

# ASSESSMENT OF TRAFFIC SAFETY AND TRAFFIC INJURIES IN SPECIAL TRANSPORTATION SERVICES USING A MIXED METHODS APPROACH

<sup>1</sup>Bylund P.-O., <sup>2</sup>Wretstrand A., <sup>3</sup>Falkmer T.,  
<sup>4</sup>Lövgren A. & <sup>5</sup>Petzäll J.

<sup>1</sup>THE UMEÅ ACCIDENT ANALYSIS GROUP, AKMC, UNIVERSITY HOSPITAL, UMEÅ,  
SWEDEN

E-mail: PerOlof.Bylund@vll.se

<sup>2</sup>DEP. OF TECHNOLOGY AND SOCIETY, LTH, LUND UNIVERSITY, LUND, SWEDEN

E-mail: Anders.Wretstrand@tft.lth.se

<sup>3</sup>DEP. OF REHAB., SCHOOL OF HEALTH SC., JÖNKÖPING UNIVERSITY, JÖNKÖPING,  
SWEDEN

E-mail: Torbjorn.Falkmer@hhj.hj.se

<sup>4</sup>DEP. OF NEUROSC. AND LOCOMOTION, LINKÖPING UNIVERSITY, LINKÖPING,  
SWEDEN

E-mail: annlo@inr.liu.se

<sup>5</sup>SWEDISH ROAD ADMINISTRATION, BORLÄNGE, SWEDEN

E-mail: Jan.Petzall@vv.se

## Abstract

The safety for older and disabled people, using Special Transportation Services (STS), has been subject for several studies, suggesting that travellers are injured without being involved in a vehicle crash. In order to estimate the societal costs for these vehicle related injuries, the focus needs to be adjusted towards an incident-oriented perspective. The aim of the project was thus to utilize such a perspective, in order to make a second-best estimation of the costs for injury incidents, related to STS in Sweden.

A mixed method approach was used, involving quantitative as well as qualitative research methods. The first stage approached four different sets of data: the hospital based material (n=32), two sets of STS material (n=127), and interview based material (n=1,000). The second stage involved a qualitative approach, using focus groups in order to address the current safety culture among operators, and suggesting ways of improving safe procedures.

The results showed that the injury incidence rate in STS is considerable, i.e., 3.2 per 100,000 trips (ranging from 1.5–1.9 in STS taxis and 3.6–5.6 in STS special vehicles). However, this high incidence rate is not due to road traffic crashes, but to non-collision injury incidents involving elderly and frail passengers, easily sustaining injuries from minor to moderate external violence. Typically, this violence is affecting an older female STS user, while boarding or alighting the vehicle. The societal costs, based on Swedish VOSL values, were estimated to be \$ 2.60 per trip.

Future injury prevention measures should therefore focus on safety during the service encounter and passenger handling: to and from the vehicle and during boarding and alighting. Also, rather than implementing rigid procedures or check-lists, the STS organisation has to acknowledge the importance of an open structure in order to promote safe behaviour.

**Keywords:** Special Transportation Services (STS) for Elderly and Disabled; Injury Incidence; Cost Estimations; Travel Chain Perspective; STS Special Vehicles; STS Taxis

## Introduction

### Background

In the Scandinavian 9 million inhabitant nation, Sweden, approximately 20% of all are disabled (Börjesson, 2002). For some of them, the use of regular public transport is highly difficult or even impossible (Wretstrand, Petzäll, & Ståhl, 2004). Thus, ~5% of the Swedish inhabitants are permitted to use special transport services (STS) (Magnusson and Delén, 2001; SIKA, 2005). More than 80% of these STS-users are older people, i.e. 65+ (Börjesson and Blomquist, 2001).

There are between 350 -370,000 STS permits, and on average 30 trips per person eligible to STS are made (SIKA, 2005). The dominating STS solution is the door-to-door, demand-responsive taxi trip. Most trips, 80%, are carried out in standard sedan taxis cars, while the remaining 20% are made with special STS vehicles, e.g. converted minivans or vans. The special vehicles can carry both wheelchair-seated travellers and travellers on ordinary seats (Wretstrand, 2003).

A research area within the field of STS, recently given much attention, is safety (Falkmer and Gregersen, 2001; Petzäll, 1997). The travellers are elderly and/or frail, some of them travel seated in wheelchairs and not in regular vehicle seats, and a majority of the travellers have few or no alternate mode of transport. It has also been shown that STS travellers run the risk of being injured without being involved in a vehicle crash (Falkmer and Gregersen, 2002; Shaw, 2000).

However, significant methodological challenges are connected to this type of investigations. The official road traffic statistics only include vehicle related injury events from police reported crashes. Hence, other sources, such as hospital based data, should be used, in order to provide a broad and accurate picture of STS safety. Many injuries are also related to non-crash events, such as harsh braking and boarding/alighting (Björnstig, Albertsson, Björnstig, Bylund, Falkmer, & Petzäll, 2005; Shaw, 2000). This, in turn, further supports that a different approach than the traditional crash investigation has to be adopted, namely a traveller incident perspective, previously used in studies on bus and coach injuries (Albertsson, Björnstig, & Falkmer, 2004). An incident is defined as an injury event resulting in a personal injury, measured in terms of MAIS, according to the Abbreviated Injury Scale (AIS) (AAAM, 1990).

### Aims and scope

The aim of the study was to utilise a traveller incident perspective to estimate the societal costs for traveller injuries related to STS. The current study limited the scope to demand-responsive road transport and the use of M1 and M2 vehicles (Directive-2001/85/EC, 2002), within STS.

A second aim was to qualitatively explore the state of safety as perceived and discussed by STS drivers, in order to elicit possible causes for incidents and occurring passenger injuries, all within a driver's workplace context and safety culture (with reference to DeJoy et al. (2004)).

## Materials and methods

In this study, four different types of materials from different sources were used. The sources were chosen in order to obtain the best possible data on travellers' injuries, sustained during STS trips. These trips encompassed the entire travel chain from door to door.

### Quantitative studies

#### *Material 1*

Material 1 was obtained from a highly urbanized county and comprised 32 travellers treated for injuries at a University Hospital after an incident during a STS travel in STS taxi or STS special vehicles. The studied population was all the people registered in the STS traveller register files at the municipality STS department, with the exception of two minor areas. The data file from the municipality was matched by the social security number to the Injury Surveillance Register (ISR) at the hospital during a 9-year-period (1996 – 2004). The calculation of the injury incidence was based on data for the years 1998-2004 because numbers of STS trips (1,134,500) were only available for those particular years. The average trip distance was about 3.8 miles. Henceforth, material number 1 is denoted the hospital based material.

#### *Material 2*

Material 2 was obtained from a highly urbanized county and comprised 77 persons injured during STS travel in STS taxi or STS special vehicles, reported by the traveller, the driver or another person to the STS city department. Data were extracted from the incident reporting system during the 2-year period of February 1st 2003 – January 31st 2005 comprising 2,680,500 trips. The average distance was unknown. However, in further calculations, the distance 6.2 miles, i.e. an estimated average for material 1 and 3, was assigned to this material. Henceforth, material number 2 is denoted STS material together with material 3.

#### *Material 3*

Material 3 was obtained from a highly urbanized county and comprised 50 injured persons during STS in special transport vehicles only, reported by the traveller, the driver or another person to the STS County Council Department. Data were extracted from the incident reporting system during the 2-year period of February 1st 2003 – January 31st 2005, comprising 1,386,500 trips. The average distance was about 7.6 miles. Henceforth, material number 3 is denoted STS material together with material 2.

#### *Material 4*

Material 4 was obtained through the Swedish Public Transport Association. The present study used an ongoing telephone survey, by adding specific safety issues. Based on registered STS trips made the day before, a random sample was drawn (n=1000), not from individuals but from trips. Two main issues were addressed. All subjects were asked whether a non-injury incident or an incident occurred during the actual trip. They were also asked about previous experiences of non-injury incidents or incidents. Furthermore, questions about time, type of injury sustained, if medical treatment was needed, various health consequences etc., were asked. Henceforth, material number 4 is denoted as interview material. This material was the only one addressing events that "potentially" could cause injuries.

## Qualitative studies

### *Material 5*

Five consecutive focus groups, with an average of five participants per group, were held in cities in southern Sweden. The main differences between the groups were the type of drivers' collective employment agreement. Some drivers working used to have regular taxi services experience, whereas other drivers had a background as bus drivers. Other differences between "taxi" and "bus" were the type of vehicle in operation. Generally, taxi vehicles are sedan cars with fully flexible operation, while the larger vans and minibuses usually are dispatched to fixed assignments and recurrent schedules if required (e.g. school transports for children with special needs or non-emergency hospital transports).

The sessions lasted for 2 hours each. The questioning route served as a catalyst for the safety discussion, and was conducted through the Power-Point slide sequence. The key questions followed the sequence determined in Wretstrand et al. (2003), separating the travel chain in five steps: arriving at the vehicle, boarding the vehicle, during the ride, alighting the vehicle, and departing from the vehicle.

All focus group sessions were tape recorded, and notes taken about significant comments were gathered together and summarized. The data were schematized according to the three main issues in the questioning route and categorized according to emerging thematic concepts.

### Other issues

The severity of the injuries has been classified in accordance with the Abbreviated Injury Scale (AIS) (AAAM, 1990). MAIS stands for maximum AIS, i.e. the most severe injury. AIS=1 designates minor injuries, AIS=2 moderate injuries (e.g. concussion), AIS=3 serious injuries (e.g. femur fracture or spleen rupture) and AIS=4-6 designates severe, critical and maximum injuries.

## Results

The results will present the hospital based material and the STS material combined (material 1-3), while data from the interview material (material 4) and focus groups (material 5) are presented separately.

### Quantitative results

#### *Material 1-3*

It was found that 102 (71%) of 143 injured (16 unknown) were 65 years or older. More than two thirds (68%) of the 156 (3 unknown) were women. Women aged 80+ constituted the largest group of injured.

Almost two out of three (100/159=63%) were injured when the vehicle was at stand still. By further scrutinizing data, falls were revealed to be most frequent (45/84=54%), taking place while boarding/alighting the vehicle or during transport in a wheelchair. One third of boarding/alighting incidents occurred when the traveller was sitting in a wheelchair. Other injury mechanisms were from getting appendages crushed in a door or bumping against the vehicle.

Thirty-eight injuries among the 32 injured travellers (1.2 injuries per injured traveller) were recorded in the hospital based material. Nine (24%) of those were fractures while two were concussions. In the STS reports, 165 injuries were noted among the 127 injured travellers (1.3 injuries per injured traveller).

### ***Material 4***

One percent of the respondents stated that a non-injury incident or an incident had occurred the day before. The major situation was "during the ride". The results also showed that 11 % had experienced a non-injury incident or an incident while using STS. Almost 3 % of the respondents had been injured while using STS. There was also a strong tendency that those who travelled more often also to a greater extent reported experience of a non-injury incident or an incident ( $\chi^2$ ,  $p < 0,001$ ). Younger travellers in urban areas were more likely to experience a non-injury incident or an injury incident, followed by younger travellers in semi-rural areas and older travellers in urban areas.

Of the 28 injured respondents, a total number of 40 specified injuries were reported. The "vehicle at stands till" was associated with 12 MAIS 1 and 5 MAIS 2+ injuries. Similarly, the "vehicle was moving" was associated with 6 MAIS 1 and 5 MAIS 2+ injuries. Based on these small absolute numbers, it still seems as "vehicle was moving" caused more severe injuries ( $\chi^2$ ,  $p < 0,02$ ). The injury incidence ranged from 3.6 to 5.6 per 100,000 trips in STS special vehicles, and 1.5-1.9 in STS taxis.

### ***Estimation of "true" costs***

The four different data sets were added. Based on the calculation 12.3 million annual STS trips and an injury incidence rate of 3.2 per 100,000 trips, approximately 394 injured occupants can be expected in Sweden per annum. Most of them, about 85%, will be "slightly injured", as described in terms used by Persson (2004), while only a few percentage, at the very most 15%, will have a MAIS 3+ injury. Furthermore, it could be estimated that the maximal societal costs are about 35 million U.S.\$ per annum, or 2.6 U.S.\$ per trip.

### **Qualitative results**

The results from material 5 support previous findings, indicating that STS passengers run the risk of being injured without being involved in a vehicle crash. The organizational view or culture didn't seem to put safety as a key issue. Clear differences were identified between bus and taxi drivers, depending on employment arrangements, operating contracts and incentive arrangements. The drivers as well as the passengers identified some relatively clear-cut safety threats, primarily before and after a ride. The driver's work place seemed to be surrounded with a reactive instead of proactive structure.

This study monitored the gap between procedure and practice by means of drivers' "confessions", trying to understand why the gap and the safety problems exist. It was concluded that not only technical safety has to be considered in STS, but also the systems safety and the safety culture. Instead of viewing drivers' error as a cause, it should be seen as a symptom of systems failure. Human error is connected to features of tools, tasks, and operating environment. Enhanced understanding and influence of these connections within STS and accessible public transport systems will promote safety.

### **Conclusion**

The present study concludes that the injury incidence rate in STS is considerable despite all confounding factors (i.e. 3.2 per 100,000 trips). However, this is not due to road traffic crashes, but to non-collision injury incidents involving elderly and frail passengers, easily sustaining injuries from minor to moderate external violence. Typically, this violence is affecting an older female STS user while entering and exiting the vehicle. Future injury mitigation should thus focus on preventive safety for boarding and alighting procedures, rather than on vehicle ride issues. Moreover, the following conclusions can be drawn from the study:

- The injury incidence was about twice as high in STS special vehicles than in STS taxis.
- Most of the incidents happen during boarding and alighting when the vehicles were at stand still.
- Most of the injuries were minor injuries MAIS1. The proportion of MAIS2+ injuries was higher when the vehicles were at stand still than during the ride.
- The proportion of MAIS2+ injuries was higher among the older passengers than among the younger passengers.

Since STS passengers run the risk of being injured without being involved in a vehicle crash, a user's perspective must be taken in order to explore, explain and improve STS safety. The focus group part of this study chose the driver and the driver's workplace as a starting point, and it was assumed that the combination of the two fields of transportation and occupational science would contribute to the data analysis.

The study revealed troubles with lifts, ramps, steps, step riders. These are facts, known and discussed before. However, in order to create safe STS services, a more holistic perspective must be adapted. It can be difficult to design a procedure in order to eliminate errors ("the human factor"). On the contrary, it could in fact be argued that it's "all human factors" that eventually will lead to better safety culture. Understanding this will improve safety, and allow for sound evaluation of the technology in use (Dekker, 2003). A sound approach will support the drivers in their work and eventually develop a safety culture within the whole STS organization.

According to Dekker (2003), organizations therefore need to:

- Monitor the gap between procedure and practice
- Try to understand why the gap exists
- Help people to develop skills to judge when and how to adapt
- Resist simply telling people to comply and follow procedures in order to promote safety and safe behavior

Eventually, such a stance would lead towards enhanced STS safety. Together with more user friendly vehicle technology and safety equipment, the societal costs due to poor safety could be reduced. Further details regarding this study could be found in Bylund et al. (2007) and in Wretstrand et al. (2007).

## References

- AAAM, 1990, The Abbreviated Injury Scale 1990 revision, Association for the Advancement of Automotive Medicine, Des Plaines IL.
- Albertsson, P., Björnstig, U., & Falkmer, T., 2004, The Haddon matrix, a tool for investigating severe bus and coach crashes, *International Journal of Disaster Medicine*, Vol. 1, Nr. 2, pp. 109 - 119.
- Björnstig, U., Albertsson, P., Björnstig, J., Bylund, P.-O., Falkmer, T., & Petzäll, J., 2005, Injury events among bus and coach occupants - non-crash injuries as important as crash injuries, *IATSS Research*, Vol. 29, Nr., pp. 79-87.
- Bylund, P.-O., Wretstrand, A., Falkmer, T., Lövgren, A., & Petzäll, J., 2007, Injuries in STS Travel – a Multi-Methodology Approach to Estimate Incidence and Societal Costs, *Traffic Injury Prevention*, Vol. 8, Nr., pp. 180–188.
- Börjesson, M., 2002, Funktionshindrades resmöjligheter. [Travel alternatives of disabled people]. (No. VINNOVA Rapport 2002:4.), Vinnova, Stockholm.
- Börjesson, M., & Blomquist, P., 2001, Utvärdering av ny lagstiftning för färdtjänst och riksfärdtjänst: ett resenärsperspektiv (No. 2001:43), Vägverket, Borlänge.
- DeJoy, D. M., Schaffer, B. S., Wilson, M. G., Vandenberg, R. J., & Butts, M. M., 2004, Creating safer workplaces: assessing the determinants and role of safety climate, *Journal of Safety Research*, Vol. 35, Nr. 1, pp. 81-90.
- Dekker, S. W. A., 2003, Failure to adapt or adaptations that fail: contrasting models on procedures and safety, *Applied Ergonomics*, Vol. 34, Nr. 3, pp. 233-238.
- Directive-2001/85/EC, 2002, Directive 2001/85/EC of the European Parliament and of the Council of 20 November 2001 relating to special provisions for vehicles used for the carriage of passengers comprising more than eight seats in addition to the driver's seat, and amending Directives 70/156/EEC and 97/27/EC., *Official Journal of the European Communities*, Vol. L 42, Nr. 13/02/2002(2001/85/EC), pp. 1-102.
- Falkmer, T., & Gregersen, N. P., 2001, A questionnaire-based survey on the road vehicle travel habits of children with disabilities., *IATSS Research*, Vol. 25, Nr. 1, pp. 32-41.
- Falkmer, T., & Gregersen, N. P., 2002, Perceived Risk among Parents Concerning the Travel Situation for Children with Disabilities, *Accident Analysis and Prevention*, Vol. 34, Nr. 4, pp. 149-158.
- Magnusson, B., & Delén, M., 2001, Preliminär slutrapport över färdtjänstens tillstånd och utveckling samt behov av tillsynsmyndighet (No. 2001:95), Vägverket, Borlänge.
- Persson, U., 2004, Valuing Reductions in the Risk of Traffic Accidents Based on Empirical Studies in Sweden (PhD Thesis), Department of Technology and Society, Lund University, Lund.
- Petzäll, J., 1997, Fordon och hjälpmedel för funktionshindrade i kollektivtrafiken. [Vehicles and Assistive Devices for Disabled Users of Public transport]. (No. Bulletin 145), Dept. of Traffic Engineering, Lund University, Lund.
- Shaw, G., 2000, Wheelchair rider risk in motor vehicles: A technical note, *Journal of Rehabilitation Research and Development*, Vol. 37, Nr. 1, pp. 89-100.
- SIKA, 2005, Special transport services and national special transport services 2004 (No. 2005:6), The Swedish Institute for Transport and Communications Analysis, Stockholm.

Wretstrand, A., 2003, Wheelchair passengers and local public transport vehicles: perceptions of safety and comfort, Department of technology and society, Lund University, Lund.

Wretstrand, A., Falkmer, T., Lövgren, A., Petzäll, J., & Bylund, P. O., 2007, Creating safe special transportation services: issues of safe procedures and safety culture, Paper presented at the 11th International Conference on Mobility and Transport for Elderly and Disabled Persons (TRANSED), Montreal Convention Centre, Canada, June 18-22 (Proceedings on CD), Montreal.

Wretstrand, A., Petzäll, J., & Ståhl, A., 2004, Safety as perceived by wheelchair-seated passengers in special transportation services, Accident Analysis and Prevention, Vol. 36, Nr. 1, pp. 3-11.

Wretstrand, A., Stahl, A., & Petzall, J., 2003, The safety of passengers in wheelchairs in special transportation services studied with interviews and assessments, Technology and Disability, Vol. 15, Nr. 4, pp. 259-269.