Journal of Transport & Health 13 (2019) 164–169

Contents lists available at ScienceDirect

Journal of Transport & Health

journal homepage: www.elsevier.com/locate/jth

A nation-wide study on the prevalence of non-collision injuries occurring during use of public buses

Maya Siman-Tov[a,*], Irina Radomislensky[a], Inbar Marom[a], Ori Kapra[a], Kobi Peleg[a,b], Israel Trauma Group (H. Bahouth, A. Becker, I. Jeroukhimov, I. Karawani, B. Kessel, Y. Klein, G. Lin, O. Merin, M. Bala, Y. Mnouskin, A. Rivkind, G. Shaked, G. Sivak, D. Soffer, M. Stein, M. Weiss)

[a] Israel National Center for Trauma and Emergency Medicine, Gertner Institute for Epidemiology and Public Health Policy, Tel-Hashomer, Israel
[b] Department of Disaster Medicine, School of Public Health, Tel Aviv University, Israel

ARTICLE INFO

Keywords:
Non-collision injuries
Buses
Injury prevention
Transportation
Older people
National trauma registry

ABSTRACT

Introduction: Bus public transportation is preferred for its perceived safety. Data from several countries, however, alarm of non-collision injuries associated with bus use. The aim of the current study was to estimate the prevalence of non-collision bus injuries, and compare and identify population group at high risk for severe injuries, to serve as a basis for policy makers.
Methods: A retrospective analysis of the Israeli National Trauma Registry cohort for the years 2015–2017 was carried out. Database consists of 20 hospitals nationwide. Casualties hospitalized following a non-collision injury on a bus were identified. Demographic, injury characteristics, and hospital resources utilization were compared according to the place of injury; inside the bus or during boarding or alighting.
Results: During follow up, 704 hospitalized non-collision related bus casualties were recorded. Most of the casualties (75%) fell inside the bus and 25% during boarding or alighting. The majority (67%) of hospitalized patients were 60 years old or above, mostly injured while boarding or alighting the bus, and 72% were women. Frequent injured body regions were lower extremities, head and torso. Passengers injured inside bus sustained more chest injuries, but less lower extremities injuries, compared to those boarding or alighting the bus. More hospital resources were required to treat passengers injured while boarding or alighting the bus.
Conclusions: This systematic registry-based analysis of non-collision bus injuries confirms the greater risk of being injured while using bus transportation among women and older passengers. Primary attention for prevention policies should be given to injuries occurring during boarding or alighting of the bus. Additional policy recommendations are discussed.

1. Introduction

Travelling by bus is generally thought of as one of the most economical, sustainable, and safest modes of transport. For this reason, authorities often favor its full or partial subsidization and tend to encourage members of the public to use it more often. Public transportation in Israel is one of the essential services in public demand. According to the Israeli Central Bureau of Statistics (CBS),

* Corresponding author. Israel National Center for Trauma and Emergency Medicine Research, Gertner Institute for Epidemiology and Health Policy Research, Sheba Medical Center, Tel Hashomer, 52621, Israel.
E-mail addresses: mayasi@gertner.health.gov.il, maylev90@gmail.com (M. Siman-Tov).

https://doi.org/10.1016/j.jth.2019.03.019
Received 4 November 2018; Received in revised form 25 March 2019; Accepted 30 March 2019
Available online 23 April 2019

57% (~3 million people) of the ≥20 year old traveled in 2015 in the public transport system. Usage of public transport is frequent among both men (51%) and women (61%). People aged 20 to 24 were the most frequent users of the public transport system (80%). Usage rates decline gradually with age, to less than 50% for people aged 35 to 64, and rise again among the elderly (over 65 years) to 60%. About a fifth (19%) of passengers use the public transport system on a daily basis and additional 14% use it once or twice a week (CBS, 2016). According to an earlier press release, Jews use the bus public transport system more than Arabs (62% versus 37%, respectively). However, according to the CBS an increase in the gross monthly income per capita in the household is accompanied by a decline in the rate of users of public transportation (CBS, 2008). Most of the passengers reported that they were satisfied with the bus public transportation system in Israel. For example, passengers mostly felt that the bus takes them to their destination at a reasonable time, are satisfied with bus station proximity to their home, and are happy with maintenance of the bus station and bus itself (CBS, 2016).

Research conducted across several countries warns that bus riding is far from safe, and is especially risky to elderly and women. These sub-groups of the passenger population are over represented in emergency wards following injuries occurring during bus travel (Kendrick et al., 2015). The fact that elderly people experience elevated risk of injury during bus travel is a growing public health concern, given that they are both often dependent on public transportation and their growing proportion in the population (United Nations, 2015).

Although non-collision bus injuries are a growing phenomenon, research into its epidemiology has been limited, despite its apparent preventable nature. Based on a recent literature review of ten studies of non-collision injuries in buses, most injuries occur during daytime hours, usually while passengers are standing or moving around the bus, as well as while boarding or alighting the bus. According to this review, between 18% and 33% of injuries involve fractures and dislocations, to limbs in particular, and 40% of injuries are classified as moderate to severe (Kendrick et al., 2015).

A key methodological concern in estimating the non-collision injury burden of bus travelers in current studies is establishing sufficient generalizability since most research data is sporadic from relatively few emergency departments (Nue Moller et al., 1982; Albrektsen and Thomsen, 1983; Kendall et al., 1994; Mabrook, 1994; Bachar et al., 1999). Alternatively, using national data, which can constitute a better source of information, is usually restricted to police reporting which often lacks sufficient medical records (Kirk et al., 2001, 2003). Therefore, current approximations are most probably an underestimation of the true scale of the problem.

Despite the importance of public transport in Israel, studies on its safety have so far been limited. A study conducted in the late 1990's analyzed a hundred consecutive non-collision injuries which occurred on buses in a single area and were referred to a single hospital (Bachar et al., 1999). A more recent study based its data on six emergency departments with an unspecified selection procedure of participants (Halpern et al., 2005). The conclusion of this study was a call for action to the transportation authorities in an effort to reduce injury by promoting decisive preventative measures. The current study, which was conducted more than a decade later, provides a present account of the issue at hand. The aim of the current study is to estimate the prevalence of hospitalized non-collision bus injuries, and compare and identify population groups at high risk for severe injuries. The outcomes of the study should serve policy makers as a basis for injury prevention among users of public transportation.

2. Methods

A retrospective cohort study was performed, including all passengers who were injured on a bus (including boarding or alighting) in a non-collision-related event and hospitalized between January 1, 2015 and December 31, 2017 in one of the 20 hospitals across Israel. Data was obtained from the Israeli National Trauma Registry (ITR), which is maintained by Israel's National Center for Trauma and Emergency Medicine Research in the Gertner Institute for Epidemiology and Health Policy Research. The ITR is an extensive database, which fairly represents all regions in the country. This registry records information concerning all trauma patients hospitalized, including demographic, injury, treatment, and discharge data.

The ITR includes all casualties who arrived at the hospital up to 72 h after the injury and were either admitted to the hospital, died in the hospital (including deaths in the emergency department), or were transferred to another hospital for admission. The registry does not include patients who died at the scene of the event or on the way to the hospital, who were not hospitalized, or who were hospitalized 72 h or more after the event. ITR are recorded by trained trauma registrars at each trauma center under the supervision of trauma director and trauma coordinator. Electronic files are transferred to the registry where quality assurance is carried out prior to the data being analyzed. The data in the ITR are anonyms and does not allow for individual identification of hospitalized patients.

Hospitalized injured bus passengers in a non-collision event were identified using the following algorithm: event textual descriptions were scanned for appearance of terms such as “fell on a bus”, “bus fall”, and “bus”. Next, road user type data was utilized to exclude bus drivers, and accident data was used to exclude accidents involving collision with an additional vehicle or pedestrians. Finally, descriptions with sufficient data were used to identify individuals injured inside the bus or during boarding or alighting.

Demographic variables included gender, population group (Jews/Non-Jews), and age. Event characteristics included place of injury (inside the bus, during boarding or alighting). Injury characteristics included injury severity score (ISS), which was stratified into two categories: ISS 1–14 (minor/moderate) and ISS 16+ (severe/critical), as is common practice in similar studies (Rozenfeld et al., 2014) and injured body region. Injured body regions were grouped into seven sections based on the Barell Injury Diagnosis

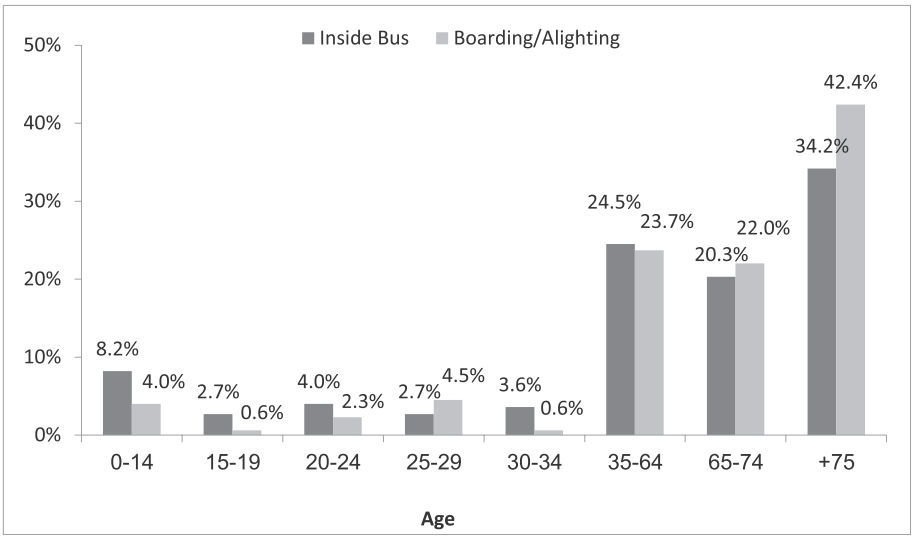

Fig. 1. Distribution of non-collision bus passengers casualties across age groups, stratified by location of injury, 2015–2017.

Matrix: head, face, spine, chest, abdomen and extremities (upper and lower) (Barell et al., 2002). Hospital resource utilization included: undergoing surgery, admission to the intensive care unit (ICU), hospital length of stay (LOS 8 + days) and discharge to rehabilitation facility; in-hospital mortality was coded as binary variables.

Data on the Israel population bus passengers was acquired from the Central Bureau of Statistics for the last update year (2015) (CBS, 2017).

Statistical analysis included both descriptive and analytical methods. Chi square analysis was used to assess the association between type of incident (inside the bus vs. boarding and alighting), injury characteristics, and hospital resource utilization. Rates of hospitalization for the entire three years per 10,000 passengers were calculate based on the CBS information on the numbers of passengers by age group (20–24, 25–29, 30–34, 35–64 65 + and for the total passengers ages 20 and above). All statistics were computed using SAS software. P-values lower than 0.05 were considered to be statistically significant.

3. Results

Between 2015 and 2017, 704 bus passengers were hospitalized with non-collision-related injuries, an average of 235 annual casualties. The rate per number of passengers among 20 year olds and older is 2.0 per 10,000 passengers; 1.48 per 10,000 passengers fell inside the bus and 0.53 per 10,000 fell during alighting or boarding from the bus. The rate of hospitalized patients varied by age group, for the age group 65 and over the rate was 6.7 per 10,000, while for the age group 35–64 the rate was 1.3 per 10,000 and among the youngest age group (20–24) the rate was less than 1.

The majority (67%) of hospitalized casualties was aged 75 years or above, mostly women (72%) and Jews (92%). The majority (75%) fell inside the bus, 18% fell during alighting from the bus and 7% while boarding the bus. Two hundred and thirteen passengers fell while the driver was braking, 22 were hit by the doors of the bus, and four passengers were injured while the bus was taking a sharp turn.

Of the passengers injured during boarding or alighting, the larger age group 75 years or older (Fig. 1). The most frequent injured body regions were the lower extremities (43.6%), head (21.2%) and torso (16.9%). Passengers falling inside the bus, compared to boarding or alighting, had significantly more chest injuries (21% vs. 3%, $p < .001$) and spine injuries (9% vs. 4%, $p = .03$). Passengers falling while boarding or alighting, compared to passengers falling inside the bus, had a significantly higher rate of lower extremities injuries (64% vs. 37% $p < .001$) (Fig. 2). Most (93%) of the casualties had minor to moderate injuries (ISS 1–14). Fifty-one (7%) passengers had severe and critical injuries (ISS 16+), constituting 8% of injuries occurring inside the bus and 5% of injuries occurring during boarding or alighting, although this difference was not statistically significant ($p = .105$).

About a fifth (21%) of the injured passengers were hospitalized for over seven days, 37% underwent surgery, and 21% were transferred to a rehabilitation facility. Statistically longer hospitalization periods (8 + days) were registered among injured passengers who were boarding or alighting compared with passengers who fell inside the bus (27% vs. 18% $p = .02$). In addition, passengers who were boarding or alighting the bus were more frequently discharged to a rehabilitation facility compared to those who fell inside the bus (30% vs. 18% $p = .01$) (See Table 1).

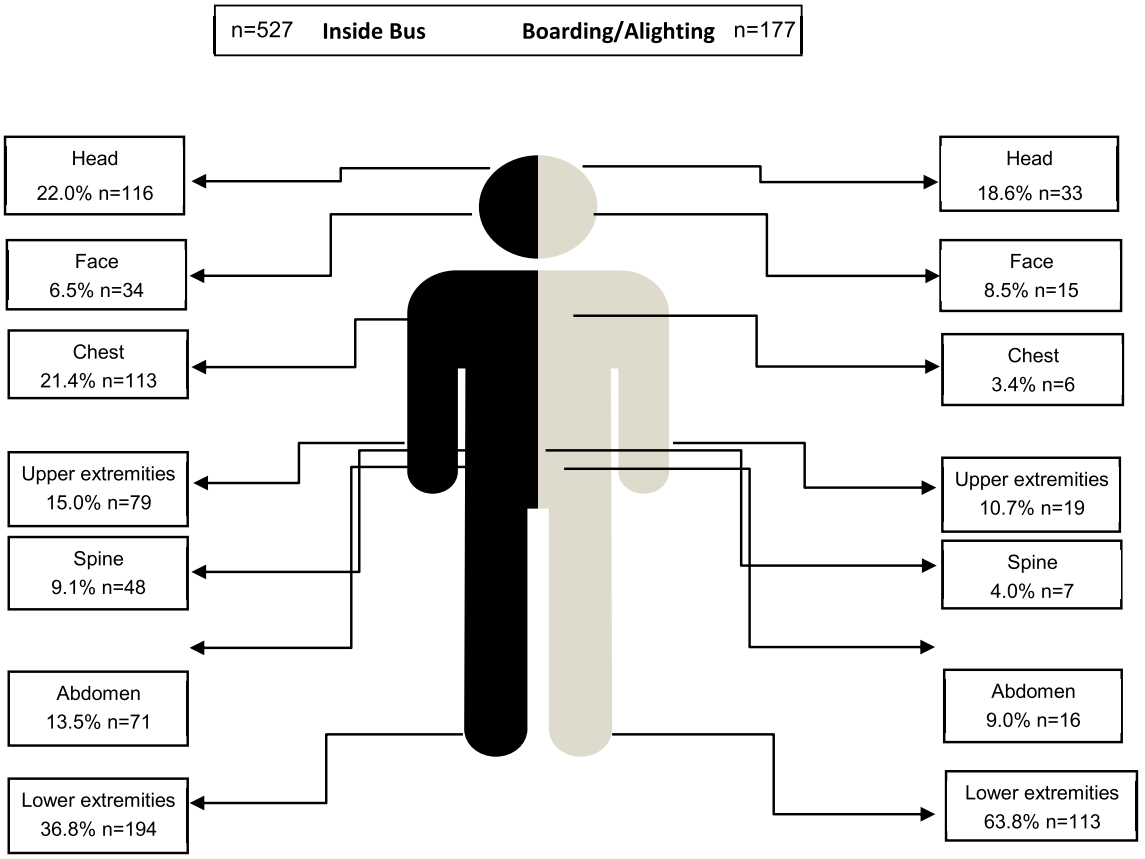

Fig. 2. Injured body regions of non-collision bus passengers casualties according to location of injury, 2015–2017.

Table 1
Hospitalization resources utilization for treatment of non-collision bus passengers casualties according to location of injury (2015–2017).

	Total injuries (n = 704)		Inside Bus (n = 527)		Boarding/Alighting (n = 177)		p-value
	%	N	%	N	%	N	
Hospitalization longer than a week	20.5	144	18.5	97	26.6	47	0.02
Undergone surgery	36.7	258	30.6	161	54.8	97	NS
Admission to Intensive Care Unit	2.7	19	2.5	13	3.4	6	NS
Discharge to rehabilitation	21.0	148	18.0	95	29.9	53	0.01

In-hospital mortality associated with bus non-collision injuries was rare (seven passengers). In 2017, a woman passenger aged 79 died following a fall occurring while she was getting off the bus. In 2016, five passengers (aged 63 +) passed away after sustaining non-collision injuries on buses, and in 2015 a single woman passenger died.

4. Discussion

To the best of our knowledge, this is the first report on the epidemiology of non-collision injuries occurring during use of Israeli public buses that utilizes nation-wide trauma registry data. The aggregate of data on this topic in the former literature has thus far been described as carrying limited interpretability (Kendrick et al., 2015), and lacking systematic and detailed information on passenger characteristics and injury mechanism. The challenges associated with non-collision injuries will not be acknowledged or effectively addressed, nor will prevention opportunities be taken, unless a more comprehensive approach will be used. Our manuscript provides a present account of the issue at hand, and serves to update and strengthen an earlier Israeli study based on only six emergency departments (Halpern et al., 2005). As seen, the phenomenon described 15 years ago is still a valid public health concern. In comparison to the previous study, the current study is based on a national database, including hospitalizations from 20 hospitals, providing a wide range of prehospital and hospital information on each casualty enabling a nation-wide portrayal of this phenomenon.

The current study reveals that individuals over 60 years, Jews, and women are at high risk as bus passengers for non-collision injuries. In general, public transportation is less accessible to the elderly Arab population since they reside in the periphery and their daily activities are often occurring within in the community. In addition, more severe injuries, and hence greater utilization of hospital resources, were associated with injuries occurring inside the bus compared to injuries occurring while boarding or alighting.

Our data suggests that Jews, women, and the elderly are overrepresented in hospitalizations following non-collision injuries on buses is in line with the data published by the CBS concerning usage rates of public transportation in Israel (CBS, 2007; 2016). Note that the largest age group of Israeli public transport users is 20–24 years of age, however older passengers sustain more injuries. The reason for this is probably due to elderly passengers being frailer. Adding to current predictions regarding further aging of the population in western countries, this data suggests that the magnitude of non-collision injuries of older people in buses is likely to increase, and ameliorating measures should be implemented at the present time.

Our findings are consistent with other reported findings demonstrating that the majority of injuries occur inside the bus, while another significant part, about a third of the injuries, are known to occur during boarding or alighting (Albertsson and Falkmer, 2005).

Research into prevention strategies of non-collision injuries in urban buses has yielded a wide array of solutions (Palacio et al., 2009). These include discouraging passengers from standing in the isles and too close to the stairwell, and creating an assigned standing area near the stairwell with vertical handholds stemming from the roof. In addition, these recommendations suggest that the number of standing passengers should be restricted, and each bus should have seats earmarked for the elderly. Additionally, where there are horizontal metal seat handles, vertical ones hung from the bus roof should come instead, low enough for older and shorter passengers to reach. Softer, but not slippery materials should replace stiff floor rubber where possible. Steps onto or off the bus should not be too high, and steps should be of a uniform height. Road and bus stop design might impact risk of injury as well; bus stops that are too small physically for stopping require sharp turns to enter or exist, putting the passengers standing to get off the bus at risk of falling. Given that sudden decelerations put passengers as risk of injuring themselves, increasing the number of exclusive bus lanes might prevent some instances of this deceleration.

A key among prevention strategies is driver training, as driving behavior directly affects the balance of standing occupants. Falls may be caused when the driver pulls away before a passenger is seated. 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. Therefore, driver training should include mandatory viewing of video simulations of non-collision accident scenarios to demonstrate the impact of driving patterns on standing passengers. Driver behavior might also be affected by stress caused by tight schedules, so it is recommended to monitor the level of stress created by schedules.

Previous research on perceptions of the public bus system has shown a high satisfaction and trust, from a convenience standpoint (CBS, 2016). While appreciating the importance of public opinion concerning comfort, it is imperative to also consider public transport safety. It is recommended that future surveys on satisfaction with public transport will focus on safety, both as means of providing insight into improving bus safety, and a potential leverage on policy makers.

5. Limitations

The data utilized in our analysis is based on the Israel National Trauma Registry, and thus includes only hospitalized casualties. Therefore, the cohort did not include patients with minor injuries, e.g. those discharged from the emergency room or treated outside the hospital. Therefore, the data presented in this manuscript is an underestimation of this phenomenon.

In addition, type of incident (inside bus or during boarding/alighting) was based on free text, and therefore this is most likely an underestimation of the number of bus related non collision injuries.

6. Conclusions

Injuries sustained by bus passengers are an important public health concern. Individuals over 60 years and women are disproportionally affected. This finding is reaffirmed in our study and suggests that future policies should focus on these populations. These non-collision incidents have potential for prevention and therefore should not be taken as a fatal scenario; therefore, regulatory and legislative changes can carry a promise of high efficacy in reducing injury rates. Without taking at least some of the suggested steps to prevention, injury incidences are more than likely to increase in the future.

Financial disclosure

The Authors did not receive any specific funding for this work.

References

Albertsson, P., Falkmer, T., 2005. Is there a pattern in European bus and coach incidents? A literature analysis with special focus on injury causation and injury mechanisms. Accid. Anal. Prev. 37, 225–233.

Albrektsen, S., Thomsen, J., 1983. A casualty ward analysis of bus passenger accidents. Med. Sci. Law 23, 102–105.

Bachar, R., Alagdem, D., Sarov, J., Sorkine, P., Szold, O., Halpern, P., 1999. Injuries due to falls in urban buses: 100 consecutive cases. Harefuah 137, 86.

Barell, V., Aharonson-Daniel, L., Fingerhut, L.A., Mackenzie, E.J., Ziv, A., Boyko, V., Abargel, A., Avitzour, M., Heruti, R., 2002. An introduction to the Barell body region by nature of injury diagnosis matrix. Inj. Prev. 8, 91–96.

The Central Bureau of Statistics, 2008. Government Services in Israel - Preliminary Findings from the 2007 Social Survey - A Press Report (Hebrew).
The Central Bureau of Statistics, 2016. Selected Data from the 2015 Social Survey: Public Opinion (Of Aged 20 and over) on the Public Transportation.
Halpern, P., Siebzehner, M.I., Aladgem, D., Sorkine, P., Bechar, R., 2005. Non-collision injuries in public buses: a national survey of a neglected problem. Emerg. Med. J. 22, 108–110.
Kendall, I.G., Hassan, T., Bodiwala, G.G., 1994. A review of injuries sustained by bus passengers. J. Accid. Emerg. Med. 11, 57.
Kendrick, D., Drummond, A., Logan, P., Barnes, J., Worthington, E., 2015. Systematic review of the epidemiology of non-collision injuries occurring to older people during use of public buses in high income countries. Journal of Transport & Health 2, 394–405.
Kirk, A., Grant, R., Bird, R., 2001. Bus and Coach Passenger Casualties in Non-collision Incidents.
Kirk, A., Grant, R., Bird, R., 2003. Passenger Casualties in Non-collision Incidents on Buses and Coaches in Great Britain.
Mabrook, A.F., 1994. Injuries sustained by passengers on buses. J. Accid. Emerg. Med. 11, 209–210.
Nue Moller, B., Grymer, F., Christensen, S.T., 1982. Bus accidents. J. Traffic Med. 10, 59–62.
Palacio, A., Tamburro, G., O'Neill, D., Simms, C.K., 2009. Non-collision injuries in urban buses–strategies for prevention. Accid. Anal. Prev. 41, 1–9.
Rozenfeld, M., Radomislensky, I., Freedman, L., Givon, A., Novikov, I., Peleg, K., 2014. ISS groups: are we speaking the same language? Inj. Prev. 20 (5), 330–335.
United Nations, 2015. World Population Ageing (Fifth Report).