

A background image showing a group of people walking on a paved sidewalk. In the foreground, an elderly woman with white hair, wearing a light purple top and a blue patterned skirt, is walking. Next to her is another elderly woman in a red jacket. To the right, a younger woman with long dark hair, wearing a black t-shirt and light blue shorts, is walking. The image is slightly blurred, suggesting movement.

## **Accident patterns in the ageing population: non-collision injuries on public transport and injuries of single pedestrians**

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## Executive Summary

Two particular areas of concern in addition to the more well researched aspects of accident patterns in the ageing population are those of non-collision injuries in public transport and single pedestrian accidents. Although the research base for these forms of accidents is slender, the data are consistently suggestive of a significant need for both concern and further research, and to ensure that the factors underlying these accidents are addressed so as to enhance preserved safe mobility for older Europeans. A particular impetus is also given by the possibility that current policies in some European countries, such as medical screening of older drivers, may give rise to increased use of both public transport and walking.

A search was undertaken on the Transportation Research Board TRID, MedLine (PubMed), CINAHL and PSYCHINFO databases using the search terms: a) 'non-collision', bus, public transport, injuries, accidents, and b) falls, older people, single pedestrian accident. The resulting papers were screened for relevance to one or both topics.

One of the earliest studies reviewed accident data over a period of 12 months supplied by 30 bus operators, and covering about 30000 vehicles in the UK in 1980. Fifty-six per cent of the passenger injuries were sustained in non-collision accidents and 43 per cent of these occurred to passengers who were estimated to be over 60 years of age. This general pattern is reflected in research from Sweden, USA and Ireland.

Although falls among older people have been recognized as a significant public health issue for many decades in Europe, a relatively new interest in traffic medicine is the extent to which these occur outdoors and particularly in geographical areas which can be considered to form part of the traffic environment.

The greatest challenge to delineating the extent of the problem is that these injuries and deaths are poorly captured in official statistics: most road traffic accident databases do not capture single-pedestrian accidents, and most falls and hip fracture databases do not capture the location of the fall, whether indoors, in garden/yard, or the traffic environment. This is despite the fact that ICD-10 classification systems commonly used in the developed world can code for an outdoor fall, but is frequently not recorded.

One of the largest studies available, (MOBILIZE in Boston USA), is a longitudinal analysis of a population aged 70 and over which indicated that indoor falls occurred mostly among the older old, and outdoor falls occurred predominantly among the younger old and fitter people with higher levels of activity. Indeed, this heterogeneity is also likely to apply also to measures to prevent both falls and single-pedestrian accidents among older people.

There is mounting and consistent evidence, albeit on a slender research portfolio, that non-collision injuries on public transport and single pedestrian injuries represent a significant risk to the health and



well-being of older Europeans. It is of critical importance that traffic injury recording systems are broadened, to include both types of accidents.

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## **1. Introduction: Towards an understanding of the full spectrum of traffic related injuries among older people**

The development of a traffic system that is age-attuned needs to take account of both mobility and safety issues, in particular in terms of interventions which lead to a change in the relative proportion of modes of transport utilized, as has been postulated for the impact of medical screening of older drivers (O'Neill 2012).

From a safety perspective, it is becoming clear that the statistics for traffic-related injury have been dominated by impacts between motorized vehicles and either other motorized vehicles or unprotected road users to the point of neglecting other significant forms of traffic-related injury.

Two particular areas of concern are that of non-collision injuries in public transport and single pedestrian accidents. Although the research base for these forms of accidents are slender, the data is consistently suggestive of significant need for both concern and further research, and to ensure that the factors underlying these accidents are addressed so as to enhance preserved safe mobility for older Europeans. A particular impetus is also given by the possibility that current policies in some European countries, such as medical screening of older drivers, may give rise to increased use of both public transport and walking (Hakamies-Blomqvist, Johansson et al. 1996).

## **2. Method**

A search was undertaken on the Transportation Research Board TRID, MedLine (PubMed), CINAHL and PSYCHINFO databases using the search terms: a) 'non-collision', bus, public transport, injuries, accidents, and b) falls, older people, single pedestrian accident. The resulting papers were screened for relevance to one or both topics.

## **3. Non-collision injuries in public transport**

Non-collision bus injuries have assumed an increasing importance, given knowledge that such injuries can be serious, and account for a significant proportion of bus and coach injuries across the lifespan. One of the earliest studies reviewed accident data over a period of 12 months supplied by 30 bus operators, and covering about 30000 vehicles in the UK. Fifty-six per cent of the passenger injuries were sustained in non-collision accidents and 43 per cent of these occurred to passengers who were estimated to be over 60 years of age: in terms of the relative concern for older people, contemporary surveys suggested that elderly passengers average less than 20 per cent of all passengers carried. Reported accident rates for females over 60 years of age were higher than those for males in this age group. Boarding accidents formed an especially significant proportion of accidents to the elderly and gangway accidents were a special risk for female passengers of all ages. The data available did not permit the effect of vehicle layout and furnishing to be clearly related to accidents (Transport and Road Research Laboratory 1980). In a related study they investigated bus design and acceleration patterns with 60 older people, and made recommendations on handhold and step design, as well as acceleration patterns for standing and sitting passengers.

A Swedish study supported these trends but also emphasized the gravity of many of the accidents: it indicated that more than half of bus and coach injuries occurred other than in a collision, 43% had injuries with a Maximum Abbreviated Injury Score of 2+ and 57% of all days at hospital were caused by non-crash events (Björnstig, Albertsson et al. 2005). Of these accidents, two-thirds occurred on boarding or alighting, and one third while the bus was moving. The authors calculated an incidence rate of 2 bus and coach injuries per 10,000 population per year.

Most of these accidents occur in local bus or transit systems, with most occurring at a speed of less than 30 miles per hour (Kirk, Grandt et al. 2003). A study from the transportation system in Portland, Oregon, showed a similar breakdown of safety incidents, with 43% arising from non-collision injuries (Strathman, Wachana et al. 2010). Over 80% of non-collision incidents involved passenger slips, trips, and falls, and about 44% of these incidents occurred during boarding or alighting. Other slip, trip, and fall incidents often occurred during the stop-servicing phases of acceleration and deceleration. The remaining non-collision incidents were associated with a wide variety of circumstances, the most common being struck by a door movement, or by a falling or moving object in the vehicle. Non-collision incidents peaked at 16.00 to 18.00.

Although a relatively small proportion of journeys by older people are made by public transport, with a tendency towards use by those who are physically more fit (Davis, Fox et al. 2011), there are a range of reasons why this is the case (Rupprecht 2007), including access (Davey 2007), convenience, security, but also unhappiness with the stability of buses and trams and the risk of falling or injury (Broome, McKenna et al. 2009). These fears are not groundless, as research indicates a significant number of injuries relating to public transport among older people (Mitchell and Suen 1998).

In an Irish study of older people admitted to hospital with traffic injuries, almost one in eight were due to non-collision bus injuries (Cunningham, Howard et al. 2000). An Israeli study indicated that such injuries may amount to almost 1,000 a year in that country, predominantly among older people (Halpern, Siebzeiner et al. 2005). In the United Kingdom, over half of injuries (57%) sustained in buses were classified as falls (Leyland Vehicles Ltd 1990) or non-collision bus injuries (63%) (Kirk, Grandt et al. 2003): this proportion was substantially greater with advancing age and among women.

Older people were also found to be over-represented in non-collision bus injuries in a US report, comprising 36% of non-collision injuries compared to 17% of collision injuries (Zegeer, Huang et al. 1993). These injuries occur during boarding and alighting, acceleration/deceleration, on turning and slip or trip-related falls. The predominance of older people was confirmed in a study in Serbia, with 52.6%, 48.9% and 49% of injuries in 2008, 2009 and 2010 respectively occurring in those over the age of 60, of which 63-70% were women (Zunjic, Sremcevic et al. 2012)

Among the underlying risk factors are the issues of inappropriate acceleration and deceleration patterns (forces up to 0.2G measured in real-life situations, well over the range of 0.15G described by Hirschfield in 1932 as the threshold at which passengers begin to lose their footing (Hirshfield 1932)) as well as inappropriate design of the internal structure of the buses in terms of both prevention and impact of primary and secondary injuries (Palacio, Tamburro et al. 2009), and the design and protocols of entry and

exit from the bus (Björnstig, Albertsson et al. 2005). These issues are replicated in the reports of a high number of injuries related to braking in Austria and Germany (Halpern & Siebzechner 2005, Korma & Smolka 2009). Resolving these problems will also help bus passengers of all ages, as a Swedish study suggests that non-collision bus and coach injuries span the life-course (Björnstig, Albertsson et al. 2005).

Driver education may be one fruitful avenue towards the reduction of non-collision bus injuries (Broome, Worrall et al. 2011), as well as reducing the barriers to public transport use by older people, yet is not immediately clear that this is widely recognized. The recent AENEAS project handbook for training bus drivers for serving older drivers makes only one small reference to careful acceleration in 58 pages (AENEAS Consortium 2010). Driver education is only one aspect of safety, as pointed out in a study of bus and taxi drivers driving wheelchair users: it is clear that driver 'errors' are probably markers of system failures, particularly deficient safety culture in traffic organizations (Wretstrand, Petzall et al. 2010).

Given that accelerations quickly followed by harsh decelerations are frequent in urban buses and are likely to result in more severe injuries in the event of loss of balance for a standing occupant, Palacio *et al* suggest that driver training should be expanded to include mandatory viewing of videos based on multibody occupant simulations of non-collision accident scenarios to demonstrate the influence of driving patterns on standing occupant balance loss and subsequent injury risk (Palacio, Tamburro et al. 2009). Some indication of factors that might be important arise from the study of Strathman et al. An increased frequency of non-collision injuries was associated with less experience (the expected incident frequency of an operator with, for example, 20 years of service being nearly 24% lower than that of an operator with 10 years of service), absenteeism, overtime hours driving, female gender (possibly a reporting issue), part-time working, late departures, and with lift usage, suggesting a link with more disabled passengers.

In addition, the development of protocols to ensure that older passengers are seated before the bus moves to the greatest extent possible, and also to ensure that they can make their way to the exit while the bus is stationary rather than still moving would be helpful. Also, passengers should be discouraged from standing in the aisles (to prevent leg injury risk from contact with the stiff seat frames) and immediately behind the stairwell (to prevent head contact with the stairwell wall). They should instead stand in a dedicated area opposite the stairwell.

The design of bus entrance and exits also appears to fall far from the needs of an older population: Björnstig and colleagues point out that even coaches and buses 'adapted' for the disabled have a step height which significantly exceeds the step height recommended for older people in housing, and that the life-span of these vehicles means that this discrepancy will remain in the Swedish transport system (and presumably many other European systems) for many years to come (Björnstig, Albertsson et al. 2005).

In terms of physical design within the bus for prevention and reduction of primary and secondary injury, Palacio *et al* offer the following recommendations (Palacio, Tamburro et al. 2009):

- Dedicated standing areas opposite the stairwell and be provided with roof mounted vertical handholds. Padding in this area is important.
- Horizontal metal seat handles should be replaced with vertical ones hung from the roof of the bus (but low enough for older shorter people to reach).

- A lower stiffness of the rubber used for the floor should be considered.

#### **4. Single pedestrian injuries**

Although falls among older people have been recognized as a significant public health issue for many decades in Europe, a relatively new interest in traffic medicine is the extent to which these occur outdoors (Li, Keegan et al. 2006), and particularly in geographical areas which can be considered to form part of the traffic environment .

The greatest challenge to delineating the extent of the problem is that these injuries and deaths are poorly captured in official statistics (Körmer and Smolka 2009): most road traffic accident databases do not capture single-pedestrian accidents, and most falls and hip fracture databases do not capture the location of the fall, whether indoors, in garden/yard, or the traffic environment. This is despite the fact that ICD-10 classification systems commonly used in the developed world can code for an outdoor fall, but is frequently not recorded (Morency, Voyer et al. 2012).

In addition, in the small number of studies extant, there are significant influences from weather conditions, particularly in northern countries where snow and ice are common in winter months (Oeberg, Nilsson et al. 1996) (Morency, Voyer et al. 2012). Körmer et al in 2009 could only make an estimate for one European country, Austria, for fatalities which suggested that 8% of pedestrian and two-wheeled transport accident which resulted in a fatality were single accidents. For injury, they calculated on the basis of four countries that 7% of non-fatal leisure and home injuries, not involving sport, occurred as single-pedestrian accidents. Finally, they calculate that older people are proportionately more involved in single-pedestrian accidents, amounting to 22% of morbidity relating to single-pedestrian accidents.

A further review, published by the International Transport Forum/OECD in 2012, suggests that one-third of pedestrian fatalities and three-quarters of injuries are due to falls in public spaces (International Transport Forum 2012). This supported by data from Sweden (Larsson 2009), which indicates that while single-pedestrian accidents occur across the life-span, they increase from the age of 42, and are their highest among the over 75s, with women accounting for the majority at each age group. The most common cause of "pedestrian-only" casualties was slipping/stumbling/tripping without the presence of ice/snow. For northern countries, some research has focused on footwear which is less likely to slip in icy weather (Gard and Lundborg 2000), as well as the nature of the path and road surfaces, but there is a growing recognition of a range of intrinsic and extrinsic factors (Berggard 2010), and of the need to factor in both for prevention strategies in countries with cold winters (McKiernan 2005).

A US study involving the emergency departments of eight hospitals quoted in support of the International Transport Forum/OECD report illustrates the complexity of interpreting the data available (Stutts and Hunter 1999). Its finding that 64 percent of pedestrian injuries were not involving a collision with a vehicle is tempered by the fact that they added 'transportation-related falls' to single-pedestrian injury: in addition, 30% of those occurring in the roadway involved sports equipment such as in-line skates, dropping to 15% of those occurring on sidewalks and parking lots Just over half (53%) were injured in non-roadway locations such as pavements, parking lots, or off-road trails, with almost two-thirds of these occurring on pavements. The age distribution for single-pedestrian accidents demonstrated that middle-

aged and the over 65 predominated, although the age- cut-off did not categorize the older old age groups. The middle-aged category (45-64) was more prone to ice-related falls, and their prominence receded when these falls were removed from the calculation.

A relatively small number of papers in the biomedical literature have examined the location and phenomenology of falls causing injuries. One of the largest, MOBILIZE in Boston, is a longitudinal study a population aged 70 and over which indicated that indoor falls occurred mostly among the older old, and outdoor falls occurred predominantly among the younger old and fitter people with higher levels of activity (Kelsey, Berry et al. 2010). When falls are studied longitudinally in this manner, the number of outdoor falls related to the traffic environment is described as 43%, occurring on the sidewalk, kerb or parking lot. Those who fell outdoors were as healthy as those who did not fall, but those who fell indoors were less healthy than those that did not. About 1 in 10 of both outdoor and indoor falls resulted in serious injury. The difference between the younger and older old people might to a certain extent be explained by the fact that those who have a fear of falling limit their outdoor exposure (Wijlhuizen, de Jong et al. 2007)

A more recent Canadian study of outdoor and indoor falls across all age groups presenting to emergency departments showed a that indoor falls were slightly more common, and that outdoor falls occurred largely in the middle-aged and young old (with 59% occurring in the under-65, although snow and ice played a likely major aetiological role), and indoor falls to the greatest extent in the older old (Morency, Voyer et al. 2012).

These findings mirror those earlier studies in the UK and Norway (Bath and Morgan 1999) (Bergland, Jarnlo et al. 2003) although the outdoor fallers were somewhat less healthy than non-fallers in the UK study, and taken together the studies emphasize the importance of disaggregating falls in older people by location and age group if we are to gain a better understanding of single-pedestrian accidents. Indeed, this heterogeneity is also likely to apply also to measures to prevent both falls and single-pedestrian accidents among older people (Kelsey, Procter-Gray et al. 2012).

## **5. Summary**

There is mounting and consistent evidence, albeit on a slender research portfolio, that non-collision injuries on public transport and single pedestrian injuries represent a significant risk to the health and well-being of older Europeans. It is of critical importance that traffic injury recording systems are broadened to include both types of accidents.

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