INJURIES TO OLDER USERS OF PUBLIC TRANSPORT IN THE UK

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Abstract

The increasing age of the United Kingdom (UK) population coupled with enhanced life expectancy impacts on transport-user demographics and will affect transport planning in the years ahead. Whist passenger car use is the ultimate means of personal independence, at some point the physiological and psychological impact of age-related conditions will inevitably shift people out of their vehicles and onto public transport systems. Overall, public transport is seen to be vital for social inclusion (Lucas et al 2008, Rowntree Foundation) and it is considered a safe means of mobility. However, it is important that the public and in particular, the elderly perceive it to be so.

Injuries (across a spectrum of severities) do occur during public transport use from time to time. In fact, over 5,000 people are injured on UK buses each year alone with over 300 bus-users killed/seriously injured (Department for Transport, 2012). This study was designed to examine the nature of injuries and their causes to older bus-users with the aim being to establish where design countermeasures may be indicated. The study uses linked (accident and injury) data involving a sample of older bus-users. Most incidents in the linked dataset were non-collisions (62 per cent) resulting in 1,381 recorded injuries in those aged 60+ years, of which 46 per cent were 'slight' and 54 per cent 'serious'.

Keywords: Bus; older passengers' injury;, 60+ years; injury; injury severity.

Introduction

Modern societies have a duty of care to help older people live in their homes and communities for as long as they want. The physical environment, and the services upon which older people rely, must be 'age-friendly', so as to remove barriers to their participation in their communities.

In practice, part of this means addressing older people's anxieties regarding incidence of crime, recognising the unique characteristics and needs of people growing older in rural communities, tackling the problems caused by isolation and loneliness and addressing older people's transport needs. This last point is particularly important as it involves providing a transport system that is safe and secure as well as affordable. In the majority of cases, the public transport of choice is the public bus since this is by far the most common form of public transport provision in terms of numbers and frequency of routes.

In the main, public transport is relatively safe - according to Mabrook (1994), injuries sustained by passengers travelling on public buses are relatively uncommon; public service vehicle passenger casualty rates, per billion passenger kilometre travelled are much lower than for cars, motor-cycles, pedal-cycles and pedestrians. Nevertheless, during the period 2008 to 2012, over 20,000 UK bus and coach users were injured whilst using this form of transport. The problem is not confined to the UK - a study in Israel (Halpern, 2005) estimated that as many as 2,700 bus-users per year might be injured whilst using the bus representing an 'alarmingly high level of morbidity'. However measuring injury outcomes does not tell the whole story since those not necessarily injured but 'shaken' or 'thrown off balance' whilst using the bus can easily be dissuaded from further bus use. This is principally because of fear of falling or future injury. Ultimately, these events can lead to social exclusivity and ultimately isolation through eventual lack of personal mobility.

Previous studies have looked at characteristics and incidence of accidents in which injuries have occurred to public bus users. An early study is reported by Jovanis et al (1991) in the United States of America which looked at 1,800 accidents between 1982 and 1984 to identify factors contributing to accidents involving mass transit buses. They observed that on a passenger-mile basis, bus travel has relatively low risk but that as many as 63 per cent of bus transit accidents involve no collision.

Related studies were conducted in Denmark by Moller et al (1982) through examining records of 183 injured bus passengers who sustained between them some 212 injuries. 85 of the 183 passengers were injured whilst the bus was in motion and 58 of these passengers were standing on the bus at the time of the incident with acceleration/deceleration of the bus therefore being a major factor in these accidents. A subsequent Danish study by Albrektsen and Thosen (1983) looked at 221 bus accidents and incidents in Copenhagen and found that 60 per cent of their sample were females aged over 60 years with most of the passengers (n=138) sustaining injury whilst the bus was in motion between stops. The vast majority of these (83 per cent) were found to be standing up at the time of the collision.

Similarly, Kirk et al (2003) found that in approximately 65 per cent of cases, there was no actual impact involved and that the injury had occurred to a seated (~44 per cent) or standing (~30 per cent) passenger whilst the bus was in motion. Their study also found that older females were particularly over-represented and that the likelihood of serious or fatal injury to both males and females increases as age increases. The cause of incidents included slippery and uneven floors, high steps and lack of visual cues.

More recently Halpern et al (2012) made similar findings in Israel to those of Kirk et al in that 56 per cent of injuries were sustained by passengers who were either standing or moving in the bus and that the major mechanism of injury was sudden deceleration or acceleration of the bus.

Mabrook (1994) noted that whilst travelling by bus is one of the safest ways to travel, little is written about injuries and injury causation and that some attention could be paid to the design of hand rails or seats which appeared to be the root-cause of many injuries. However, no study to date has made an in-depth appraisal of injury outcomes to users of buses in order to establish the likely injury mechanisms in order

to ascertain which design countermeasures might be feasible in the prevention of such injuries. . Therefore, the aim of this study was to develop a comprehensive accident analysis matching reports of accidents and injury reports where older users of public bus transportation were injured through everyday use of the public bus. The objective was to highlight the key aspects of bus travel that have an impact on the nature of specific injuries and their severity which can be used to inform future design countermeasures.

Methodology

Two main United Kingdom national databases have been used in this study – namely the UK national road accident database known as STATS19 and the Hospital Episodes Statistics (HES) database.

The STATS19 database is a national road accident database which is founded on accident records that are completed by police officers in the event of an accident occurring on the roads in the United Kingdom. To become a record within the STATS19 database, the accident has to be reported to the police and should involve human injury or death. The STATS19 data collection form collects a wide variety of information about the accident (such as time, date, location, road conditions) together with information about the vehicles and casualties involved and the contributory factors (as interpreted by the police). The form is completed at either the scene of the accident, or when the accident is reported to the police. In this study, STATS19 data were analysed for the years 2008-1012.

The Health Episodes Statistics (HES) is a data warehouse containing details of all admissions, outpatient appointments and Accident and Emergency (A&E) attendances at National Health Service (NHS) hospitals in England. This data is collected during a patient's time at hospital and is a records-based system that covers all NHS trusts in England, including acute hospitals, primary care trusts and mental health trusts. Patient confidentiality is strictly maintained within this database.

To establish injury outcomes in relation to accident characteristics, the STATS19 and HES databases have been linked so that accident records are uniquely matched to injury records.

The record-linking process is described more completely in a separate report (Department or Transport, 2012). Linked data were used for the period 1999-2009 during which 41per cent of road accident records in STATS19 were successfully linked to a hospital record.

This study focuses on public bus passengers aged 60 years and over since this is the age at which senior citizens are offered a free bus-pass and therefore where bus travel is most common within this user-group.

Results

1. UK STATS19 Data Analysis

For the 5 year period 2008 to 2012, 17,728 bus/coach passenger casualties were recorded accounting for 2.7% of all known road accident casualty types.

Table 1 – Proportion of bus and coach casualties among all casualties

Year	Bus/Coach casualties	All casualties	Bus/Coach casualties as percentage of total
2008	6,275	230,905	2.7
2009	5,735	222,146	2.6
2010	5,718	208,648	2.7
2011	5,688	203,950	2.8
2012	4,790	195,723	2.4
Total	28,206	1,061,372	2.7

When examining those aged over 60 years, there were 10,010 injured bus/coach passengers nationally over the 5 year period accounting for 8.4per cent of all 60+ casualties (Table 2).

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

Year	Bus/Coach casualties age 60+	All casualties aged 60+	Bus/Coach casualties as percentage of total
2008	2,181	24,484	9
2009	2,113	24,415	8.7
2010	2,010	23,522	8.5
2011	2,048	23,979	8.5
2012	1,658	23,357	7.1
Total	10,010	119,757	8.4

Overall there has been a general trend showing that bus and coach accident casualty costs (which are calculated according to casualty severity) have been declining over the past 5 years (Figure 1). However for the 60+ years there has been no corresponding decline with a peak in 2009 and a dip in 2010 and 2012. Examination of the average costs for the 5 year period shows that the 60+ years account for some 47per cent of the total costs of all bus and coach passenger accident casualties (Table 3)

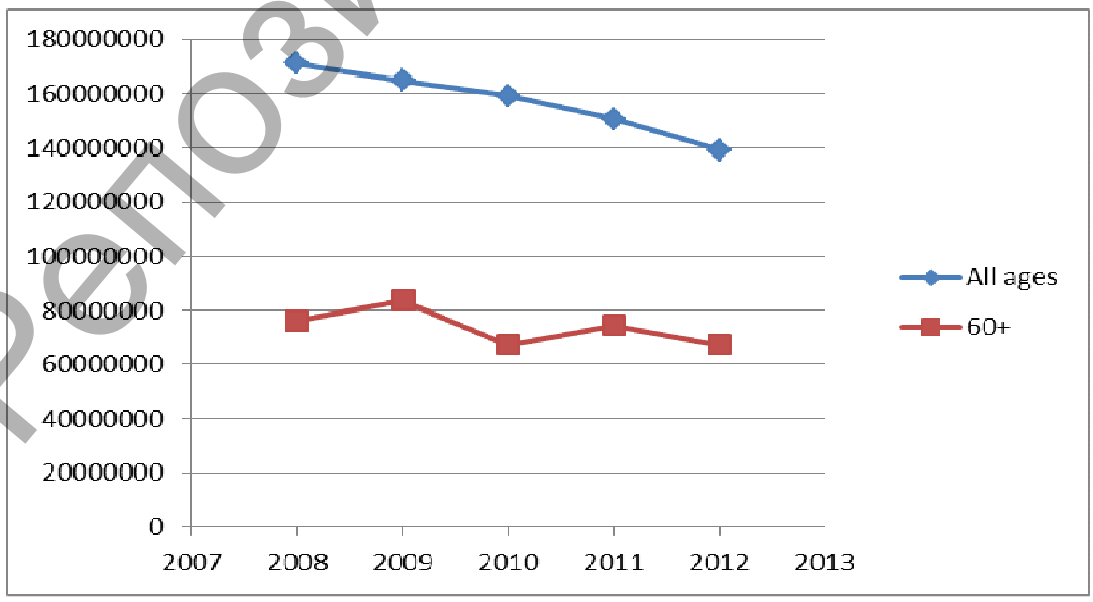

Figure 1 – Casualty costs for all bus and coach passengers and 60 + years

Table 3 – Cost (£) of bus and coach casualties by casualty age and accident year

	All ages (£)	**Age 60+ (£)**
2008	170,960,344	76,211,144
2009	164,918,066	83,517,644
2010	159,303,728	67,247,954
2011	150,555,934	74,388,380
2012	139,011,302	67,395,066
Total	784,749,374	368,760,188

Most bus/coach passengers (94per cent) are recorded as 'slightly injured' casualties with very few fatalities (table 4). The proportion of 'serious' casualties for the over 60 years was higher at 9.6per cent compared to the average 5.9per cent for all ages.

Table 4 – Severity of all bus and coach passenger and those aged 60+ (2008-2012)

	All bus users	**%**	**Age 60+ bus users**	**%**
Fatal	43	0.2	30	0.3
Serious	1,674	5.9	964	9.6
Slight	26,489	94	9,016	90.1

The distribution of age in the over 60 years (table 5) shows that the number of fatalities increased for those in the 70-79 years and 80-89 years age brackets furthermore, there was a corresponding increase in the number of serious injuries. This is further evident in the 60-69 year group where there were similar numbers of casualties as in the 70-79 year group but the proportion of 'slight' injuries was higher in the younger group.

Table 5 – Casualty age by casualty severity - bus and coach passengers aged 60+

	Age 60-69 years	**Age 70-79 years**	**Age 80-89 years**	**Age 90+years**
Fatal	5	12	12	1
Serious	250	344	323	47
Slight	3,425	3,254	2,053	284
Total	3,680	3,610	2,388	332

Passengers are categorised at the time of the incident into a particular location and table 6 shows the distribution of the passenger locations. For all passengers the majority of injuries occurred whilst seated (70 per cent) however for the older passengers the majority were injured whilst boarding the bus (63 per cent). It is also apparent that some 63per cent of the serious injuries and 79 per cent of fatalities whilst standing occurred in the 60 + age group.

Table 6 – Bus and coach passenger severity by passenger location (n=28168) all ages with known location and n=9999 60+ years with known location)

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

2. HES/STATS19 Linked Data Analysis

Overall, a total of 4,352 linked records were available for analysis for the period 1999 to 2009. Of these, some 1,016 records of older (aged 60+) bus / coach passengers were available for analysis with 63per cent of the passengers aged over 75 years (Table 7). Of the 1,016 passengers, 793 were female (78 per cent) and 223 male (22 per cent).

Table 7 – Age distribution of bus and coach passengers aged over 60

Age Category	**Frequency**	**%**
60-64	102	10.0
65-69	102	10.0
70-74	170	16.7
75-79	177	17.4
80-84	246	24.2
85-89	152	15.0
90-94	64	6.3
95-99	3	0.3
Total	1,016	100

Table 8 shows the passenger location, bus manoeuvre and injury severity and also identifies that 62 per cent (n=628) of all casualties occurred following a non-collision incident. The main cause of injury for standing and seated passengers was during normal bus driving manoeuvres mid-journey. As would be expected the boarding and alighting passengers were injured whilst the bus was stationary but 55per cent of all alighting and 40per cent of boarding passengers were recorded as being injured whilst the bus was manoeuvring. This suggests that there may be some discrepancy in the recording of the incidents of which 27per cent were classed as mid-journey across these 2 passenger locations, normally a bus manoeuvre not associated with alighting or boarding. Further to this, the distribution of injury severity identified more ‘serious’ injuries occurring whilst seated and predominantly ‘slight’ injuries occurring on boarding. Overall the risk of injury increased as age increased with 46 per cent of older bus /coach passengers in the 80+ years and only 20 per cent in the 60-69 years.

Table 8 Characteristics of older bus passengers by location

	Collision type (n=1,016)			Bus manoeuvre (n=1,016)				Casualty severity (n=1,016)		Gender (n=1,016)		Age (n=1,016)		
Total n= 1016	**Yes**	**No**	**N/K**	**Mid journey**	**Moving off**	**Slowing down**	**Parked, waiting other**	**Slight**	**Serious**	**Male**	**Female**	**60-69 years**	**70-79 years**	**80+ years**
Alighting (n=143)	9 (6%)	104 (73%)	30 (21%)	26 (18%)	28 (20%)	24 (17%)	65 (45%)	70 (49%)	73 (51%)	35 (25%)	108 (75%)	18 (13%)	45 (31%)	80 (56%)
Boarding (n=103)	2 (2%)	76 (74%)	25 (24%)	9 (9%)	25 (24%)	7 (7%)	62 (60%)	66 (64%)	37 (36%)	21 (20%)	82 (80%)	14 (14%)	28 (27%)	61 (59%)
Seated (n=348)	83 (24%)	181 (52%)	84 (24%)	260 (75%)	25 (7%)	53 (15%)	10 (3%)	136 (39%)	212 (61%)	87 (25%)	261 (75%)	83 (24%)	136 (39%)	129 (37%)
Standing (n=422)	23 (6%)	267 (63%)	132 (31%)	199 (47%)	67 (16%)	132 (31%)	23 (6%)	192 (46%)	230 (54%)	80 (19%)	342 (81%)	89 (21%)	138 (33%)	195 (46%)
	117 (11%)	628 (62%)	271 (27%)	494 (49%)	145 (14%)	216 (21%)	160 (16%)	464 (46%)	552 (54%)	223 (22%)	793 (78%)	204 (20%)	347 (34%)	465 (46%)

In total, the injured bus passengers sustained 1,381 Injuries following the bus / coach incident. The distribution according to body region is as shown in figure 3. As can be seen injuries to the upper extremity, lower extremity and head predominated, with almost one-third of injuries involving the lower extremity.

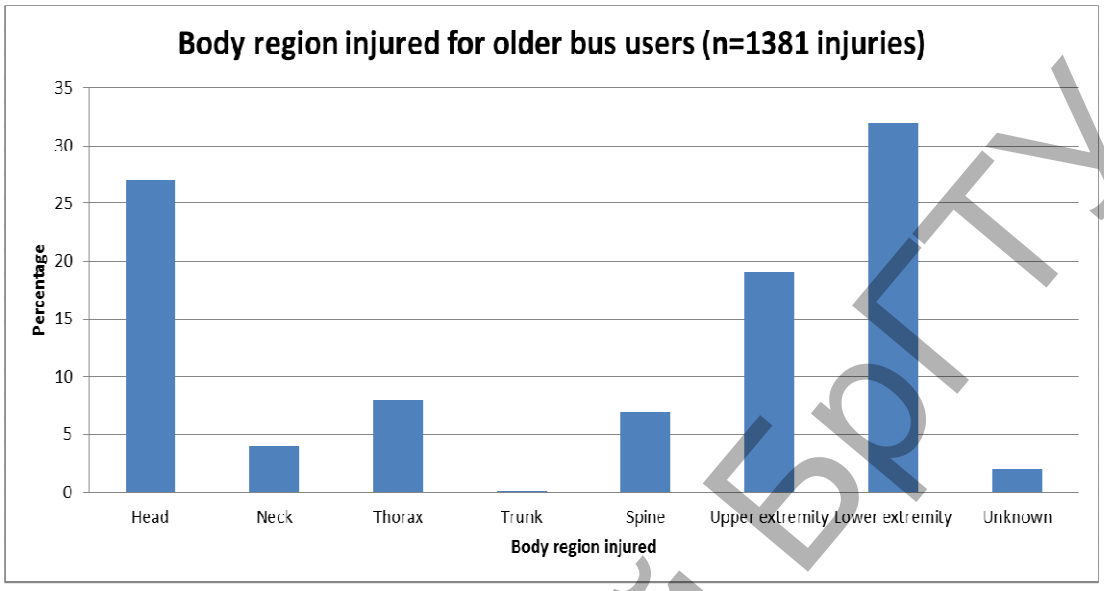

Figure 3 – Body region injured in bus/ coach passengers 60+ years

The distribution of the injuries by body region varied depending on known passenger location at the time of the incident (Table 9, n=1308; this excludes multiple injuries and unspecified injuries). There was a significantly increased likelihood of sustaining more head and chest injuries whilst seated; chest and trunk injuries whilst standing and lower extremity injuries on boarding and alighting (χ^2 109.26 d.f. = 12, $p<0.05$). For upper extremities it appeared not to matter where the passenger was located.

Table 9 – Distribution of body region injured and passenger location

	Alighting (n=190)	**Boarding (n=123)**	**Seated (n=472)**	**Standing (n=523)**	**Total (n=1308)**
Head/neck	37	17	181 *	153	388
Chest	5	7	53 *	48 *	113
Trunk/lower back	11	5	31	49 *	96
Upper extremity	38	20	94	114	266
Lower extremity	99 *	74 *	113	159	445

The severity of the casualties could be further categorised according to the most serious injury sustained by the individual based on their Maximum AIS score (MAIS, Table 10, AAAM 1998). In 18 per cent of cases, an AIS code could not be attributed to at least 1 of the passengers' injuries and therefore the MAIS was unknown. Twenty seven percent of the passengers had MAIS 1 and therefore 'minor' injuries were most severe. 'Moderate' or MAIS 2 injuries accounted for 28 per cent of passengers and 26 per cent of passengers sustained 'serious' (MAIS 3) injuries. 1.5 per cent of passengers sustained MAIS 4+ ('Severe' to Maximum) injuries.

Table 10 – Distribution of MAIS categories for passengers 60+ years

	N=1,016	%
MAIS 1	275	27.1%
MAIS 2	284	28%
MAIS 3	261	25.7%
MAIS 4	11	1%
MAIS 5	1	0.1%
MAIS 6	4	0.4%
MAIS 9 (unknown MAIS)	180	17.7%

Interestingly and as can be seen in figure 4, the distribution of passengers with a known MAIS injury severity and their corresponding police injury severity code reveals a variation between the two severity ratings. Whilst there is some consistency at the MAIS2 level, there is a notable difference in the MAIS3+ category where some 37 per cent (n=102) of passengers who were clearly 'Seriously' injured (due to sustaining MAIS3+ injury) were categorised as 'Slight' in the police STATS 19 records. This suggest that under-reporting of injury severity may be a significant issue in the UK Police reporting system.

Figure 4 – Frequency of known MAIS and police casualty severity classification

The distribution of known MAIS for passenger location suggests that there was a significant likelihood of sustaining MAIS 2 and MAIS 3+ injuries when standing (Table 11). Alighting passengers also were at risk of a significantly increased likelihood of sustaining serious (MAIS3+) injuries. For those passengers boarding and being seated on the bus, their injury severity was more likely to be minor (MAIS 1) injuries (χ^2 28.23 d.f.= 6, p<0.0001).

Table 11 – Distribution of MAIS by passenger location

Total n=836	MAIS 1	MAIS 2	MAIS 3+
Alighting	32	42	52 *
Boarding	47*	27	15
Seated	98*	90	83
Standing	98	125 *	127 *

Alighting and boarding buses were both significantly more likely to cause injuries for the older passengers 80+ years. Passengers between 60 and 79 years were significantly more likely to sustain injuries whilst seated whereas the data suggests that all ages are at risk of injury whilst standing on buses; although the 60-69 year age group have a slightly increased likelihood of sustaining injuries standing (χ^2 41.07 d.f. = 9, $p<0.0001$).

Discussion

Although UK national injury rates are low for bus and coach passengers (2.7 per cent) the age-group 60+ years are over represented in the casualty figures (8.4 per cent). Furthermore some 47 per cent of the overall bus and coach casualty costs were attributed those aged over 60 years. These higher figures possibly reflect the higher exposure to this transportation method compared to younger travellers however the injury risks associated with the physiological effects of ageing are also higher. This factor was evident in this study as the rate of 'serious' injury tended to increase with age. Interestingly and as was found in other studies, non-collision incidents predominate in injury causation for bus / coach passengers (Jovanis 1991; Kirk et al 2003).

Passenger location at the time of the incidents also had an impact on the injury outcome in terms of body region injured and also injury severity. The main body regions injured were the head and the lower and upper extremities and 'standing' was associated with sustaining more injuries, closely followed by being seated. Intuitively, this points towards loss of balance during various vehicle manoeuvres. When examining the severity of injuries using the Maximum Abbreviated Injury Scale (MAIS) level it was identified that 'Standing' and 'Alighting' were the main passenger actions for sustaining 'serious' MAIS 3+ injuries. 'Boarding' and 'Seated' passengers tended to sustain injuries that were more 'minor' (MAIS1) in nature. Previous studies have also identified standing passengers to have higher incidences of injuries (Moller, Halpern and Albreksten) whilst the study by Kirk et al identified high incidences in 'seated' passengers (Kirk et al, 2003).

Many incidences of injury have been associated with sudden braking or accelerating although this study tended to reveal higher incidences of injury that occurred in the mid-journey phase (46 per cent; Halpern 2005). However particularly noticeable was the discrepancies in passenger location and bus manoeuvres - it would be expected that alighting and boarding incidents would be associated with a 'parked' or 'stationary' vehicles but this was only recorded for 45 per cent and 60 per cent of these incidents respectively. 20 per cent of alighting incidents were recorded during 'moving off' manoeuvres which are of concern since passengers should have exited from the vehicle prior to the bus departing. In addition, some 24 per cent of boarding incidents were classed as 'moving off' and it is presumed that these represent incidences whereby the driver continued the journey before the passengers were correctly seated. This categorisation of passenger location is somewhat limited for examining injury causation as there is scope for error and subsequent misclassification as alighting incidents could be associated with moving through the bus or standing prior to getting off both of which can be interpreted as 'standing' whilst in the process of alighting the bus. For injury prevention strategies extra passenger location codes would be of future benefit in the design of countermeasures.

Analysis of the linked data allowed for injuries to be explored further and the varying severity levels to be collated and coded to an internationally recognised injury scale. What was highly evident in this study was the mismatch between police severity categories and hospital severity categorisation of the same injuries. Of most concern with regard to MAIS3+ injury severity is that 37 per cent of these injuries were categorised as 'Slight' in the STATS19 data. Similarly 51 per cent of 'Moderate' injuries, often consisting of fractures to the wrist, ribs or spine, were categorised as 'Slight' whereas the STATS20 guidelines clearly indicate that such injuries should be coded as 'Serious' casualties. These inaccuracies in the STATS19 data have been highlighted previously (Jeffrey et al) but it is evident that a large proportion of casualty severities in this study were miscoded in the STATS19 data suggesting that the morbidity and casualty costs are also under-estimated. This issue has been addressed and recommendations for helping police officers to more accurately categorise injury severity at the scene are being proposed (Ward et al 2006).

Another limitation includes the small number of road accident records that were linked for bus and coach passengers which probably leads to under-representation (1 per cent). Furthermore it was found that whilst 58 per cent of linked casualties were correctly coded as 'Serious' with the remainder being coded slight, 42 per cent of road accident injury statistics may be underestimated in terms of severity.

One of the main aims of the study was to establish injury causation patterns of older bus passengers and overall the national data has provided an insight into these issues but there is potential for under-recording of injury severity and also cause associated with passenger locations. It is recommended that extra passenger location codes are included within the police CRASH system for collecting data. Furthermore the recommendations from Ward if adopted would improve the police reporting of 'slight' and 'serious' casualties. These analyses used national datasets and are limited to those incidents reported to the police and for those linked cases who attended hospital. Further analysis will be undertaken of Bus Company data where it is expected that higher number of incidents occur that are not required to be reported to the police and therefore do not appear in any national data but are potentially rich sources of data for exploring injury causation in detail.

Overall, the results from this study suggest that sufficient information can be gained in order to consider countermeasures to injury during bus–use although more detailed information from in-depth studies would be of benefit. One of the main considerations for injury prevention includes an appraisal of existing operational procedures to ensure that in all cases, passengers have properly exited form vehicles or are correctly seated at the time the bus moves away from the stop. This could be easily achieved without radical (if any) changes to the design of the bus interior. Redesign of bus interiors is a somewhat different proposition but this could be achieved providing accurate information about injury causation is recorded. At the moment, there is scope for improving the data collection process for incidences on buses, especially where serious injury has occurred and this study suggests that an injury surveillance system relating to the more serious events would be of great benefit to the community.

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