Some Injury Scaling Issues in UK Crash Research

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Abstract

This study explores the relationships between the classification of traffic casualties by the police and by using the AIS. It examines a sample of accidents to car occupants that have been studied through the CCIS data collection system in the UK. The results show that the police categories of 'Slight' and 'Serious' have poor correspondence with AIS rankings of the same individuals. In particular the 'Serious' police category includes a third of casualties who have either AIS 1or no injuries at all. The implications of these results on estimates of national casualties and costs are discussed. Some data from the EU indicate major variations in definitions of casualties from country to country making national comparisons uncertain.

Keywords, INJURY SEVERITY, INJURIES, ACCIDENT ANALYSIS

Introduction

The importance of counting and classifying road traffic injuries is self-evident to anyone who wishes to understand the nature and scale of such trauma, and to develop appropriate policies to diminish road traffic death and morbidity. Most countries have data collection systems that provide a census counting of traffic accidents and their consequences. In the U.K. the basic data are collected by the police who use a three-point injury scale; 'Fatal', 'Serious' and 'Slight'.

A Fatality in the U.K. conforms to the W.H.O. definition, which requires death to occur within 30 days. The difference between that definition and long-term outcome is around 3 to 5%, depending on the class of road user. Deaths from natural causes to drivers that occur within a vehicle are also included in the initial accident data in Britain, but are excluded from some of the national tabulations. This is discussed further below.

A ‘Serious’ casualty classification is applied to anyone “who is detained in hospital as an in-patient, or has any of the following (whether or not detained); fractures, concussion, internal injuries, crush injuries, burns (excluding friction burns), severe cuts and lacerations, severe general shock requiring medical treatment and injury causing death 30 or more days after the accident”.

A ‘Slight’ casualty is defined as “someone with a minor injury such as a sprain, bruise or cut or ‘Slight’ shock not judged to be severe ”.

Casualties are put into these three categories by a police officer at the scene of the accident with, in the case of some ‘Serious’ and life-threatening cases, some follow up by the police to the treating hospital and discussions with the admitting medical staff, usually within a few hours of the accident. Additional information is routinely relayed to the police if a casualty died within the 30 day definition. Clearly the definition of these three categories is subjective and subject to different interpretations and varying definitions over time. For example in busy urban areas the work load on the police is at times intense, and that leads to a casualty who is merely taken to hospital being classified as ‘Serious’, even if at the casualty department nothing in the ‘Serious’ category is found. Under such conditions the police may not record some ‘Slight’ casualty accidents at all.

On the other hand, clinical research and detailed crash injury studies to assess vehicle safety performance require a more detailed and objective scale for the classification of injury. The Abbreviated Injury Scale has fulfilled that role, and has become the accepted method of classifying injury severity around the world. The AIS classifies injuries in terms of threat-to-life, and has developed into its current format over the past thirty years. The history of this scale is well documented elsewhere (Petrucelli, 1981). The Abbreviated Injury Scale is a very useful means of assessing the severity of individual injuries in road crashes and there have been numerous research papers that have used this scale for such a purpose. Its great strength is that

by having universal acceptance it allows comparisons between databases worldwide, and has lead to a large number of comparative studies that would otherwise be impossible if the basic parameter for the scaling of injury severity varies from study to study.

It is common knowledge that most killed and seriously injured road users sustain multiple injuries and it is in such cases that additional approaches are required. Two most commonly used methods of assessing overall injury severity to an injured person (rather than individual injury severity) are the Maximum Abbreviated Injury Scale (MAIS) and the Injury Severity Score (ISS). MAIS is the highest single AIS code in a patient with multiple injuries and is used to describe overall patient severity. A patient can sustain a MAIS score of between 0 (no injury) to 6 (currently untreatable). A development of the AIS is the ISS. This variable is the sum of the squares of the highest AIS score in three different body regions and thus the score can range from 0 to 75. A patient who sustains any injury at AIS 6 is automatically assigned an ISS of 75. The ISS has proved to be an effective tool for predicting mortality based on initial injury coding using the AIS (Baker 1971, Bull 1973).

Cost of injury

In-depth clinical data are also needed to accurately portray the true cost of injury (e.g. Miller, 1991). Costs of injury can be calculated in a number of ways. One example involves the 'Harm' approach. The concept of 'Harm' was first developed in the US and applied to the National Accident Sampling System (NASS) database as a means for determining countermeasure benefits for road safety programmes (Malliaris et al, 1982, 1985; Malliaris and Digges, 1987). In its simplest form, it involves quantifying individual injury costs from road trauma. A related approach involves that proposed by Miller et al (1991) whereby the costs of individual injuries are derived via the human capital approach. The National Highway Traffic Safety Administration (NHTSA) has used Miller's calculations of individual injuries to

calculate ‘Harm’ and consequently, the ‘Harm’ injury cost model has also been used in a number of studies in Australia to assess the potential benefits of vehicle safety countermeasures (e.g. Fildes et al, 1996, Morris et al, 2001).

In the UK however, road accident injury costs are derived by applying an average ‘cost’ for each casualty depending on the overall level of individual casualty injury severity as assessed by the Police Officer. Such costs are calculated on the basis of a number of factors and outcomes from the accident including police and insurance administration, property damage, etc.

In 2001, the following costs were applied to individual casualties;

Table 1; Cost of Road Casualties in Great Britain, 2001

Casualty Type	**Numbers of Casualties**	**Cost per casualty (£)**	**Approximate Cost for Total Casualties (£)**
‘Fatal’	3,450	1,194,240	4.1 billion
‘Serious’	37,110	134,190	4.9 billion
‘Slight’	272,749	10,350	2.8 billion

Source; Road Accidents Great Britain – The Casualty Report, 2001

The total cost-benefit value of road accident prevention in 2001 was estimated to be £17 billion of which approximately £12 billion is attributable to personal injury accidents, as can be seen from the table, with damage-only accidents accounting for the remainder. Crucially these costs are dependent on the classification of the casualties into the three categories of ‘Fatal’, ‘Serious’ and ‘Slight’. This study explores how those categories correspond to the AIS classifications.

Mortality

Previous studies have also examined the extent to which AIS injury severity ratings correlate with mortality. Baker et al (1974) found that whilst 0.5% of patients died with a MAIS 2 injury, 64% died with a MAIS 5 injury. Analysis of this relationship led to the development of the Injury Severity Score (ISS), which is a simple method of adjusting for multiple injured persons (Baker et al).

This study also explores some of the relationships between mortality risk, using MAIS and ISS, and the UK government national injury severity classification system for a sample of car occupant casualties. The objectives are to compare the government scale with the more detailed AIS and its derivatives, and to examine the relationships with mortality risk. A further objective was to examine costs of road injury in the UK in the light of the present system of injury classification.

Methodology

UK in-depth vehicle crash injury data covering current model cars are analysed in this study. These data were collected between 1998 and 2001 as part of the Co-operative Crash Injury Study (CCIS). The CCIS data are a stratified sample of UK crashes where the vehicle was towed from the crash-scene. Some 80% of 'Serious' and 'Fatal' and some 10-15% of 'Slight' injury crashes according to the UK government's classification are investigated in well-defined sample regions. Consequently, the resulting sample is biased towards the more 'Serious' crashes. In addition, there is a possibility of some regional bias since the study operates in a limited number of regions in the UK.

All injuries were coding using the Abbreviated Injury Scale (AIS) 1990 revision. The Maximum Abbreviated Injury Score (MAIS) was also used where possible. This is the highest Abbreviated Injury Score (AIS) injury sustained by the driver in the crash (ranging from MAIS = '0' or no injury to MAIS = '6' or maximum injury).

In total, clinical data were obtained for 13,604 occupants involved in UK vehicle crashes. All crash-types were considered but no analysis has been undertaken on the different types. Each individual injury was assigned an AIS code and each individual occupant was assigned both a Maximum Abbreviated Injury Score and an Injury Severity Score.

Occupants who died from natural causes in or prior to the crash event were not included in the data analysis.

Results

1. The Relationship between AIS Scores and the Police Categories

Table 2 shows Maximum Abbreviated Injury Scale outcome for all occupants in all crashes. As can be seen from the table, the large majority of occupants sustained No or Minor Injury only (MAIS 0 and MAIS 1). Only 10.6% of occupants sustained MAIS 3+ injuries in the whole sample

Table 2; All occupants, All crashes (13,604 occupants)

MAIS 0	18.5%
MAIS 1	50.1%
MAIS 2	14.0%
MAIS 3	5.3%
MAIS 4	2.6%
MAIS 5	1.9%
MAIS 6	0.8%
MAIS 9 (unknown)	6.8%

Table 3 shows occupant severity as determined by the UK Police for each occupant.

Table 3; UK Police Occupant Injury Severity Classification (13,604 occupants)

'Fatal'	4%
'Serious'	26%
'Slight'	48%
No injury	18%
Unknown	4%

The relationship between the Police injury severity classification and injury severity assessment as determined by the Abbreviated Injury Scale is shown in table 4.

As can be seen from the table, 2.1% of occupants who sustained injuries at the 'No' or 'Minor' level of injury classification subsequently died although it was not possible to determine the

cause of death in such cases. Of interest is the fact that over one-third of occupants of occupants are classified as 'Serious' by the UK Police yet sustain 'No' or 'Minor' injury. In fact 34% of occupants sustained MAIS 1 injuries yet were still classified as seriously injured.

Table 4; Maximum Abbreviated Injury Scale score by Police Injury Severity Classification (13,604 occupants)

	'Fatal' (n=561)	**'Serious'** (n=3595)	**'Slight'** (n=6525)	**No injury** (n=2473	**Unknown** (n=450)
MAIS 0 (n=2517)	1.4%	1.2%	8.2%	75.5%	14%
MAIS 1 (n=6819)	0.7%	34.3%	76.3%	17.8%	36.2%
MAIS 2 (n=1902)	1.2%	36.8%	8.1%	0.7%	6.7%
MAIS 3 (n=726)	9.8%	16.9%	0.9%	0	1.1%
MAIS 4 (n=351)	34.8%	4.2%	0.08%	0	0.2%
MAIS 5 (n=254)	33.0%	1.9%	0.01%	0	0
MAIS 6 (n=106)	18.9%	0	0	0	0
MAIS 9 (n=929)	0.2%	4.6%	6.5%	6.1%	41.9%

Table 5 shows occupant mean Injury Severity Score (ISS) by Police injury severity

Table 5; All Occupants, all crashes, ISS by Police Injury Severity

	'Fatal' (n=561)	'Serious' (n=3595)	'Slight' (n=6525)	No Injury (n=2473)	Unknown (n=446)
0	1.4%	1.3%	8.2%	75.4%	13.9%
1-10	3.2%	77.1%	84.8%	18.4%	43.3%
11-20	7.0%	11.2%	0.5%	0%	0.9%
21-30	22.8%	4.3%	0.05%	0%	0%
31-40	19.4%	1.0%	0%	0%	0%
41-50	20.5%	0.4%	0%	0%	0%
51-60	5.3%	0.02%	0%	0%	0%
61-70	0.7%	0.05%	0%	0%	0%
71+	19.4%	0%	0%	0%	0%
Unknown	0.1%	4.7%	6.4%	6.1%	41.9%

Of particular interest as far as police injury classifications are concerned are injuries at the 'Slight' and 'Serious' levels since table 5 indicates significant overlap between the classifications. 77% of seriously injured and 85% of slightly injured occupants sustain overall injury with an ISS of between 1 and 10. Therefore, these levels of injury severity were

examined in more detail in Table 6. This table shows the relationship between actual ISS score and police occupant injury classification (either ‘Slight’ or ‘Serious’).

Table 6; Injury Severity Scores for Police ‘Slight’ and ‘Serious’ Occupant Injury Classifications

Injury Severity Score	‘Slight’	‘Serious’
1	48%	18%
2	24%	12%
3	4%	4%
4	1%	5%
5	5%	19%
6	2%	6%
7	-	-
8	-	1%
9	1%	7%
10	-	5%

As can be seen from the table, the majority (76%) of slightly injured occupants received injury at the AIS 1 level only (i.e. those with an ISS of <4). However, a substantial number of seriously injured occupants (34%) sustained injuries classified as AIS 1 only (i.e. those with an ISS of <4). These results indicate that police assessment of injury severity in vehicle crashes differs greatly from the AIS categories. If one takes the police definitions of ‘Slight’ and ‘Serious’ given earlier, and inferred the AIS categories for those two definitions, then ‘Slight’ casualties would be a mixture of no injuries and Minor (AIS 1) injuries on the AIS scale, whilst ‘Serious’ casualties would be a mixture of Moderate (AIS 2) and AIS 3+ injuries. In reality the police ‘Serious’ category includes many AIS 1 cases.

2. Injury Severity to Fatally Injured Occupants

In this section of the analysis, the injury severity and injury types sustained by fatally injured occupants only are considered. Figure 1 shows the percentage of patients that died increased

with severity of injury, as would be expected. Figure 2 shows the corresponding analysis for crash survivors.

Figure 1

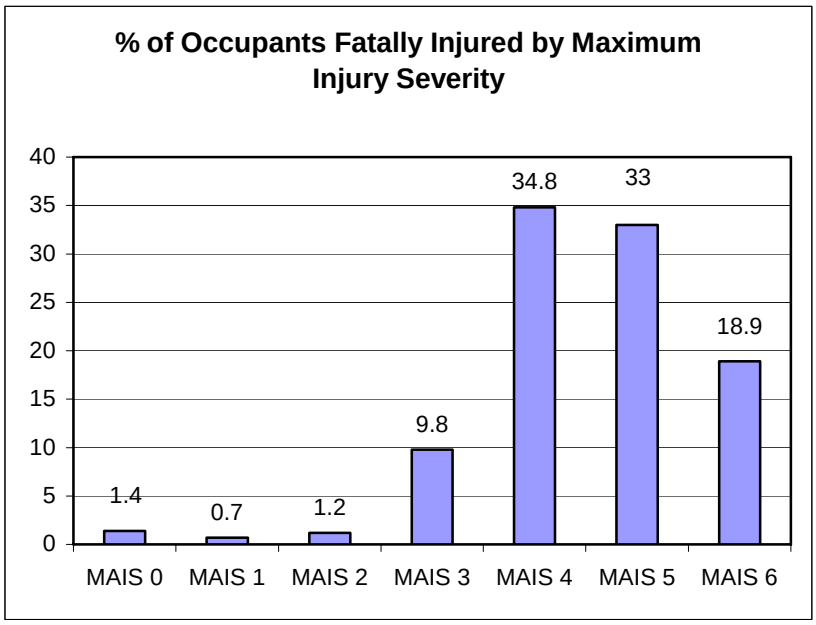


Figure 2

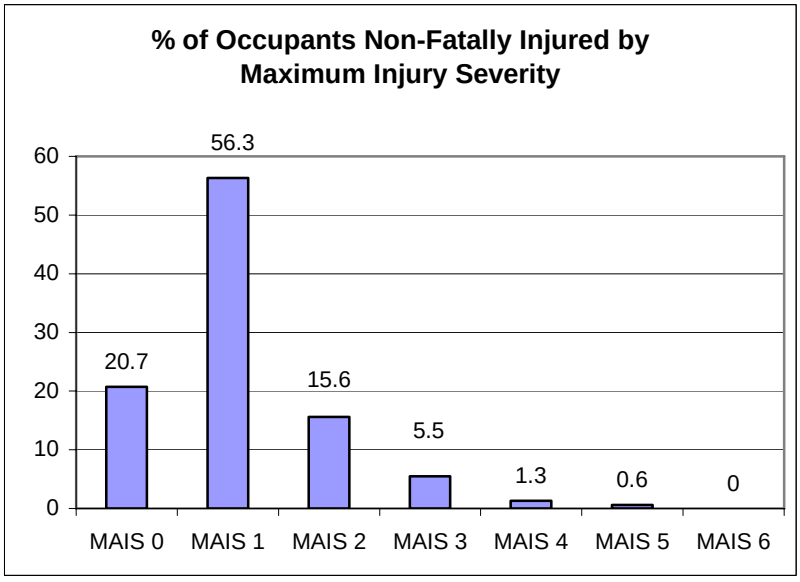
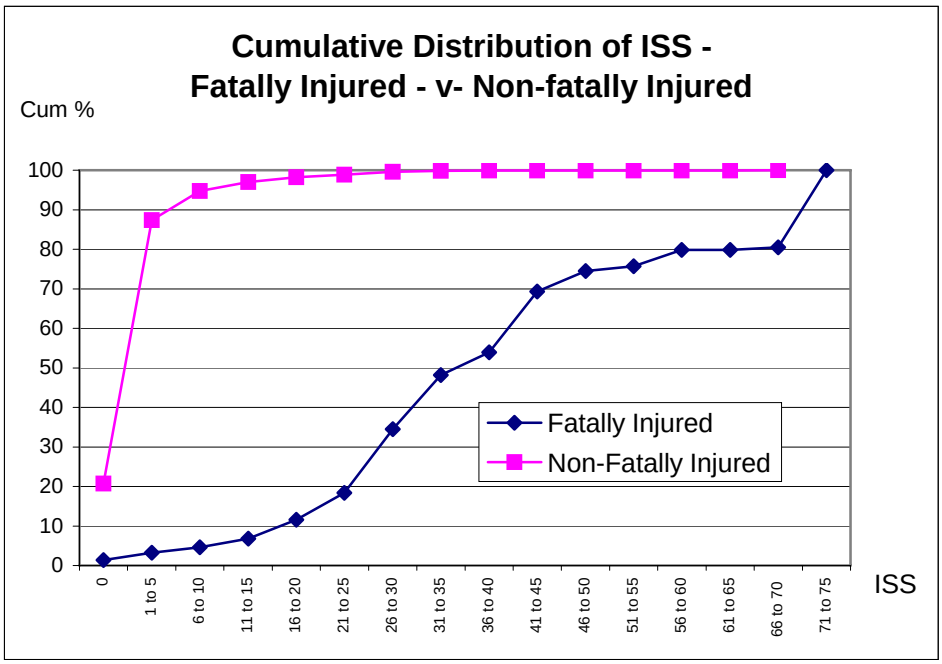


Figure 3 shows the cumulative distribution of Injury Severity Scores (ISS) for fatally injured occupants in relation to all other occupants. 50% of fatally injured occupants sustained an ISS

of 35 or less whilst 20% of fatally injured occupants sustained an ISS of 25 or less. What is of interest is that a significant number of fatalities have low ISS values.

Figure 3



3. Classification of Casualties in EU Member States

It is of interest to examine the national data of the countries within the EU. Each country collects national data from police forces in a manner similar to the UK. Each country uses three categories of casualty, 'Slight', 'Serious' and 'Fatal'. However, the definitions of those categories vary. Some insight into this is given in table 7, which shows the ratios of 'Fatal' to 'Serious' and 'Fatal' to 'Slight' for each country (ETSC, 1997).

Table 7: Ratios of 'Fatal' to 'Serious' and 'Fatal' to 'Slight' Injuries in the European Union

Country	'Fatal' to 'Serious'	'Fatal' to 'Slight'
Austria	8	32
Belgium	7	31
Denmark	8	7
Finland	4	12
France	4	13
Germany	12	33

Greece	2	13
Italy	8	23
Ireland	5	15
Luxembourg	7	14
Netherlands	8	26
Portugal	4	18
Spain	5	9
Sweden	7	18
UK	9	49
Overall EU	7	23

Clearly wide disparities are present particularly with regard to the 'Slight' categories of casualty.

There may well also be present significant under-reporting of certain categories of casualties. This is recognised for example in the UK where injured cyclists, pedestrians and motorcyclists are under-represented in police data in comparison to hospital data. As a result the national data is modified from the police data by various multiplying factors in an attempt to correct for this under reporting (RAGB).

Discussion

Classifying and hence quantifying the extent and nature of traffic injury is fundamental to understanding the epidemiology of this disease. Part of this process involves compilation and analysis of clinically diagnosed injury data. A number of issues have been raised in the study.

Firstly there is the issue of injury cost. At present, the annual road toll in terms of injury costs in the UK (as stated in Road Accidents Great Britain) are based on a calculation of the number of casualties in a particular casualty class multiplied by the costs per casualty, which is based on a number of factors including insurance costs, hospital treatment costs and property damage costs amongst other factors. It is obvious that in order to calculate a reasonably accurate overall cost of road trauma in the UK requires a reasonably accurate determination of the severity of the injury. This study has shown that in over one-third (approximately 34%) of cases, occupants

judged to be ‘seriously injured’ in crashes sustain no more than MAIS 1 injuries. Whilst in some cases, it is possible that road victims who sustain MAIS 1 injuries are hospitalised overnight (thereby automatically meeting the ‘Serious’ Injury criteria) particularly where head trauma has occurred, it is evident that the assessment of the injury by the Police Officer can be at variance with the general views of what are ‘Slight’ and ‘Serious’ injuries. The comparisons made in this study show particularly that the ‘Serious’ category as used by the police in practice contains a large proportion of casualties who in fact have AIS 1 injuries or none at all. Supposing that in all cases, the injury severity could be downgraded from ‘Serious’ to ‘Slight’, the approximate total costs for road casualties in the UK in 2001 would have decreased from £11.8 billion to £10.1 billion.

One alternative approach to calculate the true cost of road trauma in the UK would be for the development of a Harm matrix similar to that first proposed by Miller (1991) whereby accurate determination of individual injury costs can be achieved by examining the AIS injury classification scheme although this would require extensive follow-up of all road victims through the hospital system.

A second issue concerns the usefulness of AIS, MAIS and ISS as predictive and analysis tools for vehicle safety engineers. The AIS code is a very useful system since it allows the code itself to be broken down such that fractures can be selected from mass databases. Therefore researchers can use the coding system to select individual cases for in-depth analyses depending on the nature of the study (e.g. Taylor et al, 1997).

Both the AIS and MAIS systems can also be used to determine whether improvements have been derived through introduction of engineering countermeasures providing other crash factors can be controlled for. Identification of the need for the introduction of additional codes for different types of fractures has been identified previously and the suitability of the forthcoming version of the Abbreviated Injury Scale (AIS 2003) needs to be evaluated in the

context of applicability for vehicle safety research. ISS also has its uses but it has the drawback that it does not account for multiple injuries to the same body region that is commonly observed when severe trauma has occurred. Furthermore the range of ISS scores for fatalities was found to be large with a substantial proportion (over 50%) of fatally injured occupants sustaining ISS scores of between 21 and 50. Therefore it is difficult to make a prediction of probability of death based on the calculation of the ISS alone.

However, the situation with regard to whole body MAIS is slightly different. Given that 85% of occupants died with a whole-body MAIS of 4+ whilst only 1.9% of survivors were injured to the same extent, it could be reasonable to use MAIS as a tool to determine the suitability of fatal injury countermeasures providing that appropriate injury criteria can be used which are capable of predicting MAIS 4 injury outcomes.

Overall this study has shown that the actual use of the national categories of injury severity by the police does not correspond closely to any AIS values, and that across Europe there are major differences in definitions and data sets on casualties in each country. These uncertainties need to be remembered when international comparisons are being made.

There are a number of obvious factors that have not been considered in this study since the intention was merely to examine the uses of injury scales. Crash-type and severity, collision partner, vehicle type, belt use, occupant age and sex amongst factors will all affect injury outcomes and should be considered in any follow-up study.

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