent
Fatal	211	13.5%	2,913	1.4%
Serious	130	8.3%	25,029	12.6%
Slight	648	41.4%	170,793	86%
Medium	577	36.8%	-	-
Total	1566	100%	198,735	100%

\* Estimated. Source: DfT, 2006b; RTA, 2006b.



Injury crash numbers during the time under study vary considerably but there is no clear pattern of increase or decline as shown in figure 26. It is difficult to find any satisfactory external explanation for this variation, but it may be related to internal factors in the method of data gathering and recording, as no adopted definition of crash severities was found in Dubai while conducting the studies except as mentioned earlier. This is discussed in more detail in section 7.3.1.

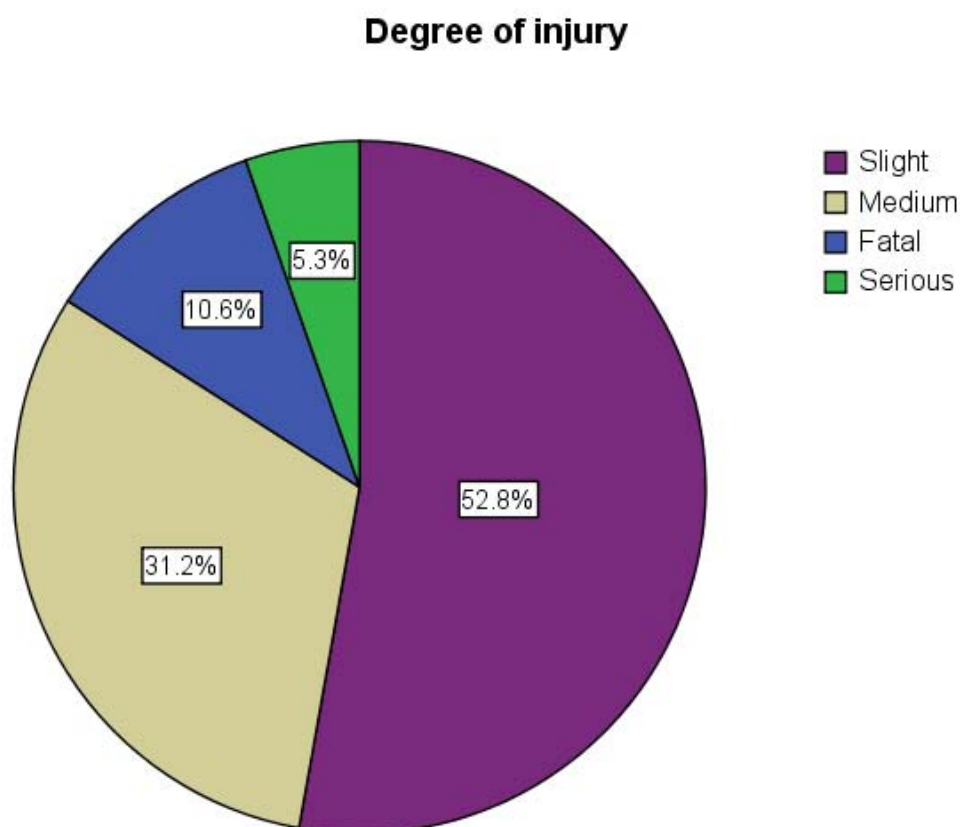


**Figure 26: Injury crash cases by severity in the Emirate of Dubai, 12 year series (Source: RTA and Police data).**

It is worth noting that slight-injury crashes first declined between 1995 to 2000 (from 1254 to 654) and then increased between 2001 and 2006 (from 674 to 743). However serious crashes have not witnessed any significant decline over the same time period instead trebling over 12 years (from 50 to 155). Fatal crash cases have more than doubled in the same period from 110 in 1995 to 259 in 2006. The proportion of fatal crashes (when expressed as a percentage of all injury crashes) was very high compared to the UK for the year 2005 (table 20). The incidence of non-fatal crashes, however, is more comparable to the figures for the UK (if medium and slight severities are considered together). The differences between years for all casualty levels were statistically significant ( $\chi^2 = 335$ ,  $df = 11$ ,  $p < 0.01$ ).



Almost half the injury crashes in the sample were of slight severity as rated by the police (figure 27). Medium, serious and fatal severity crashes make up the other half. This means that a large proportion of injury crashes have multiple consequences on those involved beyond the immediate injury. Such consequences include but are not limited to mental and physical health, financial condition and the effect on family and friends (Barnes, 2006). The proportion of fatal crashes in 2005 was more than the 12-year average while slight severity crashes were below the average.



**Figure 27: Primary degree of injury for all injury crashes, 1995-2006.**

### **5.1.3 Crashes by time of day with day of week**

Cross-tabulation of the time of day (3 hour intervals) with the day of week for the macroscopic sample results in the following table (21). The daily peaks occur exclusively in the afternoons and evenings between 1300 and 2100. Hourly peaks occur also in the afternoon and evening for most days except the weekends, which account for the most crashes in the early hours of the morning (Thursday, Friday and Saturday).

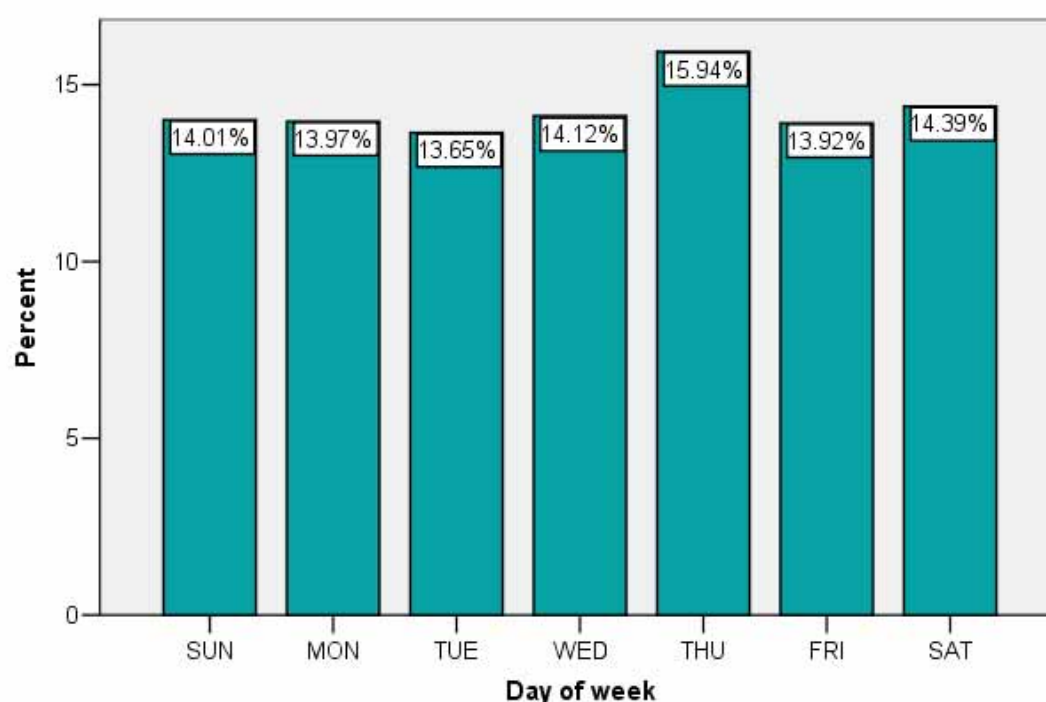


**Table 21: Cross-tabulation of time of crashes (by 3 hour interval) as a percentage with day of week, 1995-2006 sample.**

Time (hours)	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
01-03	6.7	7.4	7.3	8.1	9.2	13.5	8.6
04-06	6.3	6.1	5.7	6.2	6.6	10.8	5.9
07-09	12.7	13.4	13.0	12.9	10.4	7.3	13.3
10-12	15.0	13.5	13.4	13.1	13.1	7.7	13.5
13-15	15.8	<b>17.0</b>	16.9	15.9	13.9	11.9	<b>16.5</b>
16-18	14.3	15.3	<b>17.1</b>	15.7	15.8	<b>17.3</b>	16.1
19-21	<b>17.3</b>	15.0	15.0	<b>16.9</b>	<b>16.9</b>	17.0	14.8
22-24	11.9	12.2	11.5	11.2	14.0	14.4	11.3
Total %	100	100	100	100	100	100	100
Total cases	2534	2528	2478	2565	2897	2531	2609

Note: Maximum percentage for each day in **bold**.

**Dubai injury accidents by week day (1995-2006)**



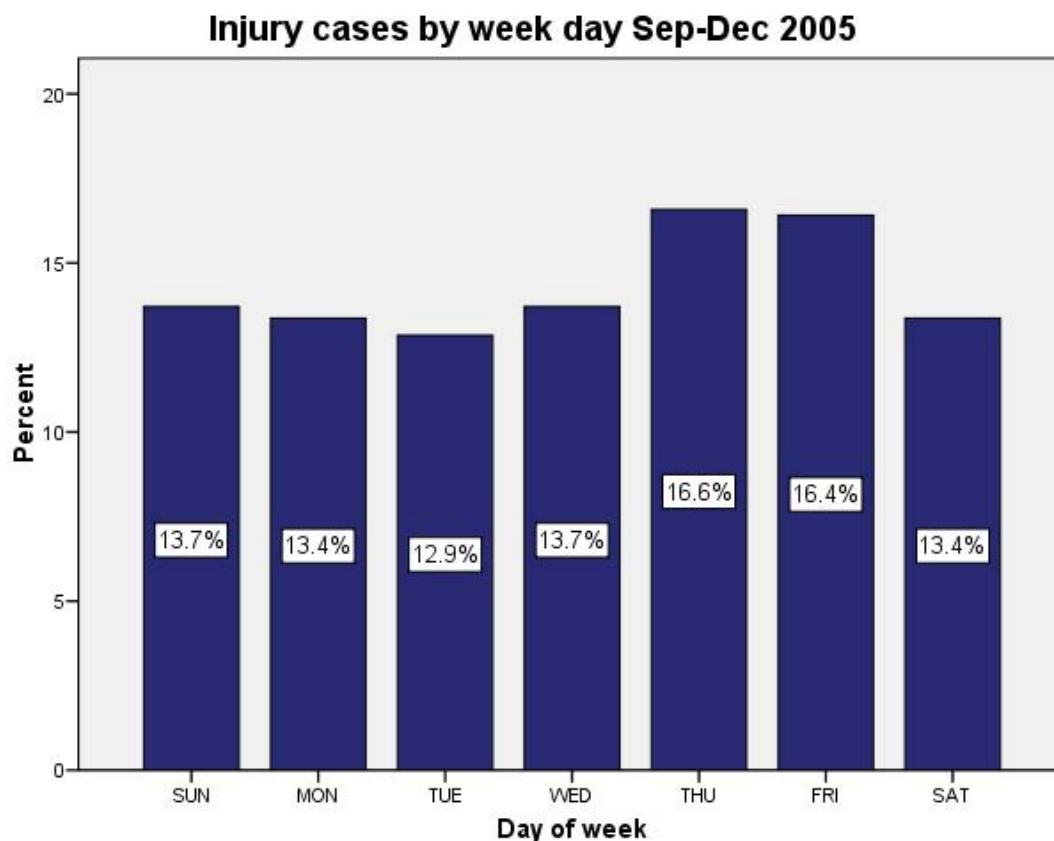
**Figure 28: Distribution of injury cases by day of week.**

Thursdays witness a disproportionately high number of crashes compared to the rest of the days of the week (figure 28) and the difference between the days is statistically significant ( $\chi^2 = 45.6$ ,  $df = 6$ ,  $p < 0.01$ ). The weekend in the UAE used to be Thursday (half day for some institutions in the private sector) and Friday for the large majority of the time period considered (with the exception of September – December 2006).



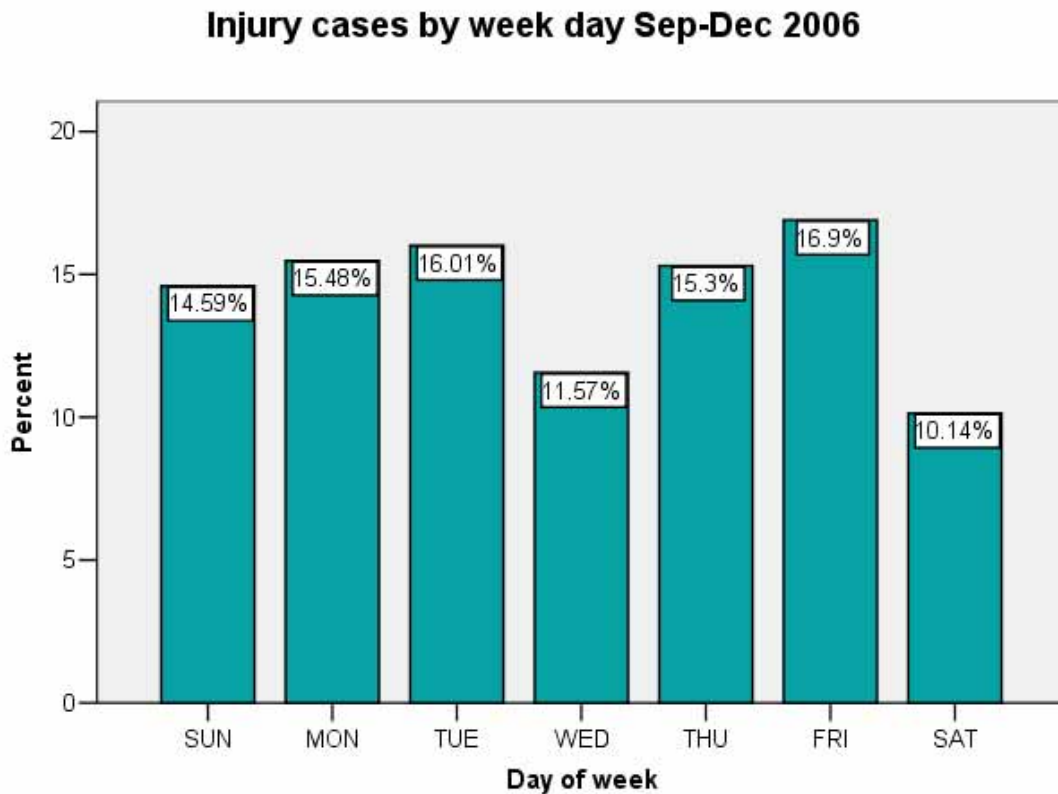
#### **5.1.3.1.1 Effect of weekend switch in 2006**

The weekend changed in September 2006 to Friday and Saturday for all government ministries and public departments. With further data it would be possible to see if the surge in crashes is a “weekend effect” that transfers to the new weekend or remains on Thursday and thus may be attributable to reasons other than weekend effects. The current availability of data is only for 4 months following the introduction of the new weekend arrangements so it was not comparable to the 11 years 8 months of data during which the old weekend arrangements were in effect. Instead the last four months of 2006 were compared to the same period of the previous year, 2005 (figures 29 & 30).



**Figure 29: Distribution of injury cases in the last 4 months of 2005 (the last year before Friday-Saturday weekend shift).**





**Figure 30: Distribution of 2006 injury cases (4 months) after Friday-Saturday weekend shift.**

Prior to the weekend shift Thursday and Friday had the most crashes. After the new weekend arrangements came into effect crashes were reduced on Wednesday, Thursday and Saturday while they increased for the remaining days of the week. Wednesday and Saturday now had the lowest number of crashes. The differences between weekdays from September to December 2005 were as expected for an equal distribution and not statistically significant as the Chi-squared statistic indicates the null hypothesis (of equal distributions) can be accepted at the lowest level ( $\chi^2 = 5.87$ ,  $df = 6$ ,  $p < 0.01$ ). However the Chi-squared statistic for the September to December 2006 sample indicates a significant difference between week days ( $\chi^2 = 14.96$ ,  $df = 6$ ,  $p < 0.05$ ).

#### **5.1.3.2 Crashes by month**

Injury crashes according to the month of occurrence were also studied and these are shown in figure 31. Crashes appear to be less frequent during the height of summer (months 7, 8 and 9) and most frequent during spring and winter (3, 4 and 10-12). The heat experienced during summer-time in Dubai



and the region might drive pedestrians (who make up the largest share of casualties) to shelter from the heat outside, thus reducing their exposure to traffic. The heat might also deter other road users from going out resulting in a decrease in activity. Similarly cooler months might have the opposite effect. Differences between the months were statistically significant and not as would be expected from an equal distribution ( $\chi^2 = 113$ ,  $df = 11$ ,  $p < 0.01$ ).

### Injury accidents by month, 1995 - 2006

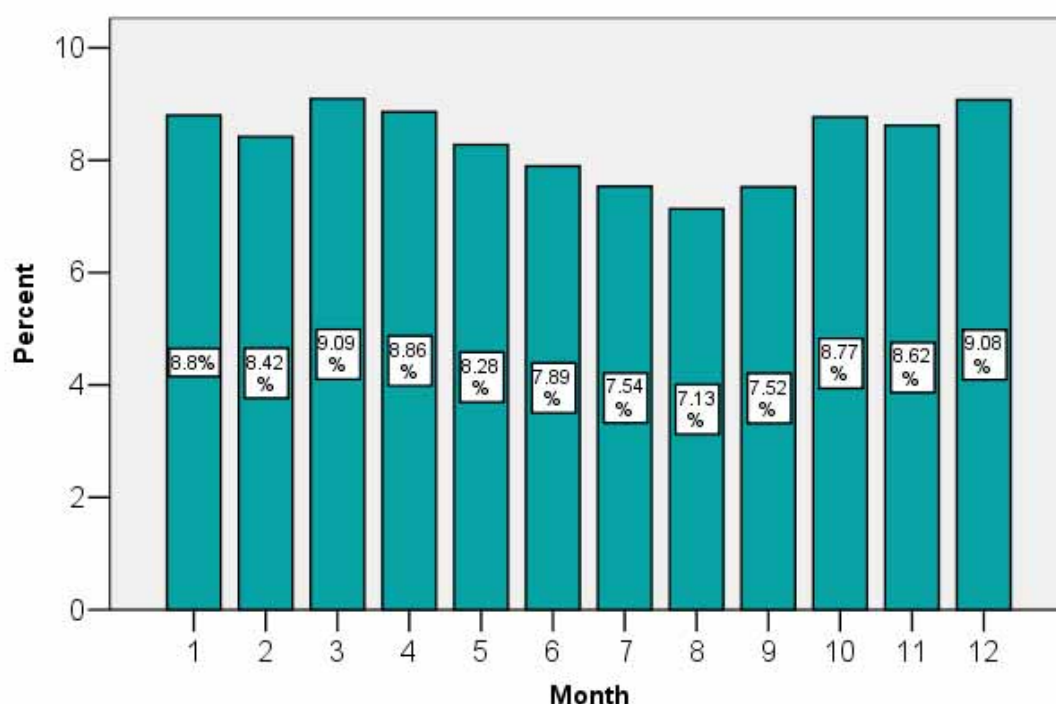


Figure 31: Injury cases by month of the year, 1995- 2006 (1=January).

Injury crashes cross-tabulated by month and time (3-hourly intervals) show the greatest number of crashes to be concentrated in the afternoon and evening periods in all months of the year.

Table 22: Injury crash numbers (1995-2006) by month and hour of day (3-hour intervals)  
Note: Highest category for month is in **bold**.

TIME/Month	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
01-03	10.0	9.9	9.1	7.8	7.2	9.3	10.1	9.8	8.5	7.2	6.6	9.3
04-06	6.1	6.2	7.0	6.8	6.3	7.5	8.2	7.8	8.6	5.9	6.0	6.0
07-09	11.2	12.8	11.6	10.6	12.8	12.1	12.1	11.6	12.3	11.5	13.0	10.8
10-12	13.3	12.7	12.3	13.8	13.7	13.3	13.2	12.2	11.8	11.6	13.3	11.8
13-15	14.9	<b>15.2</b>	14.2	<b>17.4</b>	15.1	13.5	13.5	14.9	<b>16.5</b>	17.6	15.2	<b>16.3</b>
16-18	<b>17.3</b>	15.2	<b>17.2</b>	15.4	15.9	15.7	15.2	14.3	14.8	16.8	16.9	15.9
19-21	15.2	15.2	15.8	15.1	<b>15.9</b>	<b>16.0</b>	<b>16.0</b>	<b>17.8</b>	15.9	<b>17.9</b>	<b>17.1</b>	<b>16.3</b>
22-24	12.0	12.9	12.6	13.1	13.1	12.6	11.7	11.7	11.6	11.7	11.8	13.5
Total %	100	100	100	100	100	100	100	100	100	100	100	100
Total(cases)	1594	1543	1653	1606	1500	1426	1359	1289	1361	1588	1559	<b>1664</b>

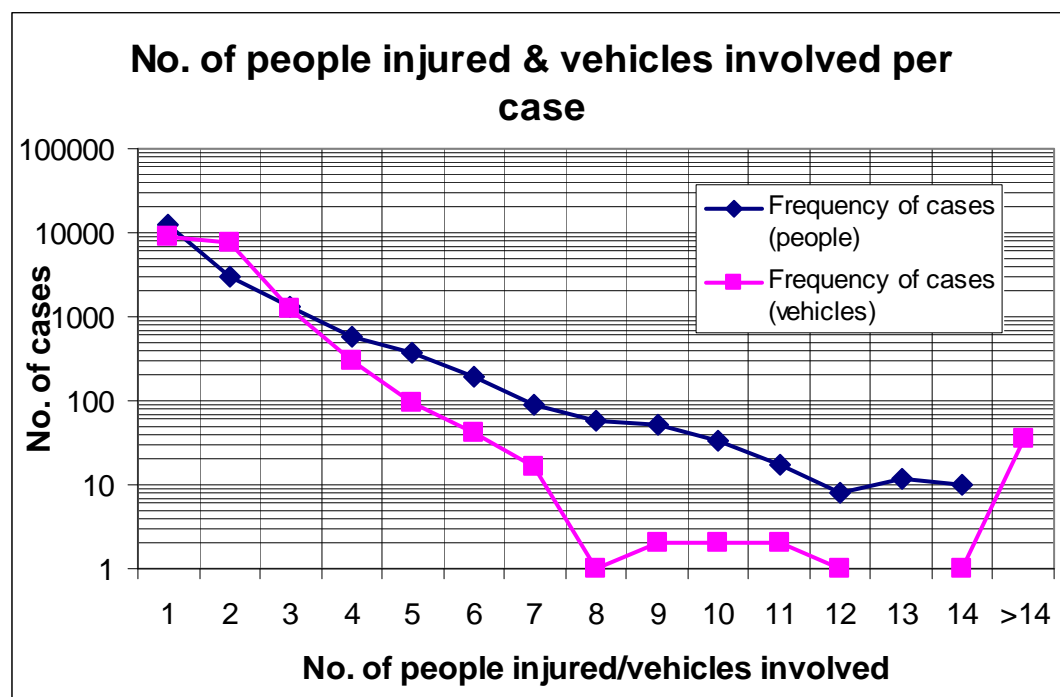


Early morning crashes appear most frequent in the winter months (December – March).

#### 5.1.4 Crashes by location and number of parties involved

##### 5.1.4.1 Crashes by number of people and vehicles involved

As seen in figure 32 single-vehicle injury crashes are the most frequent (8,843; 49%) followed closely by 2-vehicle crashes (7,593; 42%). Most cases have one injured person (12,313; 68%). This was not far from official statistics for Dubai in 2007 (Dubai Police, 2008a) which show that 2-or-more-vehicle crashes made up 48% of the crashes for that year.



**Figure 32: Number of vehicles and injured people involved in injury crash cases.**

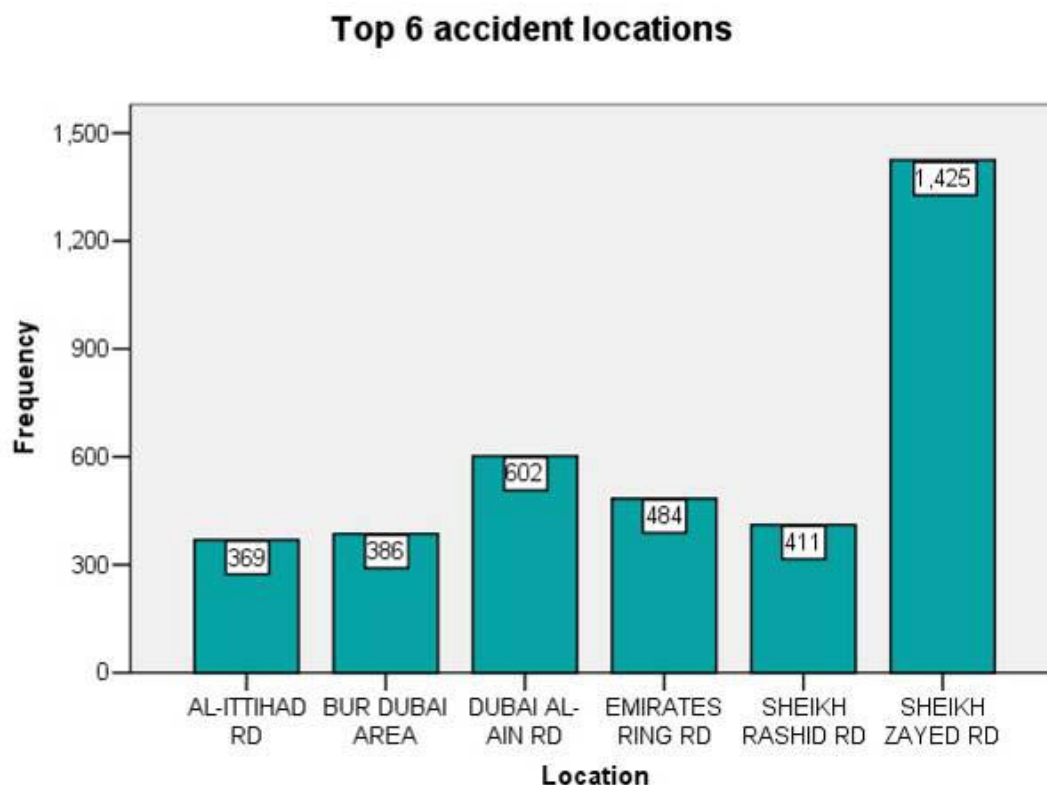
Crashes with a large number of people injured and vehicles involved are rare and few of them occurred in adverse weather conditions (fog or wet road surface) most occurring on dry roads and in fair weather.

The mean number of vehicles involved per case is 1.65 and the mean number of people injured per case is 1.71. Only one case involved 14 vehicles. However 45 cases involved 14 or more people which indicates that a heavy vehicle (bus or coach) carrying many passengers was implicated in a crash.



#### 5.1.4.2 Crashes by location

Location classification in crash reports is by road and area name and this provides an imbalanced opportunity for assessment as roads differ by length, type, configuration and traffic exposure. Bearing this in mind half the top 6 locations (figure 33) were motorways typically well illuminated and well maintained. Unfortunately these did not include facilities for vulnerable road users like pedestrians or cyclists except that all new projects since the creation of the Roads and Transport Authority in 2006 were supposed to include such provision (RTA, 2006c). One non-road location shows up in the top 6, Bur Dubai, and with reference to an old map of Dubai (Dubai Municipality issue, *circa* 1995) this is shown as part of the old market area of Dubai which has very heavy pedestrian traffic and dense vehicle traffic.



**Figure 33: Injury crash frequency by location (top 6 locations), 1995 - 2006.**

Another possibility which must be borne in mind is that this area description was used for new or unnamed streets or when the street name was unknown. “Bur Dubai” is also a generic term for the western part of Dubai separated by the creek from the east side known as Deira. To show that this is not the case with the other top locations the same analysis run on all 6 locations shows



pedestrian collisions as the fourth most common type after head-to-tail, rollover and stationary object impacts. Some of the locations can be seen more clearly in the map in section 2.3.

**Table 23: Cross-tabulation of crash type by location for top 6 locations (note: numbers after location indicate position on the map in section 2.3).**

<b>Crash type/location</b>	<b>AL-ITTIHAD RD</b>	<b>BUR DUBAI AREA ②</b>	<b>DUBAI AL-AIN RD ①</b>	<b>EMIRATES RD</b>	<b>SHEIKH RASHID RD ③</b>	<b>SHEIKH ZAYED RD ④</b>
Stationary object impact	59	27	136	64	71	291
Pedestrian collision	53	<b>102</b>	14	77	80	172
Rollover	34	78	<b>246</b>	<b>130</b>	41	273
Impact with animal	0	12	18	0	0	0
Falling off moving vehicle	1	12	0	1	0	5
Head to side impact	11	19	7	11	4	19
Hit while turning	4	24	1	2	12	11
Side to side	73	48	38	84	62	206
Head to tail	<b>124</b>	29	141	110	<b>134</b>	<b>439</b>
Head on	9	37	7	5	12	11

Cross tabulation of the top crash locations by crash type show the most common crash types at different locations (in bold). In the single low-speed location (Bur Dubai) pedestrian collisions were most evident. In high-speed roads, rollovers and head-to-tail crashes were most evident.

**Table 24: Injury rates on the main highways in Dubai**

<b>Road name</b>	<b>Length (kilometres)</b>	<b>Injury crashes/km</b>
Sheikh Zayed Rd	96 (48 each way)	14.8
Dubai Al-Ain Rd	120 (60 each way)	5.0
Emirates Rd	134 (67 each way)	3.6

The lengths of the three top locations were known (Dubai Police, 2004) and the injury crash rate per kilometre was calculated (table 24) for the time period under study (lengths of other roads were not known). Sheikh Zayed Road leads in the number of injury crashes per kilometre despite being the shortest of the three roads under comparison. It is also the closest road to the coast and the centres of urban concentration in Dubai and neighbouring emirates. Being the closest of the main highways to the coast means it is the shortest express route to cross Dubai when coming from other emirates. Traffic



exposure might reasonably be expected to be higher than the two other roads, which might subsequently affect the crash rate per kilometre.

### 5.1.5 Crashes by causation and speed limit

#### 5.1.5.1 Crash causation

Table 25 summarises the 31 crash causes used on the police crash report form (Appendix B). These were recorded by the attendant police officer based on his judgement and training.

**Table 25: Crash causation as reported by the police**

Cause	No. of cases with this cause	Percentage
Lack of consideration for other road users	4849	26.77
Violating speed limit	2287	12.63
Entering carriageway without checking for traffic	2047	11.30
Following too close to vehicle in front	1779	9.82
Lack of lane discipline	1561	8.62
Jumping a red light	1418	7.83
Carelessness and lack of attention	1214	6.70
Sudden change of direction	764	4.22
Dangerous driving	591	3.26
Effect of taking alcohol	404	2.23
Tyre blow out	288	1.59
Reversing without due care	245	1.35
Going against traffic	146	0.81
Other	124	0.68
Wandering animal	86	0.47
Incorrect overtaking	82	0.45
Wrong turn	65	0.36
Failing to give way	56	0.31
Doors not securely closed	30	0.17
No knowledge of driving and no licence	19	0.10
Effects of natural or environment factors	16	0.09
Shedding of load	10	0.06
Excess loading	9	0.05
Entering a no-entry zone	8	0.04
Tiredness and sleep	5	0.03
Trailer separation	3	0.02
Presence of obstacles in road	2	0.01
Speed humps	2	0.01
Unroadworthy vehicle	1	0.01
Faulty road	1	0.01
Effect of taking drugs	1	0.01
<b>Total</b>	<b>18113</b>	<b>100</b>

By far the most prominent recorded cause is the lack of consideration for other road users (26.8%) followed by violating the speed limit (12.6%) and entering the carriageway without checking for traffic (11.3%). The first cause



is open to interpretation as it was not known whether this lack of consideration is intentional or unintentional (a separate cause of “dangerous driving” is available on the form) while the other two causes were more precise in description.

Further down the list a couple of factors pertinent to the environment and surroundings of Dubai were tyre blow outs (due to elevated summer temperatures when air temperatures can reach 50°C, road surface temperatures are even higher) and wandering animals (due to highways sometimes cutting through virgin desert that is used by camel herds for feeding).

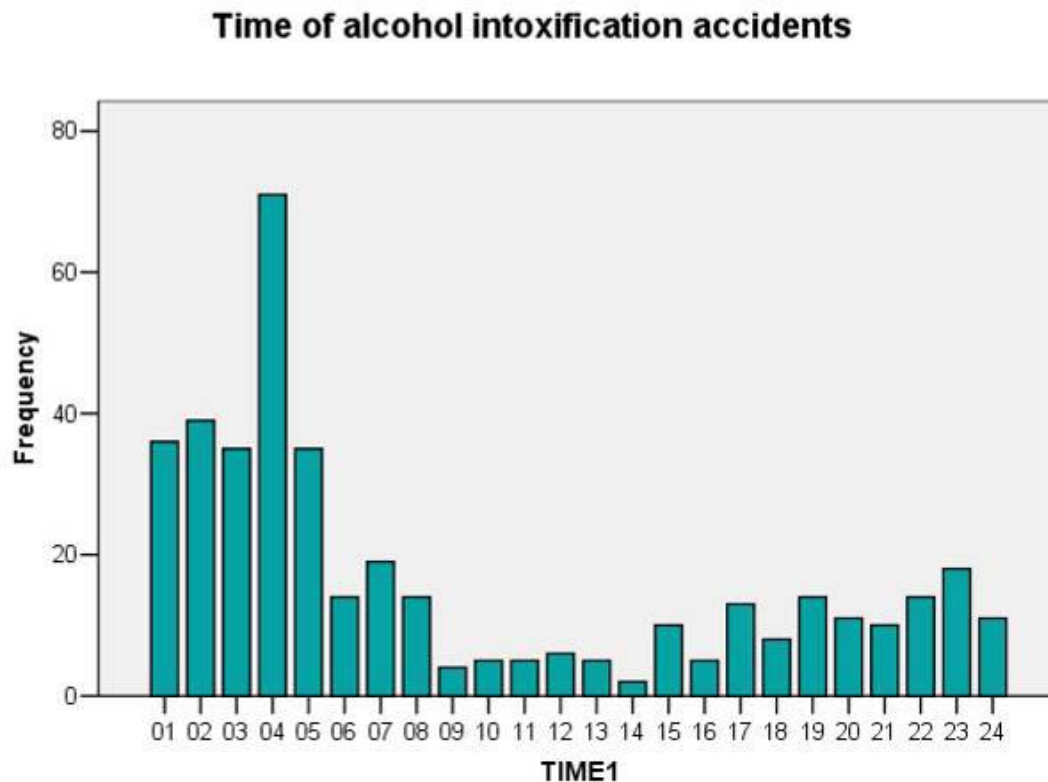
**Table 26: Crash causation - 2006 cases only**

Cause	No. of cases with this cause	Percentage
1 Lack of consideration to other road users	519	29.54%
23 Effect of taking alcohol	202	11.50%
3 Entering carriageway without checking for traffic	183	10.42%
4 Following too close to vehicle in front	157	8.94%
6 Violating speed limit	146	8.31%
5 Jumping a red light	133	7.57%
2 Lack of lane discipline	118	6.72%
32 Sudden change of direction	87	4.95%
7 Dangerous driving	58	3.30%
34 Other	57	3.24%
15 Carelessness and lack of attention	38	2.16%
19 Reversing without due care	15	0.85%
8 Tyre blow out	12	0.68%
17 Going against traffic	11	0.63%
10 Failing to give way	5	0.28%
16 Wrong turn	5	0.28%
18 Incorrect overtaking	4	0.23%
30 Wandering animal	4	0.23%
28 Shedding of load	2	0.11%
13 Doors not securely closed	1	0.06%
<b>Total</b>	<b>1757</b>	<b>100%</b>

The effect of alcohol intoxication as a causative factor is not very clearly defined from the earliest data but from the latest data in 2006 causation analysis shows a different result to the 12-year picture (table 26); alcohol-intoxication was in fact the second leading cause of injury crashes in 2006. Compared to the 2006 data publication by authorities (RTA, 2007) the top causes occur in the same order and in similar percentages. Any minor difference might be due to more complete data received by the authorities.



There was a short unusual series of crashes (27) with the cause listed as “alcohol intoxication” from 1995 to 2003 (none reported at all in 2002) then from 2004 to 2006, reporting appeared to improve. That cause made up the majority of cases (377 out of the total 404).



**Figure 34: Time of occurrence of crashes caused by alcohol intoxication (404 cases), 1995-2006.**

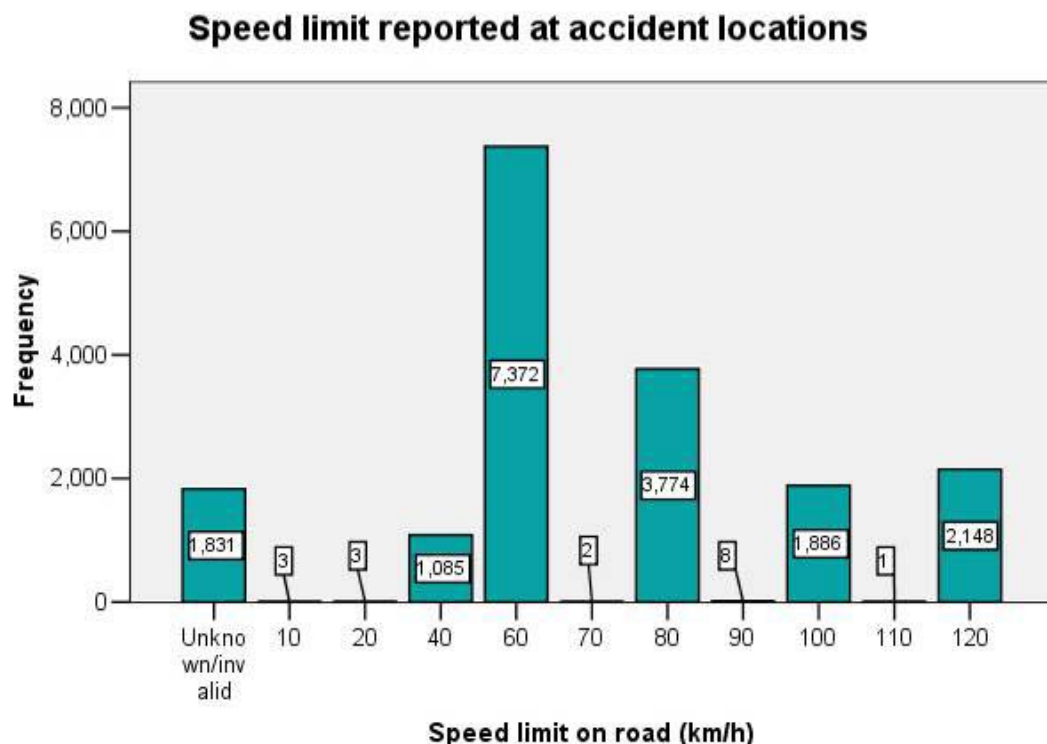
Analysing the time of occurrence of these crashes shows a rise in the early morning period (1 – 5 am) and a distinct peak at 4 am (figure 34). This peak was also found in 2007 police data (Dubai Police, 2008a) for both injury and non-injury (serious property damage) crashes. Informal enquiries led to an association between this 4am peak and closing times of alcohol-serving venues at around 3am.

#### **5.1.5.2 Speed limits at crash sites**

Roads with a speed limit of 60 km/hr (37.5 mi/hr) accounted for the largest number of injury cases (40.6%, figure 35) followed by roads with higher speeds (80 and 120 km/hr, 32.6% combined). There was a large number (~10%) of invalid reported speeds (2, 3, 4 etc) and missing values (no entry in form) which indicates that reporting of speeds can be improved significantly.



With more advanced techniques that require GPS (Global Positioning System) coordinates to be reported on the crash form it will enable the validation of speeds in a more accurate manner at the RTA (Roads and Traffic Authority) where the road speed limits and class are set in the first place. Speed limits at crash sites were not reported in official data publications by the Police and RTA.



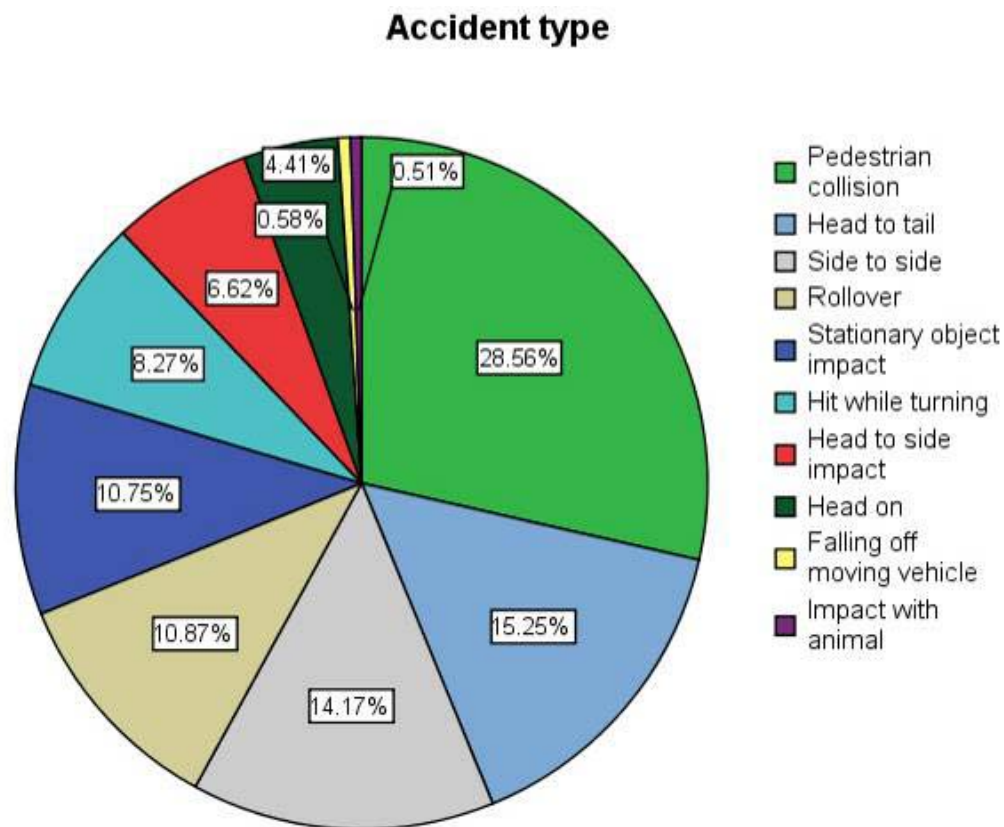
**Figure 35: Speed limits reported on sites of injury crashes, 1995-2006.**

### **5.1.6 Crashes by type**

Crash types were recorded as any of 10 general categories as shown in figure 36. Pedestrian crashes were the leading type prevalent followed by head-to-tail collisions and side-to-side or side-swipe collisions. Together these three account for over half the crash types occurring in the study period. Other significant types (with more than 10% representation) were rollovers and stationary object impacts. The data released by authorities for the year 2006 only (RTA, 2007) shows a different ranking of crash types as it uses a different classification. All vehicle-to-vehicle collisions were grouped together which makes them the most prevalent crash type followed by pedestrian collisions. If the vehicle-to-vehicle collisions in the preceding pie chart were



grouped together they will also surpass the percentage of pedestrian collisions but then the detail of the vehicle collision crash types will be lost.



**Figure 36: Injury crash classification by type, 1995-2006.**

#### **5.1.6.1 Pedestrian crashes**

The single crash type that occurred most often was the pedestrian collision followed by the head-to-tail scenario. In later years the percentage share of pedestrian crashes reported was higher than the 12-year average found from the data. This indicates that this class of crashes was increasing in proportion to overall crashes reported.

Most injuries from pedestrian crashes were rated as being of slight severity but a significant proportion (21%) were serious and fatal. From looking at the most recent official data for the proportion of serious and fatal pedestrian injuries the severity of these crashes is increasing: 28% in 2006 (RTA, 2007) and 29% in 2007 (Dubai Police, 2008a). This was consistent with the assumption that low-severity injuries occur on low-speed roads and high-severity ones occur on high-speed roads. This was supported by analysis of



the severities of the top high-speed location (Sheikh Zayed Rd, over 50% of injury crashes are fatal) and the top 3 low-speed locations (Bur Dubai area, Beni Yas St, Khalid Ibn Al-Waleed Rd, over 50% of crashes were slight). To put things in perspective the top 4 locations account for only 10% of all pedestrian crashes and a large number of crash locations were named only once in the database hence they are the site of only one pedestrian injury crash in 12 years.

### 5.1.7 Crashes by road layout and proximity to landmarks

#### 5.1.7.1 Road layouts and excessive crashes on dual carriageways

The UAE in general and Dubai in particular benefit from a modern road system mainly built around the travel needs of motorised traffic until recently when consideration has been given to other vulnerable road user types as well (RTA, 2006c). Most injury crashes occur on dual-carriageways (highways) with three lanes on each side followed by single-carriageways with one lane on each side followed closely by dual carriageways with two lanes on each side.

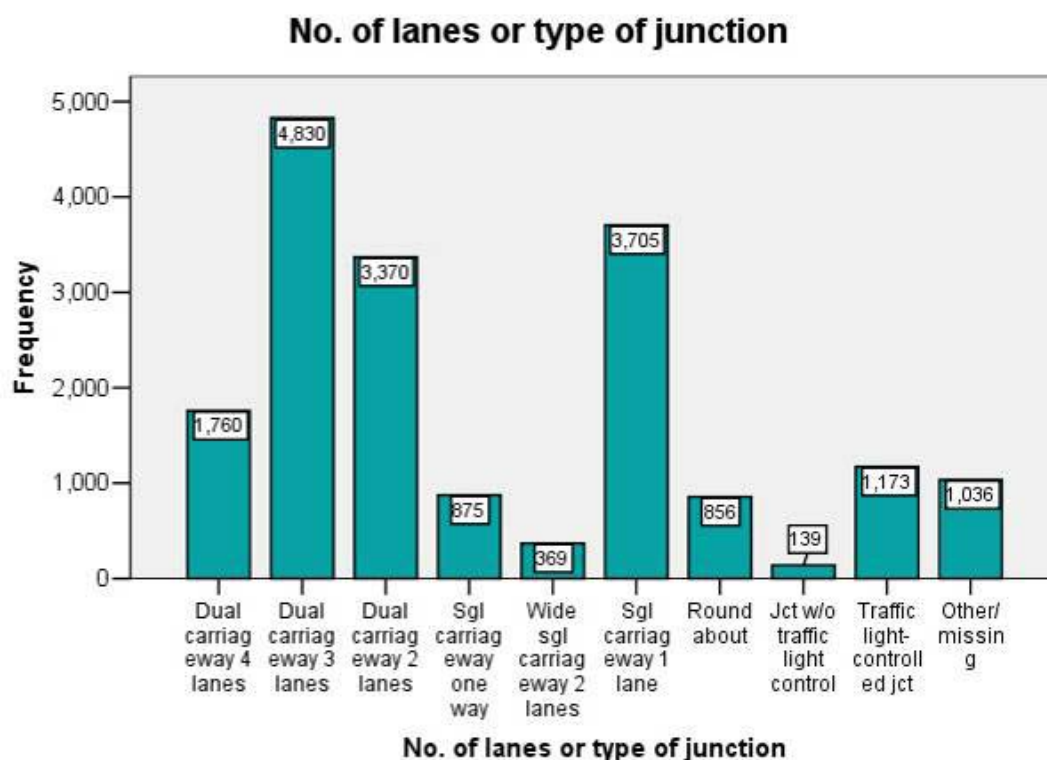


Figure 37: Crash occurrence by road layout, 1995-2006.

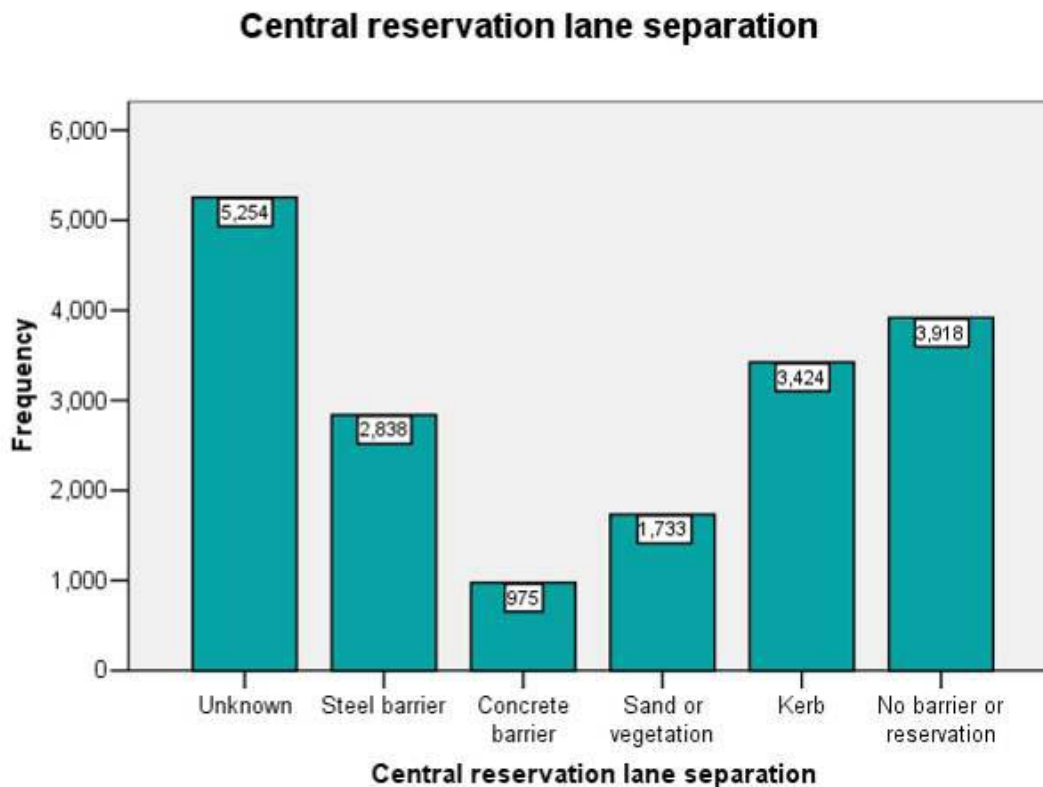


In the UK highways or motorways (dual carriageways with 2 or more lanes in each direction where the national speed limit of 70mph applies) were considered to be some of the safest roads with the least number of fatalities occurring on them (DfT, 2006b). In Dubai it is the opposite with 4 of the top 6 crash locations being motorway-equivalent (2 or 3 lane high speed dual-carriageways) and only one being in a known pedestrian area. Pedestrian and head-to-tail crashes are almost equally evident as the most common collision types on dual carriageways with three lanes in each direction. The speed limits on such roads where the collisions took place are split between 120kph and 60kph, with the majority having the latter as a speed limit. This might explain the presence of large numbers of pedestrians as a 3-lane dual carriageway with a 60kph speed limit is certainly not a motorway. Pedestrian collisions are the most evident collision type on single-carriageway roads which generally had lower speed limits.

#### **5.1.8 Central reservations, barriers and lane separation**

The presence and type of barrier that separates traffic in opposite directions was noted on the crash form (figure 38) however this seems to be a new development as the majority of cases do not have this encoded. Of the encoded cases no barrier was present in the majority of cases. The wording (in Arabic) of the field makes it clear the field is not for barriers at the side of the road. This might be equally important to record if a vehicle hits a solid object not between the opposing lanes of traffic but outside the carriageway. This data was not otherwise published by authorities in Dubai.





**Figure 38: Presence and type of central reservation or lane separation.**

### **5.1.9 Environmental conditions (lighting, road markings and weather)**

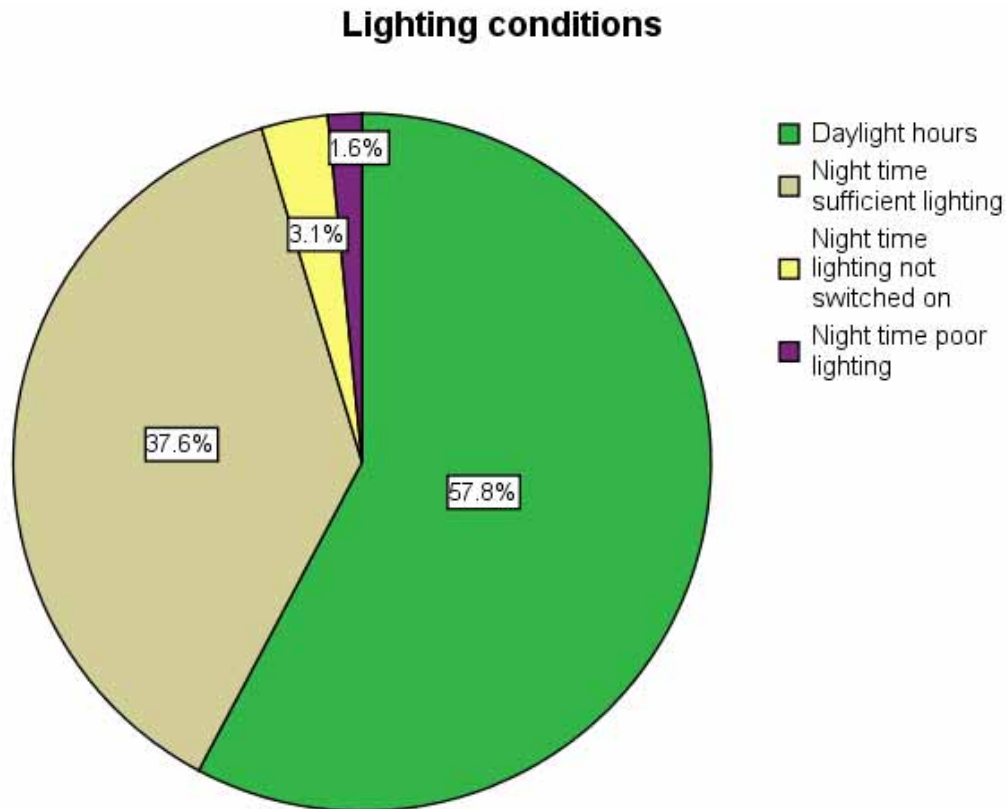
#### **5.1.9.1 Light conditions**

The hours of daylight vary during the year from 11 in winter to about 13.5 in the summer (figure 39). The lighting conditions listed on the police form were translated as:

- Daylight hours (crash occurred when daylight was sufficient for good vision).
- Night time – sufficient lighting (crash occurred at night but in an area where lighting was sufficient for good vision).
- Night time – poor lighting (crash occurred at night in a lit area but the lighting was not sufficient for good vision).
- Night time – lighting not switched on (crash occurred at night in darkness as no lighting was in use).

“Poor light” conditions and “no light” were very rare occurrences in injury crashes together accounting for less than 5% of the cases presented. 2006 data (RTA, 2007) showed that daylight crashes account for 55% of the total which is within 3% of the 12-year series.





**Figure 39: Lighting conditions in injury crashes.**

#### **5.1.9.2 Road markings and signs**

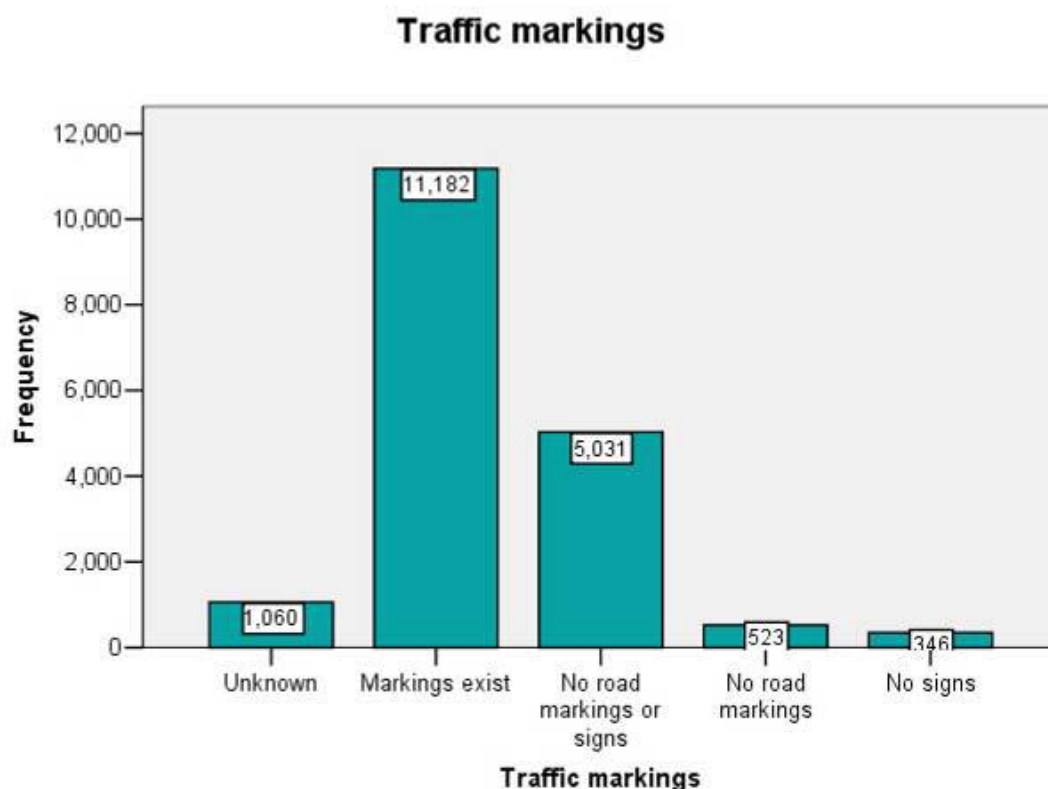
Signage and road markings at the site of the crash were noted on the police form according to one of four situations (translated):

- Markings exist: markings (showing direction of travel or priority for instance) are painted on the road.
- No road markings or signage: no road markings or road signs exist at the location.
- No road markings: no road markings exist at the location.
- No signage: no road signs exist at the location (like STOP signs or give-way inverted triangles).

Road markings and signs existed at the majority of sites as shown in figure 40 although about a third of crash sites do not have them. It was not specified in the data whether the markings or signs are out of view, vandalised, or markings washed out, or there were none to begin with. Data for these measures is not published by Dubai authorities thus comparison was not possible. In the UK OTS study for the first 3 years (Lenard & Hill, 2004)



pedestrian crashes were seldom affected by inadequate signing at the site of the crash with one exception.



**Figure 40: Traffic markings and signage at crash sites.**

### 5.1.9.3 Weather conditions

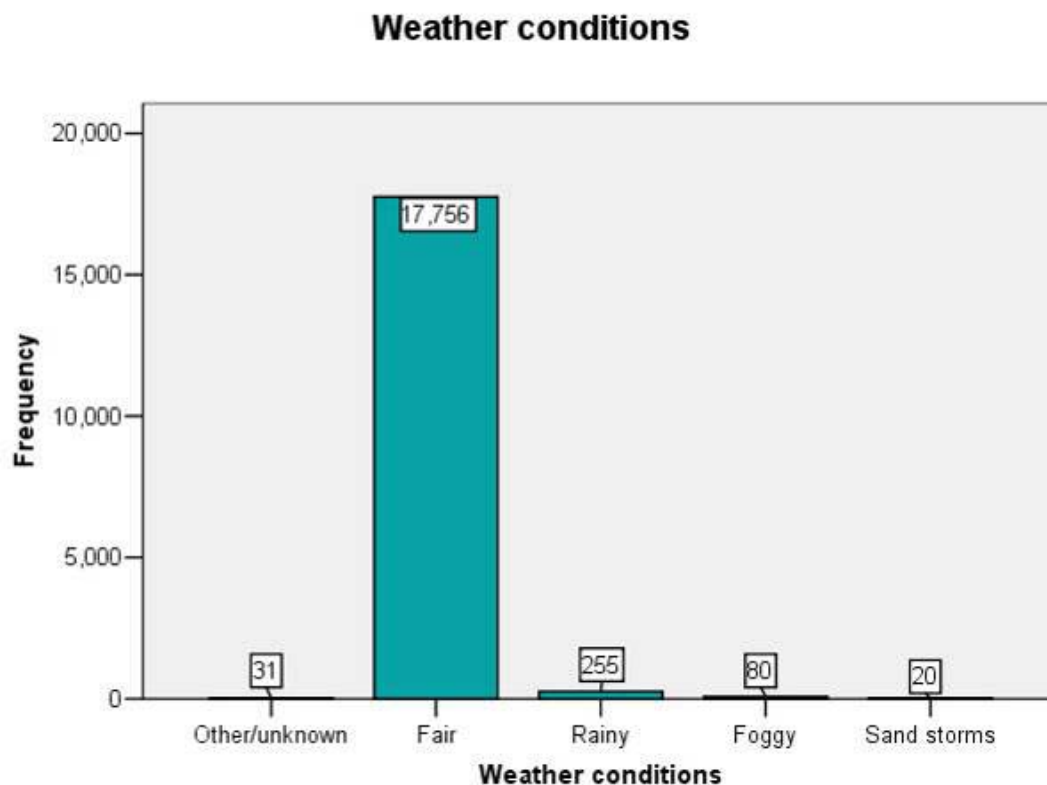
The state of weather at the time of the crash (figure 41) is noted on police forms as one of five translated below:

- Fair: fine and dry with good visibility.
- Rainy: rain was falling at the time of the crash.
- Foggy: fog had affected visibility (not further specified).
- Sand storms: sand storms were evident in the area of the crash (possibly affecting visibility, stability from crosswinds and the road surface from sand deposits).
- Other: a field to specify if other conditions other than those above exist. This was not provided as part of the data as it was manually encoded on the crash form and difficult to encode on the electronic database.

Weather conditions were fair for the vast majority of cases (>98%) which was expected given the hot and precipitation-less climate that prevails for most of



the year. This was similar to the 2007 cases (Dubai Police, 2008a) where 99.5% of crashes were recorded in fair conditions.



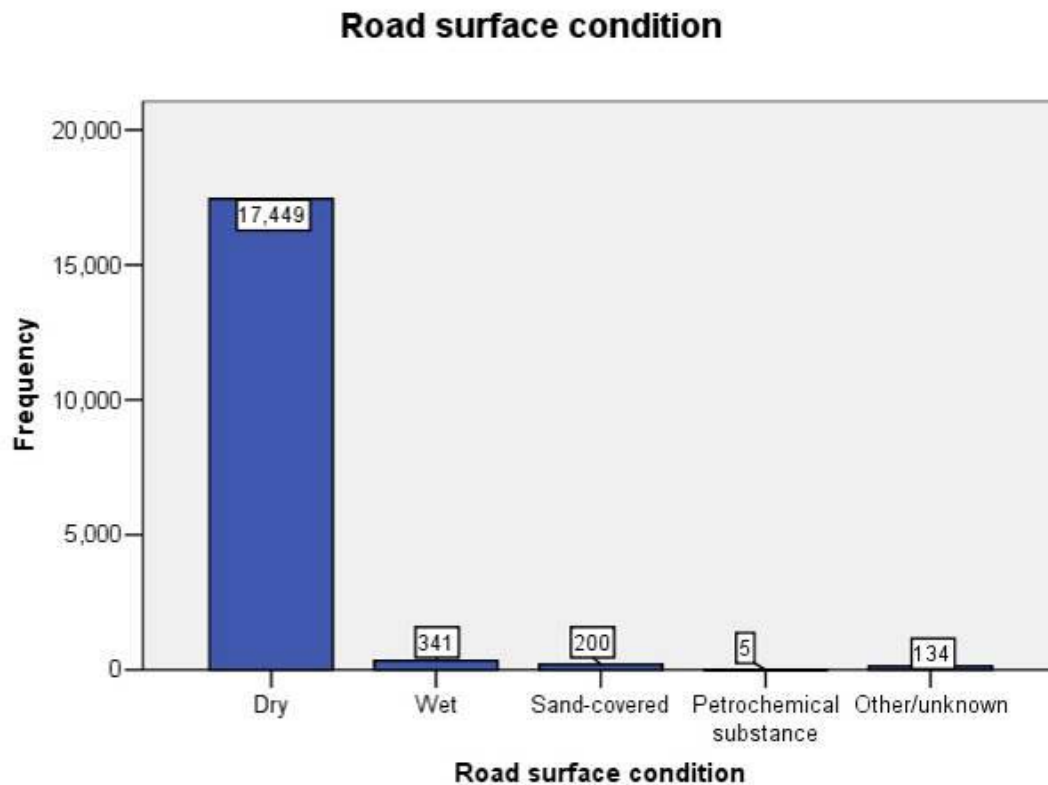
**Figure 41: Weather conditions at injury crash sites.**

#### **5.1.9.4 Road surface conditions**

Classes of road condition on the police form (figure 42) are recorded as one of five conditions translated below:

- Dry: the surface of the road was dry and free from that which may affect grip.
- Wet: surface of the road was wet (normally with water from rainfall).
- Sand-covered: the road surface was covered with sand (could be blown over by wind from the side of the road or from a sandstorm).
- Petroleum or chemical substance: a petroleum substance (e.g. diesel) or chemical (from a shed load for instance) was on the road surface.
- Other: a field was provided for other conditions or substances that may affect the road surface. However this was not provided as part of the data as it was manually written on the crash form and difficult to encode on the electronic database.





**Figure 42: Road surface condition at injury crash sites.**

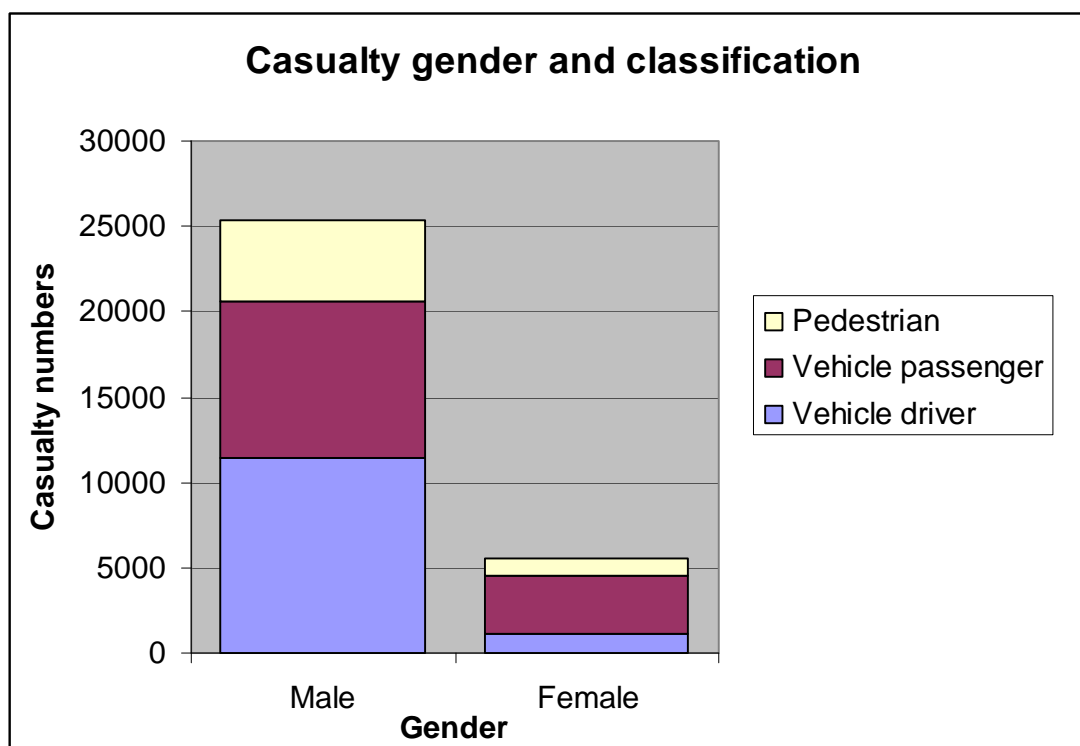
Road surface conditions were recorded as less than ideal (wet, oily or sand-covered) in 3% of cases; a very small percentage of the total. Similar data for comparison was not normally published in Dubai.

### **5.1.10 Profile of the casualties involved**

#### **5.1.10.1 Gender and nationality divisions**

Analysis of the casualty data provided (figure 43) was used to evaluate the profile of those injured in road crashes and to compare the data with previous studies. Official data releases from 2006 and 2007 show the male:female proportion around 83%:17% (RTA, 2007; Dubai Police, 2008a) which was very close to the 12-year study findings. The gender division of the driving population was not found in the public domain for the emirate of Dubai. However males appear to be mostly injured as drivers while females were injured mostly as vehicle passengers (figure 43).





**Figure 43 Gender and type of casualties in all injury crashes, 1995-2006.**

The nationality most represented in casualties was Indian (figure 44) followed by Emarati (an adjective to describe a UAE national) then Pakistani. The percentages show a slight variation from recently released data for 2006 and 2007 which shows the Indian nationality makes up approximately 33% (increased), the Emarati 12% (decreased) and Pakistani 15% (static) of the total (RTA, 2007; Dubai Police, 2008a). Indians tend to be injured as pedestrians most (figure 45) and around the time of 8am - this peak is not seen for other majority nationalities so this might highlight a specific problem that can be determined in more detail through further investigation.

It can be seen that Emaratis and Pakistanis were mostly injured as vehicle drivers while other nationalities were mostly injured as vehicle passengers (figure 45). Pedestrians make up the smallest section of road user type injured, however the numbers are still significant (and in the thousands).



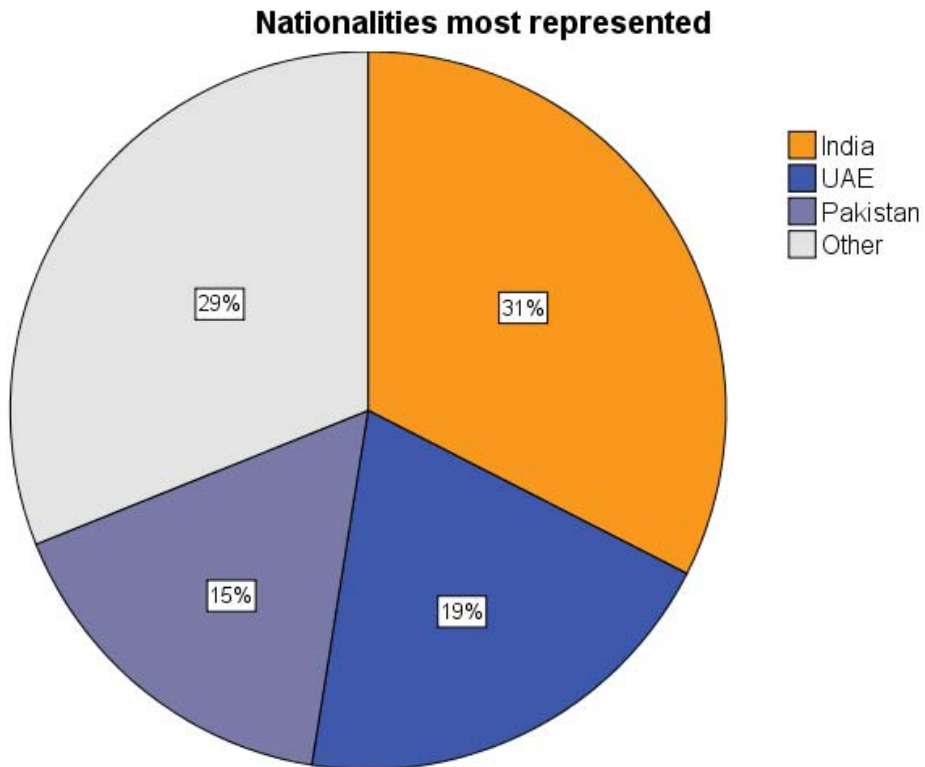


Figure 44: Nationalities most represented in casualties (n=30,942)

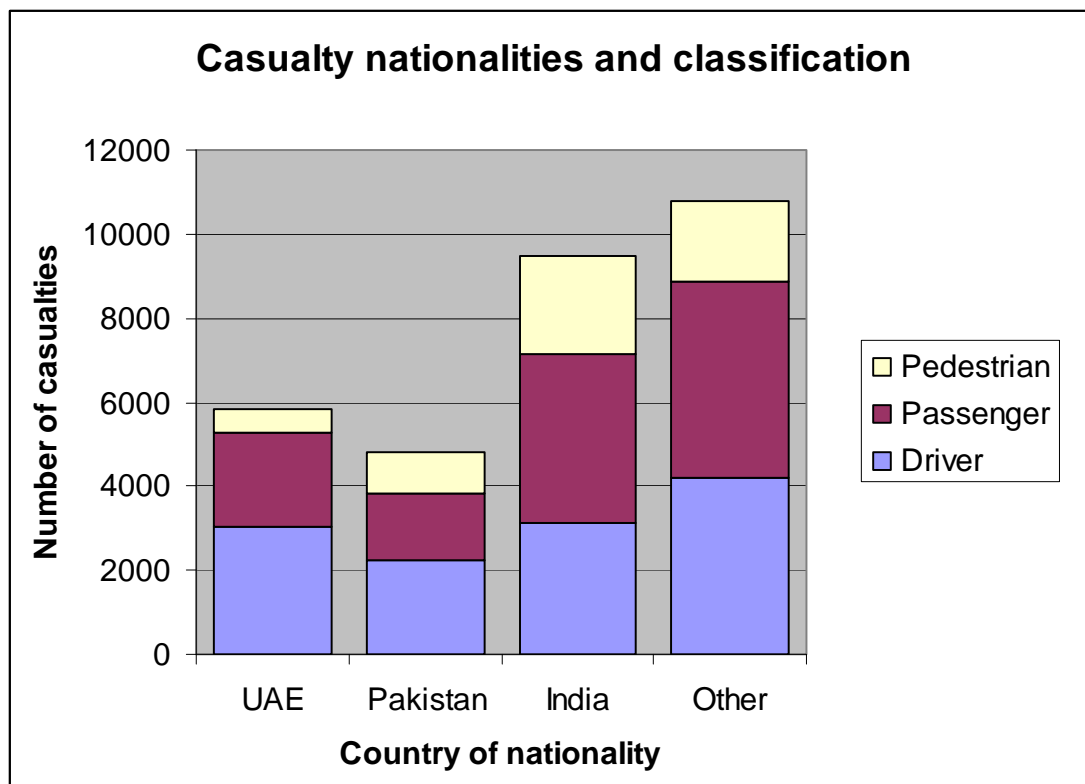


Figure 45 Nationality and classification of casualties.



#### 5.1.10.2 Age range of injured parties

Figure 46 shows that over a quarter of casualties are under 22 years of age with a significant number below the legal driving age in the UAE (18 years). Those above 50 years make up a small percentage of the total (5.4%) and with respect to their proportion in the population of the UAE (6.9%) are slightly underrepresented. This might be explained by not all of them driving. RTA published figures (RTA, 2007) show the above-51 age category to make up 5.7% of those injured in 2006 which was very close to the 12-year data set. Police published data use different age categories making it difficult to compare directly with the above. Slightly-injured casualties make up the largest proportion of both casualties and crash cases as seen previously (figure 27, page 129).

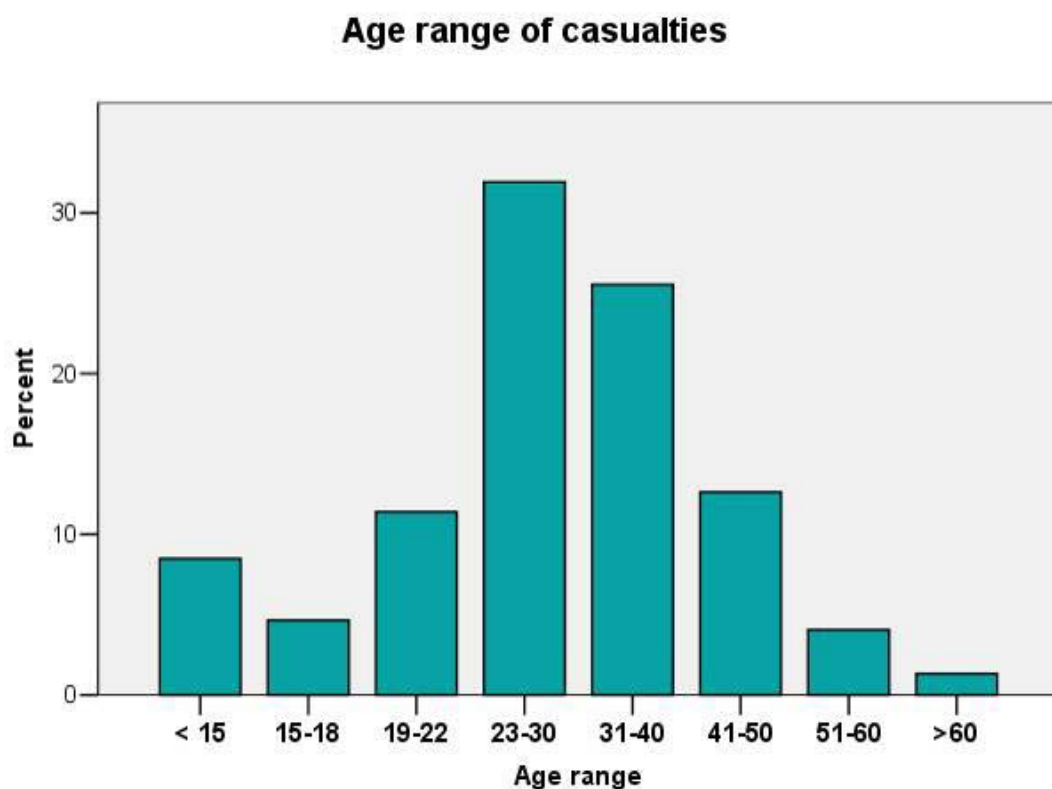


Figure 46: Age range of casualties (licensing age 18), 1995-2006.



### 5.1.11 Driver attitudes and characteristics

#### 5.1.11.1 Seat belt usage

Surveys of seat belt usage such as those performed in the UK annually (TRL, 2004) were not common in the UAE nor in Dubai. However a few roadside surveys (table 27) were conducted at a busy main road during the mid-day rush hour in 2002 (3 years after the enforcement of the front-passenger seatbelt legislation) and 2005 with the results being supplied with the crash data.

**Table 27: Surveys of seatbelt use**

Date	28/01/2002	28/01/2002	22/06/2005
Start	11.20am	12.10pm	11.30am
Finish	12.00pm	12.45pm	12.45pm
<b>Drivers</b>			
Sample size	n=468	n=631	n=556
% wearing seatbelt	88%	85%	65%
<b>Front seat pass.</b>			
Sample size	n=183	n=220	n=194
% wearing seatbelt	86%	81%	25%

Source: RTA 2006c

The percentage of drivers and front seat passengers using seatbelts stood at a reasonably good level (>80%) in 2002 which is three years after the public enactment and enforcement of the seat belt law. However by the year 2005 usage levels had dropped for drivers but even more so for passengers, with only one in four front seat passengers wearing a seatbelt. The publicity that accompanied the enactment of the legislation combined with the highly visible enforcement efforts (Abdalla, 2002; El-Sadig et al, 2004) might have become a distant memory in the mind of the motorist in 2005 compared to the motorist of 2002, contributing to the lower usage rates seen. It may be the case that the longer the time period elapsed since enforcement, the more usage rates will drop, but this can be verified by future surveys. Also the driving population in 2005 might be different to that in 2002, and might not have witnessed or even have knowledge of the seat belt legislation passed in 1999.

#### 5.1.11.2 Driver education and behaviour

The lack of consideration for other road users comes firmly on top of the injury crash causes cited by police in this dataset as well as in 2007 (Dubai Police,



2008a). This suggests a lack of discipline, knowledge, attentiveness and care to others which is more of a behavioural problem than an educational one. Behavioural issues should be considered when suggesting traffic safety interventions due to the large role they play (Oxley et al, 2004).

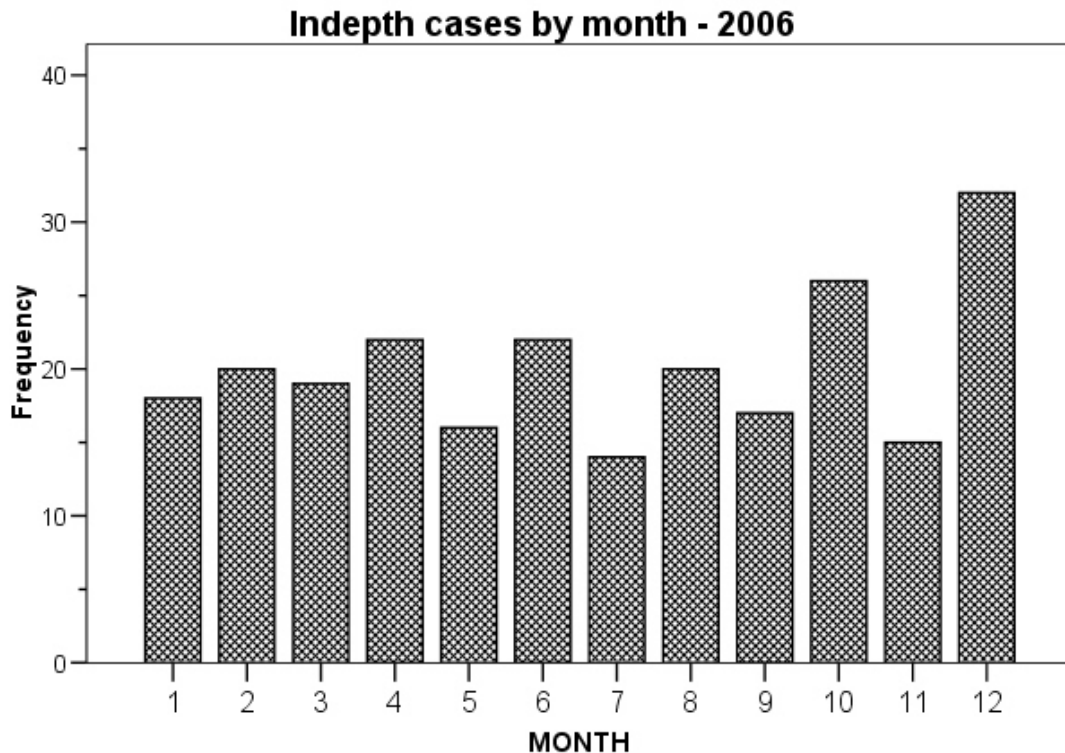
## **5.2 *Microscopic view of in-depth data***

The following sections present the results from in-depth crash investigations undertaken by the police for (mostly) severe and fatal crashes as requested by the Public Prosecution for court cases or by individual police stations. Variables that showed results similar to the macroscopic study were not included to avoid duplication. Seat belt use was not analysed due to the non-reporting of this variable in most cases (296/300).

### **5.2.1 Case breakdown by month, hour and day**

A sizeable variation existed between different months of the year (figure 47) especially the last three (October – December). This is due to the nature of the investigation team's function that supplements the standard crash investigation procedure and hence they are not called to every single fatal or serious crash that occurs. The chances of being called out to a crash are affected by the type of crash and the extent of damage incurred to road users, vehicles and other structures. They are also subject to the judgement of the Public Prosecution representative who attends fatal crashes and might request the report to support court proceedings. Individual police stations may request an in-depth investigation where the experience and training of the investigation team are called upon. All these factors affect the number of crashes investigated per month, in contrast to the base-level database which contains all injury crashes reported regardless of such external factors.





**Figure 47: Case breakdown by month, 2006 only.**

The plot of crashes by hour of day (figure 48) showed three distinct peaks at 6 am, 5 pm and 8 pm. The least number of crashes happen around 4 am and 10 am, which was similar to the findings of the macroanalysis. The peaks appear to coincide with high volumes of traffic at different rush hours but exposure data was not available to verify that relationship. Wednesday (figure 49) stands out as the day of the week with the least crashes just before the weekend of Thursday and Friday for some organisations or Friday and Saturday for others (all public departments and some private companies). Most other week days have between 41 and 48 crashes in the year. The timing of crashes might be related to the decrease in crashes on Wednesdays compared to other days. From Saturday to Wednesday most of the crashes happen during the day. Only on Thursday and Friday do more crashes happen at night than during the day. There is a clear difference in serious and fatal crash times during the weekend compared to week days which may be influenced by work patterns. Traffic exposure data with time is needed to verify the relationship between these factors.



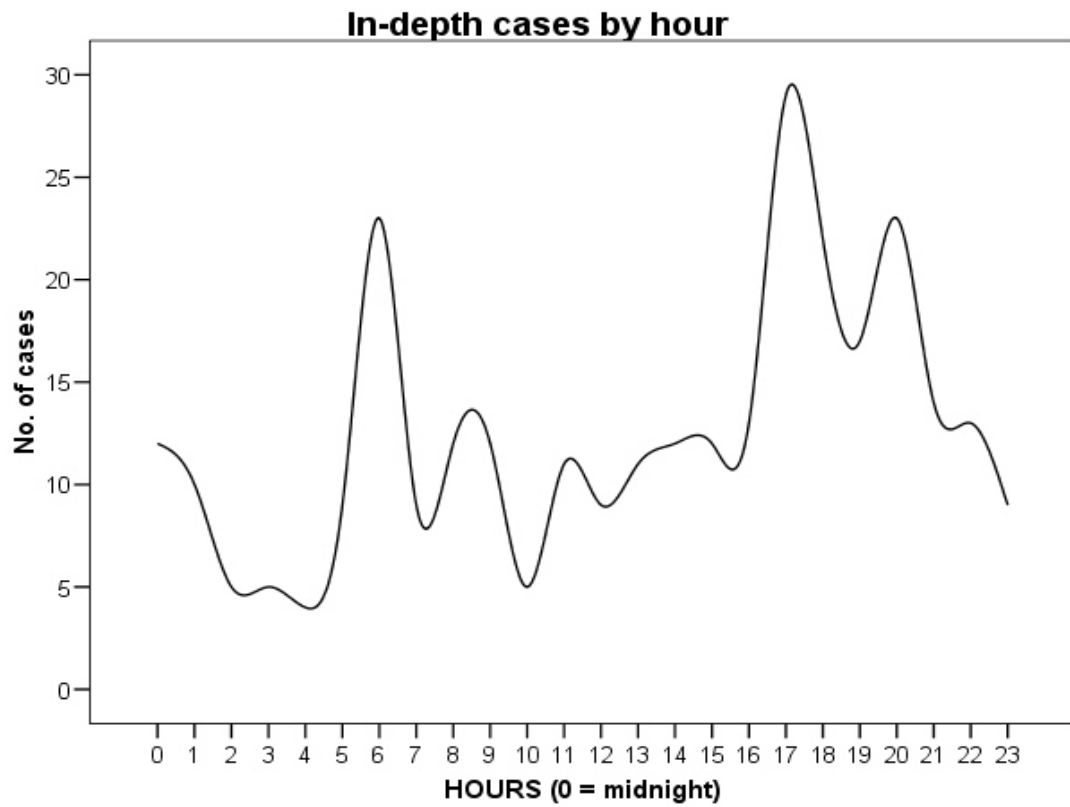


Figure 48: In-depth cases by hour of occurrence.

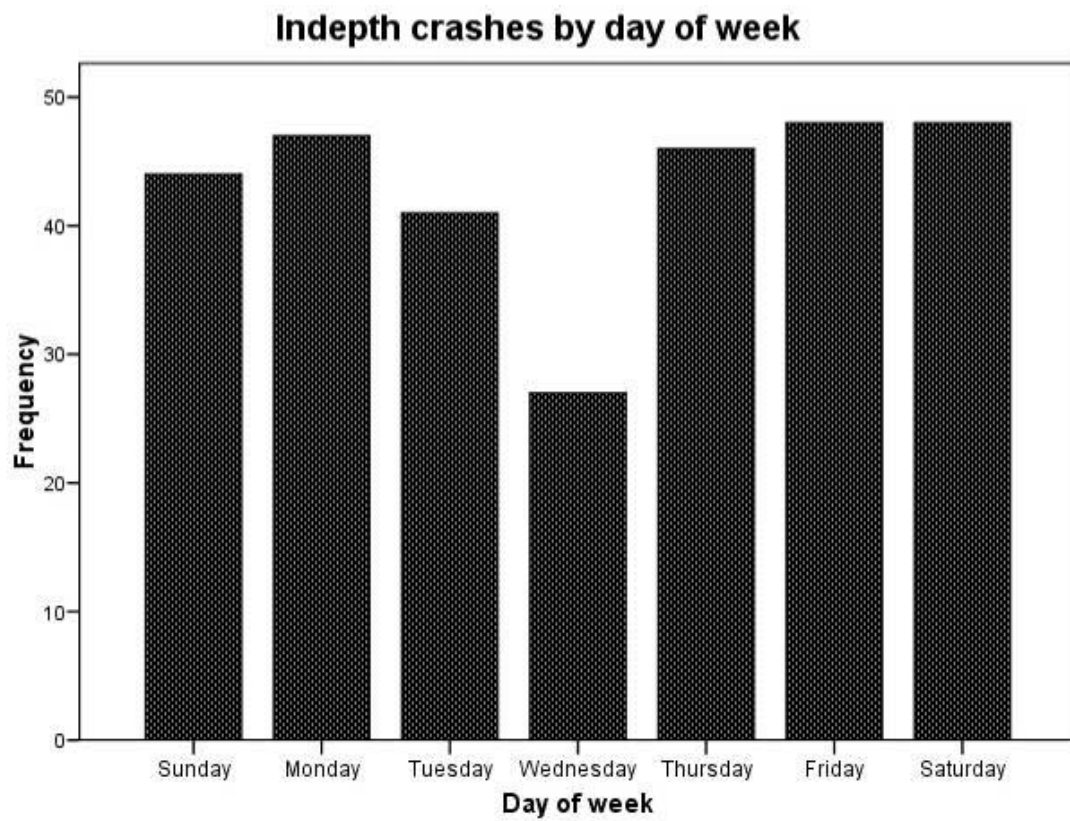


Figure 49: In-depth crashes by day.



Cross-tabulation of the most frequent crash times and days results in table 28. This shows the days with the most frequent early-morning crashes to be Monday, Tuesday and Saturday. Saturday and Sunday tend to have more mid-morning and afternoon crashes while Thursday, Friday and Saturday have the most evening and late crashes. All days have peaks in the afternoon and evening. This might point to a problem with tiredness and fatigue as the morning periods seem to be free of fatal and serious crashes.

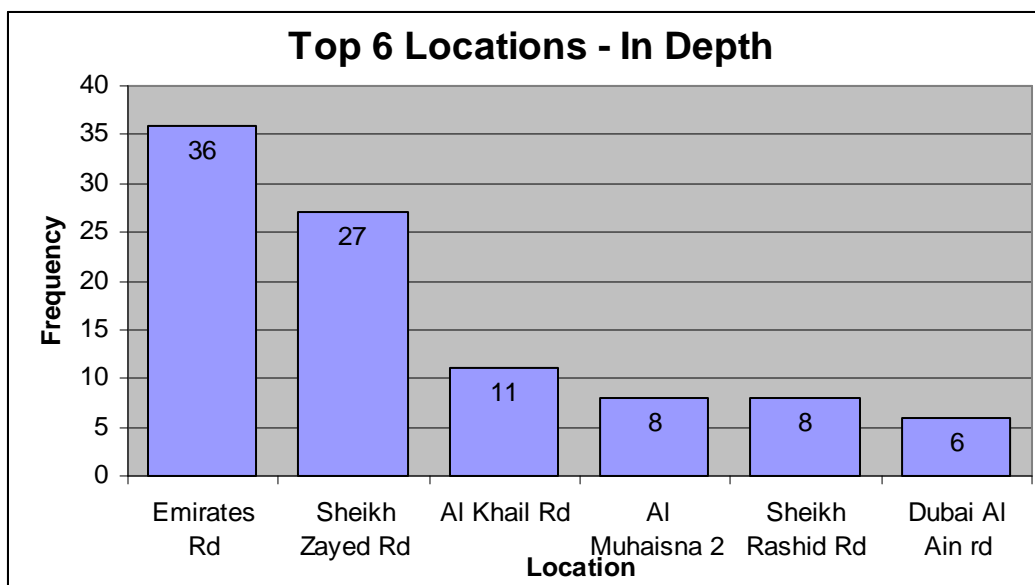
**Table 28: Cross tabulation of in-depth crash times and days (percentage -bold numbers are the largest category by day).**

Hour/day	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
0-3	4.5	14.9	7.3	7.4	11.1	12.5	14.6
4-6	11.4	14.9	17.1	11.1	13.3	10.4	6.3
7-9	11.4	14.9	9.8	14.8	11.1	4.2	12.5
10-12	13.6	2.1	12.2	3.7	4.4	4.2	16.7
13-15	18.2	14.9	12.2	<b>18.5</b>	0.0	12.5	8.3
16-18	15.9	<b>25.5</b>	<b>26.8</b>	<b>18.5</b>	15.6	16.7	<b>29.2</b>
19-21	<b>20.5</b>	10.6	7.3	14.8	<b>31.1</b>	<b>27.1</b>	12.5
22-23	4.5	2.1	7.3	11.1	13.3	12.5	0.0
Total(%)	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Total cases	44	47	41	27	45	48	48

### 5.2.2 Top 6 Locations

The top 6 locations or road names where a majority of serious crashes occur (figure 50) were mostly high speed motorway-class dual carriageways made up of 3 lanes or more. Four of the locations correspond to top locations from macroanalysis but the other two were different: Al Khail road only opened recently which might explain its absence from the base-level data. Al Muhaisna 2<sup>nd</sup> is a residential labour camp area with heavy pedestrian traffic and the only location to have a relatively low speed limit in the top six.



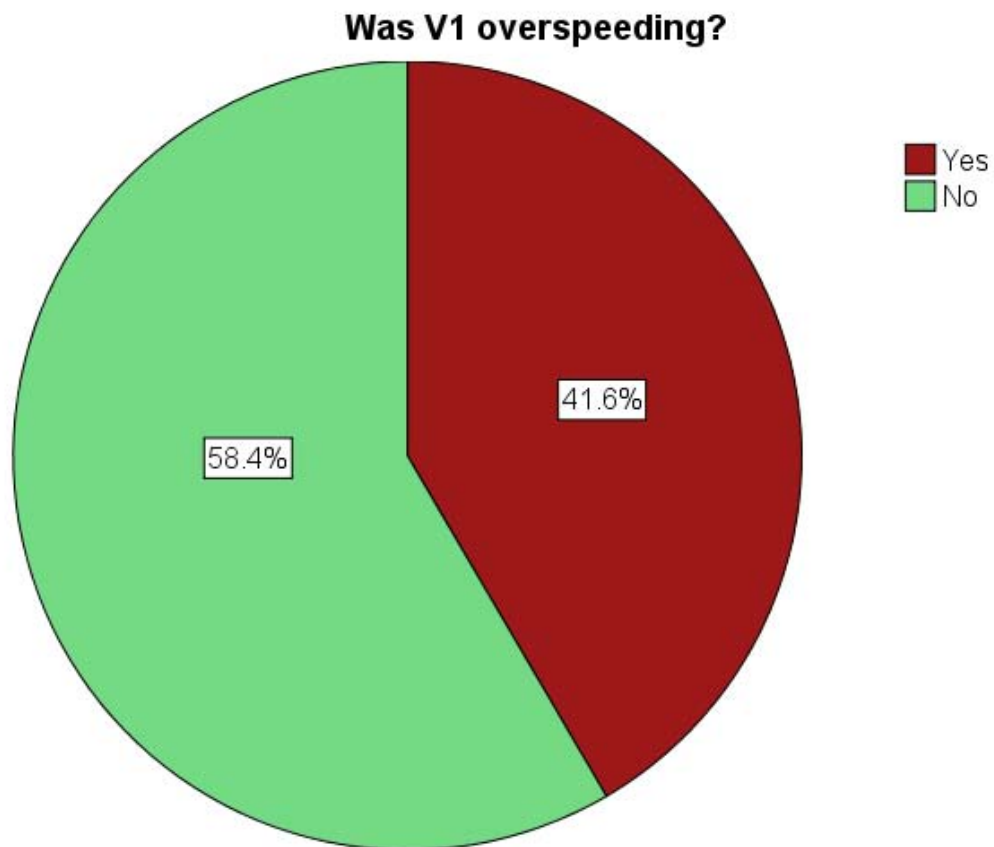


**Figure 50: Top 6 locations - In-depth cases.**

### **5.2.3 Vehicle speeds, speed limits and speeding**

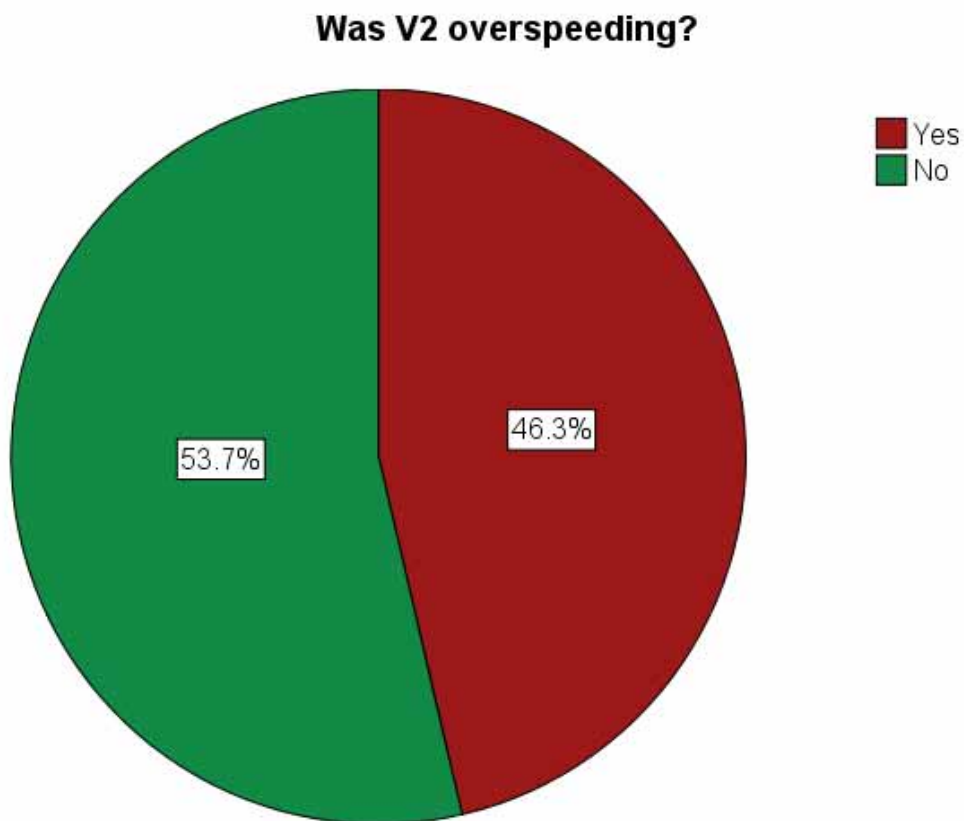
The occurrence of speeding (figures 51 and 52) was evident where the road speed limit was exceeded by the reported or calculated vehicle speed. It is important to note that if no vehicle speed was available (due to lack of evidence) then that instance of speeding was not recorded. V1 and V2 (first and second vehicles involved) show a high incidence of speeding despite the use of stationary speed enforcement (speed cameras) on a lot of the top crash locations. However if speeding was present in a crash it was not always recorded as a causative factor (see sub-section on crash causes).





**Figure 51: V1 occurrence of overspeeding.**



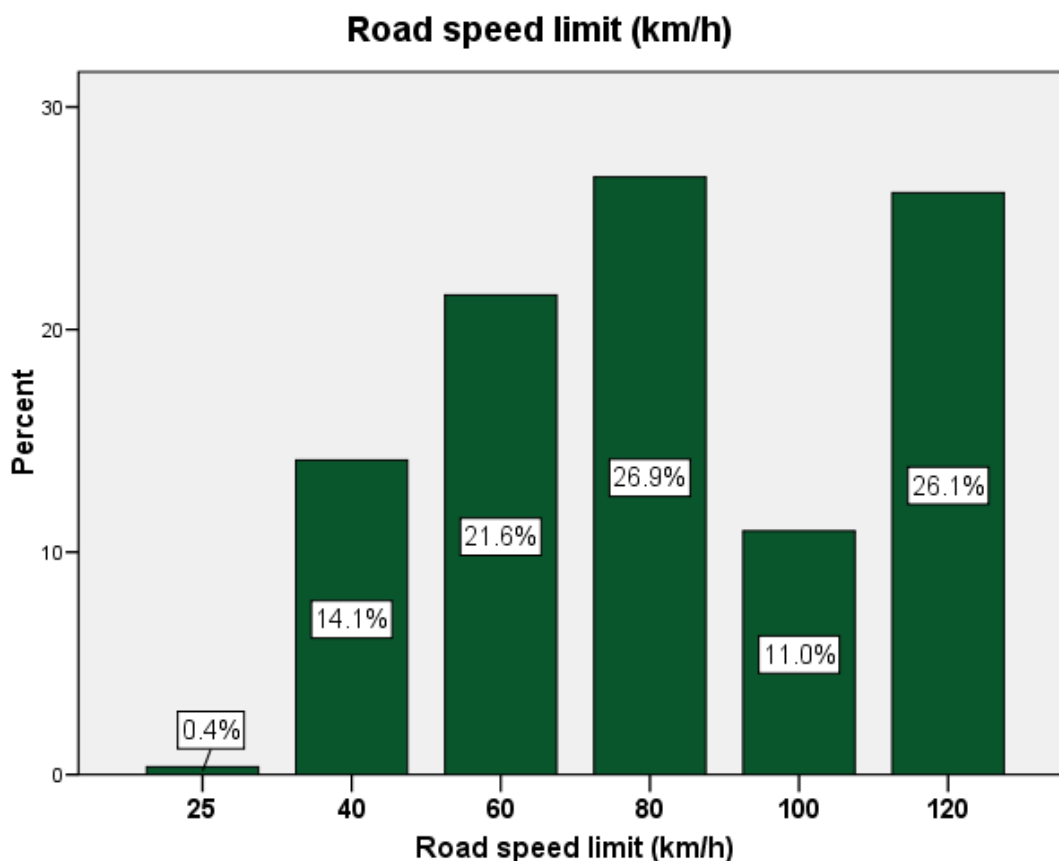


**Figure 52: V2 occurrence of overspeeding.**

Vehicle speeds were estimated by the investigation team based on evidence (tyre marks) and the statements of people involved. These were compared to the speed limit in force in the area (where applicable except in car parks or unpaved areas) to determine whether the vehicles were speeding or not. Few estimates for V2 and V3 were found (41 and 7 respectively). For V1 190 entries of an estimated speed were recorded.

283 cases with recorded speed limits were analysed (figure 53) as the rest were not on roads (i.e. desert area or construction site) or the speed limits were not known. The greatest number of cases occur on roads with an 80km/h limit which mostly applies to inner-city roads in lightly built up areas or connectors between commercial or residential areas.





**Figure 53: Speed limits at crash locations.**

A 120km/h limit indicates a motorway or outer-city route which was the second most common reported limit.

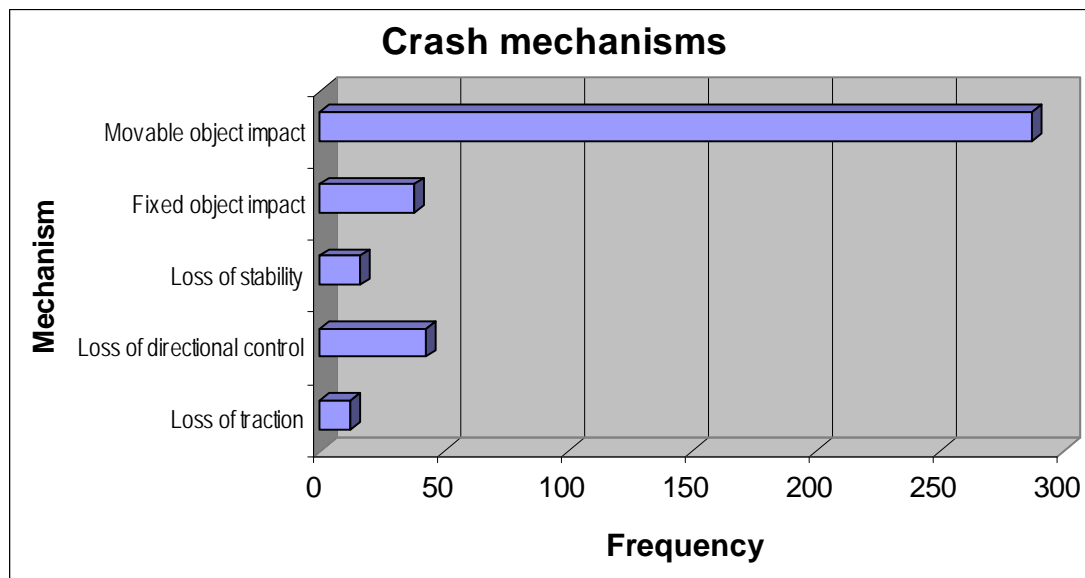
#### **5.2.4 Crash mechanisms and causes**

Some crashes were straightforward with only one crash mechanism (for instance hit another car and stopped) however many cases had multiple crash mechanisms especially if high speeds were involved. All cases had a first crash mechanism recorded while 69 had a second mechanism and only 27 had three unique crash mechanisms recorded. For simplicity only the sum of crash mechanisms is presented in figure 54. One crash defied classification as it did not involve the vehicle crashing; rather the passenger fell off due to inappropriate seating in the cargo area of a pickup truck.

The crash mechanism of the majority of cases was a movable object impact (typically another vehicle or pedestrian) followed by the loss of directional control. The most prominent secondary crash mechanism was impact with a fixed object such as a fixed barrier or lamp post which would be common after impact with a movable object or loss of directional control. A fixed object



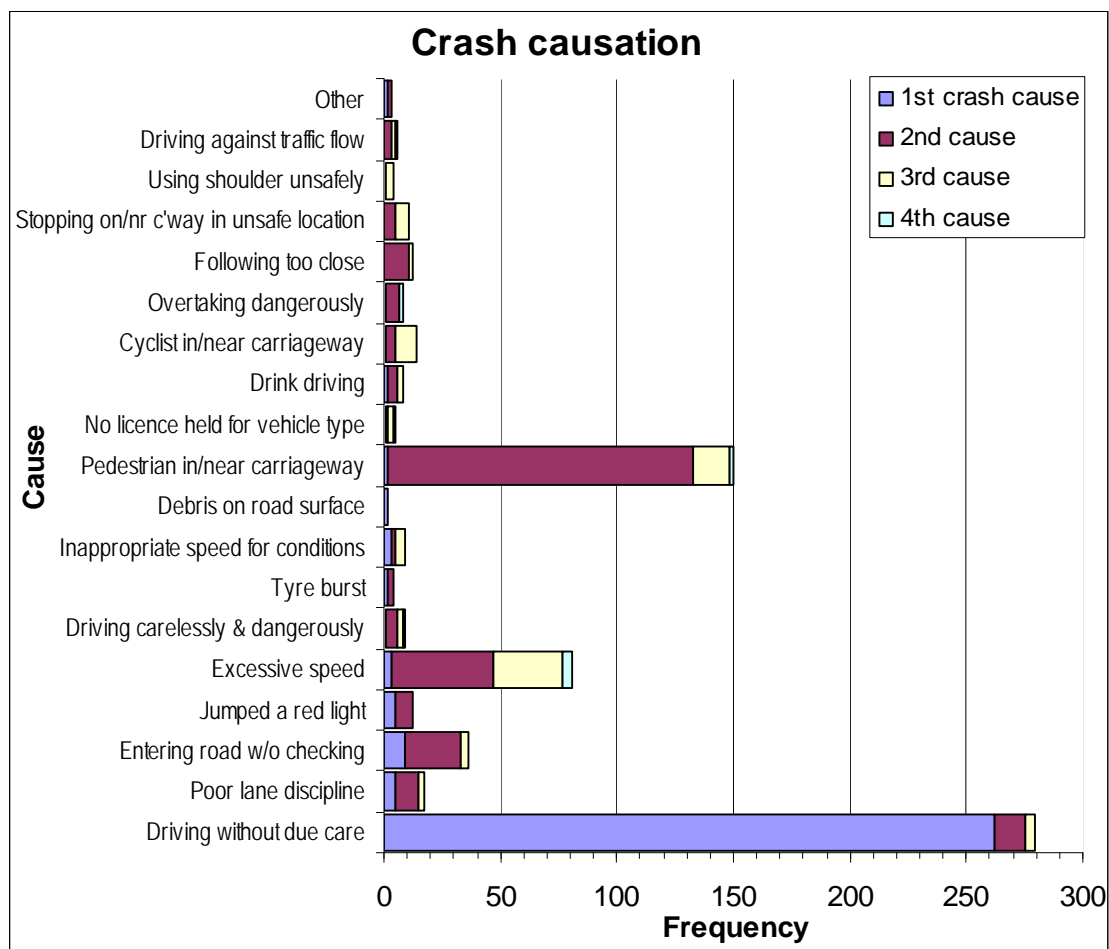
impact and loss of stability were rarely recorded as primary crash mechanisms more often occurring as secondary and tertiary mechanisms. Loss of traction and the loss of directional control were never recorded as a tertiary crash cause which makes sense considering these events typically are the precursor to an impact that most drivers would want to avoid.



**Figure 54: Crash mechanisms by frequency reported.**

The first crash cause (figure 55) most often reported was driving without due care, while the secondary crash cause most reported was the presence of a pedestrian or cyclist near or in the road. Other causes in the top four (by frequency) were excessive speed and entering the road without checking if it is safe to do so. Excessive speed is mostly marked as a secondary or tertiary cause rather than the primary cause of a crash. Drink driving is not very high on the list of causes for the microscopic analysis as opposed to the base-level data where it comes second in 2006. Possible reasons for this were mentioned in the discussion section. In UK data for 2007 (DfT, 2008) for crashes attended by the police (and where a contributory factor was noted) “failure to look properly” was the leading factor (present in 20% of all factors) noted followed by the “failure to judge the other person’s path or speed” (11%). The third most common contributory factor was “careless/reckless/hurried driving” (9%). Against this backdrop of contributory factors, “driving without due care and attention” appears to be a catch-all phrase which may be potentially broken down into a few other categories.



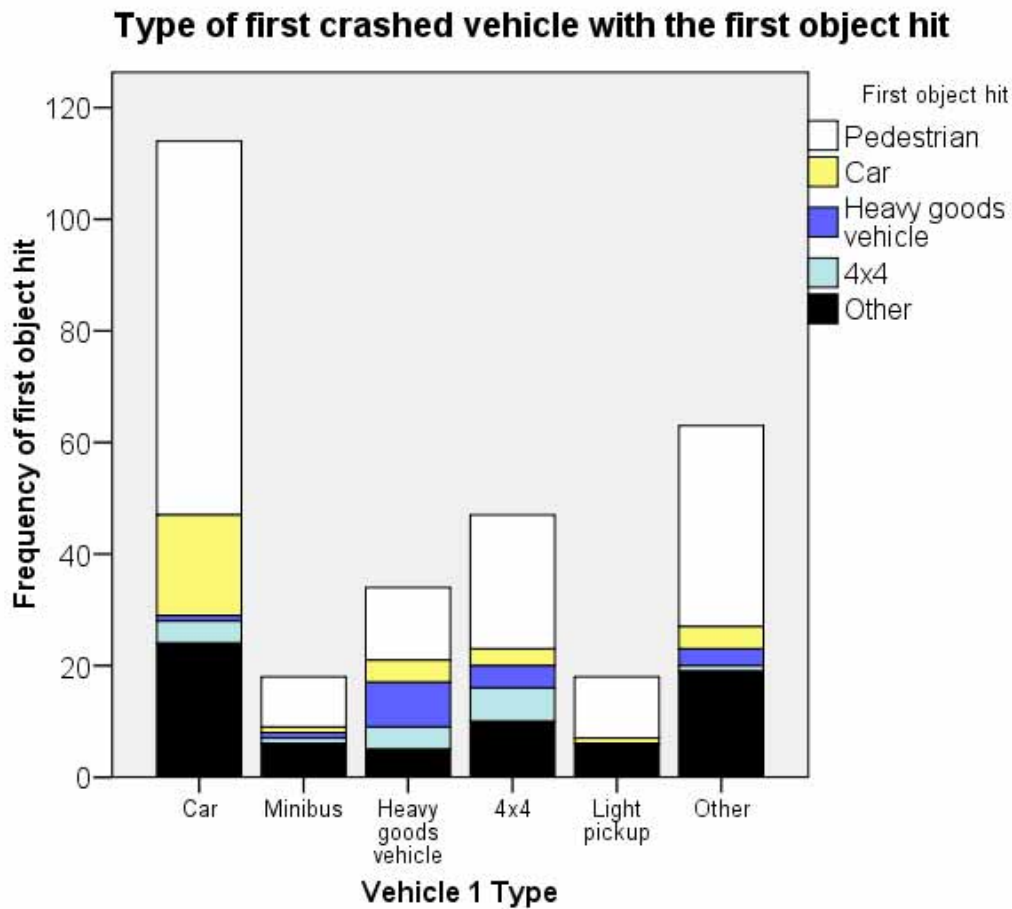


**Figure 55: Crash causation.**

### 5.2.5 Objects hit in crashes

Pedestrians were a particularly high risk group (figure 56) as they were most often the first object impacted by a vehicle (in some cases it appears that the pedestrian might have jumped at the vehicle rather than being hit by it). Such cases were suspected suicide attempts as confirmed by the police investigators (Dubai Police, 2008b). However they were not only present as a first point of impact but even as a second and third object hit (figures 58 and 59) as would be the case when a vehicle leaves the road and encroaches on pedestrian areas or hits multiple people attempting to cross a road. Further analysis of the drivers that hit pedestrians showed that 60% of those drivers had less than 4 years driving experience but 57% of drivers with less than 4 years experience were found in the main sample (all objects hit) so drivers with less experience did not seem more likely to hit a pedestrian than any other object.



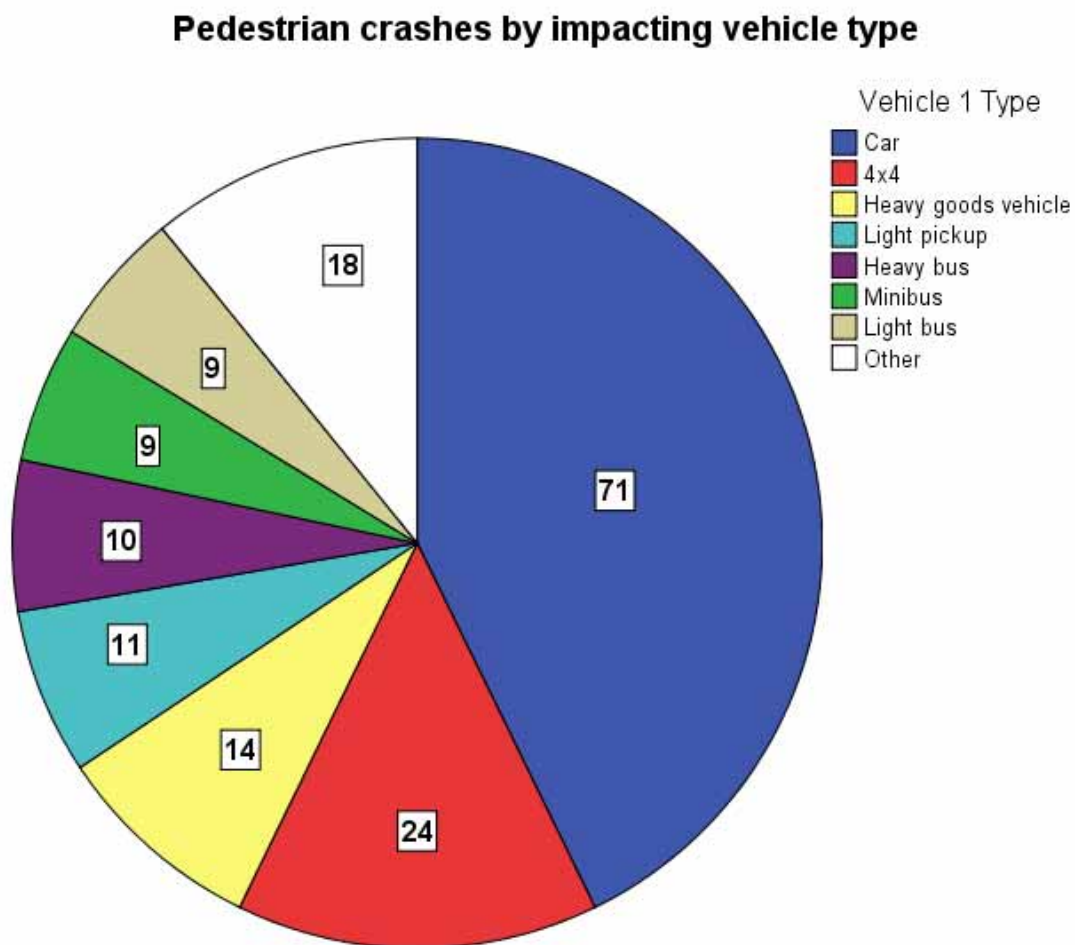


**Figure 56: First object hit in crash. Vehicle 1 is the impacting vehicle. 2006 and ¼ 2007 in-depth cases (n=295).**

Pedestrians were most frequently hit by cars followed by “other” vehicle types. This category included such vehicles as cyclists, buses, light goods vehicles, etc. Cars most frequently hit other cars.

Further analysis of pedestrian collisions (166 in total – figure 57) shows most were hit by cars and 4x4s (over 50%) followed by light and heavy goods vehicles and buses.





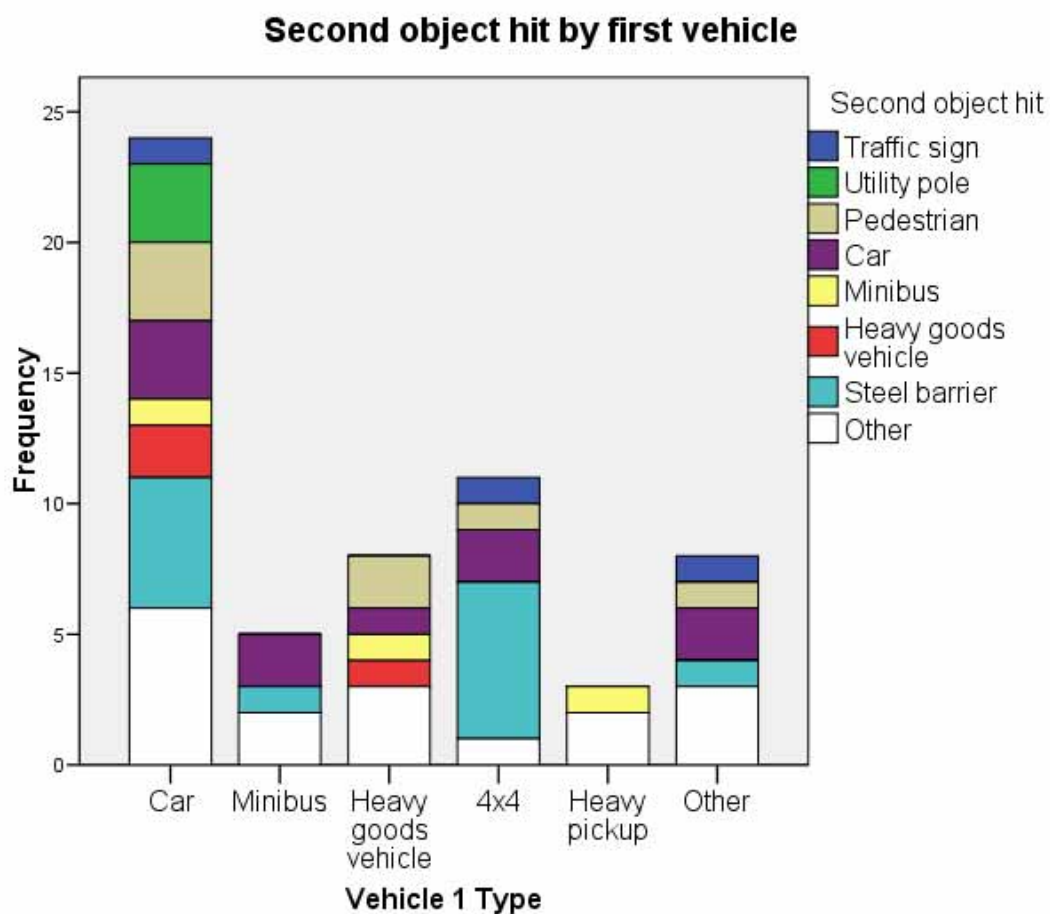
**Figure 57: Pedestrian crashes by the most frequent impacting vehicle (n=166).**

Cars and other motorised vehicles made up the bulk of other objects hit. Heavy goods vehicles (HGV) and 4x4s make up a similar and sizeable portion of first objects hit followed closely by cycles. There was no registration found for cycles but the new vehicle sales of 4x4s and HGVs or trucks were dissimilar at around 20% for 4x4s and 6% for HGVs out of total vehicle sales in 2006. Other unusual items hit appeared further down on the list such as sand, shrubs and trees.

UK casualty crashes in 2007 (DfT, 2008) involved a pedestrian and one vehicle in only 15% of the cases reported which was in sharp contrast to the extent of the problem in the Dubai in-depth data. The majority of injury crashes in the UK involved two or more vehicles other than a pedestrian (69.8%).

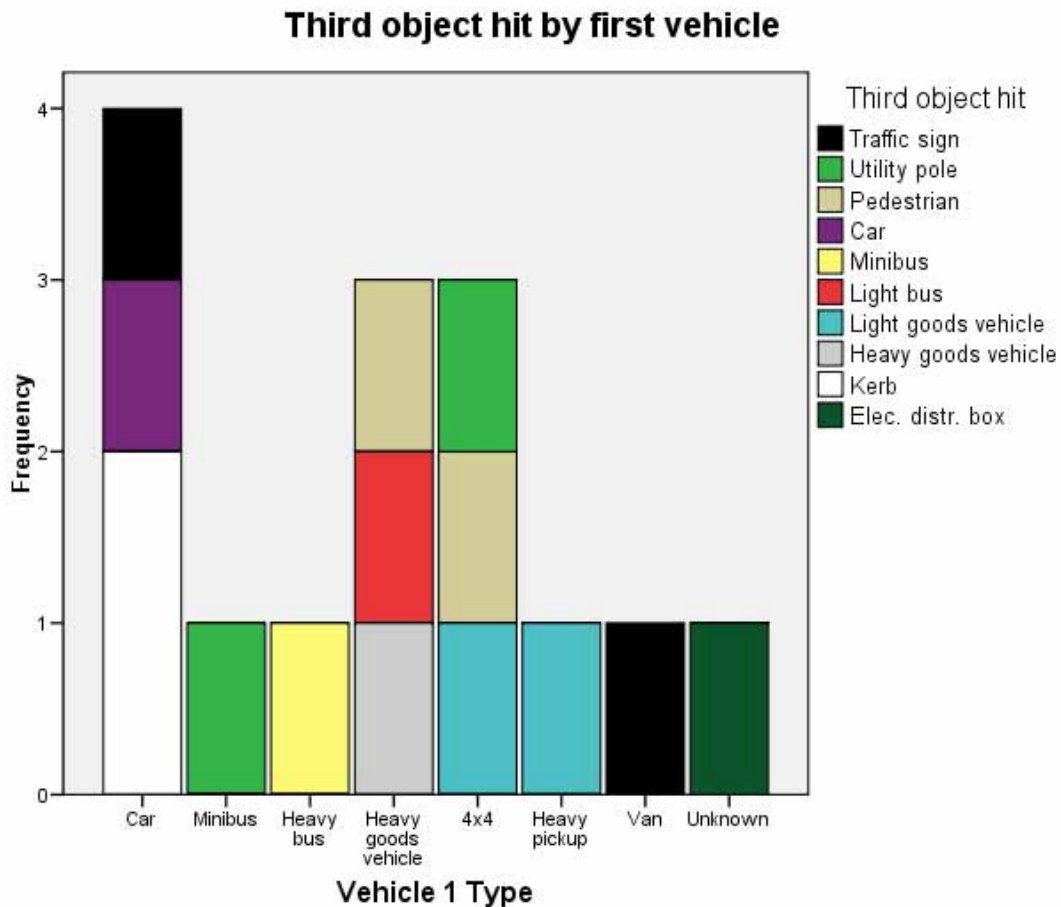


Steel barriers (figure 58) were the most common second object that was hit. This was to be expected after losing control of a vehicle or impacting another mobile object. No recent studies were found that publish this kind of analysis though this data should be available in in-depth databases where they exist around the world. In the UK (DfT, 2008) single vehicle crashes were analysed according to the first objects hit. The majority of objects hit are listed as “other permanent objects” (11% of all single vehicle crashes) while trees make up the single largest known category at 5.9%.



**Figure 58: Second object hit in crash.**





**Figure 59: Third object hit in crash.**

The total number of crashes with a first object hit recorded was 295. Cases with a report of a second and third object were significantly less at 60 and 15 respectively. Nevertheless the subset of 15 cases where a vehicle hit 3 objects consecutively necessitates further investigation. It is likely that such crashes involve high speeds and/or high energy that is dissipated through a number of impacts with different objects. Categories smaller than 5% were merged to form the “other” category.

### **5.3 Preventative measures validation**

10 in-depth sample cases were selected and reviewed with 7 experts in the field to assess their level of agreement with the preventative measures suggested. Overall the cases had 54 factors assigned to them and each factor was rated by the expert as explained in chapter 4 (Methodology) as 1 of 5 agreement levels. This gave a total of 378 scores (7 experts x 54 factors). The overall scores were added up and disagreements were measured as a



response of 1 or 2 on the scale (translating to “Disagree” or “Strongly disagree”). Some disagreement was found as illustrated in the table below, but it was not greater than 15% (i.e. 56 out of 378).

**Table 29: Frequency of scores for assessment of preventative factors by experts.**

Score	Frequency	Percentage
1 (Strongly disagree)	9	2.4%
2 (Disagree)	47	12.4%
3 (Neutral)	68	18%
4 (Agree)	160	42.3%
5 (Strongly agree)	94	24.9%
<b>Total</b>	<b>378</b>	<b>100%</b>

Reasons for the disagreement with some factors shown by UK experts were numerous. If more time was available to explain the cases and factors to the experts then it is likely that there would have been less disagreement. The main reasons for disagreement were listed below:

- The experts did not have as much information on the crashes available to them or as much time to dwell on each crash and think it through as the researcher (on average they each had 12 minutes to understand each crash as opposed to at least 37 minutes by the researcher).
- Experts did not have access to the extra information from Dubai investigators or the opportunity to discuss any of the crashes that had been attended by the team in Dubai.
- The preventative measures were devised by the researcher and were well understood, while sometimes their meaning and examples had to be explained to the experts who had various levels of experience and exposure to the different preventative factors and little experience of the UAE road system.

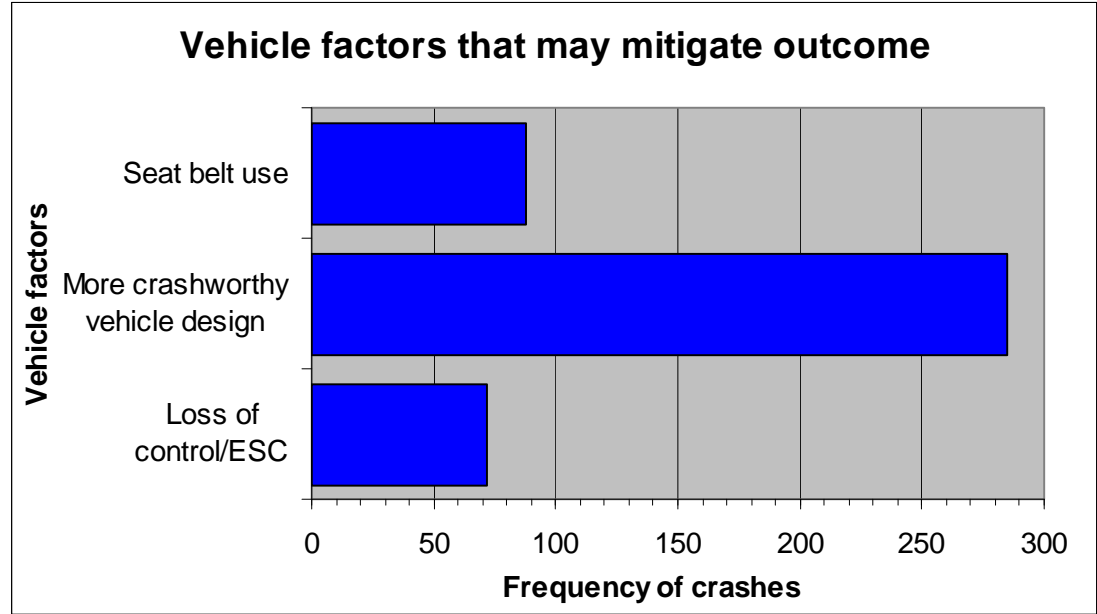
### **5.3.1 Preventative measures: vehicles**

These were the vehicle factors selected that could mitigate injury/crash occurrence had they been present according to the best judgement of the circumstances (figure 60) in the in-depth sample. The factors were not mutually exclusive (i.e. the total factors selected may exceed the number of cases as some cases have more than one factor selected). The order of factors is not significant. These factors were selected from the extensive literature review as being some of the most effective in the field as proven in



previous research, while still being relevant and largely unused in Dubai at the time of study. Effectiveness was normally measured as the calculated percentage reduction in injuries or injury crashes before/after application of a measure.

Vehicle design might have come a long way in the past few decades but the space for improvement is still available as long as people are being injured by or in cars. The description of vehicle design is purposely left vague because the remit of this area is so large that it would be difficult for a study of this size to cover all the possibilities.



**Figure 60: Frequency of crashes in which named vehicle factors would have positively affected outcome.**

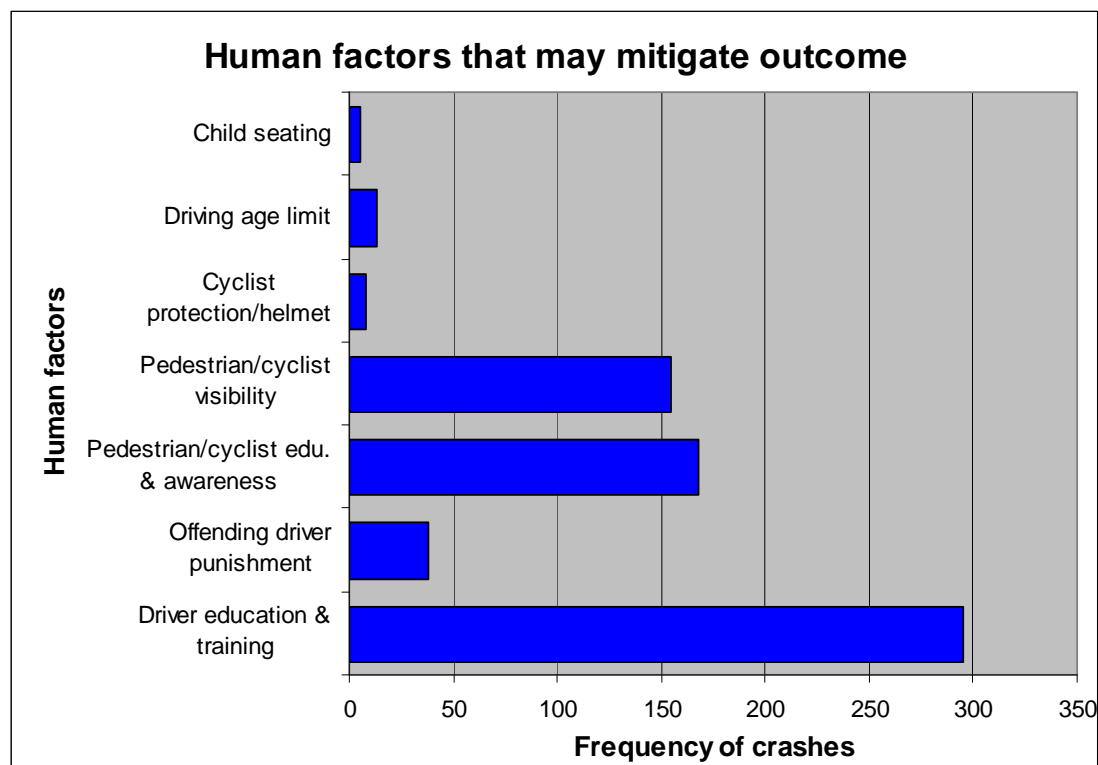
The vehicle factor that was most frequent for most cases was “better crashworthiness”. This means that a lot of crashes might have been survivable or the injury might have been less severe had the structure of the vehicle been more robust, as one example of what might constitute better crashworthiness. This did not mean that all the vehicles in Dubai had poor crashworthiness, but it might indicate that many of the vehicles involved in serious crashes were older or did not conform to the latest crashworthiness standards. Seat belt use was suggested as a mitigating factor in a number of cases but this was a difficult choice to make as it was only possible to select it when it was obvious that a seat belt was not used. This was due to the non-reporting of seat belt use for most cases. Loss of control was present in a



number of cases despite the generally dry roads and good weather conditions that prevail in Dubai. Loss of control might be the result of excessive speeds or unusual road conditions (as was the case in one crash with sand on the road). Also tyre quality and condition might contribute to loss-of-control crashes, as more than one case involved what is known as “sand tyres” (smooth balloon tyres with longitudinal tread lines) fitted on 4x4s.

### 5.3.2 Preventative measures: human factors

Here the human factors that may improve the outcome in the in-depth sample of crashes were presented (figure 61). The knowledge deficiencies were not limited to drivers but were also widespread among other vulnerable road users namely pedestrians and cyclists.



**Figure 61: Frequency of crashes in which named human factor may have positively affected outcome.**

Whilst it is easy to regulate drivers or operators of machinery there is little control that can be exerted over walking and cycling except in a very tightly controlled environment. Hence it was not practical to suggest measures targeted at pedestrian behaviour. Reading some of the witness statements proved that some pedestrians learn from experience while others were caught up in a crash before they had time to learn. Pedestrian and cyclist visibility



might also play an important role in preserving the safety of this class of road user. Drivers in witness statements have reported not seeing pedestrians in a number of cases and these problems can be exacerbated in adverse weather and visibility. Other factors (offending driver punishment, cyclist protection, child seating) came up less often but were nevertheless important for consideration because their existence in this size of sample indicates a wider presence in the whole population.

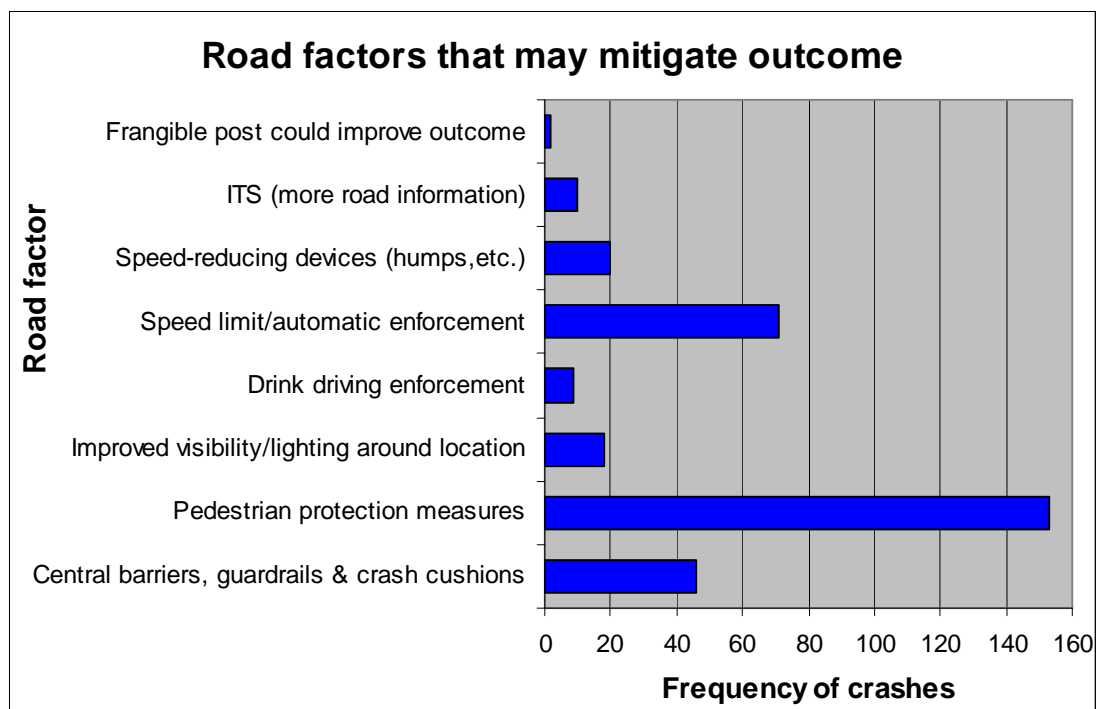
#### **5.4 *Preventative measures: road factors***

The road environment is a major contributor - or detractor - to safety in crashes. The general factor that was most frequent in this category (figure 62) in the microscopic analysis was pedestrian protection. In the absolute majority of cases for which this factor was selected the first object hit was a pedestrian.

Examples of measures included under this category include grade-separated crossing facilities, traffic segregation and fences (to prevent pedestrians from crossing at dangerous locations). The high frequency of this factor may further correlate to the human factors of education and offender punishment for both the driver and pedestrian.

Driving in excess of the posted speed limit or using an inappropriate speed was the second most common road factor selected (figure 62). This not only covered cases where the speed was established from witnesses or through hard evidence (calculations from skid marks or speed camera citations) but also situations where the speed limit in the area might have contributed to the outcome. This is likely in situations where a driver was not found to have exceeded the limit but where a lower limit would be suitable due to the nature of the road or area (e.g. known for heavy pedestrian traffic). In some cases speed enforcement was active on the road in question (through fixed speed cameras) so this might point to the limited range of effectiveness of such devices or the indifference of drivers to being caught or fined.





**Figure 62: Frequency of crashes in which named road factors may have positively affected injury or crash outcome.**

The third most common road factor (figure 62) covers a broad range of interventions including central barriers, guardrails on the side of the road and crash cushions and impact absorbers. This factor applied to cases that could have been prevented or reduced in severity had a suitable barrier been present either to prevent the vehicle from leaving the carriageway (possibly hitting a fixed object) or from crossing the median (and interacting with traffic travelling in the opposite direction).

Other factors that were related to crashes but with less frequency were speed reducing devices in the road (humps) and improved lighting or visibility in the area. The low ranking of drink-driving enforcement is testament that the problem of drink-driving is not too widespread in serious and fatal crashes in this sample though the true extent of the problem needs to be established with further investigation. Though drink-driving enforcement might not initially appear to fall under the “road factor” category it was placed there because it is an activity that generally takes place on the road. It is distinct from the factor of offending driver punishment that is listed under human factors. Only one case was found with more than 3 separate road factors recorded; the majority of cases had 3 or less.



### 5.5 Vehicle class size and risk profile

For cases where vehicle data was available the vehicles were classed into simplified categories according to their size and body type broadly similar to those used in new vehicle sales (Auto Strategies International, 2007). This allowed the classification of the first vehicle involved (V1) into the different size classes for comparison to each other and for subsequent comparison with the vehicle sales data.

Vehicles were divided into the categories of cars, sport utilities (4x4s), trucks, pickups, and buses (as described in the Methodology section). If UAE market data was representative then cars and sport utility vehicles appear under-represented in the sample whereas trucks and other heavy vehicles are over-represented.

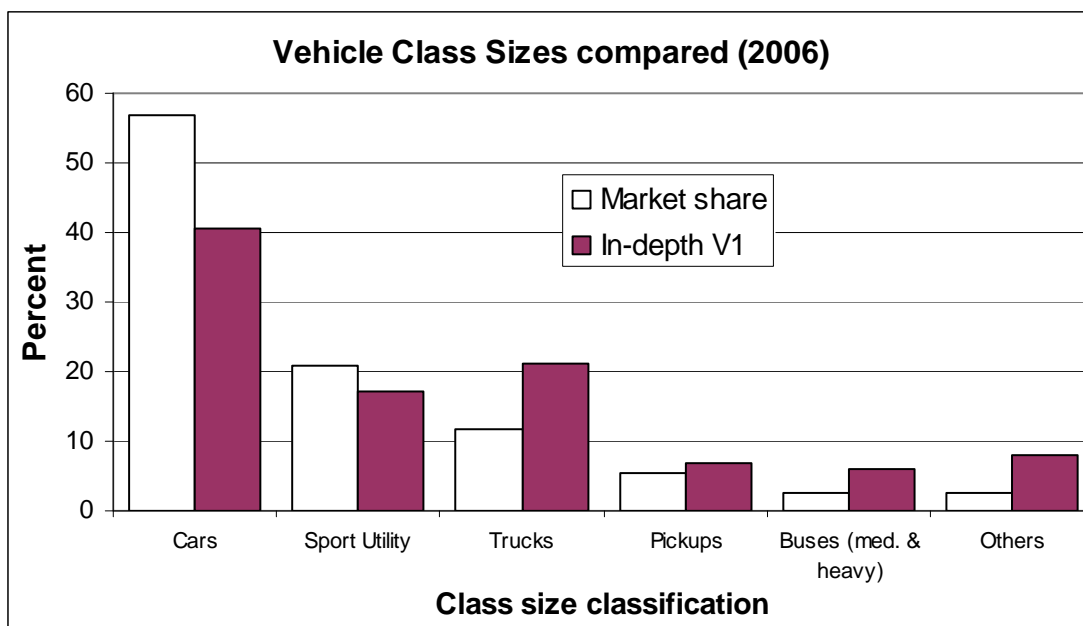


Figure 63: Comparison of UAE 2006 new vehicle sales & in-depth Vehicle 1 (impacting vehicle) data (Auto Strategies International, 2007).

### 5.6 Summary

The data presented relied on the analysis of data supplied first at the macroscopic level then at the microscopic level. Crash prevention factors were assigned to crashes based on the knowledge of crash circumstances and effective countermeasures as found in the literature (for the in-depth sample). These preventative factors were validated with crash experts to



verify their relevance to the crashes assigned. Vehicle class sizes involved in the in-depth sample were compared to new vehicle sales data for the same year to present similarities and differences between two. The following tables (table 30 and 31) present the key findings from the analysis performed (the order is adopted from the analysis and is of no significance). These were found to be the main road safety problems in Dubai.

**Table 30: Key problem areas and supporting analysis (base-level data)**

No.	Problems found from analysis	Supporting analysis	Analysis in Chapter 6 sub-section
1	High proportion of fatal crashes	13.5% fatal compared to 1.4% in UK	6.2
2	Most fatal crashes involve a single vehicle and pedestrian	60% of fatals involve a single vehicle, of which most hit pedestrians (59%)	6.8
3	More crashes used to occur on Thursday	15.94% occur on Thursdays, average is 14.28%	6.3
4	Crashes peak in the afternoon and evening	See figure 12, page 89	6.3
5	High number of single-vehicle crashes	48.7% involve a single vehicle	6.4
6	Most crashes occur on roads with a 60km/hr speed limit	40.6% occur on 60km/hr roads, more than any other	6.5, 6.7
7	Urban areas account for many crashes	Most 60km/hr roads above are in urban areas	6.5
8	Pedestrian crashes are the most common type	28.56% of crashes are pedestrian-type, more than any other	6.8
9	Inconsiderate driving is the most common crash cause	Accounts for 26.7% of crash causes, more than any other	6.6, 6.15
10	Speeding is the 2 <sup>nd</sup> most common crash cause	Accounts for 12.63% of all crashes	6.7
11	Dual carriageway roads account for most crashes	54.9% of crash roads are dual carriageways	6.9
12	More crashes occur during the day than at night	57.8% of crashes occur during the day	-
13	Males in the active population (19-50yrs old) are the most common casualties	82% of casualties are male; see figure 30 page 109	6.12
14	Drink-driving is a leading crash cause (especially in later years)	In 2006, alcohol was the 2 <sup>nd</sup> leading crash cause, at 11.5% of total	6.6

**Table 31: Key findings and supporting analysis (in-depth data)**

No.	Key finding from analysis	Supporting analysis
1	December had the most crashes in 2006	About 10% of crashes occur in Dec.
2	Crashes peak at certain rush hours	6am, 5pm and 8pm
3	Wednesdays are a relatively safe day	Least number of crashes take place on Wednesday
4	Crashes concentrated on high-speed roads	Top 3 locations are all highways with high speed limits



No.	Key finding from analysis	Supporting analysis
5	Areas of high pedestrian density account for many crashes	Al Muhaisna 2 <sup>nd</sup> is the fourth most frequent location
6	Overspeeding is a problem	41.6% and 46.3% of V1 & V2 drivers were speeding
7	Inner-city roads and highways are the most frequent crash locations	Most crashes (26%) occur on roads with a speed limit of 80 or 120kph
8	Loss of control and fixed object impacts are a key problem	Loss of directional control is the 2 <sup>nd</sup> most common mechanism followed by fixed object impacts
9	Inattentive driving and pedestrians in the road are key causes	The vast majority of cases (>90%) have inattentive driving as a main cause while half cite pedestrians in or near the carriageway
10	Pedestrians are a high risk road user group	They were the most common 1 <sup>st</sup> object hit (53%) and a common 2 <sup>nd</sup> object hit
11	Steel barriers were often hit as a consequence of a crash	The most commonly encountered 2 <sup>nd</sup> object hit was a barrier (21%)
12	Crashworthiness of vehicles was important for mitigating outcome	Almost all cases had crashworthiness as a vehicle factor in the crash
13	Driver education & training was a key mitigating factor in most crashes	Present in almost all cases
14	Pedestrian issues were common in many crashes (visibility/education/awareness)	Present in almost half the sample
15	Pedestrian issues were also common in road measures (crossings etc)	Present in almost half the sample
16	Small cars and sport utilities were the most commonly involved vehicles	Together they made up 30% of the sample
17	Trucks pose a particular problem with injury crashes	Over-represented in relation to vehicle sales and (6%:20%)



The link between crash causation and countermeasures is illustrated in the following matrix, where the base-level causation is matched against the countermeasures listed under road/vehicle/human factors (the key to the countermeasures is at the bottom of the table). The most popular countermeasures were related to driver education and punishment. Some causes are related to numerous countermeasures at the same time.

**Table 32: Crash causation (as reported by the police for base-level cases) with potential countermeasures**

Cause	Countermeasure	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Lack of consideration for other road users					✓	✓	✓											
Violating speed limit					✓	✓									✓	✓		
Entering carriageway without checking for traffic					✓	✓												
Following too close to vehicle in front					✓	✓												
Lack of lane discipline					✓	✓												
Jumping a red light					✓	✓												
Carelessness and lack of attention					✓	✓												
Sudden change of direction	✓				✓	✓												
Dangerous driving	✓				✓	✓												
Effect of taking alcohol					✓	✓								✓				
Tyre blow out	✓				✓													
Reversing without due care					✓													
Going against traffic					✓													
Wandering animal											✓		✓					✓
Incorrect overtaking					✓													
Wrong turn					✓	✓												
Failing to give way					✓	✓												
Doors not securely closed					✓													
No knowledge of driving and no licence						✓				✓								
Effects of natural or environment factors													✓					



Cause	Countermeasure	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Shedding of load					✓	✓												
Excess loading					✓	✓												
Entering a no-entry zone					✓	✓												
Tiredness and sleep			✓		✓													
Trailer separation					✓													
Presence of obstacles in road																		✓
Speed humps																		
Unroadworthy vehicle					✓	✓												
Faulty road																		
Effect of taking drugs					✓	✓												
<b>Total</b>		<b>3</b>	<b>1</b>	<b>-</b>	<b>24</b>	<b>18</b>	<b>1</b>	<b>-</b>	<b>-</b>	<b>1</b>	<b>1</b>	<b>-</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>-</b>	<b>2</b>

Key to countermeasures:

1. Loss of control/ESC
2. More crashworthy vehicle design
3. Seat belt use
4. Driver education & training
5. Offending driver punishment
6. Pedestrian/cyclist edu. & awareness
7. Pedestrian/cyclist visibility
8. Cyclist protection/helmet

9. Driving age limit
10. Central barriers, guardrails & crash cushions
11. Pedestrian protection measures
12. Improved visibility/lighting around location
13. Drink driving enforcement
14. Speed limit/automatic enforcement
15. Speed-reducing devices (humps, etc.)
16. Frangible post could improve outcome
17. ITS (more road information)



The matrix table has more spaces than tick marks. This was because the various measures could not be related to more causes with confidence as there was limited information available for the majority of cases. The non-selection of a countermeasure does not mean it is not likely to be effective in Dubai at all, but rather that with the current knowledge on most cases it is difficult to assign it to particular cases within the base sample of the macroscopic study with confidence.



## **Chapter 6 Application of results to countermeasures**

### **6.1 Introduction**

Road safety can be improved by a number of measures depending on the symptoms and causes identified in the analysis. Based on the main causes and problem areas outlined in the results, solutions were recommended and evaluated for suitability based on specific issues faced in Dubai and on their success in other contexts (as reviewed in the literature). The most effective measures were chosen first if they were deemed applicable in the Dubai environment. Using known effectiveness levels it was possible to quantify savings in injury and crash reductions as well as economic terms. The extent to which these effectiveness levels may apply in Dubai were discussed in the next chapter.

### **6.2 Countermeasures to reduce the high proportion of fatal crashes**

In the results a large percentage of crash cases were found to be fatal (13.5% for 2005, 10.6% overall) whereas in the UK only 1.4% (2005) of crashes were fatal. In analysing personal injury numbers rather than crash numbers fatal and serious injuries were sustained by 11.1% of all casualties and 15.9% of all crashes were classified as serious or fatal. This is similar to the UK rate for 2005 (DfT, 2006b) however the definitions of fatal and serious crashes were not identical (RTA, 2006a) so the comparison might not be representative. Dubai crashes were classified as fatal if the medical report showed a fatality within 4 months of the crash (RTA, 2006a). Fatal crashes in Dubai might be exaggerated by the availability of cheap fuel and long expanses of fairly straight and feature-less highways that connect the emirate with other emirates. A high level of income also meant that vehicles capable of achieving high speeds were common place and within reach for a large section of the population. Further analysis results were shown in table 33.

A two-pronged approach is needed for treatment of the ailment of traffic crashes: the prevention of crashes and the prevention of injuries. Crash prevention (active safety) is the ideal as it will save costs and limit physical damage and associated downtime for repair as well as virtually eliminating



the human cost of injury. If crash prevention is not attainable then at least a decrease in injuries and injury severity (passive safety) should be aimed for.

Safety measures relevant to the most common type of fatal crash – that involve pedestrians – include:

- Signalised pedestrian crossings (which drivers are more likely to stop at rather than zebra crossings)
- Speed humps or rumble strips at crossing sites (give the driver a speeding sensation as they approach even if speed does not increase, to encourage slowing down)
- Improved driver visibility at pedestrian locations (to ensure pedestrians approaching crossings are not hidden from view by roadside furniture)
- More pedestrian-friendly vehicle design and crashworthiness (to reduce injury severity and improve crash outcomes).

Studies conducted in Victoria, Australia concentrating on pedestrians (Corben & Diamantopoulou, 1996; Corben et al, 1996; Corben & Duarte, 2006) have made similar recommendations to improve pedestrian safety.

**Table 33: Characteristics of most fatal cases, 1995-2006.**

Involve a single vehicle (~60%), of which the majority hit pedestrians (59%)
Occur in daylight conditions (52.7%) or night time with sufficient lighting (40.3%)
Occur on Thursdays and Fridays (33%)
Have the cause listed as lack of consideration to others or over-speeding (>50%)
Have the crash type listed as pedestrian (37.4%), rollover (13.6%), or stationary object impact (11.8%)
Occur on 60km/h roads (25%) or 120km/h (24.8%), then 80km/h (22%)
Take place on dual carriageways with 2, 3 or 4 lanes (~67%)
Involve a steel barrier (31%), unknown object (18.8%), kerb (17%) and no barrier (16.5%)
Road markings exist at the majority of sites (70%)
Fair weather is prevalent (>97%), as are dry roads (>95%)
Males are over-represented (88% of fatally injured)
Some nationalities are predominant: Indian (31.9%), UAE (19.4%), and Pakistani (17.4%)
Fatalities are mostly young (23-30yrs: 27%, 31-40yrs: 27%, 41-50yrs: 14%, <b>under 18: 11%</b> )

*Note: order of the above factors is by the order of incidence of the fields in the database and is not significant.*



Safety measures that can reduce the incidence of the second most common type of fatal crashes, the rollover, and injuries sustained therein, are:

- Variants of Electronic Stability Control (ESC), as rollover is often preceded by loss of control, so if this is prevented the crash itself may be prevented or its severity reduced.
- Compulsory seat belt enforcement (however increased seat belt use in other countries has been shown to increase slight injuries while decreasing serious and fatal injuries). Seat belts help keep the occupants inside the vehicle in a rollover thus decreasing their risk of injury by being thrown out.

The third most common type of fatal crashes, hitting a stationary object, might be reduced by measures such as:

- Crash cushions at the stationary object location especially if a location is found to have been the site of more than one injury-causing crash.
- Roadside barriers to prevent the vehicle leaving the road in the first place. Barriers and crash cushions act to catch a vehicle and direct it to a controlled stop rather than throwing it back into the carriageway (Elvik & Vaa, 2004).
- Improved vehicle crashworthiness (side impact protection, front vehicle structures designed for narrow object impacts, roof strength).

#### **6.2.1 Seat belt enforcement order in January 1999**

At this point, mention should be made of the compulsory seat belt law for front seat occupants that was introduced with a high-profile awareness campaign nation-wide in 1998 and the impact it had on the number and severity of casualties. By comparing the 12-month period before and after introduction of the law the distribution of injury severity does not change significantly while the total number of injured people has decreased by about 270 (10%) the most significant reductions being in slight injuries. This follows the trend of the previous years (as seen in figure 26, page 130) thus casting doubt on whether this was a direct result of seat belt legislation or some external confounding factors during that time. In the late 1990s there was a general feeling of unease in the area due to tension in Iraq, war in the Balkans and bombings in neighbouring Saudi Arabia. These feelings of unease may be translated into less economic activity (thus reducing traffic exposure) and the movement of some activity further abroad to perceived safer havens.



The trend reverses after the year 2000 despite no change in relevant legislation but the population growth rate remains quite high compared to Western countries (1985-1995: 6.2%; Ministry of Economy, 2007). The only known surveys of seatbelt use (table 27, page 152) show a declining trend but that cannot be tied to the increase in injury crashes without further work.

### **6.3 Countermeasures to reduce timely variation**

Another major issue found was the injury crash peak at certain times. Exposure control can be an effective means of reducing daily variation and hopefully reducing the overall figures though monthly and daily variation is not necessarily a bad thing that needs to be changed or that might have any effect on overall injury crashes if it is changed.

Measures of exposure control include:

- Road pricing and toll roads (road users will try to avoid paying for using a road by using alternative roads or transport means).
- Public transport provision (will reduce the number of MVs on the road if more people chose to ride buses rather than drive)
- Compacting towns to reduce the built up area per person (this reduces the need for travel by commuters thus shortening their journeys).

Road pricing (tolls) on certain key routes have been introduced on one major route in July 2007 and expanded to another one in September 2008. Road tolls are distinct from congestion charging in that the latter applies in dense urban areas (Ison, 2005) but tolls can be in non-urban areas as well as they partially are in Dubai. The effect of road tolls on the safety of these routes can be assessed after implementation though the areas under consideration do not rank in the top 6 crash locations so the impact is not expected to be high unless there is a knock-on effect due to traffic volume shifting to other areas.

### **6.4 Countermeasures to reduce single vehicle crashes and injuries**

Almost half the injury crashes in the macroscopic study involved only one vehicle. Measures designed to reduce the high proportion of single vehicle crashes depend on the type of crash that single vehicles are involved in.



Upon first inspection Electronic Stability Control (ESC, also known by other names like ESP, ESC+T, DSC, VDC, Stabilitrak) looks like a measure that could be used to target these crashes but upon closer inspection it turns out that the majority of single-vehicle fatal crashes were pedestrian cases (where the pedestrian is assumed most likely to have been injured rather than the driver) and not loss-of-control crashes. ESC would do little to prevent a pedestrian crash unless it occurred because the vehicle went out of control first and subsequently hit a pedestrian, a situation ESC is designed to mitigate.

Single vehicle crashes involving pedestrians are multi-party crashes. They could be separated from true single-party crashes (involving a vehicle only and no other road user) but the description has been preserved to avoid confusion because this is how they were described in the original crash data supplied by the authorities in Dubai. Pedestrian crashes are dealt with in a separate section to follow while this section deals with single-party crashes.

The most common types of crash for single-party crashes were rollovers and stationary-object impacts (together accounting for 94% of this subset of cases).

Countermeasures that are most suitable for reducing single-party crashes and injuries are shared with the suggestions to reduce fatal crashes:

- Compulsory seat belt enforcement
- Vehicle stability control devices (ESC, etc)
- Improved rollover protection (passive safety, vehicle structural strength, side curtain airbags)
- Crash cushions at fixed roadside objects that are likely to be hit
- Roadside barriers to prevent the vehicle leaving the road in the first place.

Countermeasures such as ESC (Electronic Stability Control) are not recommended for retrofit but rather for inclusion of vehicles sold in the market. In the UK it was estimated (Weekes et al, 2009) that ESC fitment will have penetrated all the vehicle fleet in 2021 if the European Community regulation to make it standard on all new cars sold by 2014 was followed. In the UAE no such regulation exists so it is unlikely that the penetration of ESC in the fleet will be as high as the UK unless similar regulations are implemented.



## **6.5 Countermeasures for top crash locations**

The top six crash locations account for a significant share of all injury crashes (around 1/6). The main crash type at these locations varies by the nature of location (e.g. high-speed road vs. urban city street). Measures that might be applied to the top crash locations mainly involve:

- Black spot treatment (analysing the location of frequent crashes to identify the key causation factors and devise a treatment to remove those factors).

## **6.6 Countermeasures to control inconsiderate and drink-driving**

Driving without consideration to other road users was the most common crash cause found in all injury crashes. Inconsiderate driving is a difficult crash cause to prescribe measures for as it could encompass behavioural problems (lack of courtesy), educational problems (the importance of giving right of way was not emphasised) or psychological problems (road rage or anger management). Each has a different remedy however a longer practical driving test has been suggested as a method of vetting drivers with more care as the longer the test is, the greater the likelihood of the driver making a mistake (Fazakerley & Downing, 1980) that is dangerous.

Driving while under the influence of alcohol was found to be a leading cause of crashes (the 2<sup>nd</sup> most common in 2006 only). Crashes involving alcohol intoxication peak around 4 am so that is a clear area where enhanced patrolling (perhaps monitoring drivers leaving popular alcohol vendors) can be effective. Another known measure for tackling driving while intoxicated is blood alcohol concentration legislation and enforcement (for instance using breath-testing especially when the time of crashes is so well defined as in figure 34, page 139) to root out the greatest number of offenders. Alcohol involvement did not appear pervasive in previous years as it appears not to have been recorded as rigorously but in 2006 alone it was the second leading cause of injury crashes. This suggests that measures (such as enforcement) to tackle the problem should be applied quickly before further escalation. A concerted campaign of Random Breath Testing (RBT) such as used in New South Wales, Australia (Homel, 1990) shows the positive results that can be achieved by such a method. Random Breath Testing was not known to be in use in the UAE. The protocol for testing drivers involved in



crashes is based on suspicion or the existence of evidence (e.g. alcoholic beverages) in MVs upon which a medical test is administered at a police station or hospital.

### ***6.7 Countermeasures related to speed limit analysis***

The majority of crashes happened on roads with a speed limit of 60km/hr. Further analysis of crashes that occur on 60km/hr roads reveals that the majority of them were pedestrian collisions (34.5%), more than in the overall sample where pedestrian crashes made up only 28.6%. Almost half the crashes at that speed only involve one vehicle leading to the assumption of a pedestrian or stationary object being hit. Fortunately only a small part of those crashes (10.5%) result in serious or fatal injury.

Reducing speeds on the streets with the most pedestrian crashes (say from 60km/hr to 50 or 40km/hr) combined with monitoring speeds and automatic enforcement with speed cameras are the primary measures that are recommended especially noting the absence of speed cameras on low-speed roads (most are on roads with 80, 100, and 120km/h limits). Reducing speeds in the lower speed range (25-50 km/hr) was supported by early research on pedestrian crash survivability and impact speeds (Ashton & Mackay, 1979; Ashton, 1982). This was heavily used by the UK Department for Transport's campaign on the importance of adhering to a 30mph speed limit (DfT, 2004). Speed camera effectiveness has been shown in other parts of the world (Elvik & Vaa, 2004; Holland & Conner, 1996; Newstead & Cameron, 2003).

### ***6.8 Countermeasures for pedestrian safety***

Pedestrian crashes were the most evident crash type reported (28%). Most of the countermeasures for reducing pedestrian crashes were similar to some of those suggested in the section on fatal crashes. No barrier or central reservation exists in the majority of cases (32%). This supports the prevalence of single-carriageway roads. No road markings or signs were present in some cases (33%) and it was not known if this was a contributing factor as it may affect vehicle positioning and the line-of-sight or even improper parking (for instance when yellow lines are not painted on the roadside extremities on curves). If a significant number of pedestrian



collisions occur because an MV has lost control and mounted the pavement then barriers that prevent motor traffic from entering pedestrian areas are a consideration. Conversely if most crashes occur when a pedestrian enters the road outside proper crossing zones then barriers that control people will be needed (like fences for example).

Other factors related to the human side might be of significance in pedestrian crashes like poor road sense on the pedestrian's side with bad judgement of vehicle approach speed and the time gap available. Pedestrian impairment (from alcohol intoxication for example) was not recorded (in macroscopic analysis) or encountered (in microscopic analysis) in the data but testing for alcohol levels was ordered by the authorities if alcohol intoxication was suspected. From the driver's side, non-compliance or ignorance of pedestrian priority and vulnerability might play a role as could the lack of enforcement for this punishable offence (according to UAE traffic law). Stronger police enforcement of rules at pedestrian crossings and improvement of driver training and education to reinforce pedestrian priority rules and clarifying any rules that exist, should help in reducing the number of pedestrian collisions. The provision of pedestrian facilities must be considered at the high-risk areas to provide a safe way to cross the road. These countermeasures may be high or low cost. Examples of high cost measures are pedestrian bridges and under-passes. Signalised pedestrian crossings are an example of lower cost measures. Approaches to pedestrian crossings can be designed to encourage drivers to reduce speed by employing rumble strips or speed bumps.

Vehicle design might affect the outcome of crashes as a "soft" front end made of an energy-absorbing material will produce a softer impact than a hard or inflexible front end with a steel bull-bar fitted. Encouraging the sale of vehicles with "pedestrian-friendly" front ends is another area to consider as a large number of new cars are registered every year and regulation of this aspect can influence the vehicle fleet in the long run. The European Union has issued directives in this regard (2003/102/EC) that begin to apply to light vehicles approved for the EU market in 2010 (European Communities, 2009a;b). No such legislation existed in the UAE but if all European vehicles comply in a few years then this will have positive implications for the UAE



passenger car fleet (which had a significant European component of 15.5% of sales in 2006; Auto Strategies International, 2007).

Driver vision from inside the vehicle is another area in which improved vehicle design and regulation might contribute to a reduction in crashes. Regulations in this regard have not changed for decades (EEC Directive 77/649/EEC) although there were some test protocols being developed to establish a consumer test in this area (PNCAP - Primary Safety New Car Assessment Program, visibility section). Those had not come into effect at the time of writing (DfT, 2007a). This will be of use in assessing cars if the drivers involved in pedestrian crashes claimed not to see the pedestrian.

### ***6.9 Road layout countermeasures***

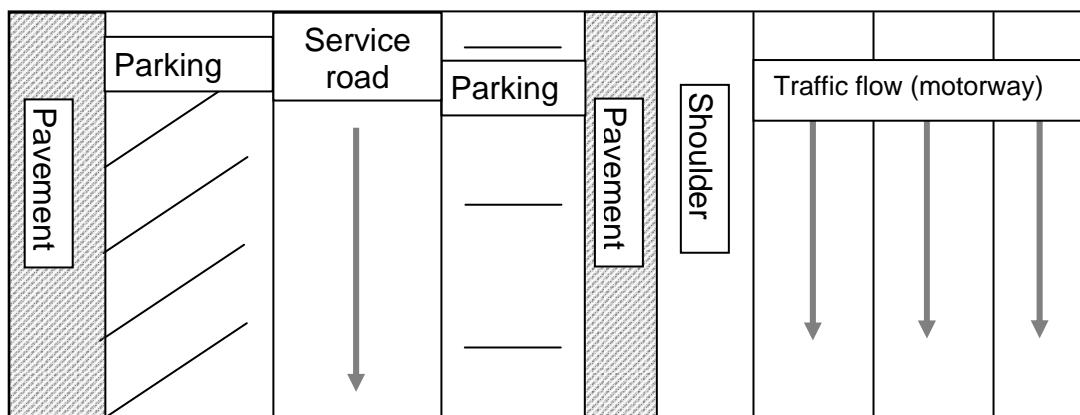
Dual carriageways accounted for most of the injury crash sites (55%). Road layout was often chosen by road planning and municipal authorities based on the service class and projected use of the road. Changing the balance of road types is not an option as a measure for improving safety due to the large costs involved but it must be considered for new road projects. Ways to improve safety on the particular road type under consideration can only be found when further analysis of crashes on these roads is performed; then weaknesses can be highlighted and addressed.

### ***6.10 Central reservations and barriers as countermeasures***

Recording of central reservations only appeared after 1997 implying it was introduced on the crash form in 1998. Adjusting for this most injury crashes from that date were at a site where no barrier or central reservation exists (30%). Of those sites the top two are a service road to a main highway (where a barrier would not normally be installed) and the old Souq (market) area that is very heavy with pedestrian traffic. The installation of barriers at these locations might be beneficial (unless the victims were pedestrians on the road then pedestrian crossings or overhead bridges would be a better solution). Overhead bridges have the attraction of allowing free pedestrian movement while not affecting vehicular traffic. This would be relevant in an area of heavy pedestrian traffic such as the old Souq. However it might not be practical on a service road as a number of pedestrians use the



carriageway to get to their cars that are parked on either side of the one-way service road (figure 64). A barrier would prevent access to the parked cars.



**Figure 64: Schematic illustration of road layout on Sheikh Zayed Service Road, where pedestrian crashes would not be helped by barriers (not to scale).**

The majority of pedestrian data supplied (base-level) did not include the location where pedestrians were hit (carriageway or pavement). A minority of cases in microanalysis showed pedestrians being struck off the road but the majority were struck on roads. The evaluation of current barriers of different design and construction was not possible as the type of barrier was not supplied in macroanalysis.

### ***6.11 Countermeasures for lighting and environmental conditions***

In the small number of cases (often less than 5%) in which lighting or weather or road surface conditions were not optimal, it should be noted that these few cases might be avoidable through specific treatment (like installing or clearing gutters to deal with standing water or improved street lighting in poorly lit areas). Road markings and/or signs exist in the majority of cases but no road markings or signs were recorded in a significant number of cases (~28%); most of those cases were from the early period of the study (1995-1997) so it was very likely that those conditions were not recorded on the form at that time. The number of cases with no road markings or signs significantly declines after those years.

Weather conditions were fair in most cases (>97%) but the few days of annual rain or fog make the headlines in the local media as large crash numbers are recorded. There are two groups of solutions to this very periodic peak. If meteorological data identifying the inclement-weather days was available and injury crashes during the few inclement days were found to be



higher than regular days then the employment of Variable Message Signs (VMS) to warn drivers of the conditions and remind them of the need for cautious driving might improve safety. Limiting exposure during these times (for instance by employers encouraging staff to work from home) can also be beneficial. In Austria, pedestrian injuries were less serious in severe weather conditions (Kim et al, 2008) so it may be the case that road users could also be more cautious in Dubai in unusual weather.

### ***6.12 Countermeasures for gender and nationality variations***

Females were under-represented as casualties (18%) compared to their share in the population (26.6% in Dubai, 32.4% in the UAE, source: Ministry of Economy, 2005) but this does not take into account exposure and driving habits. Traditionally the local population will prefer to drive women around rather than have them drive themselves so this might be a factor as well. Some conservative families prefer their daughters not to drive unless they have to (as might happen when getting a job or having to take children to school). Female vehicle drivers and occupants are of particular concern in crashes as they tend to have more severe injuries compared to male drivers and occupants (Evans, 2001; Welsh & Lenard, 2001). In the neighbouring state of Qatar (Bener & Crundall, 2008) male drivers were found to have a higher crash rate than their female counterparts so it might be an underlying issue in the UAE as well.

Nationals of India and the UAE feature most frequently as casualties closely followed by Pakistanis (see figure 44, page 150). South Asians (mainly nationals of India, Pakistan, Sri Lanka and Bangladesh) make up 50% of the UAE population (CIA, 2009). Emaratis tend to be injured most in crashes on two main highways, Sheikh Zayed Road and Dubai Al-Ain Road (combined 16% of total locations) and they have more severe crashes than the average population (14.7% fatal, 6% serious)..Analysis of the nationality of casualties by road user type shows that Indian casualties were mostly passengers in vehicles while Pakistani and Emarati casualties were most commonly injured as vehicle drivers. The time of crashes does not deviate from the average very much for the first two nationalities but for Indians a distinct peak of crashes is found around 8am. Culture and educational background are two suspected factors as pointed out by an earlier survey of drivers in the Gulf



(Al-Madani & Al-Janahi, 2002). Ethnic origin was also found to have an effect on reported seat-belt use in the USA (Boyd et al, 2008). Drink-driving among adolescents in California (Walker et al, 2003) was found to be more common among Latinos in one study based on telephone interviews. Not enough is known about exposure to single out any one nationality as being more or less risky in driving than others.

Reducing the incidence of the top three nationalities in injury crashes might be made through improved driver testing, by increasing the length of the test or introducing an advanced test for drivers that are involved in a crash due to suspected poor driving. However it might not be politically correct to apply this measure to a particular nationality so extending it to all the driving population would be the ideal. In the year 2000 the length of the practical part of the test in Dubai did not exceed 10 minutes at most for each candidate and the “written” part consisted of a verbal test of traffic sign comprehension. Increasing the test length might put extra pressure on the driver examination system and hence might not be an attractive countermeasure to authorities as it implies higher costs due to more staff time needed to conduct the tests. This may be offset by higher test fees but these might prove unpopular with the members of the public who are applying for a driving licence.

### ***6.13 Countermeasures for young casualties***

Those under eighteen years of age form a significant proportion of injured individuals (~11%) and most of those are injured on single-carriageways with a single lane in each direction generally indicating a low-speed road. The predominant crash type for this age group was pedestrian (32.7%) but it is not known if the responsibility lies with the pedestrian (if under the legal age) or the guardian or the driver of the vehicle involved. Any recommendation for dealing with this issue must take this into account. In the UK child fatalities and serious injuries that are pedestrians make up a higher proportion (61%; DfT, 2008) but that may be due to the higher incidence of walking in the UK. Universal measures that might be worth considering are school education for young pedestrians; signalised pedestrian crossings where they are not used and pedestrian barriers (fences) to prevent crossing at problem locations whilst providing alternatives. The latter measure has been applied on the road with the most injury crashes (Sheikh Zayed Road) as a 31-km long



fence along the busiest stretch. This has been effective in reducing run-over mortalities along this road from 23 in 2005 to 15 in 2006, according to Dubai road authorities (Ahmed, 2007a). A significant portion of the population of the UAE is young, especially with UAE nationals, where 51.1% are under the age of 20 (Ministry of Economy, 2005). Exposure might be higher for the young age groups as 18-30 year olds account for the greatest number of casualties. Programs of education for school-going children have been shown to improve their road crossing behaviour in the cities of Miami (Hotz et al, 2004a;b) and Melbourne (Congiu, 2008).

Measures for young casualties that were car occupants depend on the cause and type of injury. Without more detail it was difficult to suggest countermeasures but child seating and restraint are primary considerations in this area. Studies by multiple organisations in the EU have investigated this special sub-section of car occupants to develop a crash database for further work (Kirk et al, 2006).

#### ***6.14 Countermeasures to improve seat belt usage***

Seat belt use rates from Dubai and neighbouring areas indicated a serious problem with the lack of use by vehicle occupants (Barss et al, 2008). Seat belts have been mostly used in HMCs after legislation and enforcement so this is a primary area for work in Dubai and the UAE since the legislation (for front seat occupants) exists but enforcement is not strict. Legislation in the UAE only applies to front seat occupants (Dubai Court, 2006) but is still considered inadequate (Barss et al, 2008). Non-enforcement based strategies have been used in other countries to encourage seat belt use based on education, encouragement and reward of road users (Zaal, 1994). Other measures that have been proven successful in other countries like Sweden (Krafft et al, 2006) were “smart” seat belt reminders with a loud audible signal and visual signal though the control group for that study (cars without seat belt reminders) were in almost all cases older than the study group so it does not control for driver age and choice (it could be that drivers of newer cars are more seat-belt conscious than older ones). Such devices are coming on to the market partly due to pressure from consumer tests like EuroNCAP as a way of improving the score in such tests but they are not



thought to be currently fitted to the majority of cars on the road in the UAE or Dubai.

### ***6.15 Countermeasures for driver education and behaviour***

It is not realistic to apply countermeasures that might limit the driving task to people who have completed higher education or hold certain degrees as it is almost certain that holders of these degrees will have more productive things to do in their time than drive. Conversely a majority of drivers on the road undertake the driving task as part of their job if not the core of their job (like taxi drivers, bus drivers and couriers). In addition education was not considered by some experts to be an effective treatment for road traffic injuries (Mohan & Tiwari, 1998; Mohan, 2003). However these views related to less motorised countries not highly motorised ones. The educational background of drivers was found to affect traffic sign comprehension in the UAE and some neighbouring countries in the GCC (Gulf Cooperative Council). Any discussion of driver educational measures must be focused on driver behavioural issues that lead to unsafe driving and their causes. A driving test is already in use in Dubai and the UAE and as such cannot be suggested as a stand-alone measure though improving the driving test is a candidate for consideration.

While the method of driving can be taught consideration for other road users is best enforced as drivers display exemplary performance when in the vicinity of a police patrol (Axup, 1990, cited in Zaal, 1994). As consideration for other road users is a behaviour issue, it can be influenced by enforcement as other behavioural issues have responded to enforcement (seat-belt use, drink-driving, speeding; Fildes & Lee, 1993; Zaal, 1994). Revising the driving theory test (which currently consists of a test of sign comprehension only) to include situations that may teach the importance of consideration for fellow road users might assist in producing more considerate drivers. Care should be taken to ensure this cause is only recorded in the form when it is the actual main cause of a crash and not a misnomer for something else.

Speeding has been linked in the past (Mackay, 1985) with sports car driving and newer cars. The proportion of new cars in the UAE overall (as a percentage of total registrations in 2006) was 12.1% (Ministry of Economy, 2009) whereas in the UK the percentage of new cars in the same year was



6.5% (DfT, 2007c). This might be a factor in explaining non-conforming driver behaviour with regards to speed.

### 6.16 Projections if the existing situation continues

There is one factor which may be used as a fatality predictor during the years of this data collection and that is the measure of fatality risk (almost unchanged at ~20 deaths per 100,000 people throughout, see figure 7 page 36). Using official population projections for the coming twelve years (Statistics Centre of Dubai, 2007) it was possible to make projections of the fatality figures based on the constant fatality risk of previous years. If the existing trend continues then road deaths are expected to rise to 684 – more than double their number in 2006. This prediction is a very basic one using only one variable and assuming all other variables to remain the same. Confounding factors such as changes in road length, vehicle travel and road user exposure and vehicle fleet composition might all affect the actual outcome. However all these variables are likely to have changed over the past twelve years (1995-2006) but the fatality risk has not, so it might remain the same for a few years to come.

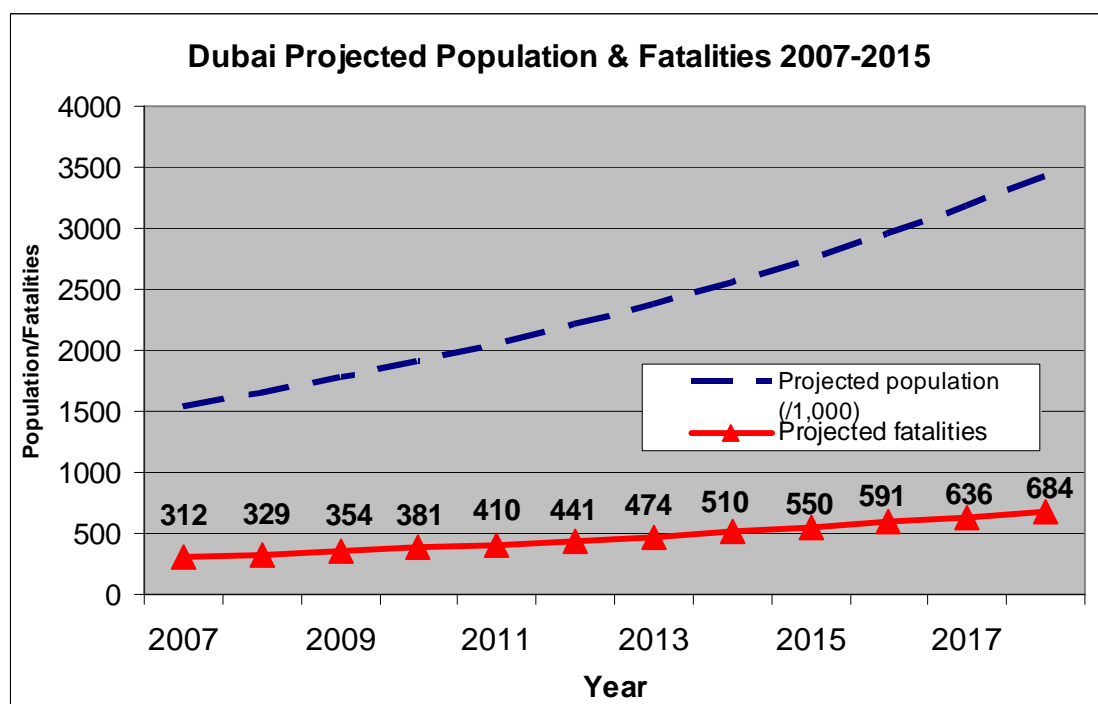


Figure 65: Dubai projected population and fatalities for next 12 years. *Source of population data: Statistics Center of Dubai, 2007.*



### ***6.17 The key: matching countermeasures and problems***

After the main problems were identified in the previous chapter and the key countermeasures for those problem areas were reviewed here it was possible to tie up the main problem areas with the main countermeasures in that area that are of proven effectiveness as found in the literature review. The main problem areas were first selected from the results. Suitable countermeasures were then considered, one by one, based on their estimated or proven effectiveness in the international field. Those countermeasures with the highest level of effectiveness (largest expected improvement in safety) were then shortlisted and matched up with the specific problems they were designed to treat.

Following this step an estimate of the improvement in road safety was made retrospectively assuming the measure was applied to all related crashes. For instance if ESC has an estimated effectiveness in reducing single-vehicle crashes by 16.7% then the number of vehicle crashes involving a single vehicle where ESC might have been effective (ex. rollovers and loss of control crashes) were selected out of the total cases. The 16.7% expected reduction is applied to this number only to derive an expected improvement in this sub-set of crashes. To make this estimate valid it is assumed that the next 12 years will have at least as many crashes as the past 12 years. From the predictions made in the previous section this is a valid assumption. If the past trend continues and crashes in the next period are more then this means the gains from using this countermeasure will increase proportionally making the savings presented an underestimate.

Some crashes may have multiple causes reported. More than one countermeasure may apply to such a crash. Interaction between different countermeasures is possible (e.g. night-time enforcement through increased patrols and automatic enforcement by speed cameras). Calculation of the effect of this interaction is made more difficult due to the number of possible scenarios. Out of the total nine measures suggested, any number of measures may interact with each other. For example, if a driver not wearing a seat belt crashes at high speed after losing control and impacts a fixed object outside the road, the crash may be affected by a number of countermeasures (seat belt legislation, ESC, automatic enforcement, crash cushions). The effectiveness of a countermeasure might change depending on the rest of



the countermeasures involved and the extent of their deployment. The study of these interactions deserves consideration for further refinement of the predictions.

### **6.18 Calculating potential cost savings**

Next a cost estimate of the safety improvements was made. This was based on the premise that every crash or injury has financial cost implications. Some countries like the UK have detailed costing information available for road crashes so these were used due to the lack of such data in Dubai and the UAE. The figures that were used came from the latest available publication of the Department for Transport (DfT, 2007*b*) and can be easily updated when more relevant data becomes available. Some of the main values used were the average cost of a crash where at least one person was injured (£64,440) and the average cost to the economy of treating one casualty from a car crash (£44,920). The first figure was used when estimates of effectiveness of a countermeasure were given as a percentage reduction in all injury crashes (this was the case for the majority of countermeasures). In one case a countermeasure had its effectiveness measured as a reduction in *casualties* not crashes. Only in that case (seat belt legislation) was it necessary to use the second cost figure (£44,920). This allowed the calculation of a final estimated figure for the grand total of savings possible by using the most effective available countermeasures.

Using the original predictions of crash fatalities for the next 12 years and the cumulative estimate of crashes over that period (5,665) it was possible to demonstrate the effectiveness of the first measure suggested in table 29. If the current situation continues unabated the cumulative number of fatalities will likely be around 5,700. If the 1,555 estimated reduction in fatalities is deducted this will reduce the total cumulative estimate to around 4,100, which is over a quarter reduction in fatalities (28%) – a significant achievement by any standard.

The effectiveness of a countermeasure was estimated over the whole injury crash data set and not only the problem that prompted suggestion of that measure. For example, a significant presence of rollovers in the sub-set of fatal crashes led to the valid assumption that a lot of rollovers were preceded by loss of control, so measures to reduce loss-of-control were suggested.



Then their effectiveness was measured as a percentage reduction in all rollover injury crashes, not just fatal ones. Measures for which quantified savings estimates exist have been selected. Estimates of the reduction in all injury crashes were found for most countermeasures (except as stated in the tables on the next pages). A breakdown of the estimated reductions for each crash severity (for example fatal, serious, slight, etc) was not available for every countermeasure and were hence not included.

**Table 34: Breakdown of key problem areas, relevant countermeasures and the number of applicable cases**

No.	Problem (number of crashes in base-level sample)	Sub-division	Countermeasure and known effectiveness (best estimate of difference in <i>injury occurrence/injury crashes</i> )	Number of applicable cases
1	High proportion of fatal crashes	Motor vehicle occupants	Seat belt use legislation (-12% <sup>2</sup> injured MV occupants)	12961 (assuming a minimum of one casualty per crash)
2	Pedestrian crashes are the most common type	-	Upgrade to signalised (separate phase) pedestrian crossing facilities (-30% <sup>2</sup> crashes)	5181
3	High number of single-vehicle crashes	Stationary object impact	Crash cushion at the site of stationary object (-69% <sup>2</sup> crashes)	1719 single vehicle stationary-object impacts
4	Urban areas account for a lot of crashes (7376 crashes on roads with 60kph limit)	Speed limits (lower end)	Reducing existing speed limits from 70→60 and 60→50 km/hr (-9% <sup>2</sup> crashes)	7376 cases on roads with 60kph limit
5	Speeding is 2 <sup>nd</sup> most common crash cause (2293)	Vehicle monitoring	Automatic speed enforcement (-17% <sup>2</sup> crashes)	2293
6	High proportion of fatal crashes (1926)	Rollovers	Electronic stability control (-16.7% <sup>1</sup> crashes)	1970
7	Highways account for a lot of crashes (2150 crashes on roads with 120kph limit)	Speed limits (higher end)	Reducing existing speed limits from 130→120 or 110, 120→110 km/hr (-14% <sup>2</sup> crashes)	2150 on roads with 120kph limit
8	Crash peaks in the afternoon and evenings (7681 occur from 12-2pm, 4-10pm)	Vehicle control	Road tolls to reduce exposure (-5% <sup>2</sup> crashes)	3680 from 12-2pm, 4-10pm at top 6 locations
9	Drink-driving (esp. in later years – 404 cases from 2004-2006)	Driver monitoring	Enforcement during night-time (-7% <sup>2</sup> crashes)	404 from 2004-2006

<sup>1</sup> Source: Lie et al, 2005

<sup>2</sup> Source: Elvik & Vaa, 2004

<sup>3</sup> Source: DfT, 2007b

Most of the figures for countermeasure effectiveness were taken from the meta-analysis carried out on the results of a number of studies by Elvik & Vaa (2004). The sources of these studies varied in location. Some were



conducted in Scandinavia (effect of toll roads and ESC) while the majority come from around the world (North America, Australasia, Western Europe and Scandinavia). Effectiveness measures were carefully selected to exclude those related to environments that differed significantly from Dubai. One example was the exclusion of studded tyres as a safety countermeasure because the effectiveness of this measure comes from studies in countries with very cold winters and heavy snowfall. Dubai in contrast normally has very little rainfall, let alone snowfall (Dubai Meteorological Department, 2006). All the studies made calculations of effectiveness based on observation before and after the application of a measure while controlling for other factors (Elvik & Vaa, 2004, Lie et al, 2005; Thomas et al, 2006*b*). In all cases these studies were the most recent and comprehensive source of information available. Differences were bound to exist between Dubai and the study areas in many aspects like weather, road user behaviour, vehicle fleet, etc. Until the individual countermeasures are studied in the same depth in Dubai (as in the international studies quoted) it will not be possible to find more accurate effectiveness estimates.



**Table 35 Suggested countermeasures; their effectiveness; and preliminary estimated cost savings**

No.	Countermeasure	Best estimate of difference in injury occurrence/ injury crashes	Estimated 12-year crash/casualty reduction (retrospective, rounded to last digit)	Avg value of est. saving in crash prevention costs (based on UK, 2005) <sup>3</sup>
1	Seat belt use legislation	-12% <sup>2</sup> (injured MV occupants)	1,555 (assuming all non-pedestrians are MV occupants)	£44,920 x 1,555 = £69,850,600
2	Signalised (separate phase) pedestrian crossing facilities (upgrade)	-30% <sup>2</sup> (crashes)	1554	£64,440 x 1554 = £100,139,760
3	Crash cushion at the site of stationary object	-69% <sup>2</sup> (crashes)	1186 (taking all single-vehicle stationary-object injury crashes)	£76,425,840
4	Reducing existing speed limits (from 70→60 and 60→50 km/hr)	-9% <sup>2</sup> (crashes)	663 (on roads with a recorded 60 km/hr speed limit)	£42,723,720
5	Automatic speed enforcement	-17% <sup>2</sup> (crashes)	389 (note: the increased use of speed cameras in the last period has already shifted speeding to 6 <sup>th</sup> leading cause in 2006)	£25,067,160
6	Electronic stability control	-16.7% <sup>1</sup> (crashes)	329	£21,200,760
7	Reducing existing speed limits (from 130→120 or 110, 120→110 km/hr)	-14% <sup>2</sup> (crashes)	301 (on roads with a recorded 120 km/hr speed limit)	£19,396,440
8	Road tolls to reduce exposure	-5% <sup>2</sup> (crashes)	184 (effect measured on top 6 locations only, as nature of other locations unknown)	£11,856,960
9	Enforcement during night-time	-7% <sup>2</sup> (crashes)	28 (noting only 2005-6 had significant records; if previous years had same rate of drinking as 2006, reduction would be 169)	£1,804,320
			<b>4,634 crashes, 1,555 casualties</b>	<b>£368,465,560 ≈AED2,690,000,000 Dirhams, the local UAE currency (mkt ex. rate mid-April 2007)</b>

<sup>1</sup> Source: Lie et al, 2005

<sup>2</sup> Source: Elvik & Vaa, 2004

<sup>3</sup> Source: DfT, 2007b

**Order is by category (casualty savings then crash reductions) and decreasing magnitude of projected savings.**



## 6.19 Summary – macroscopic analysis of base data

Following the identification of the key problems of road safety from the analysis of the base-level police crash data provided the countermeasures that were suitable for application to solve these problems were matched from the literature. The major innovative part of this work is the use of international knowledge of these countermeasures and the measured improvement from using them and matching that to current problems in Dubai. Where reliable countermeasure effectiveness data existed this was then used to measure the impact of the proposed countermeasures on the situation in Dubai making the simple assumption that there will be at least as many crashes in the coming 12-year period as in the preceding one.

**Table 36: Main problems from macroanalysis and suggested countermeasures.**

	Problem	Extent of problem	Countermeasures
1	Fatal crash propensity	13.5% in 2006 10.6% overall. Pedestrians: 37% of total	Pedestrians: signalised crossings; speed humps; improved visibility; crashworthiness
2	Rollovers & hitting a stationary object (among fatals group)	Rollovers: 13.6% Stationary object: 11.8%	ESC; seat belt enforcement Crash cushions; roadside barriers
3	Crash peaks at certain hours	Most crashes occur from noon – 9pm	Exposure control: road pricing; taxation; public transport; compacting towns
4	Single vehicle crashes	48.7% of total	ESC; seat belt enforcement; crash cushions; roadside barriers
5	Frequent crash locations	1/6 of all crashes occur in 6 areas	Black spot treatment
6	Inconsiderate & drink driving	Incon.: 26.7% of all causes, drink: 11.5% in 2006	Enforcement & breath testing; legislation;
7	Crashes in 60km/hr zones	Pedestrian crashes most common in these zones (34.5%)	Revised (lower) speed limits
8	Pedestrian safety	28.6% of all crashes with pedestrians	Separate crossings; speed humps; improved visibility; education
9	Road layout	55% of all crashes are on dual c'ways	Requires further study (not enough data)
10	Central reservations; lighting; environment	Not enough data	Requires further study (not enough data)



	<b>Problem</b>	<b>Extent of problem</b>	<b>Countermeasures</b>
11	Males are the most common casualties	82% of casualties are male	Requires further study (not enough data)
12	Young casualties	Make up 11% of all casualties	Requires further study (not enough data)
13	Seat belt use	Not enough data	Requires further study (not enough data)
14	Driver education & behaviour	Inconsiderate driving 26.7% of all causes	Requires further study

If the next 12 years were similar to the preceding period then the annual road fatality figure was expected to double (to 684) by 2017. In total nine countermeasures were selected and their estimated benefits were calculated. The reductions were estimated as 8,242 crashes and 1,555 casualties over the 12-year period. The magnitude of reductions in costs was found to be in the order of £300 million. Though the estimates are only accurate as far as the costs of crashes in the UK match the costs in the UAE updated financial figures can be incorporated once they are found and this does not detract from the main calculations of crash and injury reductions.

## ***6.20 Relating preventative measures to interventions in the microscopic analysis***

### **6.20.1 Introduction**

In a similar way to the approach used for macroscopic data, one of the main outcomes for the in-depth data analysis (the list of preventative measures) was used to match key problem areas to interventions found under the broad countermeasures area suggested. These interventions have all been reviewed in the appropriate section and the existing knowledge of these interventions (namely their level of effectiveness from previous research) was used to calculate the potential benefit on the in-depth sample.

The difference between the two data sets lies in the level of information available on crashes in each. In the first sample only fourteen fields of data were available for every case file. This put severe limitations on the extent to which the crash circumstances can be deciphered and understood completely. The second sample contained over 140 fields of information on every crash in addition to the non-encoded information such as scene photographs and drawings. The more detailed knowledge allowed the



matching of interventions to specific problems with more accuracy, down to the individual cases. Because this sample did not cover all crashes in 2006 a weighting of cases was performed to match the sample to the whole 2006 injury crash population as that data is known from the base level data.

## 6.20.2 Selection criteria

The preventative measures that were chosen most frequently were short-listed for further review. The next step was for one or more interventions of known effectiveness and expected relevance to the area to be matched to the top preventative measures assigned to cases in the in-depth sample (table 37). Only those interventions in bold were selected for further consideration because of local knowledge. The study was concentrated on measures that may be realistically implemented to keep it as close to reality as possible and applicable in the real world.

**Table 37: Top preventative measures and related interventions**

	Countermeasures area	Related intervention that may have improved outcome	Prevalence in sample. (Multiple measures may apply to the same crash)
1	Seat belt use	Seat belt use legislation	89/300 (29.7%)
2	Central barriers, guardrails and crash cushions	<b>Guardrail along roadside.</b> Vehicle crashworthiness.	<b>46/300 (15.3%)</b> 285/300 (95%)
3	Pedestrian safety	<b>Pedestrian protection measures.</b> Pedestrian visibility. Pedestrian education.	<b>153/300 (51%)</b> 155/300 (51.7%) 168/300 (56%)
4	Speed related measures	<b>Auto. speed enforcement</b>	<b>72/300 (24%)</b>
5	Loss of control	<b>Electronic stability control</b>	<b>72/300 (24%)</b>
6	Offending driver punishment	<b>Fines and detention</b>	<b>38/300 (12.7%)</b>

Seat belt legislation for front seat occupants was already in place in Dubai and the UAE (Dubai Courts, 2006). Vehicle crashworthiness is a very broad term and influencing this in the short or medium term was seen as an unrealistic proposition. Pedestrian visibility was an area where little work has been done (especially related to the local conditions in the UAE) and influencing it or the behaviour of a huge number of foreign labourers was improbable. Pedestrian education (though desirable) was not selected due to similar expectations along with the non-provision of pedestrian facilities in many cases, which is a measure of higher priority. Pedestrians may be taught to cross at appropriate locations once such locations (or crossings) were put in place.



The remaining measures (in bold) were chosen for the next step due to the greater clarity of the relationship between them and specific cases as well as their established benefit from the various studies in the literature review. For the next step every intervention was looked at in more detail and cases were reviewed individually to ensure they match the case conditions as closely as possible to have a positive impact on the outcome. Though a lot of these measures might have been used at some stage in Dubai their use was not evident in the cases selected. This problem may be solved by road safety audits and black spot treatments.

## **6.21      *Matching interventions and problems to estimate reductions***

The next step was to calculate an average reduction in the number of crashes for every intervention and make an estimate of cost savings using available UK data in British Pounds for 2005 (DfT, 2007*b*). This was converted to the UAE currency (Dirham symbol AED) using exchange rates current at the time (July 2008). One intervention (fines and detention) was excluded from the next table due to the calculated effectiveness being applicable to the whole crash population (including non-injury crashes). All other interventions had effectiveness estimates based on injury crashes only hence the calculation of their benefits was more straightforward. To calculate the benefit of fines and detention it was necessary to make an estimate of the proportion of injury crashes to the whole crash population (table 35).

For example, cases selected for grade-separated crossing facilities (intervention №3 in table 41) were only those that could have benefited from a crossing facility at the site. Cases were excluded if there were any indicators of unusual behaviour like drunkenness, attempted suicide or jumping over a pedestrian fence. For speed cameras (intervention №5) it must be stated that effectiveness was mixed between urban and rural areas and areas where the studies were made may differ significantly from Dubai.

### **6.21.1 Weighting cases according to severity**

To make the sample data applicable to the whole population of reported injury crashes in Dubai in 2006 each subset of crashes was divided into the



different severities assigned by the police. Each severity was then multiplied by the factor found from the overall population (table 39). The results and breakdown were displayed in table 40. This allowed estimation of the benefits possible from just these six interventions over the whole population of 2006 injury crashes (table 41).

#### **6.21.2 Annual cost savings**

It was not surprising that grade-separated crossing facilities for pedestrians resulted in the single largest calculated benefit as the largest proportion of objects hit was pedestrians. Surprisingly stability control accounted for the next-highest reduction in costs (but only a small number of crashes) due to the established effectiveness of the measure especially in fatal and serious crashes (Thomas, 2006*b*; Thomas & Frampton, 2007). Speed cameras accounted for the third-highest reduction in costs and this measure was already on the police agenda to see an increase in use in both quality and quantity (Al-Theeb, 2008*b*).

Guardrails along the roadside and in the median between opposing carriageways were also found to offer a substantial saving. This shows that despite the many new roads that were designed according to international standards there were still many incidents where a railing could have helped. Driver punishment through fines and detention also can result in some benefit despite the tens of thousands of fines recorded every month (Al-Theeb, 2008*a*). Increased fines and enforcement had a significant positive impact on road-related trauma in other countries with rapidly increasing motorisation (Poli de Figueiredo et al, 2001; Ribeiro & Góes, 2005).

The total cost savings possible by these few measures were substantial. The cost of the interventions was not available but when it becomes available further work on cost benefit analysis may be carried out. Whatever the cost of interventions it will be a small component of the budget of the roads authority. The cost of ongoing road projects in 2007 was 8bn Dirhams excluding the work on Dubai Metro (AED16bn; Gulf News, 2007).



**Table 38: Estimated crash and cost reductions for in-depth sample**

Preventative measure	Specific intervention	Best estimate of effectiveness	No. of matched cases	Estimated crash reduction & cost*	Estimated annual cost saving
Central barriers, guardrails & crash cushions	Guardrails along roadside	-47% <sup>1</sup>	8	3.52 x £64,440	£226,823 (AED 1.6m)
	Median guardrail on multi-lane divided highways	-30% <sup>1</sup>	10	3 x £64,440	£193,320 (AED 1.4m)
Pedestrian measures	Grade-separated crossing facilities	-82% <sup>1</sup>	96	78.72 x £64,440	£5,072,717 (AED 35.5m)
Vehicle control/active safety measures	Electronic stability control (ESP/ESC/DSC/etc).	-19% <sup>2</sup>	39	7.41 x £64,440	£477,500 (AED 3.3m)
Speed cameras	Automatic speed enforcement	-17% <sup>1</sup>	68	11.56 x £64,440	£744,926 (AED 5.2m)
Offending driver punishment	Fines and detention	-10% <sup>3</sup> all crashes	36	(special case – see next tables)	
				Total (July 2008 exch. rates)	<b>£6,715,286/ AED47,007,002</b>

\*Average value of prevention of crash – UK 2005 (DfT, 2007*b*).

<sup>1</sup>Percentage change in number of injury crashes, according to Elvik & Vaa, 2004.

<sup>2</sup>Percentage change in number of fatal and serious injury crashes (ESC vs. non-ESC cars); combined effect of ESC and passive safety improvements, according to Thomas, 2006*b*. This figure was used rather than the first estimate (for 1995-2006 crashes) as it was a more recent study.

<sup>3</sup>Percentage change in number of total crashes; Elvik & Vaa, 2004.



**Table 39: Weighting factors for in-depth sample to whole 2006 crash population by severity**

<b>Severity</b>	<b>Weighting factor</b>
Fatal	1.56
Serious	6.74
Medium	26.1
Slight	92.9

**Table 40: Weighting of cases related to selected interventions**

<b>Intervention</b>	<b>Total before weighting</b>	<b>Severity divisions before weighting</b>				<b>Severity after weighting (rounded to nearest digit)</b>				<b>Total after weighting</b>
		<b>Fatal</b>	<b>Serious</b>	<b>Medium</b>	<b>Slight</b>	<b>Fatal</b>	<b>Serious</b>	<b>Medium</b>	<b>Slight</b>	
1.Guardrails along roadside	8	2	2	0	1	3	13	0	93	<b>109</b>
2.Median guardrail on multi-lane divided highways	10	6	0	0	2	9	0	0	186	<b>195</b>
3.Grade-separated crossing facility	96	56	8	5		87	54	131	0	<b>272</b>
4.ESP/stability control	39	19	2	1	1	30	13	26	93	<b>162</b>
5.Speed cameras	68	35	5	5	3	55	34	131	279	<b>499</b>
6. Driver fines and detention	36	18	4	0	1	28	27	0	93	<b>148</b>



**Table 41: Total calculated reductions in crashes and costs 2006**

Intervention	Total before weighting	Total after weighting	Effectiveness (% change in prob. of injury)	Crashes reduced (to nearest digit)	Savings per crash <sup>◇</sup>	Total annual savings
1. Guardrails along roadside	8	109	-47%	51	£64,440	£3,286,440
2. Median guardrail on multi-lane divided highways	10	195	-30%	59	£64,440	£3,801,960
3. Grade-separated crossing facility	96	272	-82%	223	£64,440	£14,370,120
4. ESP/stability control <sup>¥</sup>	39	<b>30</b>	-19% ( <b>fatals only</b> )	6	£1,644,790	£9,868,740
5. Speed cameras	68	499	-17%	85	£64,440	£5,477,400
6. Driver fines & detention	36	148*	-10% all crashes (inc. non-injury)	1988	£1,710	£3,399,480
				<b>2412</b>	Total	<b>£40,204,140</b>
					Exch. rate July '08	<b>~AED281,400,000</b>

<sup>◇</sup> Average value of prevention of crash – UK 2005 (DfT, 2007b).

\*This intervention's effectiveness was available only as a percentage of all crashes. That figure was calculated for the next table as follows:

148 cases after weighting (injury crashes only). To weight these cases to the whole crash population (inc. non-injury) the proportion of injury:non-injury crashes was needed. Proportion of injury crashes to all crashes in 2006 is 1:134.32 (RTA, 2007). 10% of all crashes = 10% (148 x 134.32) = 0.1 x 19,879 = 1,988 cases.

<sup>¥</sup> This value decreases after weighting because the initial cases included fatal and non-fatal injury cases whereas the measure only applies to fatal and serious cases (and serious cases were not graded as such in this data set). The number of cases where ESP may have been effective included both fatal and non-fatal cases. However the effectiveness estimate only applied to fatal cases hence non-fatal cases were removed, resulting in a decrease in cases after weighting rather than an increase.



## 6.22 Summary – microscopic analysis and interventions

The findings from the in-depth data coincide with those from the base data in many cases as it was based on a subset of the whole population but there were many concerns with injury crashes that were now highlighted by the in-depth nature of the information and data collected and analysed in microscopic depth. Some variations may be due to the shorter time range covered which might make it more difficult to see trends which were easily visible over 12 years. Others highlight differences in ground conditions (new roads, increasing traffic) that are characteristic of the situation in Dubai. The concentration of this study on serious and fatal crashes made it a very strong base from which to begin tackling the most costly crashes (in terms of human and financial cost).

The top preventative measures that applied to the most crashes in the sample were selected for further analysis. These included guardrails, pedestrian measures, speed enforcement and fines and detention. Items that were excluded were already in use in Dubai to some extent or difficult to implement on the ground. Examples of excluded measures were seat belt legislation; vehicle crashworthiness and pedestrian visibility.

**Table 42: Summary of interventions and estimated reductions.**

Intervention	Crashes reduced (after weighting)	Total annual savings
1. Guardrails along roadside	51	£3,286,440
2. Median guardrail on multi-lane divided highways	59	£3,801,960
3. Grade-separated crossing facility	223	£14,370,120
4. ESP/stability control	6	£9,868,740
5. Speed cameras	85	£5,477,400
6. Driver fines & detention	1988	£3,399,480
Total	<b>2412</b>	<b>£40,204,140</b>
	Exch. rate July '08	<b>~AED281,400,000</b>

The more detailed crash causation and mechanism reporting improves on the base-level data which allowed the application of the novel preventative measures technique to the crashes in the database. The interventions that



were selected as the basis for improvements in safety were all matched to individual cases in the database to ensure relevance. Widening the process to include the whole population of casualty crashes in 2006 was possible by weighting the cases according to severity to calculate the possible gains for the whole of Dubai in one year. The severity ratios used for weighting the different crash severities were found from the results to be 1:1 for fatal crashes, 1:4 for serious crashes, 1:17 for medium crashes and 1:60 slight.



## **Chapter 7 Discussion of potential to apply counter-injury measures in Dubai**

### ***7.1 Introduction***

Road safety challenges were investigated in Dubai to establish its current standing among best-performing nations and to learn which counter-injury measures could be best applied from best-practice around the world. The results and implications were discussed in the following sections starting with the overall scenario, then proceeding to more detail.

Economic growth and development are the goals of many policies and governments around the world. They are being achieved with startling effect in Dubai. This growth has brought with it multiple costs and new problems including the exacerbation of some existing problems, of which road safety is one. This is the area with which this research is concerned. The road infrastructure has come under immense pressure in recent years and construction in some places has not been able to keep pace with demand, as has been witnessed by the decision to bring forward the construction of a multi-billion-Dirham light rail transit system (Dubai Metro) that was initially planned for 2010 and beyond.

Two main stakeholders in the field, academic institutions and road authorities, have to a large extent focused on a few specific issues permitted by their time and budgets. By their very nature, the authorities are not research-intensive or research-driven and a lot of their time is consumed by the rapid growth of the city and the multiple projects and maintenance that entails. Academic institutions exist in a culture that is not that familiar with external funding and subsequently lack support to conduct any large-scale studies to evaluate the problem but recently things are beginning to change for the better. This work is envisaged to be a key motivating factor for driving the research culture and improving the situation through scientific study and evaluation when presented to key decision-makers in an appropriate context.



## **7.2 Improvements through knowledge transfer**

In this study road safety in the emirate of Dubai in the UAE was the main focus. To understand the situation in Dubai within the global context it was necessary to review the global situation and a brief history of crash and injury-prevention research. Injury prevention in transport has been researched since the early part of the 20<sup>th</sup> century (De Haven, 1942; Stapp, 1957) and the work of early pioneers has shown that mortality and morbidity through road and air transport was not inevitable; rather it was avoidable. Little was known about the human body's tolerance to injury but those early studies showed that this tolerance was higher than most people expected (De Haven, 2000). By showing that the forces experienced in a crash were survivable in some situations this gave renewed hope to road safety proponents that more crashes should be survivable (Nader, 1965).

The global burden of road traffic crashes and injuries was studied by other researchers and estimates for the developing scale of the problem in the next twenty years were alarming. The position of traffic injuries as a cause of mortality (Murray & Lopez, 1997d) was expected to rise to 6<sup>th</sup> worldwide in 2020 (from 9<sup>th</sup> in 1990). Their position as a cause of loss of life years put them even higher in the list of diseases only third behind heart disease and depression. This established the current and expected size of the problem worldwide and the reason it demands attention from all the stakeholders in the equation.

The existing literature on Dubai and the region was sparse and outdated in most cases but enough was available to allow a basic comparison with other nations around the world. It was especially interesting to compare Dubai with the best-performing countries to highlight the best possible end-position achievable through technologies and advancements applied in those countries. The different geographical areas were often grouped together (Jacobs & Aeron-Thomas, 2000) based on their level of motor vehicle use better known as motorisation (motor vehicles per unit of population). Dubai belonged to the HMC (Highly Motorised Country) group because the level of motorisation there was around 525 vehicles/1000 people. This level was similar to the levels of motorisation of the UK in recent years (552-563; DfT,



2006b). Standard measures of road safety performance known as fatality rate and fatality risk showed the best-performing countries like the UK to have a fatality rate of around 1 (per 10,000 motor vehicles) and a fatality risk of around 5 (per 100,000 population) respectively. Comparing the data from Dubai for 2005 showed the fatality rate (3.75) and risk (20.5) to be three to four times that of the UK (Ashur, 2003; RTA, 2006b; Ministry of Economy, 2005).

The only way of assessing the standards and dimensions of traffic crashes and injuries on the roads in Dubai was through data collected by the police and road authorities. This data was available going back a number of years but it was not easily accessible. The ease of data collection improved with time until eventually access was granted to in-depth data on site at Dubai Police Traffic Headquarters.

Once the data was collected and analysed from the official sources it was possible to define the main problem areas and concerns. Some of the problems were similar to those found and dealt with in other HMCs but the proportions were different. Key examples of this were pedestrian crashes and young casualties. In the UK pedestrian and child injuries (<15 years) were a top priority (DfT, 2008) making up 12.2% and 9.6% of overall casualties respectively. In Dubai pedestrians made up 28.6% of casualties and those under 18 years of age formed 11% of casualties, with the biggest difference over the UK being in pedestrian safety. In the UK these areas were made a priority under the Road Safety Strategy for 2010 being covered in two of the ten themes (DfT, 2000). In Dubai the discontent with the situation is present but similar targets were not found to exist in practise. Research projects focusing on young casualties have been funded by the EU to address this problem (Kirk et al, 2006). In Dubai pedestrians were the most common first object hit from the in-depth database (53%) thus being a high priority problem but grade-separated crossings remain few and far between. These crossings have been verified as beneficial to safety in numerous studies (Elvik & Vaa, 2004; Reading et al, 1995) and form the basis of one of the key interventions suggested for Dubai that has a huge potential annual saving (£14 million, table 41). Further savings might be possible if more resources were dedicated to the study of this problem as



has been done in Victoria, Australia (Corben & Diamantopoulou, 1996; Corben & Duarte, 2006).

The lack of roadside barriers or guardrails was estimated to relate directly to around 109 crashes in the year 2006 in Dubai (this excludes median guardrails between carriageways). The savings estimated from the effect of this intervention on these crashes amounted to £3.2 million based on the effectiveness found in other studies (Elvik & Vaa, 2004). Most of the guardrail studies were conducted in Western countries which might have different road environments. However the effectiveness of the measure was not likely to change when applied to Dubai due to the selection process of crashes. Individual crashes were only selected where no evidence of a barrier was found and the vehicle ran off the road. Similar attention to detail was followed for all interventions when matching them to crashes so the overall reliability of the results is high.

Another example of a highly effective technological measure was the development of variants of Stability Control. Numerous studies (Farmer, 2004; Kreiss et al, 2005; Lie et al, 2005; Thomas, 2006b; Bahouth, 2005; Aga & Okada, 2003) have measured the effectiveness of this measure. It was shown to reduce crashes or injuries especially in certain conditions (single vehicle crashes; harsh winter conditions). While some of these conditions are precluded in Dubai (harsh winter) there are still a significant number of loss of control crashes (39 in 2006 in-depth sample). The vehicles involved in these crashes did not have any form of electronic stability aid fitted to ensure their selection was valid.

With the available resources and data a significant volume of crash reduction estimates was possible (2,412). The refinement of the method from the base-level data and the resulting increase in the cost savings estimate (from £30 million to £40 million annually) show how much more can be done with more data and better problem-intervention matching.



### **7.3 *Injury severity in base-level data***

#### **7.3.1 Slight and medium severity crashes**

The shift in recorded crash severities over the time period under study is worrying as the absolute number and proportion of serious injuries increases while slight injuries are on the decline. This could be an actual decrease in slight injury levels or a problem elsewhere in the system of recording or reporting crashes. Less-serious injuries may have gone unreported to the police and simply treated at hospitals as injuries due to other causes. It is not known if hospitals report motor vehicle-related injuries to the police if the police do not request the data from a known crash case. It would be tempting to relate the decrease in slight injury numbers to seat belt use, as the number of slight injury crashes post-implementation (1999) has been constantly below the pre-implementation phase except that it is rising and the last year (2006) almost reached pre-1999 levels. This is not helped by a recent study in the city of Al-Ain that showed very low seat belt use by the population (Barss et al, 2008). The proportion of slight injuries to all injury levels has decreased after 1999. This also goes against what the experience in other countries shows, that an increase in seat belt use is normally accompanied by a reduction in fatal injuries but an increase in slight injuries (Abdalla, 2005; Koushki et al, 2003). One possible explanation for the decline in the year 2000 was the enforcement of seatbelt legislation (front seat occupants only) in January 1999 (El-Sadig, 2004). The post-2000 increase was also found in another study (Abdalla, 2005) when describing the fatality rate in the year 2000, reversing the decline seen in previous years. This study also showed that fatalities accounted for 4.8% of all casualties and serious injuries accounted for 2.5% of the total based on 1999 data. Using hospital data it would be possible to verify to what extent police data reflects the actual situation on the roads and allow the injury coding to a more advanced level using conventional international standards like the AIS (Abbreviated Injury Scale; AAAM, 1990). A study conducted in the city of Al-Ain (El-Sadig et al, 2004) – which is around 150km east of Dubai – also showed that slight injuries made up the majority (77%) of the sample of hospital admissions from road crashes over 7 months in 2002.



### **7.3.2 Fatal crashes and their characteristics**

The majority of fatal crashes involve a single vehicle (49%). Analysis shows that most of those vehicles result in a pedestrian fatality (59%) so the approach must involve all dimensions, the road user, vehicle and surroundings. The road users in this case are both the driver and pedestrian and with the current data available it was not possible to deduce whether the fault lies with the driver or pedestrian and each requires a different approach to remedy the problem once it is found. However for the estimate of crash cost savings the cost of an average injury crash was used to cover both eventualities regardless of who is to blame. Driver error could include misjudgement of pedestrian actions or misjudging the braking distance needed or using inappropriate speed for the conditions or ignorance/violation of the rules regarding pedestrian priority. These are taught when new drivers undergo training but are not clearly outlined as an offence in any literature typically available to the driver (in Dubai). Possible pedestrian errors include unfamiliarity with motor vehicles and the inability to judge the speed of approach safely. Other possible causes might be impaired judgement due to external factors such as stress or very hot weather or frustration at waiting for a long time to cross and the unavailability of crossing facilities with no gaps in traffic. In Australia a review of pedestrian crossing conditions (Corben & Diamantopoulou, 1996) found low compliance by pedestrians at signal-controlled crossings when waiting times were excessive. Differences were found in the past in the ability to comprehend signs between drivers of different educational backgrounds and income levels in the UAE and neighbouring countries (Al-Madani & Al-Janahi, 2002). It is possible that a relationship exists between a driver's circumstances and crash type that needs further research to establish. Behavioural differences (seat belt use and drink-driving) between road users of different ethnic origins have been observed in a number of studies (Boyd et al, 2008; Walker et al, 2003). The effect of ethnicity on the type and severity of a crash needs further investigation (along with a population breakdown by ethnic origin) before any solid links are established.



The vehicle might be a contributor to a crash if there is a mechanical failure (which raises the question of vehicle roadworthiness tests and how comprehensive they are) or the vehicle design might not be pedestrian friendly (with EuroNCAP star-ratings for pedestrian fronts and with further data on the vehicle fleet it would be possible to estimate the proportion of vehicles with a good star rating that can be considered “pedestrian-friendly”). Visibility within the vehicle might have contributed to the driver not seeing the pedestrian in time (e.g. A-pillar obstruction) which is a consideration for human factors work. A test method for assessing visibility out of cars was established in the 1970s (EEC Directive 77/649/EEC) but has yet to be updated. Further work with drivers involved in pedestrian crashes will allow the determination of contributory and causation factors to see if visibility was a problem faced by drivers and hence needs addressing by the proposed methods. The example of police forces in the UK with the latest revision of STATS19 (the form filled by the police when reporting crashes) to include contributory factors can be taken into account and this was included in the section of proposed work for the next stage.

The countermeasures suggested in the previous chapter encompass the road user, vehicle and road environment and by tackling all three factors it is more than likely that a reduction in fatal crashes (and the most common of those involving pedestrians) can be achieved. The second most common type of fatal crash involves the vehicle occupant and the countermeasures that might reduce the injury outcomes in this case have not been exhausted yet namely through seat belt use. Most HMCs have seen a reduction in serious and fatal injuries after seat belt use increased so this is very likely to happen in Dubai as well. A counterpoint to this is the high incidence of young fatalities. If some of those are vehicle occupants then mandatory seat belt use might not benefit them as they might be better served by child restraints. A law enforcing the use of child restraints does not exist in Dubai nor is there any compulsion upon drivers or parents to correctly seat their children in vehicles. This is another area for consideration in the future or alongside seat belt legislation and implementation.



## **7.4 *Variations in crash times***

### **7.4.1 Daily and hourly variations (macro-level)**

The crash peak on one day of the week (Thursday) may be attributed to the difference in driving pattern due to the Thursday-Friday weekend (most government departments are closed on Thursday and the private sector normally opens for half a day). After the change of weekend to Friday-Saturday for the public sector the analysis showed a marked decrease in crashes during Wednesdays, Thursdays and most notably Saturdays, which would suggest that removing a large element of traffic (public sector workers) reduced injury crashes on that day (basing the calculation on the overall number of cases divided by the number of days then comparing the rate per day). This suggests that the countermeasure suggested (exposure control) is effective and was inadvertently applied here as the main reason for the weekend switch was thought to be an effort to reduce the lag-days for business transactions between the UAE and the West. For example if a business deal was initiated on a Thursday (when most institutions in the UAE were closed) it would remain inactive during the weekend (Friday) and when Saturday arrives most companies in the West would be closed until Sunday so effectively four days will have passed before anything can be done with the deal. This is wasteful in a business environment where hours and minutes count as much as days and weeks. The only other study found to reference crash times (1999-2001) was focused on an urban area in the neighbouring emirate of Abu Dhabi (Ashur et al, 2005). It reported 6% of crashes occurred at 11am, 12-2pm and 5pm. A similar calculation was attempted with the available data but it was not possible to accurately replicate the analysis as the conventions used for estimation were not published. Does 11am mean a crash occurring only at that time, or within 5 minutes of the hour? Without such knowledge it was not possible to replicate the measure for the Dubai data in addition to the significant differences in geography and composition between the two areas. A study of Al-Ain city data for 1990 (Bener et al, 1992) gave a general time range for casualty crashes between 8am and 2pm which did not correspond to the findings in



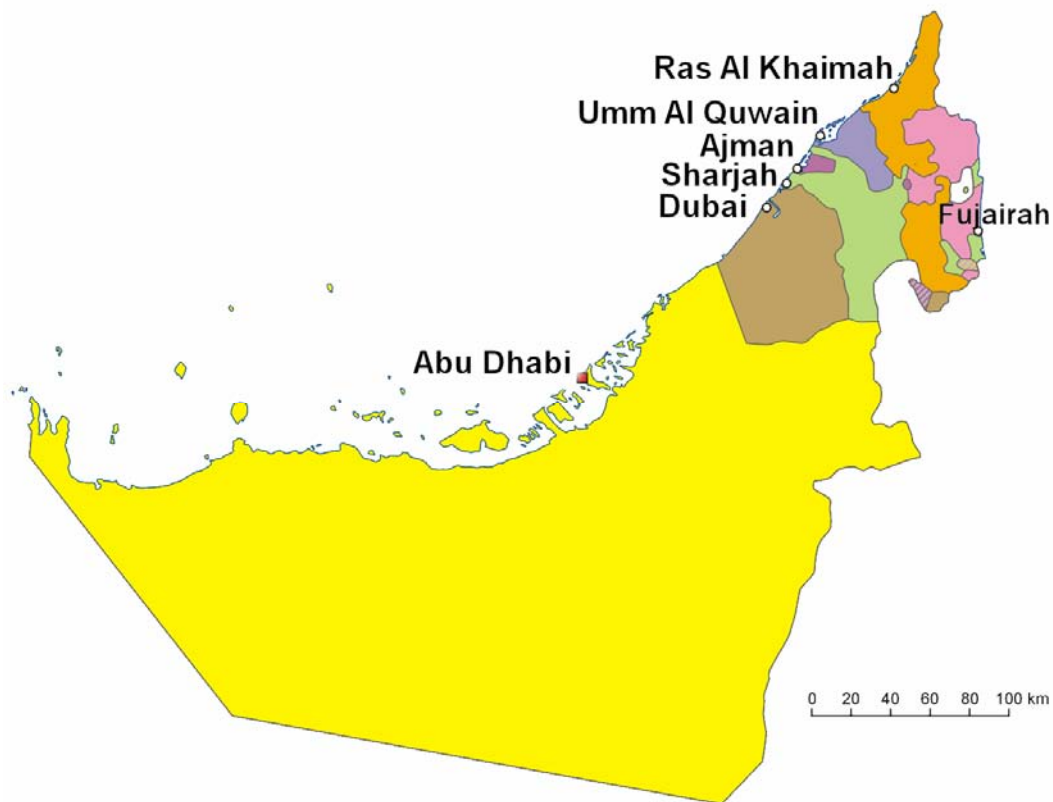
Dubai. Al-Ain city is significantly different to Dubai in size and planning as well as composition and the level of traffic.

In the UK, Friday afternoons have the highest number of crashes during the week (Ljubic et al, 2002). This corresponds to Friday being the last day of the working week before the official weekend begins on Saturday so being in a similar situation to Thursday in Dubai (and most of the Middle-East) before the Friday-Saturday weekend was implemented. This shows that exposure can have a significant impact on crash rates but it is related to many external factors that make it difficult to control individually without imposing draconian measures on society; however the acceptance of some measures by society is possible if the return (less congested, safer roads and faster journeys) is realised soon thereafter. The change in weekend shows a decrease in injury crashes on Saturdays and Wednesdays. This decrease may be related to the decreased volume of traffic due to the removal of school and government traffic on Saturdays. Fridays instead seem to take the load with an increase in crash occurrence compared to the previous months and years possibly due to people using the day more for leisure outings and non-essential trips to unfamiliar areas. Longer data series are required to see whether the effect is short-lived or not. Another factor affecting weekend traffic is the commuting pattern for motorists. A large amount of economic activity in the UAE (measured by the number of establishments) takes place in the two largest emirates of Dubai and Abu Dhabi (64%; Ministry of Economy, 2006). Some of the workforce resides in areas with more moderate living costs (such as the northern emirates) and as Dubai lies between the capital Abu Dhabi and the northern emirates it acts as a corridor for through-traffic. Official estimates (Dubai Statistics Centre, 2009) put the number of people active during the day in Dubai at the end of 2008 at 2.45 million, 49% more than the estimated resident population (1.65m). This is accounted for by residents of other emirates in addition to an element of tourists and sailors.

High-speed by-passes have been built recently to accommodate this traffic in the form of Emirates Road, Al-Khail road and the Outer Bypass Road. Licensing information for those involved in fatal crashes shows that most



vehicles (of the accused party) were registered in Dubai (72.5%) while Abu Dhabi and Sharjah vehicles come next with 9.7% each (RTA, 2006). These figures do not represent the origin of vehicles as residents of other emirates whose primary workplace is in Dubai may register their cars in Dubai but reside elsewhere.



**Figure 66: Political map of the UAE.**

A study in neighbouring Abu Dhabi (Ashur et al, 2005) from 1999-2001 (n=15,306 crashes) showed that crashes peaked on Saturdays and Sundays (19% & 17% respectively) followed by Wednesdays (16%). This could be due to the fact that in those years Dubai was thought of as a leisure destination for a lot of the population of Abu Dhabi who consequently head to Dubai on weekends reducing traffic in Abu Dhabi (Thursday and Friday had the lowest percentage of crashes out of all days in Abu Dhabi – 11% and 9% respectively).

In looking at crash times along with days of the week, the afternoon and evening periods account for more crashes, which might correspond to more exposure during that time compared to the morning period. When looking



exclusively at the morning period, the weekend (Friday and Saturday) has the most crashes out of all the other days. This indicates a possible link to the type of activities and nature of trips undertaken in weekends (involving return trips very late at night or early in the morning that are associated with tiredness and fatigue).

#### **7.4.2 Hourly and monthly variations (macro-level)**

The difference in crash rates with time can be a pointer to an underlying problem that is time-sensitive like the level of traffic at a certain time of day or week. If for example traffic levels at peak hours result in more crashes then alternative routes to reduce traffic during those peak hours can be a solution. If, however, traffic levels in morning and evening rush hours were similar yet more crashes happen in the evening rush hour then it might be the case that the crash cause is more due to driver fatigue and exhaustion rather than the increase in traffic levels as drivers in the morning are expected to be more alert. In the UK and other countries drivers were found to be more prone to a sleep-related crash between the times of 02.00-06.00 and 14.00-16.00 (Horne & Reyner, 1999). No such work was found on the UAE. Exposure data and traffic counters placed at strategic sites can assist in further study of the timely variations and comparing them to crash occurrence, type and severity. Variations throughout the year might be due to changes in the commute of workers in the different sectors of the economy. For instance construction and haulage traffic is expected to remain high all year round as construction in the past few years has been a constant activity in high gear. Academic traffic on the other hand is tied to the school or university calendar and is expected to be reduced to a minimum during the long summer vacation (around July – August) and the effect of this is seen in traffic. One possible counter-argument to this is that leisure activities outside school terms increase thus balancing out the decrease in academic traffic. It is common in the UAE population to take a summer break outside the country often to cooler climates so the whole population of vehicles on the road might decrease in these times. Ultimately the distribution of crashes during the year or day might be useful when countermeasures to tackle a certain problem highlighted by timely variations



can be applied. However generally it was thought that variations (especially monthly) are too vague to point to any particular problem that can be solved by measures like exposure control as the primary reason they are monitored is for overall reductions and year-on-year monthly comparisons. Earlier work in Al-Ain (Bener et al, 1992) showed similarly high levels of crashes during winter months followed by spring with the least number of crashes in summer (1990 data). That study also showed higher crashes in the Muslim fasting month of Ramadan that coincided with April that year but the month falls at a different time every year so it is difficult to compare this result over a number of years. The summer period is particularly hot in the region and high temperatures and humidity drive a large part of the population to take leave during this time so driving activity decreases. This is aside from the reduced traffic due to the closure of universities and schools. In winter months tourist traffic increases due to the more moderate climate and this – tied along with large promotions (like the Dubai Shopping Festival) – leads to more demand for travel on the roads. Other studies of peak times show increased involvement of certain road user groups like child pedestrians in early mornings in Austria (Mayr et al, 2003) which correspond to the time of going to school. The comparison of casualty crash numbers per month with the time of occurrence shows similar findings to the daily comparison (i.e. peaks during the afternoon and evening for all months of the year). The cooler winter months and hotter summer months do not appear to affect the time of day when injury crashes peak. However the size of the peak for every month seems dependent on whether it is summer or another season (summer months 6 to 9 have lower peaks than the rest of the year). This is in line with the lower traffic expected due to school and work holidays and a reduction in activity due to the summer heat.

#### **7.4.3 Variation in month, hour and day of occurrence (micro-level)**

The month of December stands out as having the most crashes in the year. This may be due to meteorological factors like a few days with impaired visibility (due to fog or sandstorms) or low traction (due to rainfall; Dubai Meteorological Office, 2006). Crash rates in some Nordic countries actually improve in wintry conditions (Fridstrøm et al, 1995) but this may be due to



more careful driving in such conditions. Exposure of traffic during that time is not known, so it was not possible to attribute the variation to these factors with any certainty when the volume of traffic or number of trips might be responsible. In 2006 tourist traffic (measured by the number of hotel guests) peaked in Dubai during the months of March, July and December (Department of Tourism and Commerce Marketing, 2009) exceeding 500,000 tourists per month. Most schools also remain shut during the summer. The fact that July (along with November) had the lowest incidence of crashes was surprising as July was a peak month for tourist numbers. Tourists have been found to have a higher crash risk in previous studies (Wilks, 1999; Yannis et al, 2007). Because the in-depth sample is mainly composed of fatal and serious crashes (figure 23 p.121) these may be more random events compared to the overall distribution of injury crashes seen in the larger population of the base-level sample where fluctuation from month to month was less. In the UK for 2007 (DfT, 2008) July and August account for the highest number of serious and fatal crashes. This might be related to the more moderate summer temperatures in the UK that encourage more road usage.

The peaks seen in hourly variation correspond to periods of rush hour traffic well known to the residents and commuters throughout Dubai. These were different from the peaks found in the base-level data possibly due to the hectic pace of construction in 2006 which was unmatched by the period before. The large volume of vehicles on the road during these hours corresponds to a greater possibility of interaction between them. It also increases the chances of a vehicle hitting other vehicles if it loses control. While UK data (DfT, 2008; Ljubic et al, 2002) showed peaks at 8am and 4-6pm this may be due to the different timings of public and private sector corporations. In the UAE public departments varied in the pattern of working hours but many finished earlier in the day than the UK (around 3pm) and started earlier (7.30am). Commuters to work from far away places will have to leave their homes very early especially as labour camps that house the hundreds of thousands of construction workers are often located far from their work sites. Two shifts in a day were common in many organisations



with a long afternoon break (2 or 3 hours) so the evening shift ends at around the second evening peak (8pm).

Wednesdays witnessed a lower number of crashes than any other weekday. The weekend for employees of government departments and many corporations in the financial sector is Friday and Saturday so linking this reduction to traffic generated by these two sectors is not viable. However some companies still operate a Thursday-Friday weekend for most employees and these might have an effect on the number of serious crashes that occur on the day preceding the weekend. It may be that drivers try their best to return home safely at the end of a long week or that some leave early to avoid the rush hour thus spreading traffic load over a longer time. Times of lighter traffic were seen to have a lower frequency of crashes in microscopic analysis. Thursday and Friday traffic may be different in composition to traffic during the working week as it is not work-related. In the UK Fridays and weekends (Saturday and Sunday) accounted for the largest number of drink-drive crashes (2006: 63%; DfT, 2008) with most of them taking place between the hours of 9pm and 3am. This reflects the drinking culture in the UK that is less evident in Dubai especially for fatal and serious crashes. The UK working week is fairly different in that practically all organisations have the same weekend. In that situation, Friday accounts for the largest number of serious crashes and Sunday for the smallest number (Mansfield et al, 2008) but the study sample was larger (2000-2005).

## **7.5 Enforcement**

### **7.5.1 Base-level data**

Police enforcement of rules and regulations is always a balancing act between behaviour-affecting affirmative action and time-wasting administrative action. Before any law enforcement is discussed it is important to emphasize that enforcement is only as good as the laws behind it. It is pointless to have a law banning the wearing of red socks as it would: a. be unenforceable; and b. have no effect on road safety or crash outcome. Effective laws are needed for enforcement to be effective. Excessive administrative work related to enforcement (like filling in time-consuming



forms for every act of enforcement) is a strong discouragement to active and constant enforcement. The balance between practicality and effectiveness is often down to the police officer's judgement. It would be unsafe to stop on a blind corner – putting the patrol car and other drivers at risk – for the sake of citing a minor offence to a pedestrian that may be stopped later down the road, or that has very little to do with safety in the first place. Effective enforcement also depends on the officer's training and equipment level as they need to have excellent knowledge of any relevant legislation and be well trained to police it effectively. Dubai Police is generally seen as a well-funded organisation with state-of-the-art equipment and policing methods however it is possible – as with many rapidly-developing departments and areas – to overlook some of the training and legislative needs to support this growth in requirements especially where traffic enforcement is concerned. The effect of enforcement in Stockton, California (Voas & Hause, 1987) was encouraging however the differences between the perception and powers of the police in Dubai and the USA are very different. It is likely that the effects of enforcement will not be directly translated across continents but some positive effect is still possible. A prime example is with the drink-driving problem when crashes are found to peak around 4am. This correlates with the closing time for entertainment venues where alcohol is served. Concentrating enforcement around that time or around known alcohol-serving venues could have a direct effect on drink-driving levels or crashes. The experience of Australia (Zaal, 1994) with Random Breath Testing (RBT) combined with publicity positively influenced driver behaviour with respect to drink-driving over a period of time.

### **7.5.2 Automatic speed enforcement**

Automatic speed enforcement might be effective in the short term but once camera locations are known their effectiveness might decrease significantly as was experienced in Kuwait (Koushki & Hasan, 2000) which shares a similar cultural, geographical and economic background to the UAE. The same suggestions made to tackle the problem in Kuwait (Koushki & Hasan, 2000) - "live" enforcement with police patrols - might be effective in Dubai also but the issue of human resource availability will limit the extent to which



this can be applied. This is based on the assumption of similar behaviour in reaction to the suggested countermeasure. The reactions may differ due to previous work in the Gulf Cooperative Council (Al-Madani, 2000; Al-Madani & Al-Janahi, 2002) that showed drivers differ in self-reported behaviour (such as seat belt use and comprehension of traffic signs) between the countries. A study on speed camera locations and driver speeds similar to that described in Kuwait, if performed in the UAE would help quantify the effect of this measure and the extent to which the situation differs from neighbouring countries. The deployment of visible speed camera vans was successful in reducing fatalities in Australia (Newstead & Cameron, 2003) when positioned according to the guidelines of a local road safety manual (Queensland Transport, 2000). In Queensland the deployment of these cameras was estimated to result in an annual reduction of 32% thus avoiding 110 fatalities (Newstead & Cameron, 2003). Encouraging results were also found in other countries (Pilkington & Kinra, 2005).

### **7.5.3 Seat belt enforcement**

Seat belt use data was not supplied for these crashes but roadside surveys were conducted by the authorities during the same time period covered by the data. This allowed a snapshot of seat belt use to be taken in the overall driving population of which this data was a subset of. These indicate the most recent usage rates since the enforcement of the seat belt law in January 1999 are around 65% for drivers and 25% for front seat passengers (table 27). Self-reported usage in the UAE before January 1999 falls considerably below these levels. Bener et al (1994) in a survey of 800 drivers admitted to the emergency departments of two major hospitals in Al-Ain as a result of a crash found that 10.5% reported “constant” usage and 5.8% reported usage as “frequent”. This was before the enforcement of seatbelt legislation. A repeat of these surveys will provide valuable information on this area which currently lacks definition however recent work in the UAE shows the legislation to have become ineffective after a few years (Barss et al, 2008).

Another medical study conducted in Al-Ain on 1995 data (Sankaran-Kutty et al, 1998) showed a very low level of seat belt use for casualties (6%, n=247).



The latest published work (Barss et al, 2008) at the time of writing also in the city of Al-Ain showed an alarming rate of seat belt use over a sample of 500 vehicles. Drivers had a 29% usage rate, while front seat passengers had a 14% rate and only 2% of rear seat adults wore seat belts. Even more worrying was the rate for children, 23% sat in front, of whom 4% were restrained and only 1% in the rear were restrained.

If the general population of drivers has a low seat belt utilisation rate then it is safe to assume those drivers involved in crashes will have a similar usage rate, if not lower, because the experience of other countries has shown non-seat belt wearing drivers to be over-represented in crashes (Hunter et al, 1990). Seat belts are thought to be most effective in scenarios of frontal impact or running-off-the-road crashes (Evans, 1990). Their effectiveness in reducing fatalities (by 23%) and injuries (by 26%) is supported by the experience of the UK with mandatory wearing laws (Mackay, 1985) and is difficult to explain by other factors like exposure or risk compensation (also known as “risk homeostasis”, “closed loop compensatory feedback” or “behavioural adaptation”; Adams, 1994). In the UK usage rose from around 40% for drivers before the law to around 90% after. It was assumed that this was the main factor in reducing injuries and fatalities in the following year (Mackay, 1985) despite other events happening in that year (1983) that might have influenced these figures like the campaign against drunken driving which included more breath tests than any previous year (Adams, 1994). If the latest usage rate measured in Dubai drivers (65%) is still current and is assumed to rise to 90% with enforcement of the existing law then a decrease in death and injury of 20% is predicted (based on the UK experience). In numbers this would mean a reduction in the number of people fatally injured from a stationary object impact or rollover by 102 but this is only a rough estimate assuming all other factors (crash rate, exposure, etc) over the next 12 years remain the same. Reasons why this might not be the result if the seat belt law was strictly enforced include the difference in driving population (that of Dubai is relatively small compared to the UK at the time – 16 million) and might not respond behaviourally in the same way due to cultural differences. These cultural differences were highlighted by previous work on driver behaviour that compared Emarati



drivers in the UAE to their peers in Britain, the Netherlands, Finland and Australia (Bener et al, 2004). Bener found large differences in behaviour between UAE drivers and those in the Western nations with the Arabian drivers prone to riskier behaviour. In related studies different factors were found to affect drivers' seat belt use such as the level of comprehension of traffic signs (UAE; Al-Madani & Al-Janahi, 2002) and ethnic origin (USA; Boyd et al, 2008). There is also no representative monitoring of restraint use over a long time period like there is in the UK (Broughton, 1990; 2003). In a literature review from studies in Australia and around the world enforcement along with primary seat belt legislation, education and publicity were all recommended for improving seat belt utilisation rates (Zaal, 1994). Secondary seat belt legislation (where a driver can only be cited for a seat belt offence if first stopped for another reason) was commonly found in the USA but the effectiveness of primary legislation was higher (Rivara et al, 1999). If long-term use was only affected by enforcement then the cost and feasibility of constant increased enforcement needs to be taken into account. However the experience in many Western nations suggests seat belt use rates remain high with minimal enforcement as the emphasis for compliance lies with the individual vehicle occupant (Zaal, 1994).

## ***7.6 Crashes by number of involved parties (macro)***

### **7.6.1 Single vehicle crashes**

The prevalence of single-vehicle crashes deserves further attention for the main reason that they are more common than two-vehicle crashes (49% vs. 42%). Hence their reduction (and the reduction of associated injury outcomes) will mean a reduction in a major sub-set of crashes. Most of the single-vehicle crashes are either pedestrian crashes (57%) or rollovers (21%) and stationary-object impacts (19%) where it is assumed the vehicle leaves the road. In the UK a smaller proportion of crashes (30%) involve one vehicle (with or without a pedestrian) and more (59%) involve two vehicles (DfT, 2008).

Pedestrian crashes occur wherever there is interaction between pedestrian and vehicular traffic so separating these traffic streams is the ideal way to



prevent them. This has severe practical implications for both types of traffic as it is not realistic to always exclude one type of traffic where the other exists due to prohibitive costs (for instance building pedestrian bridges or underpasses at frequent intervals over urban streets). The more practical alternative is allowing the interaction of different traffic streams while controlling it to prevent the worst outcome: an injury. Voluntary methods of control (zebra crossings, pedestrian priority rules) already exist at a lot of locations but their effectiveness does not appear to be high at all as would be witnessed if an observer stands at a zebra crossing in Dubai for long enough. This can be evaluated scientifically through field surveys. Enforced control of traffic as with a pedestrian-controlled or activated signal to stop motor vehicles (MVs) and the recording of offending MVs that do not stop on camera is a more effective way of permitting mixed-traffic streams while reducing the danger to the more vulnerable road users. Enforcement has proven successful in other fields (like speed control) so it is likely that, by analogy, its effectiveness can be extended to pedestrian signal control. The experience of other countries, especially where urban settings mean pedestrians almost always have priority, might be applicable to some extent in some areas of Dubai. However the level of attention paid to pedestrians by drivers in Dubai and the UAE shows a large disparity when compared to the behaviour of drivers in Western countries (Bener et al, 2004). This lack of pedestrian awareness by drivers was also found in neighbouring Qatar (Bener et al, 2005) by the self-reported incidents of not noticing a pedestrian crossing when turning into a side street from the main road. Speed enforcement was shown to be successful in tackling speeding in many studies (Zaal, 1994). The effect of fines and penalty points on speeding enforcement was mixed and depended on existing enforcement levels. If enforcement (and hence the risk of detection) of an errant driver was low then it was not likely that even severe fines would affect road user behaviour (Ross & Voas, 1990). In Sweden in the 1980s speeding fines were increased twice but with no effect on driving behaviour (Aberg et al, 1989; Andersson, 1989; cited in Zaal, 1994). The financial penalty may be insignificant compared to income or social status and might not be a deterrent so changes in enforcement to increase the perceived risk of



detection must be considered. Feedback to drivers given in the form of signs showing the percentage of speeding drivers in the preceding time period have been effective in reducing average speeds while in use (Rooijers & de Bruin, 1990; Maroney & Dewar, 1987; cited in Fildes & Lee, 1993). Instantaneous feedback to drivers showing their speeds to other drivers have been suggested as a means to embarrass individuals into compliance (Fildes & Lee, 1993). Such devices have been used in Dubai in the past in a very limited context. Penalty points have been used in the past to deter drivers from committing offences and were found to be most effective on drivers with consistent violations (Dingle, 1985, cited in Zaal, 1994). Haque (1987, cited in Zaal, 1994) also showed a beneficial effect to the system of penalty points in Victoria, Australia. One possible drawback to the scheme is the impression given to drivers that a certain number of offences is acceptable before punishment was due (Williams et al, 1992, cited in Zaal, 1994). The authorities in the UAE introduced a penalty points system in legislation for 2008 (Abu Dhabi Police, 2008) which shows that the recommendations made here were already being implemented in some areas.

Rollovers were the second-most common crash type (evident in 10.9% of cases) and this could be due to a number of factors. The vehicle fleet under discussion contains a large number of 4x4 vehicles that mostly have a higher centre of gravity than saloon cars and thus are more prone to rollover rather than spin when there is loss of control at speed. New vehicle sales data in 2006 (Auto Strategies International, 2007) for the UAE showed that over 21% of sales were attributed to 4x4 vehicles. Four-wheel drive vehicles have already been identified as a priority for research in a previous study in the UAE (Bener et al, 2006). Electronic systems that prevent the vehicle from leaving the road or prevent the driver from losing control in the first place have shown their effectiveness in Scandinavian countries (Lie et al, 2005) as well as Japan (Aga & Okada, 2003), Australasia (Scully & Newstead, 2007), the UK (Thomas & Frampton, 2007) and USA (Bahouth, 2005; Farmer, 2004). The effect of these technologies is likely to be positive on the road users in Dubai as the first studies of ESC effect (especially on 4x4 vehicles) show great potential in single-vehicle crashes (Dang, 2004).



However the argument remains that making a car safer leads to the driver taking more risks hence cancelling out the benefits. This debate existed since seat belts first came on to the scene (Adams, 1982; 1994) and will likely be heard in the future in respect of more advances in vehicle technology (lane-departure warning, night vision, blind spot monitoring, etc).

High speed roads form a significant section of the road network and carry a large amount of traffic every day so combining high speed roads with driver error is likely to result in an unforgiving road environment. It is fortunate that most rollovers (94.5%) are single-vehicle crashes which means there is no obvious involvement of other vehicles but this might change with time given the increasing traffic flow. Through making the road environment more forgiving (by the suggested countermeasures like steel barriers) the outcomes of these crashes might be less severe. To prevent them in the first place further investigation of their causes is required. It is likely that driver error and misjudgement is the leading cause though other contributory factors might be present, like excess speed, over-confidence in the ability of the vehicle and sudden unexpected movement from other traffic. More modern technologies are slowly beginning to offer some assistance in this respect, such as being able to alert a driver when they start leaving the lane unintentionally (without using the indicator). These technologies are still new to market and in the future as their use becomes more widespread it is hoped they can be evaluated with regard to their effect on this type of crash.

Hitting a stationary object almost certainly involves losing control of the vehicle as it is very rare for a driver to intentionally want to damage their vehicle and public property and risk their lives in the process. This type of crash is similar to a rollover in that a lot of energy is dissipated in such a crash. With a rollover there is a greater distance over which this energy is dissipated whereas a stationary object impact can be over a very short distance (thus testing the structure of the vehicle to the maximum) as stationary roadside objects are often only a few metres from the main carriageway (like lamp posts, sign posts and bridge supports). This problem was reported widely in the literature (Elvik & Vaa, 2004) and treatments at one area were presented in depth from the experience in Victoria, Australia



(Corben et al, 1997). Countermeasures such as crash barriers, guardrails, crash cushions and frangible poles that increase the deceleration distance (and thus allow for more energy absorption over a longer time) are a clear candidate for reducing injuries in these crashes. The Australian recommendations (Corben et al, 1997) highlighted the effectiveness of changes to horizontal road geometry alignment (44% reduction in casualty crashes) and shoulder sealing (32% reduction). Road design guidelines also came under criticism (Delaney et al, 2002) for failing to reduce the severity or frequency of crashes into fixed roadside objects. This reinforces the importance of local investigation and treatment of blackspots using known crash causes as performed in Victoria (Corben et al, 1997). Other countermeasures that reduce the possibility of loss-of-control of the vehicle (already described above) are also important to prevent these crashes happening in the first place.

## **7.7 *Crash locations (macroscopic analysis)***

### **7.7.1 Introduction**

Initially it was intended to use the precise crash location on a GIS (Geographical Information System) platform along with a digital roads base-map of Dubai to analyse the location of crashes and their concentration in different areas. However this was not possible due to a number of difficulties so analysis using street names was performed and some meaningful data was extracted from this.

### **7.7.2 Main roads involved**

Differences in crash rates between the main roads must not be given too much significance as traffic on Sheikh Zayed Road far exceeds that on Dubai Al-Ain Road as it is a main through-route for traffic between the capital Abu Dhabi and the Northern Emirates. Emirates Ring Road only came into existence in late 2000 so it is much newer than the other two roads. The 2007 data release (Dubai Police, 2008a) from official publications shows that in 2007 the top crash blackspot was the same (Sheikh Zayed Rd) but the lower ranking roads are shuffled around due to new roads being built and



existing roads being expanded in the past few years. It is logical for the roads with the heaviest traffic flow to have the most opportunities for a crash occurring. However the adjustment of road users to different roads and speeds and the performance of vehicles in different crash configurations also has a large effect on the chances of a crash happening and the injury outcomes associated with it. In building a modern road infrastructure to cope with current demand, Dubai has a rapidly-growing network of mostly new or well-maintained roads that is used by hundreds of thousands of vehicles every day. However, at any one time, the number of road users is likely to be from a large number of different backgrounds and cultures. In Germany for instance the number of non-Germans on the road who are unfamiliar with the road system is unlikely to be high as Germans make the absolute majority of the residents of Germany. In the UAE this is not so especially in Dubai. The mix of different nationalities might be a contributor to users of the road system adhering to different values and conceptions which does not help the road safety situation. Sometimes different emirates have different enforcement levels of the same rules (such as the level of window glass tinting allowed) which might cause some confusion for motorists travelling between the emirates. The top crash locations are all well-known and well-used thoroughfares and in an effort to reduce impacts and delays with heavy vehicles the police have banned trucks and heavy vehicles from most of the main highways during rush hours. If vehicle type was available in the data the effect of this on the involvement of heavy vehicles in injury crashes on arterial roads could be further assessed. Black spot treatment of these locations combined with detailed crash data is likely to yield dividends in reducing crash scenarios that recur frequently. Cross-tabulation of the top crash locations with crash types reveals an association between the type of crash and location. The most frequent crash types listed for high-speed roads (rollovers and head-to-tail crashes) might be influenced by measures discussed in the enforcement section (speed enforcement and police patrols). Speed is often contributory to a rollover and increasing the distance between vehicles can improve safety margins (e.g. with chevrons to indicate safe following distances). Further countermeasures related to specific crash



types are discussed further in the following sections (on crash types, causes, objects hit and preventative measures).

## **7.8 Crash locations (*microscopic analysis*)**

The top 6 locations of crashes are mostly multi-lane dual-carriageways where vehicles can achieve high speeds and hence gain a lot of momentum that is dissipated in various ways often resulting in injury or death. These roads also acted as corridors for traffic in and out of the city of Dubai connecting it on the south west to Abu Dhabi, on the east to Al-Ain and in the north east to Sharjah and the Northern Emirates and hence carry a lot of inter-emirate traffic. New roads parallel to the above roads were planned for the future so a shift in load (and crashes) might occur. The top ranking road (Emirates Rd) was fairly new compared to the next one down (Sheikh Zayed Rd) but it has quickly taken position as the top crash location. This may be due to the relieving effect it had on traffic from Sheikh Zayed Rd as it runs almost parallel to it. Emirates Rd also has the distinction of being built across plain desert so the surrounding areas were not as interesting to drivers as Sheikh Zayed Rd (which is lined by towers and sky scrapers). It was expected this will likely change in the future as the areas between the two major routes get populated and they eventually become more alike than different. The remaining top locations (three with the exception of Al Muhaisna 2<sup>nd</sup>) were all high speed roads with a speed limit of 100 or 120kph so there was a clear link between serious crashes and high speed roads. Al Muhaisna 2<sup>nd</sup> was the exception being a residential area where low-income workers were housed. The roads there had generally low speed limits (40 or 60kph) but the mix of road users in that area was unique in that it consisted of a large pedestrian and cyclist population as motorised vehicles were out of the reach of most residents there. In the UK smaller roads with higher speed limits account for more serious crashes (Mansfield et al, 2008). The low-speed roads in Dubai were seen to be more modern and less risky for drivers due to more recent construction with wider shoulders and lanes.

Severe and fatal crashes in the UK (Mansfield et al, 2008) were more common to non-trunk A-roads and roads with a 60mph (~100kph) speed limit. Smaller roads in the UK may be less forgiving than their counterparts in



Dubai due to the different environment with grass verges or ditches lining a lot of country roads. In Dubai the warm climate dictates that the verges were often made up of sand or an asphalt shoulder is put in place. The main crash type associated with the six top locations was pedestrian crashes, most occurring on roads with a speed limit of 120 kph (i.e. motorways) whereas in the UK pedestrians are banned from motorways.

### ***7.9 Speed limits (macroscopic analysis)***

Speed reductions can result in a small decrease in injury crashes but with an associated cost to businesses, the economy and the environment. Businesses suffer due to longer delivery times for goods and longer commuting times for workers which all translate into higher operating costs. The environment is affected by the increased emissions, fuel bills and fuel consumption which are thought to contribute to climate change. The consequential effect of increased costs to business will be passed on to the economy by raising costs and contributing to inflation. Working out a favourable balance between these factors is not possible without detailed economic and environmental analysis but if it is found that speed reduction on certain roads is feasible then it can become a key element in improving road safety as it has been shown to work in that way especially in Scandinavian countries. However road user behaviour in Scandinavia and in Dubai is very different (Bener et al, 2004) so a direct comparison might not be entirely valid. However the majority of the population is assumed to be law-abiding when it comes to speed limits until further work is conducted to prove or disprove this. The increased cost of policing these new speeds must be taken into consideration as well as enforcement seems to be one of the few ways that road users in this region can be persuaded to adhere to speed limits.

### ***7.10 Speed limits and speeding (microscopic analysis)***

The figures for speeding for the first and second vehicles involved may not reflect the actual incidence of speeding due to a number of missing values where speeding might have taken place but was not recorded due to the lack of evidence. In most cases V1 was the accused vehicle and V2



sometimes shared some of the blame but it was unusual to find that the incidence of speeding in V2 was more common than in V1. This pointed to an endemic speeding problem in the drivers of vehicles involved in serious crashes (over 41% and 46% of the first and second vehicles involved were speeding respectively). This made it more likely that speeding was a contributory factor to these types of crashes as was seen in the official injury crash causation publication for 2006 (RTA, 2007). There speeding appears fourth on the list of causative factors (8.2%) and third in the case of fatal cases only (14.3%). In a representative study (Mansfield et al, 2008) from the UK excessive speeding was the third most common contributory factor recorded at the scene. Speeding in Western studies was shown to be tied in with societal values (Makinen & Oei, 1992, cited in Zaal, 1994) while being widespread and condoned within society (Croft, 1993, cited in Zaal, 1994).

Speed limits were known in the majority of cases except in a few where the location was unconventional (in six cases only). Crashes that occur on such locations (on private land, in the desert or on construction sites) were not strictly the responsibility of the traffic police and were classed as occupational safety problems. They were included in the analysis because they were investigated by traffic police and involved motor vehicles. The cause was down to driver error in almost all cases. The two most prevalent speed limits, 80 and 120km/h, reflected the locations they were set in. Roads with an 80km/h limit were more likely to be within the city limits and near areas of commercial activity with traffic-light controlled junctions and numerous entry and exit routes for traffic. If a large number of pedestrian crashes occurred in the 80km/h zones (as they did) then lower speed limits might be one way to reducing the casualties there. If, however, the 120km/h regions account for most of the pedestrian crashes then different methods of excluding or protecting pedestrian traffic must be devised because mixing unregulated pedestrian traffic with vehicles travelling at such high speeds had disastrous consequences. Roads with speed limits of 120kph were the next most common category after 80kph roads with a minor difference between them.



There was a significant difference between roads where most injuries occur and the designated speed limit in the UK and the findings of microscopic analysis. In the UK in 2007 roads with the worst incidence of injury crashes (62.8%) were 30mph roads (DfT, 2008). All injury crashes occurring on 50mph limit roads (closest to 80kph) made up 2.9% of the total while roads with a 70mph speed limit (closest to 120kph) accounted for only 7.8% of total crashes. The most frequent speed limit at UK injury sites in 2007 was 30mph (62.8%) which might highlight the different types of roads involved in crashes. These differences may be attributable to the difference in road construction and age mentioned earlier as well as differences in the climate conditions and general population of drivers and vehicles involved and their travel patterns.

### ***7.11 Crash causation (macro-level)***

Federal (UAE-wide) records from 1990-1998 (El-Sadig et al, 2002) show that the leading cause for fatal crashes was careless driving (43% average). This was not listed as a cause on Dubai crash forms due to non-unification of crash report forms at that time unless it is equated to “inconsiderate driving”.

Crash causes were seen to vary significantly between the latest year available (2006) and previous years. The most frequent crash cause (inconsiderate driving: 26.7%) has not changed but the order of other causes has changed significantly with the ominous rise of drink-driving as a significant contributor to injury crashes in 2006. This rapidly-changing scenario reflects the dynamic pace of development and the ever-changing population and 24-hour economy with many construction projects working around the clock to finish on time and before competitors and deadlines. Delays in construction can lead to large fines and lengthy and costly disputes between clients and construction companies (Zaneldin, 2006). The recording of crash cause is assumed to be reasonably reliable but the degree to which this recording is repeatable and accurate is not known. As with any human activity some degree of error is to be expected especially when the recording is hardly ever done under the same circumstances. The number of fields available for crash types appears to be sufficient to cover most crashes but the definitions of certain causes were not fully understood.



This may be improved by discussions with crash investigators that use the form frequently.

The prime crash causation (inconsiderate driving) is a problem with behavioural and psychological dimensions, as well as educational ones. It would be too simplistic to assume a different driving test or curriculum of driver education at schools will help solve this problem taking into consideration the experience of other countries with these measures. However this area deserves more detailed study to come up with realistic and effective countermeasures. It might also be the case that this is used as a cause when it is closest to the actual crash cause but the actual cause is not recorded due to time constraints or the need for extra information when those involved in the crash are not easily accessible. Speeding is a common cause and associated with more severe crashes in other countries especially for pedestrians (Gårder, 2004; Kim et al, 2008; Pitt et al, 1990) so tackling this even as a contributory factor would be desirable.

Causations that are expected to be frequently encountered in a hot desert environment are not that common namely blown-out tyres and animal collisions (especially camels). The rarity of tyre defects could be attributed to the relatively modern vehicle fleet and to annual inspections by the authorities that are compulsory at the time of vehicle registration renewal. Animal collisions are not as high up the list of causes due to the extensive fencing around almost all major motorways and many routes that cut through uninhabited land where animal farming might take place. The problem is much more evident in countries with larger unpopulated areas as is seen in the neighbouring Kingdom of Saudi Arabia which witnesses around 600 camel-vehicle collisions annually (Al-Ghamdi & AlGadhi, 2004).

Treatment of causes is mainly based on their frequency and share of the total crash causation though some consideration must be given to costs (if countermeasures for certain causes are too expensive) and to less-common causes if their treatment is not that difficult or expensive. It might be more appropriate to expedite it before the more costly and complex countermeasures are put into place. This applies to all suggested countermeasures in a similar vein.



## 7.12 Crash types (macro-level)

Crashes are classed according to only 10 types and the most common of those, pedestrian collisions (28.6%), might not receive the most attention due to non-car users being affected.

**Table 43: The 10 crash types from macro-level analysis**

No.	Crash Type
1	Pedestrian collision
2	Head to tail collision
3	Side to side collision
4	Rollover
5	Stationary object impact
6	Hit while turning
7	Head to side impact
8	Head on collision
9	Falling off moving vehicle
10	Impact with animal

In 2006 pedestrian crashes accounted for 33.3% of injury crashes (RTA, 2007) while in 2007 they made up 35.6% of all injury cases (Dubai Police, 2008a). Dubai is notable for the absence of pedestrianised zones in busy market areas except at seasonal times of the year like the annual Dubai Shopping Festival. This was generally held in the winter months (January – March) when a popular shopping boulevard – Al Rigga Street – is closed to traffic. Aside from speed which was discussed in the previous section, other factors that can improve the pedestrian situation are more controlled crossing facilities and wider pavements with good visibility as found from previous work in the literature review (Corben & Diamantopoulou, 1996; Corben & Duarte, 2006; Elvik & Vaa, 2004; Reading et al, 1995). Further analysis of these crashes reveals that most occur at lunch-time or in the evening (6 – 9pm) when it is generally dark. The time of year also plays a role with more pedestrian cases happening during winter months than in



summer as could be explained by the very high temperatures in summer that drive people indoors.

For the top 4 locations of pedestrian crashes the top spot is a main 3- and 4-lane highway (with a speed limit of 120km/hr) but the other three are all smaller inner-city roads with the main speed limit of 60km/hr. For the highway a solution effectively preventing pedestrians from being present there or alternatively providing them with safe crossing facilities must be considered. In the UK and other countries pedestrians are banned from highways (except in emergencies) but no similar ban was found in past UAE legislation so this must be suggested on review. In a similar way to Dubai rural roads in Virginia and Maine in the USA carried a higher risk for pedestrians than urban ones (Garber & Lienau, 1996; Gårder, 2004, respectively). For inner-city roads most of the crashes take place on single-carriageways with one lane in each direction so reducing the speed limits on these roads or providing controlled crossing facilities must be considered. Vision and visibility might factor in the equation if drivers cannot see pedestrians when coming along a tight curve or if obscured by objects close to the carriageway. This has been shown to be relevant in a recent study from On-The-Spot crash data (Lenard & Hill, 2004). Visibility for the pedestrians is also an important issue as highlighted in previous work especially for children (Mayr et al, 2003).

If a comparison was to be made between the design of cities in the UK and USA in terms of car-friendliness then Dubai would be closer to the latter than the former in that cars are almost always catered for in any residential, industrial or leisure development. Pedestrians often come as a second thought, or not at all except in planning the paths to and from the car parking locations. This might be used to explain the presence of pedestrian crashes at the top of the list though there are increasing moves to introduce countermeasures for pedestrian safety in existing trouble spots and to ensure all new developments cater for pedestrian and vulnerable traffic as well as the motorised variety. The effect of these countermeasures on crash safety can be reviewed after implementation and the effect should be clear to see in terms of pedestrian-related crash numbers. The other common



type of crash, head to tail, is easy to attribute to not leaving enough distance between vehicles as related to speed as most head-to-tail collisions can be averted if a. the driver saw the obstruction or vehicle in front and b. the driver managed to stop in time. The lack of driver attention might be affected by in-vehicle distractions (mobile phones, navigation and entertainment devices) and further work (possibly interviews with drivers involved in such crashes) can establish if this is a significant factor in these crashes. Side-to-side crashes need further categorisation as those that happen between vehicles travelling in the same direction are different in cause and treatment to those that happen between vehicles travelling in opposite directions. Lane discipline might be a factor affecting same-direction side-swipe crashes while lane separation might affect side-swipes between traffic going in opposite directions.

The crash type does not indicate the area of damage to the vehicle, though this can be assumed for some types (a “side-to-side” crash would be assumed to have damaged the sides of the vehicles involved) but the direction of force or the involvement or amount of crush of certain vehicle structures, specifically stiff structures, was not known from the given data. This information is useful in calculating estimates of the crash speed and deceleration which are of use in reconstruction. Large-scale studies like CCIS (the Cooperative Crash Injury Study, Mackay et al, 1985, as cited in Welsh et al, 2006) have looked at vehicle damage and injury outcome trying to correlate the two and a lot of vehicles already exist in the database. A similar study to CCIS based in Dubai would offer the chance to compare findings as well as investigate vehicles that are not found in the UK market but are available in the UAE. To be of most use this would have to be done in association with collecting more extensive injury information preferably according to an international convention like the AIS (AAAM, 1990).

### ***7.13 Crash mechanisms and causes (micro-level)***

Knowledge of the crash mechanism is key to understanding the crash cause, and hence the relevance of any countermeasures proposed. Though it is more directly related to primary safety it does not mean that it should be ignored because if the crash happens anyway the outcome might be



reduced in severity if the crash mechanism can be controlled by external factors (like Stability Control, or a crash barrier). Loss of traction is rarely recorded as a mechanism possibly due to the dry nature of roads for most of the year due to low rainfall. The loss of directional control could be as a result of evasive action taken to avert impact with an object (whether movable or fixed) so the different mechanisms may be related. For every crash mechanism there might be a number of underlying reasons (like poor vehicle control by the driver, poor vehicle roadworthiness, worn tyres or adverse road conditions). Such factors are difficult to extract from the available data without probing further into the case by doing more scene information and interviews with the involved parties. The crash mechanisms listed were unique to this study and developed with knowledge of the types of crashes in the base-level data so they were not found in other studies in the field to allow for comparisons to be made. An impact with a movable object may have two different dimensions depending on whether the object hit was another motor vehicle or another type of road user (pedestrian or cyclist). In the case of impacts with other vehicles the underlying cause might be an unexpected movement or manoeuvre by the other party or the classical case of not leaving enough space between vehicles to allow time for reaction in case of an emergency. In the case of impacts with other types of road users the situation may be related to the unexpected presence or behaviour of certain road users (pedestrians or cyclists). A case in point is the attempt to cross multiple lanes of a wide motorway during peak traffic times. While the law in the UK bans pedestrians and cyclists from motorways altogether, the only item in UAE legislation found to relate to pedestrians was a fine for crossing from locations "other than designated" but only where these crossings exist (Dubai Courts, 2006). This leaves the matter open to interpretation by judiciary and enforcement authorities as pedestrian crossings did not exist on most motorways.

Crash causes mostly laid the blame on human rather than machine error which highlighted the presence of a problem with driver behaviour and education. This was too complex to allow recommendation of one universal solution to fit all cases as such a solution did not exist from the literature. Rather a number of interventions targeting specific problems were suitable



once the problems were understood in more detail. Many crash causes involve vulnerable road users and this again drew attention to a problem with the actions or behaviour of this section of road user which might have contributed to the crash if it was not already a main cause. Motorised vehicle driver testing and licensing is achievable on a large scale while pedestrians and cyclists are much more difficult to regulate in any form without extensive legislation and enforcement. The cost of such measures is often too prohibitive to allow for universal application. Comparison with crash causation and contributory factors from the UK was difficult due to the difference in terms and classifications but some trends were distinguishable. The largest single contributory factor in the UK in 2007 (DfT, 2008) was failure to look properly while in the in-depth sample it was driving without due care, a factor more closely resembling the UK STATS19 factor “careless, reckless, in a hurry” which was the third most common in that year. However in the OTS data (Mansfield et al, 2008) inattention was the most commonly mentioned scene factor that may have more closely approximated the in-depth factor “driving without due care”. The OTS study was meant to be representative of the overall UK crash population in terms of severity (Hill & Cuerden, 2005). Excessive speed was found to be similarly high in causative and contributory factors ranking third in the microanalysis and second in OTS (Mansfield et al, 2008). Pedestrian-related causes were high on the list of the in-depth sample (second) and may be related to the STATS19 factor of “pedestrian failed to look properly” which ranks eighth in the UK in 2007 (DfT, 2008) which indicated the different magnitude of the pedestrian problem between the UK and Dubai as found in the in-depth sample. Comparison with the whole population of injury crashes in 2006 (RTA, 2007) showed the first cause to be the same (inconsiderate driving) while the second most common cause was far less evident in microanalysis (drink-driving). This meant that drink-driving – while highly evident in the overall crash sample – was less evident in the in-depth sample. Due to the higher severity of the in-depth sample this implied that most drink-driving crashes were of low severity otherwise they would have been included in the in-depth sample.



### **7.14 Objects hit in crashes (micro-level)**

The situation appeared very different between the in-depth sample and any UK data found. Data on objects hit in the OTS study (Mansfield et al, 2008) showed most impacts were with another car followed by stationary object impacts. For UK crashes in 2007 (DfT, 2008) single vehicle crashes that hit nothing were the most common followed by impacts with “other permanent objects” then tree impacts. This difference arose due to the classification of single-vehicle crashes separately from pedestrian crashes with one vehicle.

In Victoria, Australia fixed object impacts made up a significant portion (23%) of all crashes in 1994 (Natalizio, 1995, cited in Corben et al, 1996) whereas in microanalysis the impact type occurs in only 12.6% of crashes. Single-vehicle crashes in the UK (DfT, 2008) in 2007, where an object was hit outside the carriageway, made up 9.5% of all injury crashes in that year.

Due to the nature of the supplied data, single-vehicle crashes included both crashes of a vehicle alone (e.g. rollover) and crashes of a vehicle with a non-vehicle road user (pedestrian or cyclist). As a total, crashes involving pedestrians and one vehicle numbered almost half the total crashes classified as “single vehicle” crashes. The first object hit by all the main motor vehicle groups was also a pedestrian. This highlights compatibility issues between vehicles and vulnerable road users, which should be of a higher priority than vehicle-to-vehicle crashes as they are more frequent and severe. Pedestrian-hit crashes appear over-represented in microanalysis compared to Dubai 2006 figures (RTA, 2007) that show pedestrian crashes made up 33% of the total while fixed object impacts made up 11% of the total, as compared to 53% (first object hit) and 12% respectively, in microanalysis. This pointed to the generally higher severity of pedestrian crashes because they were more evident in the sample which was shown to contain crashes of higher severity compared to the whole population. The classification used in the UK of hitting nothing may have accounted for some crashes in the in-depth sample where more detail was found like hitting “sand” or the kerb. These generally came under the category of “other” in the relevant pie chart. No information was found on the second or third objects



hit in crashes in the UK or from official Dubai publications which meant further comparison was not possible.

### ***7.15 Road layout and furniture (macro-level)***

It is worth mentioning that non-motorway routes (especially B-roads) can be very unforgiving in terms of driver error often with no shoulder or runoff space if a vehicle leaves the carriageway. Most minor roads in Dubai are lined by pavement or a shoulder, or in the worst case by sand. There are a few exceptions in outlying areas where roads run through rocky landscapes. The most common crash type on 3-lane dual carriageways is jointly shared by pedestrian and head-to-tail collisions. Pedestrian collisions are the most common on single carriageways with one lane in each direction. Dual carriageways with 4 lanes appear less dangerous (smaller number of injury crashes occur on them) but this might be misleading due to the recent introduction of such roads (they only came into existence in 1998). Selecting only cases from 1998 onwards shows they are relatively safer than 3-lane highways but this may be explained by less exposure (traffic volume) due to the reluctance of drivers to use them as they lead to an increase in distances travelled. Some types of roadside treatment (e.g. guard rail ends and new street lighting) were found to increase injury crash frequencies (Corben et al, 1997). This might be due to the introduction of a new roadside hazard (e.g. lamp post) where none was present before. The majority of dual-carriageway motorways in Dubai have a steel central reservation but further work is required to assess the effectiveness of the barrier in reducing crash severity and injury occurrence. Local data on road width and configuration for injury crashes is not published. The information on what divider exists between carriageways is of limited use as the majority of cases are recorded as “unknown” so it was likely this field has only been introduced in the last few years or that the entries are not suitable in a large number of cases hence alternate entries must be suggested. In places where no barrier or separation is recorded as being present it was logical to assume that the road is a single-carriageway. A kerb exists in a large number of cases but no account is made of the type or height of kerb as there are a number of them in use on different roads and the deflection of a vehicle might differ



significantly according to what type of kerb it hits (some kerbs are designed to arrest the vehicle tyre and prevent it mounting the kerb). Where a barrier was recorded steel was the most common material followed by concrete. As indicated by the literature review concrete is a less favourable countermeasure than steel barriers but to validate this in Dubai further description is needed as no differentiation is made in recording the different types of barrier materials. Certain standards exist in Europe (ex. EN-1317) that test barriers in a standardised test but it is not known if any of these standards are currently adopted or specified for new roads in Dubai. From the description of the field on the crash report form it appears that barriers at the side of the road are not recorded. These could be an important part of the environment surrounding a crash site and allowing for this to be recorded in future will add valuable information on barriers that do not divide traffic in opposite directions.

Roadside conditions and objects hit are important factors in serious crashes and improvement of these conditions has been successful in reducing crashes cost-effectively in Victoria, Australia (Corben et al, 1997). That state counts fixed roadside hazards as possibly the single largest component of all road trauma (Delaney et al, 2002).

### ***7.16 Environmental and local conditions (macro-level)***

The recording of light and weather conditions is essential for being able to estimate the effect of variables that are outside human control. Whereas in the UK night-time driving is seen as more dangerous than day-time driving, in Dubai this cannot be concluded from the current availability of data as exposure might be different between night and day. Night-time driving might put more stress on a driver as road features are more difficult to distinguish than in daytime, and the darkness outside might lead to sleepiness behind the wheel. If exposure is not taken into account then night and day are almost equal in crash occurrence. The climate in Dubai is well known for year-round sunshine and rare days of cloud or haze. Sandstorms and fog happen on occasion but not very often. Sunshine can sometimes present a hazard if it is low on the horizon and causes the driver to squint or the driver does not employ sunshades (visors) or sun glasses to improve visibility in



these conditions which make it otherwise difficult to make out the contrast between road hazards, especially smaller ones. It is not known whether road users compensate in such situations by lowering their speeds or being more careful. Data from North Carolina (Kim et al, 2008) shows inclement weather to have a positive effect on pedestrian injuries reducing the probability of fatal injury by 35% which is a demonstration of this effect. Darkness however results in an increased probability of death or serious injury for pedestrians (Kim et al, 2008). Poor lighting conditions (due to overcast skies and cloud cover) are more common in Europe than in Dubai as shown by UK data for 2007 where 25.9% of casualty crashes happened in unlit conditions. In North Carolina over 3 years (Kim et al, 2008) 42% of pedestrian crashes occurred during darkness with or without streetlights which was not far from the 37.6% figure seen in Dubai for all crashes. Data for pedestrian crashes in a study of Maine state in the US (Gårder, 2004) showed that 39% of crashes happen in non-daylight conditions, again not very different to the findings in Dubai. This indicated that night-time crashes might not be a serious problem when compared to studies in the USA.

Other extreme or unusual weather conditions can affect driving by affecting vision or vehicle handling (namely tyre grip, braking and cornering) and if drivers are not taught to adjust their driving style accordingly these times can become more dangerous than they need be. To improve the road surface friction in these conditions will not be cost-effective as they only occur during a short time of the year. Driving instruction almost never takes place in these conditions as driving tuition vehicles are banned from operating outside certain hours (which purposely excludes night driving). Other conditions are very rare to be faced by any significant number of learner drivers. This is in sharp contrast to Germany where the learner driver must complete a requisite number of hours of motorway and night driving in order to get the licence.

### ***7.17 Casualty and driver profiles (macro-level)***

The vast majority of drivers in injury crashes were male and it was not known whether this is reflected in the licensed population or actual drivers on the road at any one time so the conclusion that male drivers are more



dangerous cannot be made without further study. Previous studies of hospital admissions from road crashes in 1995 in a city not far from Dubai (Al-Ain, 150km east of Dubai) showed males to be the majority of casualties at 86% (Sankaran-Kutty et al, 1998). An earlier study (Bener et al, 1992) at

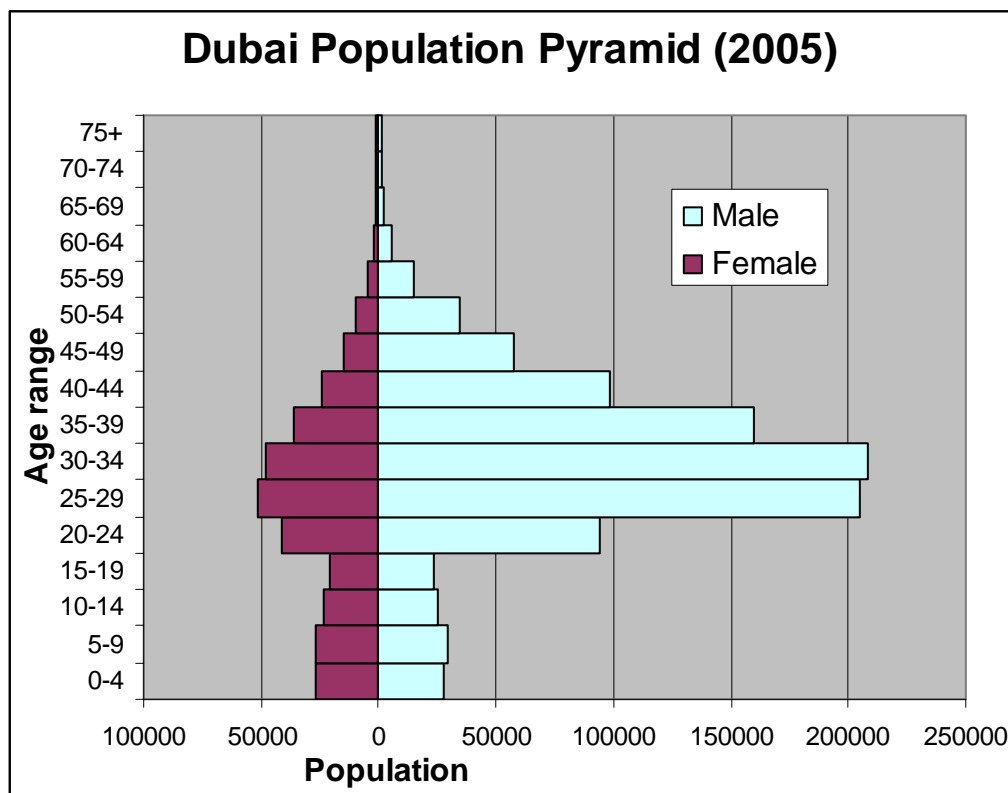


Figure 67: Dubai Population Pyramid 2005 (DMSC, 2007a)

the same city but at a different hospital in 1990 showed males to form 87% of admissions from road crashes so the 82% male figure from this data is in keeping with this trend. The latest census data shows the percentage of males in the population to stand at 75.5% (DMSC, 2007c) so the division of the sexes in injury figures follows the division in the general population though exposure data is unavailable for a more accurate comparison. The best representation of the population is by a population pyramid (figure 67). Within each gender, the dominance of male driver casualties and female passengers might be a result of the social structure of the population in Dubai, where it is common for families to have drivers for female members of the family (even if they possess a driving licence). In this way females would be less likely to drive and more likely to be driven. If travel data were available to measure the exposure to driving between genders then it would



be possible to compare crash involvement more accurately but with the data in hand it is not possible to advance the discussion on this issue further.

Other studies in the region on crash involvement (Abdalla, 2002; Bener et al, 2004) have shown a difference in crash risk between genders with males always having a higher crash risk than females. Surprisingly, when driver behaviour and errors were surveyed in questionnaires (Bener & Crundall, 2008) females reported more errors and lapses or at least as many (Bener et al, 2008) as males did. The age range of casualties is worrying due to the large number of children present as this section of casualties requires special countermeasures that take into account the very vulnerable type of road user and their occasional inability to judge road situations safely. The majority of countermeasures suggested however target the adult road user and it is hoped a child will always be under the supervision of a responsible adult. The casualty age profile generally fits with the population age profile as most of the population is economically active and driving is an integral part of many jobs. Public transport is hardly used by middle-income individuals in general.

It is no surprise to anyone familiar with Dubai that the nationality of casualties was divided so clearly. This is not very different to the findings of Bener et al (1992) who grouped Asian nationalities together and found they collectively made up the largest group of cases (37.8%). The latest census data from 2005 (Ministry of Economy, 2005) for the whole UAE shows Emaratis to make up 20.1% of the total or slightly higher than their proportion in the sample. This goes back to the demographic make-up of the population and the economically active nature of these nationalities. The type of road user injured (driver, passenger or pedestrian) varies with nationality. Emaratis and Pakistanis are most often injured as drivers while Indians are more commonly injured as pedestrians. This might reflect the economic status of certain nationalities as lower-income groups will have limited travel options compared to higher-income groups. Pedestrians might not always be pedestrians by choice rather by necessity. To counteract or change this balance means changing the structure of the whole population or targeting those specific nationalities. Every driver in Dubai must have a



UAE-issued licence or exchange his licence for a local one if working there. Nationals of certain countries (36 in total) are allowed to exchange their home licence without undergoing a driving test (but an eye test is required), while all other nationals must undergo a driving test locally (Dubai Government Information and Services Portal, 2010). This may be a way to influence the mix of nationalities as previous studies on drink-driving and licensing between drivers of different ethnic origins in the USA (Colorado and California respectively; Harper et al, 2000; Walker et al, 2003) suggested targeted programs of education for groups that were over-involved in crashes. These studies' suggested measures might need to be sensitively targeted towards Hispanics due to their relatively higher incidence of drink-driving and other safety breaches. Asian Americans were found to have a lower propensity to drink and drive or ride with drunk-drivers, which might relate to societal differences between the two groups.

Driver attitudes and their level of education and comprehension of signs have been flagged by a number of studies from the region. One such study was based on a driver survey (n=2,820) conducted between three GCC countries: Bahrain, Qatar and the UAE (Al-Madani, 2000). The findings of that study bring up some encouraging signs that UAE drivers had slightly better comprehensive abilities possibly due to the existence of a written driving test in that country which is not the case in Bahrain and Qatar at the time of study. The survey also had a self-reported rate of seatbelt usage of 38.6%. This might be skewed by the nature of person that would have been targeted by the survey in the first place (literate, educated) and hence those that were more likely to respond though the methodology is justified in the study. A later study (Al-Madani & Al-Janahi, 2002) expanded to five countries (UAE, Kuwait, Bahrain, Qatar and Oman) also showed that drivers in these countries had substantial problems with the comprehension of road signs with UAE drivers doing marginally better than the rest.

Driver behaviour in the region has been the subject of a few studies. Bener & Crundall (2008) conducted a questionnaire-based study on 1110 drivers in the neighbouring state of Qatar looking at self-reported driver behaviour, skills inventory and seatbelt use. Qatar shares many features with the UAE



as it undergoes rapid growth and development. Women reported a higher number of certain violations and lapses than men (examples include jumping a red light and ignoring the speed limit). However men had higher crash rates than women. Mobile phone use was also studied in Qatar (Bener et al, 2005) among drivers involved in crashes (n=822). Self-reported mobile phone usage was reported by 73% of respondents despite a third of them favouring a law against mobile phone use while driving. Mobile phone use has been linked to crash causation and driver distraction in a number of studies (Redelmeier & Tibshirani, 1997; Violanti, 1998; Violanti & Marshall, 1996; as cited in Bener et al, 2005). This phenomenon needs to be studied in more depth in Dubai and the UAE to establish the extent to which it affects crash involvement.

### ***7.18 Data recording (macro-level)***

The data supplied did not contain all the fields available in the crash form due to data sensitivity and other formalities. Some of the fields could be of great use for further analysis like those describing the type of injured person, seat belt use, vehicle tyre condition and the involvement of a bicycle or pedal cycle. Some of the fields could be updated to make them easier to use or gather more useful information. The first example is the road barrier field where the investigator can either choose concrete or steel as the type. There are many types of steel barriers (wire, continuous s-shape) so changing the options might help gather more useful data on this area. A second example is the field describing “crash site proximity to local feature”; this is not very useful in the current state as the majority of cases have “other” listed as the feature (which was not supplied with the data). If this “other” category was supplied then it might show other features that are common to crash sites. If other features are frequently entered manually the crash form or options can be updated by including the most commonly selected “other” feature to save time and encourage correct coding of the form, and improving the usefulness of data collected.



## **7.19 Good aspects of road safety (macro-level)**

Lighting conditions are good in the majority of cases as are weather and road surface conditions. This is definitely due to the geographical location as well as the constant upgrade, construction and maintenance of roads that has been taking place in Dubai over the past 10 years. Spending on roads in 2006 was reported at AED 3.5 billion or around £500m (Ahmed, 2006) which is a lot considering the population of Dubai in 2006 was equivalent to that of two medium-sized British counties combined. The spending of one medium-sized county in Britain (Leicestershire, 2006/7) on road transport was £21 million (Leicestershire County Council, 2009). This illustrated the huge gap in spending between the two.

## **7.20 Preventative measures (micro-level)**

### **7.20.1 Validation**

The validation carried out was necessary to verify the factors were assigned to cases with reasonable confidence. The ideal situation would be validation by experts in Dubai who were familiar with the Dubai cases and scenarios, if they were also trained in understanding the preventative measures and contributory factors suggested. As this was not possible UK experts were used. Agreement with the factors may have been more extensive had the experts had more knowledge of the crashes and first-hand experience of the transport system in the UAE. In some limited cases different measures or interventions were suggested by the experts. These may be useful for future revisions of the protocol.

The assessment and suggestion of mitigating factors and countermeasures was often attempted or desired in many other studies (Corben et al, 1996; Corben et al, 1997; Corben & Duarte, 2006; Delaney et al, 2002; Gårder, 2004; Keall & Newstead, 2007; Mansfield et al, 2008; Welsh & Lenard, 2001) to point the way forward for improved conditions for road users.

### **7.20.2 Vehicle Factors**

Crashworthiness was by far the most commonly suggested preventative factor for crashes in the vehicle category. Seat belts might be viewed as part



of vehicle crashworthiness but their fitment has been standard in most locations in a vehicle for many years so seat belt use was separated from crashworthiness. Improvements in vehicle crashworthiness have improved injury outcomes for car occupants in the past (Richter et al, 2005) and future improvements were expected to improve safety for other road users as well with the revision of consumer testing standards (EuroNCAP, 2008). Seat belt use was selected due to the low observed use in many areas in and around Dubai (Abdalla, 2005; Barrs et al, 2008; Bener et al, 1994; El-Sadig et al, 2004; Koushki et al, 2003; RTA, 2006c). It was significantly higher in the UK for many years (Broughton, 1990; 2003). Other studies have shown a distinct link between non-use and injury in a crash. In one study in New Zealand (Blows et al, 2005) unbelted drivers had ten times the risk of being involved in an injury crash compared to belted drivers. Seat belts have been tried and tested in reducing fatalities and injuries over many years in many localities (Adams, 1994; Elvik & Vaa, 2004; Evans, 1991; Lund & Zador, 1984). Their recommendation as a measure is not surprising given the worrying usage rates shown in regional studies (Abdalla, 2005; Barrs et al, 2008; Bener et al, 1994; El-Sadig et al, 2004; RTA, 2006c; Sankaran-Kutty et al, 1998). Airbags were not suggested as a measure due to the lack of any data on the extent of their presence in the vehicle fleet in the UAE. Records of airbag deployment or involvement were not supplied in crash data either.

In the Euro NCAP test up to 2007 very few cars achieved a good pedestrian safety rating (Euro NCAP, 2008). This is especially relevant in areas where pedestrians make up a majority of casualties. Efforts to improve the performance of vehicles in pedestrian impacts were outlined by European directive 2003/102/EC which applies to vehicles for sale in Europe in two stages beginning in 2005 (European Communities, 2009a; 2009b). Japan also introduced regulations for testing bonnet surfaces for head impacts but without a knee impact test as in Europe (Kerkeling et al, 2005). Vehicles sold in the UAE do not currently need to meet such standards but as European and Japanese vehicles begin to meet these regulations the UAE vehicle fleet is expected to benefit.



Electronic stability control was suggested as a valid intervention mostly for single vehicle loss of control crashes found in the sample. The effectiveness of ESC was established through numerous studies in different geographical areas, but some studies (Thomas & Frampton, 2007) showed less effectiveness in dry conditions (the majority of situations in Dubai) than in wet and snowy conditions so slightly decreased effectiveness was expected. Still most of the vehicles involved in loss of control crashes were not equipped with ESC so fitment may have altered the outcome. ESC only has a relatively small number of studies published on its effectiveness since it was introduced to the market in the late 1990s but all agree on some benefit particularly in low friction conditions or for single vehicle crashes (Farmer, 2004; Kreiss et al, 2005; Lie et al, 2005; Scully & Newstead, 2007; Thomas & Frampton, 2007). This is particularly relevant considering there is a known proportion of single vehicle loss-of-control crashes in Dubai (6.6% in the in-depth sample).

### **7.20.3 Human Factors**

Human factors may be considered the most important – and most controversial – of all due to their divisiveness amongst road users and road safety stakeholders. Nader (1965) illustrated this with the coming of age of safety in the US car market and many stakeholders continued to blame the human element for any safety shortcomings, refusing to improve design to accommodate human error. Driver education and training were foremost in the factors that may improve the outcome in a crash or prevent it altogether as most crashes are due to human fault despite some criticism of some parts of education as ineffective or even counterproductive (Christie, 2001; Mohan, 2003). The education, training and awareness of the three most commonly involved road user classes – drivers, pedestrians and cyclists – were recurring themes in most cases in microanalysis. This highlighted the size of the problem in this area especially with such a diverse population of various nationalities with the largest section being made up of young and middle-aged males. Until control is completely removed from the road user and handed over to a fault-free “system” the driver or person in command will have to be a focus for interventions. The existing system of driver



training and qualification was found to be very different to those in place in the best-performing countries around the world in road safety terms. The overhaul and improvement of this process may seem daunting with the large number of applicants and personnel involved, however it only gets harder the more it is postponed due to the unrelenting population growth seen in the area (Statistics Center of Dubai, 2007). Driving licences were seen as an essential part of doing business in Dubai and they were a requirement or strongly desired in most job advertisements. A thorough driver education and licensing scheme is distinct from post-qualification advanced driver training in emergency manoeuvres. The latter was not found to be effective (Christie, 2001) in improving safety in other studies.

It is also true that countries that had a thorough regime of driver testing (e.g. UK and Germany) and qualification have some of the most disciplined drivers and lowest fatality rates (DfT, 2008). Distinction must be made between driver education at the qualifying stage and training that takes place later in an effort to “boost” certain driving skills that are hardly ever put to use in everyday driving. The former was the natural counterpart to that cause most often quoted by the police: driving without due consideration to others. The latter type of training is hardly ever put to use in the real-world. Also the increased confidence might lead drivers to take more risks, as one study of holders of a racing licence showed that they had worse driving records than non-racing drivers despite their increased training (Williams & O'Neill, 1974, *in* Dorn & Brown, 2003).

Pedestrian education was especially relevant to road users who were from other countries in which the mix and speeds of traffic were very different. This was highlighted by one case where the casualty had only arrived in Dubai a week before and had crossed the road when his more experienced relative refrained from crossing. Pedestrian visibility may be a dual effect of either the pedestrian or road environment or both. Dark clothing at night would not aid visibility nor will an unlit street or pavement or overhanging trees and other road features that may conceal pedestrians and cyclists. The road factors may be differentiated from the human factors if exact location data was available. If a particular spot on a road was the scene of multiple



pedestrian crashes then it might be a road design issue whereas if the crashes happen at different locations it might be a human factor though both cannot be ruled out. Such factors are difficult to establish from a scene plan drawing or photographs. On-site inspection is needed. When a driver commits an offence (e.g. runs a red light) that causes a crash, this crash could have been avoided had the driver known that the risk of being caught and punished was high. This might have prevented the offence (and hence the crash) from happening, thus providing a better overall outcome. In this way offending driver punishment acts as both a deterrent to some drivers and as a punishment after the event. This generally meant more effective legislation, licence restrictions, financial penalties, education, publicity and enforcement was needed as these measures have been shown to improve safety in various ways in different countries (Delhay, 2006; Lawpoolsri et al, 2007; Lund et al, 1986; Nichols & Ross, 1990; Poli de Figueiredo et al, 2001; Zaal, 1994).

#### **7.20.4 Road Factors**

Factors related to the road and surrounding environment were mainly focused on pedestrian measures. This made sense considering pedestrians were most often the first object hit in crashes. While the human factors of education, awareness and visibility played a part, the environment's role was also considered. The majority of sites could have benefitted from the separation of pedestrian and motor traffic (by crossings or bridges or tunnels) and in some cases measures controlling pedestrians may have been more appropriate (like fencing). This was especially relevant on long stretches of motorway where pedestrian traffic was not expected. Cyclist traffic was not considered in the majority of new road developments and improvements and cycling was not even an option for consideration by the majority of commuters. Future integration of cycling within the transport system must be considered to institutionalise the usage of this environmentally-friendly transport mode and protect the users without compromising motorised traffic.

Speed limit enforcement by automatic means, namely speed cameras, has proved effective in a number of studies (Elvik & Vaa, 2004; Newstead &



Cameron, 2003; Pilkington & Kinra, 2005) while there remain some problems with the halo- and time-limited-effect (Champness et al, 2005; Holland & Conner, 1996; Koushki & Hasan, 2000). These effects show that the deterrent effect of speed cameras is limited to the vicinity and time of deployment. The measure has been in use in Dubai for a number of years and concentrated on some major routes (Sheikh Zayed Rd) but plans to introduce more (Al-Theeb, 2008*b*) cameras - both mobile and stationary - were attributed to the police. This indicated a positive alignment of policies between some results of this study and actions by some stakeholders in Dubai. Monitoring of the incidence of speeding as a cause for serious crashes after the application of new cameras might validate their effectiveness if confounding factors were accounted for. Location of mobile speed cameras in Dubai was left to the discretion of the operator (Dubai Police, 2008*b*).

Central barriers, guardrails and crash cushions were often observed at high speed roads and obstacles (such as lamp posts) but these were missing at the scene of some crashes at lower speeds where there was interaction between opposing traffic. In some cases impacts with fixed objects beyond the carriageway occurred despite the presence of a barrier; such cases were excluded from the count. The case for such measures may not be as obvious as it is in countries with twisting roads at high altitudes but the straight and featureless nature of many high speed roads meant that when a vehicle departed the road at high speed the consequences were sometimes severe. Also the large number of interchanges and multi-level junctions (both planned and in use) mean that vehicles that lose control may have severe impacts with these solid structures. The loss of control aspect of such crashes was already accounted for in the section on vehicle factors. Other factors (speed humps, lighting, etc) were also found but in a smaller percentage of serious crashes. Higher priority should be given to those factors that appear most frequently in crashes, then those factors that are less common can be tackled.



### **7.21 Vehicle class size (micro-level)**

While the full vehicle fleet data for Dubai was not obtainable some useful insights were gained from representative data from new vehicle sales in the UAE (Auto Strategies International, 2007) as the Dubai fleet makes up a significant percentage of the total UAE market. The full data would have revealed interesting information on the performance of the different vehicle makes and models in different crashes and on their level of occupant protection. The involvement of heavy vehicles (labelled as “buses” and “trucks” in the list of models) was difficult to match to the market data, though general segment size classification showed trucks were more evident in microanalysis than in their market share of new vehicles (figure 63, section 5.5). Trucks made up a large proportion (20%) of the in-depth sample vehicles indicating they were present in many of the serious and fatal crashes but their proportion of sales was not as high. This may be due to the fact that many trucks in service are older and imported types with a long service life and new trucks are very expensive and thus rare. Heavy trucks were also found to be involved in a large proportion of all injury crashes (7.1%) and fatal crashes (11.7%) for all 2006 Dubai cases from official statistics (RTA, 2007).

Trucks (by virtue of their mass) were involved in more severe crashes than smaller and lighter vehicles (only one Heavy Goods Vehicle crash was non-fatal). This explains their increased presence in the sample compared to new vehicle sales in the same year (Auto Strategies International, 2007). This meant that attention must be focused on this size segment of vehicles with all types of interventions. In the UK legislation means professional drivers (including heavy goods vehicles) must be monitored and limited in their hours of driving (Horne & Reyner, 1999) but no such legislation was found in the UAE.

Division of the in-depth sample vehicles according to size revealed the high ranking of 4x4s in the overall population which indicated the vehicle fleet is closer in composition to the USA than to the UK. This was supported by new vehicle sales data (Auto Strategies International, 2007). New truck and bus sales made up a small percentage of the total for 2006 and these may be



mostly purchases by government departments for transport or other services. Further work that is possible in this area was suggested in the relevant chapter if more data was available.

## ***7.22 Estimated reductions and their derivation (micro-level)***

The level of detail in the in-depth sample allowed a more useful outcome to be assigned to each crash, namely a countermeasure area. This general area of improvement would be of limited use if not further specified. With the increased familiarity and knowledge of the crashes in microanalysis and the surrounding environment and factors it was possible to tailor interventions to the crashes to which they may apply with a high level of confidence as supported by expert validation of these factors.

The method of calculating possible or actual reductions through relevant countermeasures was used in many studies and is a logical approach to solve such problems (Corben et al, 1996, 1997; Corben & Duarte, 2006; Mansfield et al, 2008; Thomas & Frampton, 2007). The limited availability and age of the cost data locally led to the adoption of more recent UK costs to calculate improvements in monetary terms in addition to reductions in serious and fatal crash numbers. Pedestrian-related measures had the largest calculated cost saving but pedestrians were also the most frequently hit object so the related crashes account for a majority of the total population. Loss of control interventions appeared high on the list too while the loss of control was not frequently an overall crash cause but because the effect of the measure is particularly significant for fatal crashes, their prevention is also highly rewarded. Speed cameras were already in limited use in some areas in Dubai and their recommendation is timely as more were planned for deployment in 2008 (Al-Theeb, 2008*b*). Other measures were a mix of roadside infrastructure (guardrails) and enforcement and legislation issues (driver punishment). The latter is more difficult to implement as it involves politics and rule-making while the former may be seen as part of road building and maintenance which is an almost permanent activity in Dubai. The roads and laws in the area as a whole were fairly young in the age of nations so revisions and improvements were expected and this made these suggested measures even more realistic.



The total number of crashes reduced through these interventions (2,412) were greater than the total number of injury crashes reported for that year (1,812). This was because the interventions were not mutually exclusive as many crashes had multiple contributing/causative factors. For example if one crash injury was due to both the loss of vehicle control and lack of a barrier at the roadside, either one of the interventions could improve the outcome or prevent the crash from happening. The sample of injury crashes was bound to contain crashes similar to those that took place in the overall population but were excluded from the in-depth sample as there were so many crashes in total (the total crashes reported for that year were 243,386; RTA, 2007). This allows for the over-estimation of improvements. For this reason the savings may be described as slightly optimistic because non-injury crashes typically cost less than injury crashes according to UK figures (DfT, 2007*b*). This does not mean all injury crashes were subject to microscopic analysis; on the contrary there were 87 fatal cases and 1430 non-fatal injury cases in 2006 outside the in-depth sample.

With little information available on the cost of these measures it was not possible to make accurate cost-benefit calculations but this would have been the next logical step after this. Though a human life should not normally be forsaken for anything if cost benefit calculations showed a real economic gain to implementing countermeasures and interventions then the case for such implementation cannot be argued against.

## **7.23 Limitations**

### **7.23.1 Introduction**

Numerous limitations were encountered in collecting and analysing the quantitative data and these were outlined in the analysis where possible. The presence of “other” or “unknown” as an entry in many fields created a large gap in data in some cases. The time of introduction of some fields or the modification of others was not conclusively known though it can be deduced for some variables. This is often encountered in large databases that span many years and is expected where the data collection process evolves over time.



### **7.23.2 Data coverage**

The comprehensive nature of this data is assumed but it is possible that certain crashes have been missed and others have been miscoded so complete accuracy is not guaranteed. However the data is still useful in the current form bearing the limitations in mind. It is tempting and easy to make a long list of “required” data but in the real world only the bare essentials will be collected, even then with some reservation. Data fields that were present on the form but not supplied (as described in the methodology) were key to assessing the use and effectiveness of restraints or the effect of mechanical failures (like tyre blowouts).

### **7.23.3 Dynamism of Dubai**

The dynamism of Dubai is a limiting factor in that the picture changes from one minute to the next and as large changes were seen between years (in causation for instance) similar variations might occur by month and day. In some cases the analysis was outdated as soon as it was performed as the data that had been used for analysis has been supplanted by newer and possibly different data. The advantage of this dynamism is the possibility to influence data collection in the future as dictated by the requirements of research and policy formulation. Monitoring of countermeasures in a dynamic country or city should also be easier as compared to a city with little or no growth due to the farsighted nature of those in leadership.

### **7.23.4 Countermeasure assumptions**

The assumptions made to arrive at the summary table of countermeasures were numerous and were outlined in that section. Beginning with the effectiveness of countermeasures that was in itself an estimate from previous studies of international best-practice and ending with the biggest assumption that these estimates will be valid when applied to Dubai. The countries that supply the studies with data range from the USA to Sweden, Australia, Germany and the UK and none of these share all the characteristics of roads or road users or vehicles with Dubai (or each other). Similarly UK crash costings were not exactly identical to costs in Dubai nor are the costs of medical care, insurance or lost output. Nevertheless these



approximations were necessary in drawing cost figures for improvements until economic costings in Dubai and the UAE are established in the future.

#### **7.23.5 Location data**

The location data supplied with the variables is of great use if it was readable and combined with a digital map of Dubai (including roads). It was known to be of good accuracy as it was input using GIS coordinates by staff who are trained in that field. The analysis of the basic location data by street name was therefore very limited. Some of the streets can be over 100kms long and others were only mentioned once (in twelve years) yet they were bound to be close to other small streets so casualty black spots might be present in some areas but it was not possible to pinpoint them using existing methods and applications.

#### **7.23.6 Vehicle fleet and interventions**

Electronic stability control effectiveness was not found in any region with a similar climate or vehicle fleet to that found in Dubai. The results in this area (calculated effectiveness) may be overly optimistic as the vehicle fleet in Japan, the USA and Europe might have significant differences to that in the UAE and the vehicles surveyed or involved in crashes were also different. In two studies from Germany, mainly Audi, VW, Mercedes and BMW cars were involved. However in Japan mainly Toyota group vehicles were investigated. A significant minority of the vehicles in the in-depth sample were not small vehicles or different to the models described in other studies which raises some questions on the extent of similarity and effectiveness of new active technologies on different fleets. New vehicle sales in 2006 (Auto Strategies International, 2007) showed the second highest sales among all vehicle types to be mid-sized sport utilities.



## **Chapter 8 Conclusions from the studies**

### **8.1 *Introduction***

The work in hand shows how the analysis of existing data is used to arrive at an overall picture of road safety in a particular region. The importance of relevant data collection and validation over time is shown through the limitations faced in analysing existing data. The experience of other countries in developing, applying and testing countermeasures and their level of success was utilized to suggest these measures – if they are not currently in extensive use – in Dubai. Safety measures that have been proven elsewhere vary greatly in cost and applicability depending on the local environment and context and this was taken into consideration in the work. Some measures can be carried over with good correlation of effectiveness seen in other countries and applications as shown by automatic speed enforcement reducing speeding as a crash cause in 2006 after fixed speed camera installations increased significantly in 2005-2006. The savings in crash costs that were possible through these measures were estimated using available data. This part of the work is expected to be of great value as an incentive in implementing countermeasures on the regional or national level. This can be easily updated with more accurate costing information as it becomes available. Closer scrutiny of crash causation factors was made difficult due to the nature of the data that was considered base-level by European standards. This was remedied in the follow-up microscopic analysis of in-depth data.

### **8.2 *Conclusions from macroscopic analysis***

The following were in brief the main findings and results from the first study:

- ◆ Some evaluation and assessment of the road safety situation in any region is possible if some base level of data is provided. The greater the level of data the clearer the picture is of the situation.
- ◆ The state of road safety in Dubai as shown from the records of the previous 12-year period (1995-2006) provides a mixed message.



- ◆ The general fatality risk has stayed the same over the study period but it was significantly higher than all motorised countries found for comparison.
- ◆ The almost exponential rise in population that has been witnessed and predicted will mean a poorer road safety situation as time progresses.
- ◆ The main problems identified were as follows:
  - High proportion of fatal crashes
  - High proportion of single-vehicle and single-casualty crashes
  - Crashes peaked during afternoon and evening rush hours
  - Most crashes occurred at roads with speed limits of 60km/hr
  - Many crashes occurred in urban areas
  - Pedestrian crashes were the most common crash type
  - Inconsiderate driving was the most common crash cause listed
  - Speeding was the 2<sup>nd</sup> most common crash cause
  - Dual carriageway roads were the most frequent crash location
  - Males and younger persons made up the majority of casualties
  - Drink-driving was a problem of increasing magnitude
- ◆ The treatment of road safety problems has been a field of increasing diversity and depth since the dawn of the motor age.
- ◆ The study of road safety improvement has taken place mostly independently and sporadically around the world with some collaborative effort especially in later years.
- ◆ A wealth of research material exists on the various road safety countermeasures in use in most countries of varying quality. Study design is an important factor in differentiating the confidence in and usefulness of the results.
- ◆ The cross-application of measures across different geographic regions often produced the same results which encouraged the cross-use of safety countermeasures that have been shown to work.
- ◆ The prioritisation of countermeasures can be made according to their measured or estimated effectiveness along with the significant presence



of the problem that they are designed to address in the area of their intended application.

- ◆ Improving road safety in countries with traffic safety issues is possible through a logical method of problem appraisal; solution deployment and continuous assessment and monitoring.
- ◆ Estimates of road safety improvements can be made according to a step-by-step methodology of comparison while building upon existing data and economic costs.
- ◆ The derivation of economic costs was an important process for quantifying crash savings which was particularly useful to monitor their impact on the economy and to provide the basis for future Cost Benefit Analysis.
- ◆ As the amount of research work conducted on road safety measures increased so did the pool of available international knowledge increase in size and usefulness.
- ◆ The process can be used to draw a prioritised plan for applying road safety countermeasures with reasonable predictions of improvement.
- ◆ The process can be repeated for different areas and in different times to provide the same useful outcomes and once that is done a comparison can be made between estimated accuracies for different areas.

This extensive process has not been conducted for Dubai in the past and on the current set of data. It has great potential for application in the future. However some further knowledge on crashes especially regarding causation to enable the assessment of possible preventative measures was curtailed by the data available at this level. More detailed and in-depth data is required to better understand crash scenarios and subsequently be able to suggest preventative measures with increased confidence. This was done in the microscopic analysis.

### **8.3 *Microscopic analysis conclusions***

A number of conclusions may be drawn from the results of this sizeable survey of 2006 and part of 2007 for serious and fatal crashes and their main characteristics. They were summarised as follows:



- ◆ Crash times varied significantly from month to month with the most crashes in December (13%) and the least in July (6%).
- ◆ Peaks in crash times corresponded mostly to the rush hours (6am, 5-8pm) while Wednesdays saw the least crashes in the week (9%).
- ◆ The roads where most crashes took place were high speed roads (motorways): Emirates Rd (12%) and Sheikh Zayed Rd (9%).
- ◆ Overspeeding was an evident problem in both the first (42%) and second (46%) vehicles in a crash. This is excluding incidences where the speed was not known.
- ◆ Roads with an 80kph (50mph) speed limit accounted for most crashes (27%) closely followed by 120kph (70mph) speed limit roads (26%).
- ◆ Impacts with movable objects were the most common crash mechanism (72%) either hitting a pedestrian/cyclist or other vehicles. Fixed object impacts (barriers, lamp posts, trees, etc) were far less common (9.6%) as a first crash mechanism. Multiple object impacts were evident in some cases (20%).
- ◆ Crash causes were dominated by driving without care (42%) and vulnerable road users in the carriageway (22%). Speed was the third most cited cause (12%).
- ◆ Heavy vehicles were over-represented in crashes in the in-depth sample by comparison with their sales (20% vs. 6%) while 4x4's accounted for a large percentage of sales (21%) and had a correspondingly smaller crash involvement (17%).

The main preventative measures that were chosen were grade-separated crossing facilities for pedestrians and ESP/stability control for vehicles. The estimated savings from these 2 measures - if they were applied in all the crashes that matched the specific measure for that year - works out at nearly £20 million. Many more interventions and estimates could be made with more data collection and more information on the crashes.

The findings of microanalysis were different to macroanalysis in most cases because the sample was of a different severity level and the attendance of crashes (and thus selection) was determined by mostly external factors to the crash investigation team. Some cases of similarity were found when the



method and findings of microanalysis were compared to other studies. These included the percentage of single vehicle crashes that hit an object outside the carriageway (9.6% in Dubai in-depth sample vs. 9.5% in the UK) and the occurrence of speeding as the third most common crash cause or contributory factor (in-depth Dubai sample vs. On The Spot data as reported in Mansfield et al, 2008).

Vehicle sales data in the UAE was put to good use for comparison with the observed fleet composition at the microscopic level but more detailed vehicle fleet data would have been useful in shedding light on the involvement of vehicles according to their share of registrations. Some knowledge of injuries could be used to estimate the effectiveness of interventions and vehicle technologies such as seat belts and ESC. When the cost of interventions was known overall cost-benefit analysis would be possible for an economic assessment of the suggested interventions.

The data gathered and analysed showed what was possible with a few months of collection and comparison. Even more benefit could be gained if the data originally collected at crashes matched the intended outcome of the analysis. Great potential was evident from using existing data but even greater outcomes were expected with improved methods of collection and archiving of data.

#### ***8.4 Review of research questions***

A considerable body of knowledge exists on road safety countermeasures and interventions to reduce crashes and injuries. Many of these have been successfully tested in different areas around the world. The existence of a road safety challenge has been established globally then locally in Dubai. Key indicators of road safety performance show the gap between the UK and Sweden (some of the best-performing countries in the field) and Dubai to be large and significant.



The research questions asked at the beginning of chapter 2 have been answered as follows:

1. Is there a road safety problem?

Yes. This problem is manifested in many ways, from a high fatality rate (deaths per motor vehicle) and risk (deaths per population size) to a high severity of injury crashes (over 10% are fatal) when compared to the UK.

2. What is the nature of this problem?

The problem is of multiple dimensions covering road factors, vehicle factors and human factors. It extends to areas such as road user behaviour, enforcement, legislation and data analysis.

3. How can this problem be dealt with using knowledge gained from the experience of other nations?

Many safety countermeasures and interventions have been proven successful in other countries (such as guardrails between carriageways and on the roadside; pedestrian crossing facilities; automatic speed enforcement). These can be applied in Dubai and an estimated benefit from these measures can be calculated from the known effectiveness levels found in other scientific studies.

4. What are the expected benefits from the above process?

The study has calculated that savings in financial cost from crashes and injuries can be made totalling between £25m and £40m annually. This is in addition to the effects of reduced congestion and associated societal costs that road casualties result in.

Based on the recommendations and observations set out earlier, numerous changes can be made to the different factors involved in road safety. These range from the driver and road user, to the environment and road, to the vehicle, and ending with legislation and enforcement to change and improve the record of road safety in Dubai. Particularly at this time of growth, once



certain countermeasures are institutionalised it will be easier to adopt them on the larger scale (UAE-wide) or even at the Gulf or Mid-Eastern level. There is much scope for further work and for improving the collection and use of available crash and injury data and for the dissemination of that data to better effect. This shows what was possible in the capacity of this substantial work alone which can and should be built upon to realise the calculated gains.



## **Chapter 9 Future work to further develop knowledge and evaluate countermeasures**

### ***9.1 Introduction***

The absence of a well-conceived and applied safety strategy became obvious as progress was made throughout the work. While various different local and federal authorities have authored and published strategy documents their effect was not evident. A new approach to road safety is needed involving all key stakeholders working together towards an attainable target focused on the themes outlined in the findings of this work. This must be led by one neutral body in Dubai with main responsibility for the issue of traffic safety that coordinates all the parties involved and sets the strategy and monitors implementation. The recommended actions outlined in the conclusion of the WHO world report on traffic injury prevention (Peden et al, 2004) form an appropriate working plan that can be adapted to local conditions.

Other gaps in current knowledge and data availability were revealed in this work of research. These have helped direct the work in different phases. Expansion in other directions was possible and needed to uncover all the issues related to this field and to maximise the benefit to society. Some of the gaps provided the impetus for further work and have been translated below into the nucleus of future research areas and proposals.

### ***9.2 Consultation with stakeholders***

The attitudes, opinions and ideas of major stakeholders in the road safety operation in Dubai are important in gauging the level of the problem from both the executive and end-user perspective along with the solutions that might be applied in the future. These opinions and important ideas can fill in the gaps about the situation in the near future and plans for Dubai roads in the medium-term. Qualitative surveys of decision-makers, stakeholders and road users can help establish a foothold in this area as no recent work has been found in the literature. It is likely that any such work will need to be repeated at regular intervals as ideas can change quickly in such a dynamic



environment as Dubai. The suggested countermeasures, interventions and costs can also be reviewed with key stakeholders in Dubai (like the Traffic Police and Roads and Transport Authority) to determine the level of their acceptance and suitability. This will also serve to validate the countermeasures along with public policy and stakeholder views.

### **9.3 *Location surveys and black spot treatment***

Historically (Leeming et al, 1969) the very first safety interventions were carried out by blackspot treatment and this method can still reveal valuable information that cannot be found in crash studies and photographs except with great difficulty. Further work can be carried out at crash sites as the location (using GIS – Geographical Information Systems) was supplied for the majority of crashes but problems of access and manipulation prevented making further use of the data. Central barrier presence was not recorded in a majority of cases in the macroscopic analysis so further analysis using location data can be carried out on site to evaluate if barrier installation would be beneficial at these locations. Also a comparison of the performance of different types of barriers and central reservations would be possible if more detailed location data were available and accessible.

The condition of road markings and signs was not clearly known. This type of information can be found if precise location information and scene photographs were provided in the base-level data (though without photographs this activity will be very time-sensitive as road signs might have changed). With such information it would be possible to survey crash locations to assess whether they contributed to crashes or were irrelevant. Road condition was listed very rarely as being anything other than dry but there might be a case for improving road surface friction to reduce stopping distances at certain locations with a high number of head-to-tail crashes or the resurfacing of old roads might improve their characteristics. In the UK chevrons are placed on some roads to aid drivers in keeping a safe distance from cars ahead. Vehicle technology developments have resulted in systems such as adaptive cruise control to help a driver maintain a set distance from vehicles ahead (Marsden et al, 2001). Such measures could be used to aid drivers in maintaining a safe distance to other traffic and avoiding head-to-



tail crashes. Further information is needed especially with regards to cost-effectiveness as road construction and repairs tend to be capital-intensive activities.

#### **9.4 *Meteorological and exposure data***

It was not known if crashes peak during unconventional weather conditions or if drivers were more cautious during such times. Data on specific weather conditions, like rainfall or fog, from meteorological sources can be used to assess any variation in crashes during those times. If they were found to vary significantly against the data recorded by the police then they deserve more study. Exposure data was found to be lacking in a number of analyses. If this data was found for different nationalities it will allow the comparison of proportions to see if any gender or nationality has a better safety record. Then the reasons for that can be traced and hence applied to other “worse-performing” nationalities. One theory found in one study (Shefer & Rietveld, 1997) claims that safety may have improved due to more congestion and less opportunities for speeding. This can only be verified by surveys of congestion and travel time none of which have been found to date.

#### **9.5 *Vehicle standards***

A number of standards and regulations apply to vehicles sold in the UAE and these were found to be largely based on American standards especially as related to crashworthiness. The current relevance of these standards to crash conditions in Dubai was neither established nor assumed. An appraisal of these standards and their effectiveness in the local context is important to ensure the most suitable standards are applied in the area and matched to the problems faced there.

#### **9.6 *Hospital studies and trauma registries***

The comparison of police and hospital data for road casualties (such as in the UK; DfT, 2006a) facilitates a process of verification and validation and may highlight problems such as under-reporting of crash numbers and miscoding of injuries. A few studies were found from hospitals in the UAE but none that covered the most recent data. Correlation of these studies with police data or even independent assessment of trauma admissions to



hospitals from road crashes will improve the reliability of current data and might provide more detailed injury data. This in turn can be useful in a number of ways (correlating injury with crash or vehicle type, seated position, restraint use and misuse, etc). In the UK, similar efforts were made using data from the National Health Service – NHS (DfT, 2006a) that may be used for guidance.

### ***9.7 Improving the crash data collection form***

Crash data collection is a world-wide activity and numerous different methods exist for the efficient and simple collection of data from the crash scene. Surveying the existing state-of-the-art in this area should be performed to improve the crash data collection in Dubai. A pilot study using an improved form for Dubai crash investigations can assist in collecting further data that is desired but not available on the original form. For instance despite lighting conditions and weather being good in the majority of cases an additional field can be introduced on the crash form for driver's quality of vision or distraction. This may be used to note down if glare from the sun reflecting on the road surface or another vehicle or a dirty windscreen or faulty wipers might have contributed to the crash. Other conditions of fair weather might also be worth mentioning (like the sun being at a low angle or excessive heat with no air-conditioning in a vehicle that might contribute to fatigue and loss of concentration). Contributory factors (such as those mentioned on the latest revision of the UK police reporting form, STATS19) are also a valuable addition to help understand crash causation and their development in the UK has been detailed already (Broughton et al, 1998). Performing this type of pilot study will be valuable in understanding the circumstances under which crash forms are normally filled and conducting this in the summer has the added advantage of presenting the most difficult situations in which to fill it for Police (extremes of temperature and humidity). The methodology used in more in-depth and longer-established crash studies in the UK (OTS, CCIS) and other countries (FARS, SAFETYNET) can also be incorporated as well as the latest crash methodology research (Lindquist et al, 2003) depending on suitability.



## **9.8 Road lengths and speed limits**

If the total length of the road network was known along with the speed limits for every road then the speed limits on the roads involved in the in-depth sample can be compared to the overall speed limit divisions to determine whether roads with certain speed limits posed higher risks for road users. This can also be compared to the incidence of speeding to determine whether some roads appear to have higher violation rates than others and to note if there is any relation between speeding and road length.

## **9.9 Vehicle fleet analysis**

The fleet composition of MVs in Dubai is not currently known but this information, if made available, would be very useful in monitoring certain trends. For instance: to see if 4x4s were over-represented as partners in a crash compared to their proportion in the fleet; or to find the extent of older cars and compare their presence with their crash involvement; or to see if sports cars present a significant problem or not. One study indicates an increase in 4x4 vehicles in the fleet from 11.3% (1995) to 18.3% (2000) in Dubai only (El-Sadig, 2002). This might be linked to the high number of pedestrian crashes or single-vehicle crashes (loss of control etc). Heavy and moderately-sized passenger vehicles have decreased in proportion to smaller-sized cars (38% in 1985 → 23% in 1998) (*ibid.*). With fleet data the effect of this change on the type and severity of crashes could be monitored as can the issue of compatibility between different crash partners. This fleet analysis will also permit an estimate of the percentage of the fleet with a certain EuroNCAP star rating based on recently-developed methodology in other projects (Page & Rackliff, 2006; SAFETYNET project, Work Package 3). The benefits of improved crashworthiness can be measured by comparing the crash involvement and outcomes of the same models of cars from different generations as their EuroNCAP ratings improve. Comparisons between vehicles would make it possible to find the best and worst performing ones in terms of outcome as was done in Australia for many years (Newstead et al, 2008).



### **9.10 Seat belt surveys**

Seatbelt use information is scarce in the UAE in general and Dubai in particular with some work found at one busy site in 1999, 2002 and 2005 (RTA, 2006c). With a time-series of this data, a lot of additional work can be carried out (like evaluating the effectiveness of legislation or enforcement or wearing rates for different vehicle types). Monitoring of seat belt use must be conducted at sites that are selected such that the data can be representative of the whole driving population to keep track of this important performance indicator. The protocol used can be based on an evaluation of studies in other countries (Broughton, 1990 & 2003; Krafft et al, 2006) and the local surveys previously performed.

### **9.11 Pedestrian and heavy vehicle driver focus**

Pedestrians were the single largest affected group by most serious crashes. Some background was revealed on the reasons for their behaviour and involvement. To attempt to reduce this involvement further studies need to be conducted focusing on pedestrians and other vulnerable road users namely cyclists. The visibility of cyclists and pedestrians might be a factor in some crashes or the road conditions and driver attentiveness could be to blame. The reasons behind the involvement of vulnerable road users can be established through specific studies focusing on drivers and other road users involved in such crashes. Heavy vehicle drivers were less regulated (than in the EU) and over involved in crashes in comparison to their share of new vehicle sales. This needs further study to determine what factors come into play in these crashes (fatigue, sleepiness, exhaustion, carelessness, etc).

### **9.12 Economic costs and cost benefit analysis**

If the average cost and quantity of the countermeasures needed was available then a cost analysis may be carried out using approximate cost data for crashes until UAE costs were calculated in the future. Some countermeasure cost data was found from other studies (Elvik & Vaa, 2004) but they were not deemed suitable for application in Dubai. Differences between the two regions include the fact that a lot of new overhead road crossings planned for Dubai will be airconditioned (Al-Theeb, 2007) which was unheard of in Scandinavian countries and adds a new element of cost



to such countermeasures. Relevant costs for countermeasures could be found from local authorities where measures have already been partially implemented, or from road building contractors and consultants. Further work on combining these sources of cost data would be very useful.

### **9.13 Safety Performance Indicators (SPI)**

Other methods of measuring the level of road safety have been sought and recently developed, such as Safety Performance Indicators (SPI) for traffic safety (ETSC, 2001; Page & Rackliff, 2006; Talvitie, 1999; Vis, 2005). Such measures can be a standardised way to measure the safety performance of an area over a period of time. One example of such measures were developed by the World Bank from a meeting of experts in the late 1990s. At the time performance indicators were developed for many aspects of road sector administration including but not limited to accessibility and mobility; equity and community; environment; and traffic safety. Those performance indicators dealing with traffic safety include crash risk; the existence of a national traffic safety program; the involvement of drunk drivers in crashes; the time from a crash alert to treatment; and the percentage of roads not meeting minimum design standards (Talvitie, 1999). A later report by the European Traffic Safety Council (ETSC, 2001), defined SPIs as a “measurement that is causally related to crashes or injuries, used in addition to a count of crashes or injuries in order to indicate safety performance”. A few examples of SPIs in use in European countries were given such as the mean speed of traffic at selected points; speed variance between different vehicles; the percentage use of seat belts and the incidence of red light running among others.

More recent work on SPIs related to road safety was performed within the European project SafetyNet (aimed at building a European Road Safety Observatory). The developmental work is ongoing to find a usable and realistic set of indicators using an iterative process of surveying the current factors and legislation related to road safety in EU member states then using that to inform the development of SPIs (Vis, 2005).



The SafetyNet road SPIs were divided into the following seven categories:

1. Alcohol and drug use
2. Speeds
3. Protective systems
4. Daytime running lights
5. Vehicles
6. Roads
7. Trauma management

Once the process of development is complete it was understood the outcome will be a full set of realistically applicable SPIs from a large geographic area. This in turn means that the same process can be applied in different areas to achieve the same or similar results (if the two areas are similar in nature). For areas that are significantly different in nature (ex. areas without a tarmac road system in place) the process is expected to be more complex and produce more original outcomes.

#### **9.14 Road safety audits**

The process of auditing roads (both existing and at the design stage) for evaluating safety is well-established in many areas. It is a systematic process for checking the safety of new and existing schemes on roads and is practised in many countries around the world, with the UK leading developments in this field in the 1980s (Proctor et al, 2001).

#### **9.15 Other factors**

Other interesting factors that come out of the analysis are the cultural differences between drivers as highlighted by work in the island-state of Bahrain (Al-Madani & Al-Janahi, 2002) showing that American and European drivers comprehend signs better than Arab and Asian drivers. Most traffic signs from the West have been adopted in the rest of the world. It might be that users from the East find difficulty in understanding some signs as they come from a different background. Hence some studies on the comprehension or development of signs more suitable for the region could be undertaken. Also some peaks in crashes of a certain type occur for just one nationality and this defies logical explanation from available data. Focusing on either problem could provide more information on why these



differences exist and show how to improve conditions for comparatively low-performers. If the 2005 census data is provided in detail (including nationality breakdown) then comparisons to the overall population structure will also be possible.

Nationality and cultural differences could be incorporated into a study of driver testing and qualification as the two research areas might be related. The process of driver licensing and qualification has been changing in Dubai but it is not clear what brought about these changes or how they will impact on road safety. Also drivers from different driving backgrounds might have different safety levels despite undergoing the same driving test in Dubai.

### ***9.16 Further countermeasures***

Other countermeasures not mentioned here but that may have a positive impact upon road safety in Dubai might have been missed due to insufficient data on them or the small expected improvement and due to time limitations that do not permit the inclusion of everything. Regular updates of the work can overcome such shortcomings that are found in every research project.



## **Publication**

Al-Dah, M., Frampton, R., Morris, A., 2010. Characteristics of Injury Crashes in Dubai, UAE. Proceedings *Road Safety on 4 Continents*, Abu Dhabi, UAE. 28-30 March 2010.



## **Appendix A: Abbreviations and Definitions**

4x4: Four-wheel-drive vehicle.

AED: United Arab Emirates Dirham (local currency 1AED=3.67US\$, fixed exchange rate as the Dirham is pegged against the Dollar)

AIS: Abbreviated Injury Scale

CARE: Community database on Crashes on the Roads in Europe

CCIS: Cooperative Crash Injury Study

DfT: Department for Transport, UK

DHA: Dubai Health Authority

DM: Dubai Municipality

DMSC: Dubai Municipality Statistics Centre, later Dubai Statistics Centre

DOHMS: Dept. of Health and Medical Services, Dubai.

DSA: Driving Standards Agency (UK)

DSC: Dynamic stability control

ESC: Electronic stability control

ESMA: Emirates Standardization and Metrology Authority

ESP: Electronic stability program

ETSC: European Transportation Safety Council

EU: European Union

EU Member Countries (2007): Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom.

Euro NCAP: European New Car Assessment Program

FARS: Fatality Analysis Reporting System

FMVSS: Federal Motor Vehicle Safety Standard (USA)

GBD: Global Burden of Disease Study

GIS: Geographical Information System

GCC: The Cooperative Council for the Arab States of the Gulf

GPS: Global Positioning System

GVW: Gross Vehicle Weight

HC: Human capital costing method

HMC: Highly-motorised country



IRTAD: International Road Traffic and Crash Database  
 ITS: Intelligent Transport Systems  
 KSA: Kingdom of Saudi Arabia  
 KSI: Killed and seriously injured casualties  
 LMC: Less-motorised country  
 Meta-analysis: the calculation of a weighted mean estimate of effect based on the estimated effectiveness of the measure from a number of studies (see Elvik & Vaa, 2004 pp. 22-27 for a more detailed explanation).  
 MV: Motor vehicle  
 NASS: National Crash Sampling System  
 OECD: Organisation for Economic Co-operation and Development  
 OECD Member countries - 30 (October 2006):  
 Australia, Austria, Belgium, Canada, Czech republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States.  
 PNCAP: Primary Safety New Car Assessment Program.  
 RACV: Royal Automobile Club of Victoria.  
 RBT: Random Breath Testing.  
 RFID: Radio Frequency Identification.  
 RTA: Roads and Transport Authority, Dubai.  
 SAE: Society of Automotive Engineers.  
 SAFETYNET: A European-funded project to build a Road Safety Observatory for Europe.  
 SPI: Safety Performance Indicator(s)  
 SUV: Sport Utility Vehicle (4x4).  
 TRL: Transport Research Laboratory, UK.  
 UAE: United Arab Emirates  
 UNECE: United Nations Economic Commission for Europe.  
 UNECE member countries - 55 (January 1995):  
 Albania, Andorra, Armenia, Austria, Azerbaijan, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Canada, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Georgia, Germany, Greece, Hungary,



Iceland, Ireland, Israel, Italy, Kazakhstan, Kyrgyzstan, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Monaco, Netherlands, Norway, Poland, Portugal, Republic of Moldova, Romania, Russian Federation, San Marino, Serbia and Montenegro, Slovakia, Slovenia, Spain, Sweden, Switzerland, Tajikistan, The Former Yugoslav Republic of Macedonia, Turkey, Turkmenistan, Ukraine, United Kingdom, United States of America and Uzbekistan.

USA: United States of America.

VMS: Variable Message Sign.

VSRC: Vehicle Safety Research Centre, Loughborough University, UK.

WHO: World Health Organisation.

WHO region abbreviations:

MEC = Middle Eastern Crescent

SSA = Sub-Saharan Africa

CHN = China

OAI = Other Asia and Islands

IND = India

LAC = Latin America and the Caribbean

FSE = Formerly Socialist Economies of Europe

EME = Established Market Economies

WTP: Willingness to pay (costing method)



## Appendix B: Dubai Police Crash Data Collection Forms

إحصاء حوادث المرور		دولة الإمارات العربية المتحدة وزارة الداخلية الإدارة / القيادة العامة للشرطة إدارة / قسم / مركز مدينة: .....	
١ - حوادث بدون إصابات (قضية)	<input type="checkbox"/>	٢ - حوادث بإصابات	<input type="checkbox"/>
رقم الحادث	وقت الحادث	تاريخ الحادث	رقم البلاغ
م			
<b>Report author, investigator and rank</b> منظم التقرير : الرتبة : المحقق في الحادث :	<b>Degree of injury</b> ١ وفاة ٢ إصابات بليغة ٣ إصابات متوسطة ٤ إصابات طفيفة	<b>No. of vehicles and casualties involved</b> عدد المركبات المشتركة بالحادثة مجموع عدد الإصابات بما فيه المشاة عدد المشاة المصابين	
<b>Crash location</b> اسم أو رقم الشارع والمسافة إلى أقرب تقاطع يمكن استعمال أرقام أعمدة الإنارة للإشارة			
<b>Crash type</b> (١) عدم التقدير لمستعملي الطرق (٢) عدم الالتزام بخط السير (٣) دخول الشارع قبل التأكد من خلوه (٤) عدم ترك مسافة كافية (٥) عبور الإشارات الحمراء (٦) السرعة الزائدة (٧) السقوط بطيش وتهور (٨) انفجار إطار (٩) أخرى (حدد)			
<b>Primary &amp; secondary crash cause</b> (١) صدم غير متحرك (٢) دهس (٣) تدهور (٤) صدم حيوان (٥) سقوط (٦) صدم عمودي (٧) صدم أثناء الدوران (٨) صدم جانبي (٩) صدم متتالي (١٠) صدم متقابل			
<b>Crash location conditions</b> ١ - الأحوال الجارية في موقع الحادث			
<b>Speed limit at site</b> حد السرعة على الطريق			
<b>Road type</b> عدد المسارات ونوع التقاطع:			
(١) طريق مزدوج ٤ ممرات في كل اتجاه (٢) طريق مزدوج ٣ ممرات في كل اتجاه (٣) طريق مزدوج ممرين في كل اتجاه (٤) طريق فردي اتجاه واحد فقط (٥) طريق فردي واسع ممرين في كل اتجاه (٦) طريق فردي ممر ١ في كل اتجاه (٧) دوار (٨) تقاطع بدون إشارات ضوئية (٩) تقاطع إشارات ضوئية (١٠) أخرى (حدد)			
<b>Crash proximity to local landmark</b> (١) بالقرب من مدرسة (٢) بالقرب من مسجد (٣) بالقرب من مستشفى (٤) بالقرب من دائرة حكومية (٥) في منطقة سكنية (٦) على خطوط مشاة (٧) عند فتحة الدوران للخلف (٨) بالقرب من عبور مشاة (٩) أخرى (حدد)			
<b>Road conditions</b> (١) فاصل حديدي (٢) فاصل خرساني (٣) فاصل رملي أو زراعي (٤) رصيف (٥) بدون فاصل (٦) ليلاً - بدون إضاءة (٧) ليلاً - الإضاءة كافية (٨) ليلاً - الإضاءة غير كافية (٩) ليلاً - بدون إضاءة (١٠) ليلاً - بدون إضاءة			
(١) توجد علامات (٢) لا توجد علامات أرضية ولا شواخص (٣) لا توجد علامات أرضية (٤) لا توجد شواخص (٥) عوامل أخرى (حدد)			
(١) جيد (٢) ماطر (٣) ضباب (٤) عواصف رملية (٥) عوامل أخرى (حدد)			
(١) جاف (٢) مبلل (٣) مغلف بالرمال (٤) مواد بترولية أو كيميائية (٥) عوامل أخرى (حدد)			
(١) الفاصل بين الشارعين (٢) الرؤية والإضاءة (٣) العلامات المرورية (٤) الطقس (٥) حالة سطح الطريق			



٢ - تفاصيل عن المركبات المشتركة في الحادث					
رموز الجسبيات ومصادر الرخصة القيادة وتسجيل المركبات	المرحلة المرحلة المرحلة المرحلة (٤)	المرحلة المرحلة المرحلة المرحلة (٣)	المرحلة المرحلة المرحلة المرحلة (٢)	المرحلة المرحلة المرحلة المرحلة (١)	
١ الجنس السائق (١) ذكر (٢) أنثى (٣) مجهول أو هارب					
٢ عمر السائق	<b>Driver age and nationality</b>				
٣					
٤ جنسية السائق * (للإشارة من الجدول)					
٥ رقم رخصة القيادة	<b>Licensing details</b>				
٦ تاريخ إصدار رخصة القيادة					
٧ جهة إصدار رخصة القيادة * (للإشارة من الجدول)					
٨ رقم لوحة المركبة					
٩ الرمز					
١٠ جهة ترخيص المركبة * (للإشارة من الجدول)					
١١ السكر (السائق) (١) لم يفحص (٢) سكران (٣) متعاطي	<b>Drug/alcohol involvement</b>				
١٢ الهروب (السائق) (١) متواجد (٢) هارب ولكنه معروف	<b>Hit-and-run</b>				
١٣ هارب وغير معروف (٤) في المستشفى					
١٤ حزام الأمان (السائق)	<b>Seat belt use</b>				
١٥ (١) مستخدم (٢) غير مستخدم (٣) غير معروف					
١٦ صنف المركبة :	<b>Vehicle type</b>				
١٧ (١) دراجة هوائية (٢) دراجة نارية					
١٨ (٣) مركبة أجرة (٤) مركبة خصوصية					
١٩ (٥) حافلة خفيفة (٦) حافلة ثقيلة					
٢٠ (٧) مركبة شحن خفيفة (٨) مركبة شحن ثقيلة					
٢١ (٩) أخرى (حدد)					
٢٢ اصطدام بأشياء خارج الطريق	<b>Objects struck outside carriageway</b>				
٢٣ (١) لم تصطدم بشيء (٢) بإشارة مرور					
٢٤ (٣) بعمود كهرباء (٤) بشجرة					
٢٥ (٥) وقعت في حفرة (٦) أخرى (حدد)					
٢٦ حالة الاطارات	<b>Tyre condition</b>				
٢٧ (١) جيدة (٢) متوسطة (٣) ضعيفة جدا					
٢٨ عدد المحاور	<b>No. of axles</b>				
٢٩ (١) ليست مركبة شحن (٢) محاورين (٣) ٣ محاور					
٣٠ (٤) ٤ محاور (٥) ٥ محاور (٦) أكثر من ٥ محاور					
٣١ درجة الأضرار	<b>Damage level/severity</b>				
٣٢ (١) بدون (٢) بسيطة (٣) متوسطة (٤) بليغة					
٣٣ نوع المركبة (ماركة)	<b>Vehicle make/model</b>				
٣٤ سنة الصنع					
٣٥ تلوين زجاج :	<b>Tinted windows</b>				
٣٦ (١) نعم (٢) لا					
٣٧ مالك المركبة المتسببة (للشركات والمؤسسات فقط)	<b>Insurance &amp; owner details</b>				
٣٨ تأمين المركبة المتسببة : (١) شامل (٢) ضد الغير (٣) بدون					
٣٩ مهنة سائق المركبة المتسببة					

ملاحظة : إذا كان عدد المركبات أكثر من ٤ يرجى الاستعانة باستمارة أخرى.



كشف ونخطيط حداث مرورى

## Scene plan

رقم البلاغ

كشف الحداث

(١) .....

(٢) .....

(٣) .....

ملاحظات .....

لاستخدام هندسة المرور

الموقع: .....

الحلقة / الوصلة: .....

التفاصيل: .....

شركات

شماليات

ملاحظة:

يرجى تحديد الاتجاه والمسافة إلى أقرب  
موقع على مخطط الحداث



٣ - تفاصيل عن المصابين في الحادث

Injured party details				
المصابين في المركبة المتسببة (١) عدد المصابين: <input type="text"/>	المصابين في المركبة الأخرى (٢) عدد المصابين: <input type="text"/>	المصابين في المركبة الأخرى (٣) عدد المصابين: <input type="text"/>	المصابين في المركبة الأخرى (٤) عدد المصابين: <input type="text"/>	
المصاب رقم: <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>	المصاب رقم: <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>	المصاب رقم: <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>	المصاب رقم: <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>	<u>نوع:</u> (١) سائق (٢) راكب (٣) مشاة <u>الجنس:</u> (١) ذكر (٢) أنثى <u>الجنسية:</u> * (للإشارة من الجدول صفحة ٢) <u>العمر:</u> <u>درجة الإصابة:</u> (١) وفاة (٢) بليغة (٣) متوسطة (٤) بسيطة <u>حزام الأمان:</u> (١) مستخدم (٢) غير مستخدم (٣) غير معروف
المصاب رقم: <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>	المصاب رقم: <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>	المصاب رقم: <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>	المصاب رقم: <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>	<u>نوع:</u> (١) سائق (٢) راكب (٣) مشاة <u>الجنس:</u> (١) ذكر (٢) أنثى <u>الجنسية:</u> * (للإشارة من الجدول صفحة ٢) <u>العمر:</u> <u>درجة الإصابة:</u> (١) وفاة (٢) بليغة (٣) متوسطة (٤) بسيطة <u>حزام الأمان:</u> (١) مستخدم (٢) غير مستخدم (٣) غير معروف
المصاب رقم: <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>	المصاب رقم: <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>	المصاب رقم: <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>	المصاب رقم: <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>	<u>نوع:</u> (١) سائق (٢) راكب (٣) مشاة <u>الجنس:</u> (١) ذكر (٢) أنثى <u>الجنسية:</u> * (للإشارة من الجدول صفحة ٢) <u>العمر:</u> <u>درجة الإصابة:</u> (١) وفاة (٢) بليغة (٣) متوسطة (٤) بسيطة <u>حزام الأمان:</u> (١) مستخدم (٢) غير مستخدم (٣) غير معروف
المصاب رقم: <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>	المصاب رقم: <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>	المصاب رقم: <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>	المصاب رقم: <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>	<u>نوع:</u> (١) سائق (٢) راكب (٣) مشاة <u>الجنس:</u> (١) ذكر (٢) أنثى <u>الجنسية:</u> * (للإشارة من الجدول صفحة ٢) <u>العمر:</u> <u>درجة الإصابة:</u> (١) وفاة (٢) بليغة (٣) متوسطة (٤) بسيطة <u>حزام الأمان:</u> (١) مستخدم (٢) غير مستخدم (٣) غير معروف

ملاحظة: إذا كان عدد المصابين في المركبة الواحدة أكثر من ٤ أشخاص، يرجى الاستعانة باستمارة أخرى.



## Appendix C: SPSS Syntax files

### File 1: “Dubai 1995-2006 import.SPS”

```
*
* IMPORT TABLES FROM MS-ACCESS DATABASE
*
.

GET DATA
/TYPE=ODBC
/CONNECT=
    'DSN=MS Access Database;'
    'DBQ=U:\phd\DATABASE\UAE\AccNewVersion\CrashData_Mustaf.mdb;'
/SQL=
    'SELECT * FROM "TbCrashGeneral Details"'.

variable width
    DATE (16)
    DEGINJ (12)
    LOCATION (22)
    CAUSE (20)
    TYPE (16)
    SITECOND (20)
    SITENRTO (16)
    CNTRESV (16)
    LIGHT (20)
    TCONTROL (20)
    WEATHER (10)
    RDSURF (10)
    ADATE (12)
.

variable labels
    NUMBERVEH "No. of vehicles involved"
    NOPERINJ "No. of people injured"
    DEGINJ "Degree of injury"
    LOCATION "Location"
    CAUSE "Cause of crash"
    TYPE "Crash type"
    SPDLIMIT "Speed limit on road"
    SITECOND "No. of lanes or type of junction"
    SITENRTO "Site proximity to local feature"
    CNTRESV "Central reservation/lane separation"
    LIGHT "Lighting conditions"
    TCONTROL "Traffic markings"
    WEATHER "Weather conditions"
    RDSURF "Road surface condition"
    RDTYPE "Road classification"
.

value labels DEGINJ
'0' "No injury"
'1' "Fatal"
'2' "Serious"
'3' "Medium"
'4' "Slight"
```



.

value labels CAUSE

'1'	"Lack of consideration to other road users"
'2'	"Lack of lane discipline"
'3'	"Entering carriageway without checking for traffic"
'4'	"Following too close to vehicle in front"
'5'	"Jumping a red light"
'6'	"Violating speed limit"
'7'	"Dangerous driving"
'8'	"Tyre blow out"
'9'	"Unknown"
'10'	"Failing to give way"
'11'	"Unroadworthy vehicle"
'12'	"Faulty road"
'13'	"Doors not securely closed"
'14'	"Entering a no-entry zone"
'15'	"Carelessness and lack of attention"
'16'	"Wrong turn"
'17'	"Going against traffic"
'18'	"Incorrect overtaking"
'19'	"Reversing without due care"
'20'	"Stopping in the road"
'21'	"Effects of natural or environment factors"
'22'	"Effects of medicines"
'23'	"Effect of taking alcohol"
'24'	"Effect of taking drugs"
'25'	"Presence of obstacles in road"
'26'	"Tiredness and sleep"
'27'	"Excess loading"
'28'	"Shedding of load"
'29'	"Trailer separation"
'30'	"Wandering animal"
'31'	"Speed humps"
'32'	"Sudden change of direction"
'33'	"No knowledge of driving and no licence"
'34'	"Other"
'0'	"Not entered or not specified"

.

value labels TYPE

'1'	"Stationary object impact"
'2'	"Pedestrian collision"
'3'	"Rollover"
'4'	"Impact with animal"
'5'	"Falling off moving vehicle"
'6'	"Head to side impact"
'7'	"Hit while turning"
'8'	"Side to side"
'9'	"Head to tail"
'10'	"Head on"
'0'	"undefined"

.

value labels SITECOND

'1'	"Dual carriageway 4 lanes each direction"
'2'	"Dual carriageway 3 lanes each direction"
'3'	"Dual carriageway 2 lanes each direction"
'4'	"Single carriageway one way"
'5'	"Wide single carriageway 2 lanes each direction"
'6'	"Single carriageway 1 lane each direction"
'7'	"Roundabout"
'8'	"Junction without traffic light control"
'9'	"Traffic light-controlled junction"



```

'10'    "Other (specify)"
.
value labels SITENRTO
'1'     "Near to school"
'2'     "Near to mosque"
'3'     "Near to hospital"
'4'     "Near to government department"
'5'     "In residential area"
'6'     "On pedestrian (zebra) crossing"
'7'     "At U-turn"
'8'     "Near pedestrian crossing"
'9'     "Other (specify)"
.
value labels CNTRESV
'1'     "Steel barrier"
'2'     "Concrete barrier"
'3'     "Sand or vegetation"
'4'     "Kerb"
'5'     "No barrier or reservation"
.
value labels LIGHT
'1'     "Daylight hours"
'2'     "Night time sufficient lighting"
'3'     "Night time poor lighting"
'4'     "Night time lighting not switched on"
'5'     "Night time no lighting present"
.
value labels TCONTROL
'1'     "Markings exist"
'2'     "No road markings or signs"
'3'     "No road markings"
'4'     "No signs"
'9'     "Unknown"
.
value labels WEATHER
'1'     "Fair"
'2'     "Rainy"
'3'     "Foggy"
'4'     "Sand storms"
'5'     "Other (specify)"
.
value labels RDSURF
'1'     "Dry"
'2'     "Wet"
'3'     "Sand-covered"
'4'     "Petrochemical substance"
'5'     "Other (specify)"
.
value labels RDTYPE
'1'     "Freeways"
'2'     "Expressways"
'3'     "Arterial"
'4'     "Arterial"
'5'     "Collector"
'6'     "Local"
'7'     "Other"
.

sort cases by CASE_ID (a).

```



\*Select only fatal and injury cases as sample seems to include some non-injury cases.  
 FILTER OFF.  
 USE ALL.  
 SELECT IF DEGINJ =1 OR DEGINJ = 2 OR DEGINJ = 3 OR DEGINJ = 4.  
 EXECUTE .

save outfile='U:\phd\DATABASE\UAE\Dubai1995-2006acc.sav'  
 /DROP=CASE\_ID1 ATIME INJURY LINK NODE EAST NORTH DETAILS ADATE  
 GDO\_GEOMETRY /COMPRESSED  
 .

## **File 2: “naming year variable.SPS”**

\* Date and Time Wizard: DATEYR to create a variable containing the YEAR called YEAR for all cases.  
 COMPUTE YEAR = XDATE.YEAR(DATE).  
 VARIABLE LABEL YEAR "Year".  
 VARIABLE LEVEL YEAR (SCALE).  
 FORMATS YEAR (F8.0).  
 VARIABLE WIDTH YEAR(8).  
 EXECUTE.

\*Try to plot injury severity by year.  
 FREQUENCIES  
 VARIABLES=YEAR  
 /BARChart  
 /ORDER= ANALYSIS .

\*Select only fatal and injury cases as sample seems to include some non-injury cases.  
 FILTER OFF.  
 USE ALL.  
 SELECT IF DEGINJ =1 OR DEGINJ = 2 OR DEGINJ = 3 OR DEGINJ = 4.  
 EXECUTE .

\*Now select all 2006 cases.  
 FILTER OFF.  
 USE ALL.  
 SELECT IF(YEAR = 2006).  
 EXECUTE .

\* Date and Time Wizard: Create new variable called Month.  
 COMPUTE Month = XDATE.MONTH(DATE).  
 VARIABLE LABEL Month "Month".  
 VARIABLE LEVEL Month (SCALE).  
 FORMATS Month (F8.0).  
 VARIABLE WIDTH Month(8).  
 EXECUTE.

\*To produce the frequency of case by month of the year.  
 FREQUENCIES  
 VARIABLES=Month  
 /BARChart PERCENT  
 /ORDER= ANALYSIS .

\*Now to compare old weekend with new weekend, select cases from Jan-Aug 2006, keeping unselected cases.  
 USE ALL.



```

COMPUTE filter_$=(Month <= 8).
VARIABLE LABEL filter_$ 'Month <= 8 (FILTER)'.
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .

```

\*Alternatively, to select old weekend cases by dropping unselected cases.

```

FILTER OFF.
USE ALL.
SELECT IF month <= 8.
EXECUTE.

```

\*To select Sep-Dec 2006 cases.

```

USE ALL.
COMPUTE filter_$=(Month >= 9).
VARIABLE LABEL filter_$ 'Month >= 9 (FILTER)'.
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE .

```

\*Alternatively, to select new weekend cases by dropping unselected cases.

```

FILTER OFF.
USE ALL.
SELECT IF month >= 9.
EXECUTE.

```

\*Select only non-injury crash cases.

```

*FILTER OFF.
*USE ALL.
*SELECT IF DEGINJ = 0.
*EXECUTE.

```

\*Sort cases by date (ascending).

```

SORT CASES BY
  DATE (A) .

```

### **File 3: "seatbelt law analysis.SPS"**

\*Finding the effect, if any, of seat belt legislation in force in January 1999.

\* Date and Time Wizard: DATEYR to create a variable containing the YEAR called YEAR for all cases.

```

COMPUTE YEAR = XDATE.YEAR(DATE).
VARIABLE LABEL YEAR "Year".
VARIABLE LEVEL YEAR (SCALE).
FORMATS YEAR (F8.0).
VARIABLE WIDTH YEAR(8).
EXECUTE.

```

\*Now select all 1998 cases for comparison, then 1999.

```

FILTER OFF.
USE ALL.
SELECT IF(YEAR = 1998).
EXECUTE .

```

### **File 4: "analysis1datetime.SPS"**

\*RUN dubai import first.



\*NOTE RECODE COMMAND IS CASE-sensitive.

\* Dividing the time into 24 equal intervals.

STRING TIME1 (A8) .

RECODE

TIME

(0000 thru 100='01') (101 thru 200='02') (201 thru 300='03') (301 thru 400='04')  
(401 thru 500='05') (501 thru 600='06') (601 thru 700='07') (701 thru 800='08')  
(801 thru 900='09') (901 thru 1000='10') (1001 thru 1100='11') (1101 thru 1200='12')  
(1201 thru 1300='13') (1301 thru 1400='14') (1401 thru 1500='15')  
(1501 thru 1600='16') (1601 thru 1700='17') (1701 thru 1800='18')  
(1801 thru 1900='19') (1901 thru 2000='20') (2001 thru 2100='21')  
(2101 thru 2200='22') (2201 thru 2300='23') (2301 thru 2359='24') INTO TIME1 .

VARIABLE LABELS TIME1 'TIME1'.

EXECUTE .

\*line graph for time periods.

GRAPH

/LINE(SIMPLE)=COUNT BY TIME1

/TITLE= 'Time of day, 1 hr intervals'.

\* Dividing time into 12 intervals.

.

STRING TIME2 (A8) .

RECODE

TIME

(0000 thru 200='1-2AM') (201 thru 400='2-4AM') (401 thru 600='4-6AM')  
(601 thru 800='6-8AM') (801 thru 1000='8-10AM')  
(1001 thru 1200='10-12noon') (1201 thru 1400='12-2PM') (1401 thru 1600='2-4PM')  
(1601 thru 1800='4-6PM') (1801 thru 2000='6-8PM') (2001 thru 2200='8-10PM')  
(2201 thru 2359='10-12midnight') INTO TIME2 .

VARIABLE LABELS TIME2 'TIME2'.

EXECUTE .

\*variable width

\* TIME1 (20)

\* TIME2 (20).

\*table of frequencies for time periods.

FREQUENCIES

VARIABLES=TIME2

/PIECHART FREQ

/ORDER= ANALYSIS .

\*pie chart for time periods.

GRAPH

/PIE=COUNT BY TIME2 .

\*line graph for time periods.

GRAPH

/LINE(SIMPLE)=COUNT BY TIME1

/TITLE= 'Time of day, 1 hr intervals'.

GRAPH

/LINE(SIMPLE)=COUNT BY TIME2

/TITLE= 'Time of day, 2hr intervals'.

\*To produce the frequency of case by day of week.

\* Date and Time Wizard: dayofwk.

COMPUTE dayofwk = XDATE.WKDAY(DATE).

VARIABLE LABEL dayofwk "Day of week".

VARIABLE LEVEL dayofwk (NOMINAL).



```
FORMATS dayofwk (WKDAY3).
VARIABLE WIDTH dayofwk(3).
EXECUTE.
```

```
FREQUENCIES
  VARIABLES= dayofwk
  /BARCHART PERCENT
  /ORDER= ANALYSIS .
```

### **File 5: “analysis2locations causes.SPS”**

\* The frequencies of different crash locations.

```
FREQUENCIES
  VARIABLES=LOCATION
  /FORMAT=DFREQ
  /BARCHART FREQ
  /ORDER= ANALYSIS .
```

\* frequencies (bar charts) of the top 6 crash locations (2005 fatalities).

\* FIRST select the top 6 locations.

FILTER OFF.

USE ALL.

```
SELECT IF ANY (LOCATION, 'SHEIKH ZAYED RD', 'EMIRATES RING RD',
'DUBAI AL-AIN RD', 'DUBAI HATTA RD', 'SHEIKH RASHID RD', 'AL-KHAIL RD').
EXECUTE .
```

\*Bar chart of the top 6 locations by frequency.

```
FREQUENCIES
  VARIABLES=LOCATION
  /BARCHART FREQ
  /ORDER= ANALYSIS .
```

\* frequencies (bar charts) of the top 6 crash locations (1995-2006 INJURIES).

\* FIRST select the top 6 locations.

FILTER OFF.

USE ALL.

```
SELECT IF ANY (LOCATION, 'SHEIKH ZAYED RD', 'DUBAI AL-AIN RD', 'EMIRATES
RING RD',
'SHEIKH RASHID RD', 'BUR DUBAI AREA', 'AL-ITTIHAD RD').
EXECUTE .
```

```
FREQUENCIES
  VARIABLES=LOCATION
  /BARCHART FREQ
  /ORDER= ANALYSIS .
```

\*Causes analysis - ignore CAUSE2 definition hazy.

```
FREQUENCIES
  VARIABLES=CAUSE
  /PIECHART FREQ
  /ORDER= ANALYSIS .
```

\* Table of Frequencies for CAUSE.

```
TABLES
  /FORMAT BLANK MISSING('.') /TABLES
  (LABELS) BY
  CAUSE
```



```
/STATISTICS COUNT ((F5.0) 'Count' ).
```

\*Location frequencies.

```
FREQUENCIES  
  VARIABLES=LOCATION  
  /FORMAT=DVALUE  
  /STATISTICS=MEAN MEDIAN  
  /PIECHART FREQ  
  /ORDER= ANALYSIS .
```

\*Analyse crashes with alcohol intoxication, first select them.

```
FILTER OFF.  
USE ALL.  
SELECT IF ANY (CAUSE, 23).  
EXECUTE .
```

```
FREQUENCIES  
  VARIABLES=CAUSE  
  /BARChart FREQ  
  /ORDER= ANALYSIS .
```

\*Then run time analysis to see when these crashes occur.

\*NOTE RECODE COMMAND IS CASE-sensitive.

\* Dividing the time into 24 equal intervals.

```
STRING TIME1 (A8) .  
RECODE  
  TIME  
    (0000 thru 100='01') (101 thru 200='02') (201 thru 300='03') (301 thru 400='04')  
    (401 thru 500='05') (501 thru 600='06') (601 thru 700='07') (701 thru 800='08')  
    (801 thru 900='09') (901 thru 1000='10') (1001 thru 1100='11') (1101 thru 1200='12')  
    (1201 thru 1300='13') (1301 thru 1400='14') (1401 thru 1500='15')  
    (1501 thru 1600='16') (1601 thru 1700='17') (1701 thru 1800='18')  
    (1801 thru 1900='19') (1901 thru 2000='20') (2001 thru 2100='21')  
    (2101 thru 2200='22') (2201 thru 2300='23') (2301 thru 2359='24') INTO TIME1 .  
VARIABLE LABELS TIME1 'TIME1'.  
EXECUTE .
```

```
FREQUENCIES  
  VARIABLES=TIME1  
  /BARChart FREQ  
  /ORDER= ANALYSIS .
```

\*Further analysis of the Bur Dubai area crashes, to see if they involve pedestrians.

```
FILTER OFF.  
USE ALL.  
SELECT IF ANY (LOCATION, 'BUR DUBAI AREA').  
EXECUTE .
```

```
FREQUENCIES  
  VARIABLES=LOCATION  
  /BARChart FREQ  
  /ORDER= ANALYSIS .
```

\*Analyse by type of crash, to find frequency of pedestrian crashes.

```
FREQUENCIES  
  VARIABLES=TYPE  
  /BARChart FREQ  
  /ORDER= ANALYSIS .
```



### **File 6: “analysis3type and deg of injury.SPS”**

\*frequencies of degree of injury.

```
FREQUENCIES  
  VARIABLES=DEGINJ  
  /PIECHART PERCENT  
  /ORDER= ANALYSIS .
```

\*frequencies of type of crash.

```
FREQUENCIES  
  VARIABLES=TYPE  
  /PIECHART PERCENT  
  /ORDER= ANALYSIS .
```

### **File 7: “analysis4 vehic&ppl involved.SPS”**

\*The number of vehicles involved, and the number of persons involved, is investigated here.

```
FREQUENCIES  
  VARIABLES=NUMBERVEH NOPERINJ  
  /ORDER= ANALYSIS .
```

\*again take to excel to produce graphs.

\*Select only fatal cases for further analysis, then run above again and take to Excel.

```
FILTER OFF.  
USE ALL.  
SELECT IF DEGINJ = 1.  
Execute.
```

### **File 8: “analysis5 speedlimit conditions ftrs.SPS”**

\*For finding the speedlimits of roads on which crashes occur, frequencies.

```
RECODE  
  SPDLIMIT (SYSMIS=SYSMIS) (11=SYSMIS) (25=SYSMIS) (0 thru 9=SYSMIS) .  
EXECUTE .  
RECODE SPDLIMIT (sysmis=9).  
add value lab SPDLIMIT  
9 'Unknown/invalid'.
```

\*try menu-generated recoding of invalid values of speed (above).

```
FREQUENCIES  
  VARIABLES=SPDLIMIT  
  /BARChart FREQ  
  /ORDER= ANALYSIS .
```

\*Site condition, number of lanes etc.

```
RECODE  
  SITECOND (SYSMIS=SYSMIS) (0=SYSMIS) (10=SYSMIS).  
EXECUTE .  
RECODE SITECOND (sysmis=10).  
add value lab SITECOND  
10 'Other/missing'.
```

```
FREQUENCIES
```



```
VARIABLES=SITECOND
/BARChart FREQ
/ORDER= ANALYSIS .
```

\*Site proximity to local feature.

```
RECODE
  SITENRTO (SYSMIS=SYSMIS) (0=SYSMIS) (10=SYSMIS).
EXECUTE .
RECODE SITENRTO (sysmis=10).
add value lab SITENRTO
10 'Missing/invalid'.
```

```
FREQUENCIES
  VARIABLES=SITENRTO
/PIEChart FREQ
/ORDER= ANALYSIS .
```

### **File 9: “anals6 rd divider lighting signs weathr surface.SPS”**

\*frequencies of central barrier or reservation or lane divider.

```
RECODE CNTRESV (sysmis=0).
add value lab CNTRESV
0 'Unknown'.
```

```
FREQUENCIES
  VARIABLES=CNTRESV
/BARChart FREQ
/ORDER= ANALYSIS .
```

\*frequencies of light condition at crash sites.

```
FREQUENCIES
  VARIABLES=LIGHT
/PIEChart FREQ
/ORDER= ANALYSIS .
```

\*frequency of road markings and signs existence.

```
RECODE
  TCONTROL (0=SYSMIS) .
EXECUTE .
RECODE TCONTROL (sysmis=0).
add value lab TCONTROL
0 'Unknown'.
```

```
FREQUENCIES
  VARIABLES=TCONTROL
/BARChart FREQ
/ORDER= ANALYSIS .
```

\*frequency of pre-existing weather conditions.

```
RECODE
  WEATHER (5=SYSMIS) .
EXECUTE .
RECODE WEATHER (sysmis=0).
add value lab WEATHER
0 'Other/unknown'.
```

```
FREQUENCIES
```



```
VARIABLES=WEATHER
/BARChart FREQ
/ORDER= ANALYSIS .
```

\*frequency of road surface conditions.

```
FREQUENCIES
VARIABLES=RDSURF
/BarChart FREQ
/ORDER= ANALYSIS .
```

## File 10: "Injuries import.SPS"

```
*
* IMPORT TABLES FROM MS-ACCESS DATABASE
*
.

GET DATA
/TYPE=ODBC
/CONNECT=
'DSN=MS Access Database;'
'DBQ=U:\phd\DATABASE\UAE\AccNewVersion\CrashData_Mustaf.mdb;'
/SQL=
'SELECT * FROM "tblINJURYDetails".'
```

```
variable width
CASE_ID (10)
ASSVEHNO (10)
totinj (6)
CLASSINJ (8)
SEXINJ (6)
NATINJ (12)
AGEINJ (7)
DGINJ (6)
STBLTINJ (7)
OnBicccycle (8)
.
```

```
variable labels
totinj "Total no. of injured people"
CLASSINJ "Classification of injury"
SEXINJ "Gender"
NATINJ "Nationality"
AGEINJ "Age"
DGINJ "Degree of injury"
STBLTINJ "Stability of injury"
OnBicccycle "Cyclist"
.
```

```
value labels SEXINJ
'1' "Male"
'2' "Female"
.
```

```
value labels NATINJ
'1' "UAE"
'2' "Abu Dhabi"
'3' "Dubai"
'4' "Sharjah"
```



'5'	"Ajman"
'6'	"Umm Al Quwain"
'7'	"Ras Al Khaimah"
'8'	"Fujairah"
'9'	"Army"
'10'	"Saudi Arabia"
'11'	"Kuwait"
'12'	"Bahrain"
'13'	"Oman"
'14'	"Qatar"
'15'	"Yemen"
'16'	"Jordan"
'17'	"Syria"
'18'	"Iraq"
'19'	"Lebanon"
'20'	"Palestine"
'21'	"Egypt"
'22'	"Sudan"
'23'	"Somalia"
'24'	"Morocco"
'25'	"Pakistan"
'26'	"India"
'27'	"Bangladesh"
'28'	"Iran"
'29'	"Japan"
'30'	"United Kingdom"
'31'	"France"
'32'	"Holland"
'33'	"Germany"
'34'	"America"
'35'	"Australia"
'36'	"Russia"
'37'	"Sri Lanka"
'38'	"Phillipines"
'39'	"No licence presented"
'40'	"Bicycle"
'41'	"Incorrect"
'42'	"No licence"
'43'	"Other countries"
'44'	"Unknown"

.

value labels DGINJ

'0'	"No injury"
'1'	"Fatal"
'2'	"Serious"
'3'	"Medium"
'4'	"Slight"

.

sort cases by CASE\_ID (a).

SAVE OUTFILE=\\ranger\users\ehma\phd\DATABASE\UAE\1995-2006casualty.sav'  
/DROP=OnBicycle /COMPRESSED.

## File 11: "Merging acc and injury tables.SPS"

\*Merging crash and injury tables for 1995-2006 Dubai cases.

\*Use MATCH command.



```

GET FILE='U:\phd\DATABASE\UAE\1995-2006casualty.sav'.
MATCH FILES FILE=* /TABLE="\ranger\users\ehma\phd\DATABASE\UAE\Dubai1995-
2006acc.sav'
/BY CASE_ID.
sort cases by CASE_ID (A).
SAVE OUTFILE='U:\phd\DATABASE\UAE\1995-2006mergeacc-cas.SAV'
/COMPRESSED.
Execute.

```

File 12: "merged acc casualty analysis.SPS"

```

*Gender piechart.
FREQUENCIES
  VARIABLES=SEXINJ
  /PIECHART PERCENT
  /ORDER= ANALYSIS .

```

```

*Nationality piechart.
FREQUENCIES
  VARIABLES=NATINJ
  /PIECHART PERCENT
  /ORDER= ANALYSIS .

```

\*Age ranges.

```

STRING AGERNG (A8) .
RECODE
  AGEINJ
  (0 thru 14='< 15') (15 thru 18='15-18') (19 thru 22='19-22') (23 thru 30='23-30')
  (31 thru 40='31-40') (41 thru 50='41-50') (51 thru 60='51-60')
  (61 thru 100='>60') INTO AGERNG.
VARIABLE LABELS AGERNG 'Age range'.
EXECUTE .

```

```

FREQUENCIES
  VARIABLES=AGERNG
  /BARChart PERCENT
  /ORDER= ANALYSIS .

```

```

*Degree of injury pie chart.
FREQUENCIES
  VARIABLES=DGINJ
  /PIECHART PERCENT
  /ORDER= ANALYSIS .

```

## File 12: "indepth analysis.SPS"

\*2006-7 indepth cases analysis.

```

FREQUENCIES
  VARIABLES=V2DIRECT
  /FORMAT=DFREQ
  /BARChart FREQ
  /ORDER= ANALYSIS .

```

```

FREQUENCIES
  VARIABLES=STLIGHT
  /FORMAT=DFREQ

```



```
/BARChart FREQ  
/ORDER= ANALYSIS .
```

```
FREQUENCIES  
VARIABLES=ROADTYPE  
/FORMAT=DFREQ  
/PIEChart FREQ  
/ORDER= ANALYSIS .
```

```
* Extracting hours from TIME variable.  
COMPUTE HOUR = XDATE.HOUR(TIME).  
VARIABLE LABEL HOUR "HOUR".  
VARIABLE LEVEL HOUR (SCALE).  
FORMATS HOUR (F8.0).  
VARIABLE WIDTH HOUR(8).  
EXECUTE.
```

```
*line graph for hourly distribution.  
GRAPH  
/LINE(SIMPLE)=COUNT BY HOUR  
/TITLE= 'Crashes by hour'.
```

```
*Extracting the year from date of crash.
```

```
COMPUTE AYEAR = XDATE.YEAR(DATE).  
VARIABLE LABEL AYEAR "ACTUAL YEAR".  
VARIABLE LEVEL AYEAR (SCALE).  
FORMATS AYEAR (F8.0).  
VARIABLE WIDTH AYEAR(8).  
EXECUTE.
```

```
*select 2006 cases only.  
SELECT IF AYEAR = 2006.  
exe.
```

```
*Extracting month data from date.  
COMPUTE MONTH = XDATE.MONTH(DATE).  
VARIABLE LABEL MONTH "MONTH".  
VARIABLE LEVEL MONTH (SCALE).  
FORMATS MONTH (F8.0).  
VARIABLE WIDTH MONTH(12).  
EXECUTE.
```

```
*BARChart for MONTH.  
FREQUENCIES  
VARIABLES=MONTH  
/FORMAT=DFREQ  
/BARChart FREQ  
/ORDER= ANALYSIS .
```

```
*Extract day from DATE (USED TO CHECK ACCURACY OF DAY ENTRY).
```

```
* Date and Time Wizard: DAYOFWK.  
COMPUTE DAYOFWK = XDATE.WKDAY(DATE).  
VARIABLE LABEL DAYOFWK "DAYOFWK".  
VARIABLE LEVEL DAYOFWK (NOMINAL).  
FORMATS DAYOFWK (WKDAY3).  
VARIABLE WIDTH DAYOFWK(3).  
EXECUTE.
```

```
*Piechart of road conditions, to be presented in excel.  
FREQUENCIES
```



```
VARIABLES=RDPAVED RDCLEAN RDDRY  
/PIECHART FREQ  
/ORDER= ANALYSIS .
```

\*Frequency table for visual conditions, to be presented in excel.

```
FREQUENCIES  
VARIABLES=CLEARVIS VISOBSTRC  
/ORDER= ANALYSIS.
```

\*Selecting cases with adverse visual conditions.  
SELECT IF (CLEARVIS = 2) OR (VISOBSTRC = 2).  
EXE.

\*Frequency table for estimated speeds of vehicles.

```
FREQUENCIES  
VARIABLES= V1SPEED V2SPEED V3SPEED  
/ORDER=ANALYSIS.
```

\*Recoding speeds into appropriate ranges.

```
STRING SPEEDRG (A10)  
RECODE  
V1SPEED  
(1 thru 40='<40') (41 thru 80='41-80') (81 thru 120='81-120') (120 thru 140='>120') INTO  
SPEEDRG1.  
VARIABLE LABELS SPEEDRG 'V1 speed range'.  
exe.
```

\*Age ranges.

```
STRING AGERNG (A8) .  
RECODE  
V1DRVAGE  
(1 thru 14='< 15') (15 thru 18='15-18') (19 thru 22='19-22') (23 thru 30='23-30')  
(31 thru 40='31-40') (41 thru 50='41-50') (51 thru 60='51-60')  
(61 thru 100='>60') INTO AGERNG.  
VARIABLE LABELS AGERNG 'V1 driver age range'.  
EXECUTE .
```

```
FREQUENCIES  
VARIABLES=AGERNG  
/BARChart PERCENT  
/ORDER= ANALYSIS .
```

\*Selecting inexperienced drivers.  
SELECT IF (AGERNG = '19-22').  
exe.

\*V2 driver age more complex, 69 cases with no age (hence no V2) must be removed before  
analysis can be carried out.

```
SELECT IF V2DRVAGE >= 1.  
exe.
```

\*Selecting cases with a driver nationality entered.  
SELECT IF (VALUE (V2DRVNAT) GT 0).  
exe.

\*Select cases with a DRVDAT specified.  
SELECT IF (VALUE (V1DRVDAT) GT 0).  
exe.

\*Select cases with adverse road conditions.



SELECT IF (RDPAVED = 2) OR (RDCLEAN = 2) OR (RDDRY = 2).  
exe.

\* Date and Time Wizard: calculating DRIVER EXPERIENCE in years V1DRVEXP.  
COMPUTE V1DRVEXP = DATEDIF(DATE, V1DRVDAT, "years").  
VARIABLE LABEL V1DRVEXP "V1 driver experience in years, since licensing".  
VARIABLE LEVEL V1DRVEXP (SCALE).  
FORMATS V1DRVEXP (F5.0).  
VARIABLE WIDTH V1DRVEXP(5).  
EXECUTE.

\*Frequencies of above.  
FREQ  
VARIABLES= V1DRVEXP  
/ORDER=ANALYSIS.

\*Selecting drivers with less than 4 years experience.  
SELECT IF (V1DRVEXP <=4).  
exe.

DO IF (V1DRVEXP >= 10) .  
RECODE  
V1DRVEXP (10 thru Highest=10) .  
END IF .  
EXECUTE .

\*Select cases with an entry for speeding.  
SELECT IF (VALUE (V1OVERSP) GT 0).  
exe.

\*Piechart of speeding cases.  
FREQUENCIES  
VARIABLES= V1OVERSP  
/PIECHART FREQ  
/ORDER= ANALYSIS .

\*Select cases with a road speed limit recorded.  
SELECT IF (VALUE (RDSPDLMT) GT 0).  
exe.

\*Frequencies of crash mechanisms.  
FREQUENCIES  
VARIABLES= CRASHMC1 CRASHMC2 CRASHMC3  
/ORDER=ANALYSIS.

\*Frequencies of crash causes.  
FREQ  
VARIABLES= CRASHCS1 CRASHCS2 CRASHCS3 CRASHCS4  
/ORDER=ANALYSIS.

\*Frequencies of objects hit.  
FREQ  
VARIABLES= HITOBJT1 HITOBJT2 HITOBJT3  
/PIECHART FREQ  
/ORDER=ANALYSIS.

\*Frequencies for seat belt use for driver and first occupant.  
FREQ  
VARIABLES= STBLTDRV STBLTOCC1  
/ORDER=ANALYSIS.



\*Frequencies for V1axles and damage of vehicles.

```
FREQ  
VARIABLES= V1AXLES  
/BARChart FREQ  
/ORDER=ANALYSIS.
```

```
FREQ  
VARIABLES= V1DAMAGE V2DAMAGE V3DAMAGE V4DAMAGE  
/PIEChart FREQ  
/ORDER=ANALYSIS.
```

\*Frequencies for V1 occupant age.

\*Age requires recoding into ranges.

```
FREQ  
VARIABLES= V1OCC1AG V1OCC2AG V1OCC3AG V1OCC4AG V1OCC5AG V1OCC6AG  
V1OCC7AG V1OCC8AG  
/PIEChart FREQ  
/ORDER = ANALYSIS.
```

```
STRING V1OCC3RG (A8) .  
RECODE  
  V1OCC3AG  
  (1 thru 14='< 15') (15 thru 18='15-18') (19 thru 22='19-22') (23 thru 30='23-30')  
  (31 thru 40='31-40') (41 thru 50='41-50') (51 thru 60='51-60')  
  (61 thru 100='>60') INTO V1OCC3RG.  
VARIABLE LABELS V1OCC3RG 'V1 Occupant 3 age range'.  
EXECUTE .
```

\*Then set missing values manually, before conducting frequency count.

```
FREQUENCIES  
  VARIABLES= V1OCC3RG  
  /BARChart PERCENT  
  /ORDER= ANALYSIS .
```

\*Analysing injury levels.

```
FREQ  
VARIABLES= V1DRVINJ V2DRVINJ V3DRVINJ V4DRVINJ V5DRVINJ  
/PIEChart PERCENT  
/ORDER=ANALYSIS.
```

```
FREQ  
VARIABLES= V1OCC2IN V1OCC3IN V1OCC4IN V1OCC5IN V1OCC6IN V1OCC7IN  
V1OCC8IN  
V2OCC1IN V2OCC2IN V2OCC3IN V2OCC4IN V2OCC5IN V2OCC6IN V2OCC7IN  
V2OCC8IN V2OCC9IN  
V3OCC1IN V3OCC2IN  
/ORDER = ANALYSIS.
```

\*Selecting all fatal cases.

```
SELECT IF (V1DRVINJ = 1) | (V2DRVINJ = 1) | (V3DRVINJ = 1) | (V4DRVINJ = 1) |  
(V5DRVINJ = 1) |  
(V1OCC1INJ = 1) | (V1OCC2IN = 1) | (V1OCC3IN = 1) | (V1OCC4IN = 1) | (V1OCC5IN = 1)  
| (V1OCC6IN = 1)  
| (V1OCC7IN = 1) | (V1OCC8IN = 1) | (V2OCC1INJ = 1) | (V2OCC2IN = 1) | (V2OCC3IN =  
1) | (V2OCC4IN = 1)  
| (V2OCC5IN = 1) | (V2OCC6IN = 1) | (V2OCC7IN = 1) | (V2OCC8IN = 1) | (V2OCC9IN = 1)  
|  
(V3OCC1IN = 1) | (V3OCC2IN = 1).
```



EXE.

\*Piecharts of useable data.

```
FREQ
VARIABLES= V1OCC2IN V2OCC1INJ
/PIECHART PERCENT
/ORDER=ANALYSIS.
```

\*Analysing vehicle, human and road factors.

```
FREQ
VARIABLES= VEHFACT1 VEHFACT2 VEHFACT3
/ORDER=ANALYSIS.
```

```
FREQ
VARIABLES= HUMFACT1 HUMFACT2 HUMFACT3 HUMFACT4 HUMFACT5
/ORDER=ANALYSIS.
```

```
FREQ
VARIABLES= RDFACTR1 RDFACTR2 RDFACTR3 RDFACTR4 RDFACTR5 RDFACTR6
RDFACTR7 RDFACTR8
/ORDER=ANALYSIS.
```

\*Analysing make and model of vehicles, by recoding into trimmed variables of width 8.  
missing values V1MAKE V1MODEL V2MAKE V2MODEL V3MAKE V3MODEL V4MAKE  
V4MODEL (" ").

```
STRING V2MK V2MOD V3MK V3MOD V4MK V4MOD V1MK V1MOD V1TRM (A8) .
RECODE
  V2MAKE V2MODEL V3MAKE V3MODEL V4MAKE V4MODEL V1MAKE V1MODEL
V1TRIM
  (ELSE=Copy) INTO V2MK V2MOD V3MK V3MOD V4MK V4MOD V1MK V1MOD
  V1TRM .
VARIABLE LABELS V2MK 'V2 make short' /V2MOD 'V2 model short' /V3MK 'V3 make'+
' short' /V3MOD 'V3 model short' /V4MK 'V4 make short' /V4MOD 'V4 model short'
/V1MK 'V1 make short' /V1MOD 'V1 model short' /V1TRM 'V1 trim short'.
EXECUTE .
```

\*Manually set missing values to new variables, then run freq.

```
FREQ
VARIABLES=V1MK V1MOD V1TRM V2MK V2MOD V3MK V3MOD V4MK V4MOD
/ORDER=ANALYSIS.
```

\*Checking total of fatalities.

```
FREQ
VARIABLES= FATALS
/ORDER=ANALYSIS.
```

\*Selecting cases with vehicle factor = 2.

```
SELECT IF ANY(NUMBER, 1, 2, 3, 9, 10, 12, 32, 33, 51, 55, 145, 174, 179, 228, 271).
exe.
```

\*Make and model risk profiles.

```
SELECT IF V1MODEL = "Landcruiser".
exe.
```

```
FREQ
var= crashmc1 crashmc2 crashmc3 crashcs1 crashcs2 crashcs3 crashcs4 hitobjt1 hitobjt2
hitobjt3
/order=analysis.
exe.
```



\*Hit object further analysis.  
SELECT IF (HITOBJT1 = 6).  
exe.

\*HUMFACTOR further analysis.  
SELECT IF (HUMFACT1 = 5) OR (HUMFACT2 = 5) OR (HUMFACT3 = 5) OR (HUMFACT4 = 5).  
exe.

\*ROADFACTOR Further analysis.  
SELECT IF (RDFACTR1 = 3) OR (RDFACTR2 = 3) OR (RDFACTR3 = 3).  
exe.

### **File 13: “selecting indepth from base cases.SPS”**

\*Create a new file with all the 2006 indepth case ids, and give them a flag variable with value 1.

compute flag=1.

\*(then Ctrl+G to run pending transforms).

\*Then aggregate data with 2006 base file, inserting variables from there. Those with no flag can be removed.

match

\*Selecting those cases that appear in the indepth sample, from those in the base-level data.

\*Dataset number is the donor file of data.

```
MATCH FILES /TABLE=*  
/FILE='DataSet1'  
/BY CASE_ID.  
EXECUTE.
```

```
FILTER OFF.  
USE ALL.  
SELECT IF flag=1.  
exe.
```

\*Must rename CASERTA into CASE\_ID, and sort cases in ascending order of CASE\_ID, for Merge command  
to work from Transform Menu (merge variables).

### **File 14: “analysis 6 corrections.SPS”**

\*Weekend change analysis.

\* Date and Time Wizard: DATEYR to create a variable containing the YEAR called YEAR for all cases.

```
COMPUTE YEAR = XDATE.YEAR(DATE).  
VARIABLE LABEL YEAR "Year".  
VARIABLE LEVEL YEAR (SCALE).  
FORMATS YEAR (F8.0).  
VARIABLE WIDTH YEAR(8).  
EXECUTE.
```

```
FILTER OFF.
```



```
USE ALL.  
SELECT IF(YEAR = 2005).  
EXECUTE .
```

```
* Date and Time Wizard: Create new variable called Month.  
COMPUTE Month = XDATE.MONTH(DATE).  
VARIABLE LABEL Month "Month".  
VARIABLE LEVEL Month (SCALE).  
FORMATS Month (F8.0).  
VARIABLE WIDTH Month(8).  
EXECUTE.
```

```
*Alternatively, to select new weekend cases by dropping unselected cases.  
FILTER OFF.  
USE ALL.  
SELECT IF month >= 9.  
EXECUTE.
```

```
*To produce the frequency of case by day of week.  
* Date and Time Wizard: dayofwk.  
COMPUTE dayofwk = XDATE.WKDAY(DATE).  
VARIABLE LABEL dayofwk "Day of week".  
VARIABLE LEVEL dayofwk (NOMINAL).  
FORMATS dayofwk (WKDAY3).  
VARIABLE WIDTH dayofwk(3).  
EXECUTE.
```

```
FREQUENCIES  
  VARIABLES= dayofwk  
  /BARCHART PERCENT  
  /ORDER= ANALYSIS .
```

```
NPAR TEST  
  /CHISQUARE=dayofwk  
  /EXPECTED=EQUAL  
  /MISSING ANALYSIS.
```

```
CROSSTABS  
  /TABLES=CLASSINJ BY SEXINJ  
  /FORMAT= AVALUE TABLES  
  /CELLS= COUNT  
  /COUNT ROUND CELL .
```

```
CROSSTABS  
  /TABLES=CLASSINJ BY NATINJ  
  /FORMAT= AVALUE TABLES  
  /CELLS= COUNT  
  /COUNT ROUND CELL .
```

\*analysis on in-depth cases.

```
CROSSTABS  
  /TABLES=HOUR BY DAY  
  /FORMAT= AVALUE TABLES  
  /CELLS= COUNT  
  /COUNT ROUND CELL .
```

```
*Vehicle (accused) type against object hit.  
CROSSTABS  
  /TABLES=V1TYPE BY HITOBJT1
```



```
/FORMAT= AVALUE TABLES  
/CELLS= COUNT  
/COUNT ROUND CELL .
```

\*Bar chart of vehicle 1 type vs 1st object hit.

```
GRAPH  
/BAR(STACK)=COUNT BY V1TYPE BY HITOBJT1 .
```

\*Selecting all pedestrian collisions.

```
SELECT IF (CRSHTYPE1 = 2) OR (CRSHTYPE2 = 2) OR (CRSHTYPE3 = 2).  
EXE.
```

\*Pie chart of pedestrian crashes by first vehicle type.

```
GRAPH  
/PIE=COUNT BY V1TYPE .
```



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