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Analysis of injuries to young and old Victorian public transport users: 2006 to 2010

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Analysis of injuries to young and old Victorian public transport users: 2006 to 2010

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Abstract

An injury analysis was undertaken of young and older transport users from 5 years of injury surveillance data collected at participating trauma hospitals in Victoria, Australia. The analysis was undertaken for inclusion in the UK project on Improving the Safety for Older Public Transport Users. Details of injuries were recorded on attendance including the patients' account of the circumstances of the accident and causation factors. Results showed that injury risk was more common among bus passengers than those on either trams or trains. The most common injuries were to the head and face regions and upper and lower limbs. Chest injuries were especially problematic among older travellers and they sustained more multiple life-threatening injuries than their younger counterparts. Entering or exiting the vehicle accounted for almost two-thirds of all injury-causing events. The most common mechanisms involved a slip, trip or fall while getting on and off the vehicle or while on-board or running to catch public transport. Being hit, struck or crushed by another person or an object was also noted. Injuries to older public transport users was positively correlated with increasing age. The majority of those injured required out-patient treatment at the participating hospital but was dependent on the participant's age. Opportunities for intervention included improved boarding and exiting facilities at bus and tram stops and reducing hazardous structural members inside these vehicles would be helpful. A number of limitations in this study were noted and areas requiring further research were identified for future studies. The need for more definitive in-depth studies of public transport injurious incidents was especially noteworthy.

Keywords: public transportation, safety, accidents, ageing, injury, surveillance, mechanism of injury, outpatients, interventions, research.

1 Introduction

This study was carried out as part of the research project on Improving Safety for Older Public Transport Users program for the Medical Research Council (MRC) in the UK. The study by Fildes and Morris [1] set out to analyse the nature and circumstances of injuries that afflict younger and senior citizens according to public transport mode to specifically outline mechanisms of injuries and that occur to older public transport users. While it is based on surveillance data collected in Victoria, Australia, it is argued that many of the findings are still of some relevance to public transport users in the UK. Besides, it provided an international comparison as a benchmark for comparing with similar findings in the UK.

Injury surveillance data in Victoria is collected and managed by the Victorian Emergency Minimum Dataset (VEMD). It is a valuable source of information for injury prevention, containing de-identified demographic, administrative and clinical data. These data are collected from presentations at various public hospitals across Victoria that receive a non-admitted emergency services grant by VicHealth [2]. In order to maintain and protect patient privacy, only the minimum data required for effective analysis purposes are included.

Collection processes are based on standard definitions and collection protocols to ensure comparability over time and across geographical and agency boundaries. Definitions of patient categories and other terms used in the VEMD are set out in the most recent VEMD Manual. Where possible, these conform to the definitions in the National Health Data Dictionary, published by the Australian Institute of Health and Welfare (AIHW), and the DHS Common Client Dataset.

1.1 Public transport in Victoria

Public Transport Victoria is a statutory authority of the Victorian Government that administers the states' train, tram and bus services. According to Charting Transport [3], public transport trips per kilometre was around 11% of all journeys in Melbourne in 2009 (private motor vehicle trips accounted for 89%). The same year, "The Age" newspaper (Lucas [4]), noted that there had been no growth in private car travel over the preceding 5 years. Conversely, public transport use (trains, trams and buses) in Melbourne rose from 36 million boardings to 50 million between 2000 and 2009 (Gardiner [5]).

Serving the residents of the Melbourne Metropolitan area is challenging, given its relative small population, hence public transport systems tend to include radial train services from the central rail station with connection trams and buses in the outer regions. The city is blessed with a matrix of tram and bus services to cater for its growing business and commercial activities. Most of these services are operated by private organisations, under contract to Public Transport Victoria. Photographs of typical public service units are shown in Figures 1 to 3.

1.2 Boarding and alighting infrastructure

Boarding and alighting infrastructure for public transport in Melbourne is quite variable. Older buses tend to discharge and collect passengers at roadside stops (as

Figure 1: Melbourne tram.

Figure 2: Metro train.

Figure 3: Smartbus.

shown in Figure 3) where passengers have to “step up to board”. More modern buses do have low floor or adjustable heights to improve access. Locations adjunct to other feeder services also offer improved, isolated and safer access (in Figure 7).

Similarly, tram stops in and around Melbourne suburbs vary considerably from on-road locations where the traffic is expected to stop to allow passengers to cross the road (Figure 4) to more recent designs with isolated raised island platforms (Figure 5). As trains run on separated tracks, their stations are generally purpose-built and generally allow at-level access (Figure 6).

Figure 4: On-road tram stop.

Figure 5: Melbourne, “Superstop”.

Figure 6: Melbourne railway station.

Figure 7: Bus and train interchange.

1.3 Interior design

Interior design of trains, trams and buses can be an issue when it comes to passenger security and comfort. Figures 8 and 9 illustrate the interior designs of the E-Class tram and X'trapolis train passenger infrastructure. With the introduction of new train and train designs, these interior designs have gone through a variety of changes over recent years. Generally, they seemed to have improved travel and safety, although little evidence is available on this.

Figure 8: E-Class tram interior.

Figure 9: X'trapolis train interior.

1.4 Public Transport safety

Very few papers were found on the level of safety of the Public Transport system in the state of Victoria. Travelling on a bus or tram is one of the safest ways to travel in Melbourne but they note various things a traveller should do to keep safe while waiting for a bus or tram, getting on or off, and while in transit. Most of these issues relate to personal security while travelling.

Public Transport Victoria note on their website the need for boarding and getting off trains (and trams) safely. They specifically note the need for using the grab rails to steady yourself when boarding or alighting and preparing to alight before reaching your destination. They further stress the need to take a seat or steady yourself by holding a grab rail if you are standing and offering a seat to elderly people or those with special needs and pregnant women. Unfortunately, little information on the effectiveness of these measures.

The World Health Organisation [6] reported that safe public transport systems need to be viewed as an important way of improving safe mobility, especially in urban areas with increasing traffic congestion. There has been strong emphasis in many high-income cities, to decreasing individual car use through investments in public transport systems. Investing in safe public transport is also seen as a mechanism to encourage increased physical activity and thus promote health. Many countries have policies to invest in regulated public transport offering considerably safer travel than in private cars. They particularly note that in many developing regions, growth in unregulated and unsafe public transport has led to increases in road traffic injuries among public transport users. Governments must ensure that public transport systems are safe, accessible and affordable.

A study in the UK by Barnes *et al.* [7], explored how older users were injured on buses and the potential design solutions for preventing injury. The analysis covered a limited dataset of police and hospital records, covering only a small percentage of all bus injuries in the UK. They reported that most incidents were non-collisions (62%) resulting in non-fatal injuries in those aged 60+ years. The highest cause of injury for older users with a fairly even split between slight and serious police rated casualties. Causes of these injuries were attributed to standing and alighting passengers with the more serious sustained while standing. They noted that areas of concern within the bus were from internal structures and the lack of handrails resulting in falls when the bus stops suddenly in an emergency.

Civitas [8] reported on a new initiative undertaken in Ljubljana to improve the safety and security on public transport for senior citizens on buses. They installed video surveillance systems on 109 buses to discourage offenders of public law and order on buses and to measure their effectiveness. They reported an 18% reduction in Injuries of PT users, with a 12% increased perception of security when using PT service, with fewer complaints by PT users and substantial increases in assistance from drivers, and reductions in vandalism costs.

2 Method

To help address this shortfall, an analysis was undertaken of injuries to public transport users in and around Melbourne, the capital city of the state of Victoria. Data were obtained from two sources. First, the Victorian Emergency Minimum Dataset (VEMD) containing de-identified demographic, administrative and clinical data, collected from presentations at various public hospitals across Victoria that receive emergency attendances in Victoria. Second, from the National Coronial Information System (NCIS) is a collection of coronial data on deaths reported to the Australian coroner from 2000 onwards and the New Zealand coroner from 2007 onwards. However, only the findings from the VEMD database analysis are reported here, due to space restrictions.

3 Results

The injury sample was based on 3,152 public transport related unintentional injury cases listed on the Victorian Emergency Minimum Dataset (VEMD). This number includes persons who sustained an injury while on a train, tram or bus in the state of Victoria as well as person hit by public transport, injured while running to catch public transport or injured on train/tram tracks.

It included all persons (by age and sex) who attended a contributing Victorian hospital between 2006 and 2010.

3.1 Demographics

Table 1 shows the demographics of the sample of those who sustained an injury and presented to a Victorian hospital during the study period. Of interest, there were relatively consistent numbers of hospital attendances each year in the state

of Victoria from public-transport related injuries, roughly spread across the three age groups. While the three age groups were roughly equal in terms of attendances, older people were, however, over-represented compared to their younger counterparts when adjusted for their percentage of the population. Interestingly, females were around 5 percent over-represented in transport-related injuries compared with males when adjusted for their population percentage.

Table 1: Demographics of the 5-years of hospital presentations in Victoria.

Factor	Number (n=3,152)	Percent	Population Adjusted
Year			
2006	575	18%	-
2007	632	20%	-
2008	636	20%	-
2009	683	22%	-
2010	626	20%	-
Age Group			
<30 years	1,098	35%	25% (40% pop)
30-59 yrs	1,003	32%	22% (42% pop)
60+ yrs	1,050	33%	53% (18% pop)
Sex			
Male	1,386	44%	45% (49% pop)
Female	1,766	56%	55% (51% pop)
Transport			
Train	884	28%	-
Tram	1,097	35%	-
Bus	1,171	37%	-

NB: Population figures only available for June 2005

3.2 Injury causing events

The interviews by the public transport user about their injuries and the cause of their injuries on presentation at a participating hospital are shown in Table 2. They also provided a short statement about the events leading up to their injuries and outcomes. These statements are the basis for prescribing their injury-causing event. The results show that injuries among bus passengers were more frequent than either tram or train injuries. Getting on or off the bus accounted for almost half of these public transport passenger injuries, compared to only 15% for train passengers. Hit by a tram, especially on the tram tracks, and getting on and off the vehicle accounted for the majority of all tram injuries.

Getting on or off, as well as accidents while on public transport units, accounted for almost two-thirds of all injury-causing events on the three forms of public transport. As shown in Table 3, those aged 60 or more were particularly over-represented for these types of injury-causing events, especially if these findings are adjusted for their small numbers in the population. Running to catch a public transport unit was involved in almost one-quarter of injury-causing events during the analysis period.

Table 2: Public transport use by injury-causing event (n=3,152).

Injury causing event	Train	Tram	Bus	Total (event)
Getting on/off and on the unit	303 (15%)	752 (37%)	975 (48%)	2030 (64%)
Pedestrian hit by public transport	40 (18%)	119 (55%)	58 (27%)	217 (7%)
Running to catch public transport or injured at the stop	465 (64%)	126 (17%)	134 (18%)	725 (23%)
Pedestrian hit on the tracks	76 (43%)	99 (57%)	-	175 (6%)
Other unspecified	-	2 (33%)	4 (67%)	6 (0%)
Total	884	1098	1170	3152
(proportion of transport)	-28%	-35%	-37%	-100%

Those aged 80 or more were almost twice as likely to sustain an injury while using public transport in Victoria (and around three times when corrected for their lower exposure), and therefore even more dangerous for them, reflecting their increased mobility and frailty. The older public transport users (those aged 80 or more) were seemingly at higher risk of injury in getting on and off or while travelling on the bus, tram or train. However, consistent with younger users, even those aged 80 or more were still likely to sustain an injury while running to catch public transport or at the stop.

Table 3: Injury causing-event by age-group (n=3,152).

Injury causing event	<30 yrs	30-59 yrs	60 plus yrs	Total (event)
Getting on/off and on the unit	672 (61%)	590 (59%)	768 (73%)	2030 (64%)
Pedestrian hit by public transport	104 (9%)	81 (8%)	32 (3%)	217 (7%)
Running to catch public transport or injured at the stop	255 (23%)	263 (26%)	206 (20%)	725 (23%)
Pedestrian hit on the tracks	67 (6%)	67 (7%)	41 (4%)	175 (6%)
Other unspecified	-	2 (33%)	3 (67%)	5 (-)
Total	1099	1003	1050	3152
(proportion of age-group)	-35%	-32%	-33%	-100%

3.3 Hospital attendance

As shown in Table 4, the majority of those attending a participating hospital were treated as out-patients and sent home after treatment. Of particular note, people aged 60 or more were two to three times more likely to be admitted to hospital from sustaining an injury in a public transport accident, considering their lower exposure. Furthermore, the likelihood of admittance increased with increasing age beyond 60 years (those 80 or above were three times more likely than 60 yr olds).

Table 4: Attendance by age group for those injured in public transport (n=2,028)*.

Attendance status	Age group			
	<30yrs	30-59yrs	60+yrs	Overall
Admissions	12%	10%	28%	17%
Out-patient treatment	88%	90%	72%	83%
Unspecified	0%	0%	0%	0%
Total	671 (33%)	590 (29%)	768 (38%)	2028

*The 2028 is a subset of public transport users on trains, trams and buses from the overall number of PTU cases reported in VEMD.

3.4 Injuries sustained

The injuries sustained by those presenting were categorised by age and sex, body region injured and nature of the main injury. The findings by body region injured for all age groups as well as those aged 60 plus are shown in Appendix 1. Of particular interest, the most frequent injuries to all those who presented were to the head and face region (18%), followed by the ankle (10%), knee (9%), lower leg (7%) and the shoulder (6%). For those aged 60 or over, the injury patterns were quite similar, apart from the extra 8% injuries to the thorax (chest). It should be stressed that injuries to the head and chest are commonly considered to be serious life-threatening injuries.

Older transport users sustained a sizeable 38% of all body region injuries, which again illustrates their over-representation when taking into account their smaller population numbers (exposure). Given their increased frailty, these injuries are likely to lead to severe consequences in terms of threat to life and increased disabilities.

4 Discussion

The analysis undertaken focused on public transport injury events that occurred in the State of Victoria between 2006 and 2010. These years were selected as they represented the most recent forms of injurious events and hence relevant to today's forms of public transport systems. The three most prominent form of public transport namely trains, trams and buses were focused on, given their predominance in Victoria. While the primary focus of the analysis was on older persons, injuries to all adults were included for comparison and to try and tease out the ageing effects from overall injury trends.

4.1 Mode of public transport usage

The results show that injurious events among bus passengers were more frequent than either tram or train events (37% c.f. 35% and 28%). Lagura *et al.* [9] reported that daily trips by bus in the Melbourne metropolitan area in 2005 were significantly less than those by tram and train (19% c.f. 38% and 43%). While the usage rate for buses in Victoria is likely to be much higher in rural areas, given

their predominance as the primary mode of travel in these outer regions, nevertheless, these findings do suggest that bus travel is associated with a higher risk of injury than the other two modes. While injury causing events are discussed in the following section, it is not clear why buses are more hazardous for all travellers and particularly seniors.

Little evidence was found to confirm these findings. RED [10] reported the average numbers of injuries and deaths for travel modes across all Australia. While death and serious injury rates were significantly lower for all forms of public transport (less than one percent compared with motor cars), buses were twice that of trains and much more than trams. Fact Sheet, Trams in Edinburgh [11] claimed evidence shows that trams have few accidents when compared to other transport modes (although this evidence was not disclosed). AASHTO [12] argued for public transport in the USA needs to improve these services for the elderly and special needs populations by better coordination and improvement of services (presumably including their safety).

4.2 Injury causing events

The injured public transport users limited statement about the events leading up to their injuries, collated into five injury-causing events, showed that “*getting on or off the vehicle*”, as well as accidents while on public transport units, accounted for almost two-thirds of all injury-causing events across the three forms of public transport. The analysis of what caused the injury and the mechanism of injury was dependent on the limited statement of the events leading up to sustaining the injury. In addition, not every participant was able to report these events, either through lack of memory or inability. Nevertheless, for those who could, “*get on or off the vehicle*”, as well as accidents while on public transport units, accounted for almost two-thirds of all injury-causing events across the three forms of public transport, and surprisingly, more frequent among bus passengers than those of either trams or trains.

Bjornstig *et al.* [13] also reported similar proportions in his study of injured bus occupants. Those aged 60 or more were particularly over-represented for these types of injury-causing events, both in terms of numbers and exposure. As noted in the results, running to catch a public transport unit was involved in 23% overall and buses, again, were over-represented here.

4.3 Injuries sustained and nature of the injury

The analysis revealed a significant number of injuries to these public transport users. As noted earlier, the most common injuries from public transport accidents were to the head and face region. Less common, but still noteworthy, were injuries to the lower limbs and the shoulder. For those aged 60 or more, the injury patterns were quite similar apart from an increase in chest injuries. However, older transport users sustained more injuries in all body regions and were more likely to have sustained multiple injuries generally compared with comparative younger injured adults. This was also reported by Bylund *et al.* [14] in their study of Special Transport Services in Sweden where they noted that many of these injuries when the vehicle was at a standstill. Bjornstig and his colleagues also reported that two-

thirds of the injuries to bus occupants occurred while the bus was stationary, and predominantly among older occupants.

The predominance of injuries to the head from public bus incidents in the USA was also noted by Olivares and Yadav [15] involving mainly senior occupants. They further observed that many of these head injuries occurred from body-to-body contacts between unrestrained passengers as well as impacts with seatbacks and other internal structures and argued for greater improvement in structural design and seat belts to restrain occupants in a collision. Bjornstig further reported that the frequent injuries among injured occupants from bus and coach passengers were to the head/neck and extremities (as found in this study). Clearly, head and chest injuries need to be avoided as they are major life-threatening injuries.

4.4 Injury mechanisms

It should be stressed that the analysis of what was the mechanism of injury to each of the participants was dependent on their brief statement of the events leading up to their injury. While not every participant was able to verbalise these events, nevertheless, these statements throw some limited light on what the most common mechanism of injury category was. From these statements, the overwhelming "mechanism" was from a slip, a trip or a fall while either getting on or off the vehicle or while on board, accounting for two-thirds of all the mechanisms of injury among older people. Being hit, or struck or crushed by person or an object was also noteworthy. It was not possible to breakdown the injury mechanisms on these public transport units any further using these data.

In analysing the Swedish Traffic Accident Data Acquisition system, Berntman *et al.* [16] noted that while the injury risk for bus passengers is low compared to car users, passengers do still run the risk of sustaining injuries, especially for seniors. They noted that older people were over-represented in bus-related injuries from falls on pedestrian paths, inside the bus, while entering or exiting the bus, or from collisions. These findings concur with what was found here. They further noted that passengers hit various interior parts of the buses, such as stanchions, sharp edges, glass barriers or seats inside the bus. No similar analyses were found for injuries on trains and trams though which clearly show the need for a more detail in-depth study.

Yarra Trams in Melbourne noted that passengers on trams (and possibly buses and trains too) need to follow five "Golden Rules" for their own personal safety. These include (i) hailing a tram driver as the unit approaches to alert the tram and passenger cars of intent to board, (ii) holding on while on-board to maintain stability and avoid surprise acceleration and deceleration forces, (iii) maintain a sturdy stance to position yourself to absorb forward and backward movements of the vehicle, (iv) seek a seat wherever possible, even on short trips (this would seem especially important for older people), and (v) plan your parting or departure from the vehicle and be careful when alighting, ensuring the vehicle has fully stopped and watch for passing cars.

While these all seem sensible strategies for all public transport users, it is clear from the evidence presented here that not all passengers obey these rules no doubt for a variety of reasons. Moreover, as some of the mechanisms observed here

suggest, there is also scope for more closely examining the engineering aspects of these public vehicles to minimise or prevent injuries when passengers, knowingly or not, find themselves in a vulnerable position. This could include eliminating sharp edges and unnecessary stanchions, and an increase in padding hard surfaces. A lesson from road safety is that engineering the situation to protect the passenger is much more likely to be an effective safety strategy than expecting the passenger to modify their behaviour.

4.5 Intervention

The available data for this analysis was not sufficiently detailed to permit a definitive list of interventions to be identified and prioritised. However, from the numbers of events reported and the injuries sustained, a few possible key solutions seemed relevant. These included:

- At-grade entry and exit for all three modes of travel would conceivably help to address problems for users getting on and off these vehicles. External islands or platforms to the vehicle itself on entry or exit would help to address this (a program is currently underway in and around Melbourne at high volume tram stops);
- Alternatively, or in addition, low floor buses and trams that require less step-height from the curb would help especially older users enter or exit;
- Removing or padding structural hazards inside these vehicles may help to address injuries that occur to free-standing occupants on losing balance during sudden braking or acceleration;
- Vehicle design that maximises seating capacity would go some of the way to minimise the risk of slipping or stumbling on-board; and
- Education to alert public transport users of the dangers they face when using these services would be worthwhile, although it is recognised that engineering away the problems and difficulties they face is more likely to be effective than relying entirely on behavioural change.

4.6 Strengths and limitations of the study

This analysis provided evidence of passenger injuries on three major Victorian public transport services, their causes, relative frequency, and age-related effects. Given the paucity of studies in this area, it is a valuable contribution to public health in the region and adaptable to other countries that provide similar services.

However, there were several limitations in this research that need to be highlighted from this research.

- The analysis was based on surveillance data at a number of participating trauma hospitals in Victoria. It focused on survival injury incidents on the three main forms of predominantly urban public transport.
- These data are essentially subjective reports and their widespread representativeness is unknown.
- None of the cases reported to the VEMD involved a fatal outcome at the time of reporting. It is recognised that fatal incidents are likely to show different injury characteristics and causes than those reported here.

- These data were limited in terms of detailed objective analysis and missing a number of important characteristics such as crash and injury severity and source of injury.
- Detailed exposure data that precisely matched the injury events was unavailable to permit accurate relative risk estimates to be made.

While it is based on surveillance data collected in Victoria, Australia, it is argued that many of the findings are still of some relevance to public transport users in other western countries. Besides, it provides an international comparison as a benchmark for comparing with similar findings in the UK.

Appendix 1: Injuries sustained by age group (n=3,152).

Body region injured	<30yrs	30–59 yrs	60 plus yrs	Total (event)
Head, excludes face	92 (14%)	54 (9%)	93 (12%)	239 (12%)
Face, excludes eye	36 (5%)	27 (5%)	50 (7%)	113 (6%)
Neck	22 (3%)	27 (5%)	16 (2%)	65 (3%)
Thorax	11 (2%)	31 (5%)	65 (8%)	107 (5%)
Abdomen	1 (0%)	9 (2%)	3 (0%)	13 (1%)
Lower back	14 (2%)	30 (5%)	18 (2%)	62 (3%)
Pelvis	4 (1%)	2 (0%)	11 (1%)	17 (1%)
Shoulder	29 (4%)	40 (7%)	49 (6%)	118 (6%)
Upper arm	7 (1%)	10 (2%)	21 (3%)	38 (2%)
Elbow	37 (6%)	18 (3%)	18 (2%)	73 (4%)
Forearm	30 (4%)	10 (2%)	18 (2%)	58 (3%)
Wrist	31 (5%)	21 (4%)	37 (5%)	89 (4%)
Hand, includes fingers	42 (6%)	31 (5%)	28 (4%)	101 (5%)
Hip	6 (1%)	13 (2%)	57 (7%)	76 (4%)
Thigh	7 (1%)	9 (2%)	7 (1%)	23 (1%)
Knee	57 (8%)	54 (9%)	80 (10%)	191 (9%)
Lower leg	29 (4%)	28 (5%)	90 (12%)	147 (7%)
Ankle	91 (14%)	77 (13%)	27 (4%)	195 (10%)
Foot, includes toes	35 (5%)	37 (6%)	18 (2%)	90 (4%)
Unspecified body region	6 (1%)	8 (1%)	7 (1%)	21 (1%)
Multiple injuries	44 (7%)	41 (7%)	43 (6%)	128 (6%)
Body region code not req'd	33 (5%)	11 (2%)	8 (1%)	52 (3%)
FB in eye	6 (1%)	3 (1%)	3 (0%)	12 (1%)
Total (proportion of age-group)	1098 (35%)	1004 (32%)	1050 (33%)	3152 (100%)

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