ELSEVIER

Injury, Int. J. Care Injured 33 (2002) 485–488

INJURY
INTERNATIONAL JOURNAL OF THE CARE OF THE INJURED

www.elsevier.com/locate/injury

Child pedestrian injuries at tram and bus stops

R. Unger [a], C. Eder [a], J.M. Mayr [a,*], J. Wernig [b]

[a] *Department of Paediatric Surgery and Austrian Committee for Injury Prevention in childhood, University of Graz, Auenbruggerplatz 34, A 8036 Graz, Austria*

[b] *Steyr-Daimler-Puch Fahrzeugtechnik AG & Co, Vehicle Safety Engineering, Magna Company, Graz, Austria*

Accepted 12 February 2002

Abstract

In order to analyse these injuries and to create guidelines for prevention, injuries at bus or tram stops were analysed retrospectively. Medical records were analysed and questionnaires were sent to the parents in order to obtain detailed information about the mode and physical sequelae or post-traumatic behavioural disturbances of the injury.

Thirty children of a median age of 9.5 years (2.7–15.3 years) were treated within a 6-year period. Sixteen out of 30 children (53.3%) were injured on their way to school and 3 (10.0%) on their way to kindergarten. Nine out of 30 children (30%) were injured when crossing the street from behind the bus or the tram. Five children (16.7%) were injured by buses, 6 (20.0%) by trams and 19 (63.3%) by passing motorised vehicles. Twelve (40.0%) were injured in the presence of accompanying adults. In 17 of 30 cases (56.7%) the visibility of the vehicle and/or the child was obstructed. The median Injury Severity Score (ISS) was 4.5 (1–75) and the mortality rate 2 out of 30 (6.7%), both children had been killed at bus stops alongside country roads. Nine out of 28 surviving children (32.1%) suffer from minor physical sequelae and 6 (21.4%) from post-traumatic behavioural disturbances.

Crossing the road from behind a bus in the area of a stop alongside a country road is extremely dangerous. It is mandatory to increase the safety at bus stops along country roads. © 2002 Elsevier Science Ltd. All rights reserved.

1. Introduction

In Austria the yearly mortality rate of child pedestrians is 0.66 out of 100,000 children aged between 0 and 14 years [14]. Prompted by some severe child pedestrian accidents in the area of bus and tram stops, we decided to analyse this kind of child pedestrian injuries. Some studies describe the occurrence of these injuries [2,5,13] but there are only few studies which examine the causes and sequelae of such injuries [6,7,11,12,15]. It is the aim of this study to create guidelines for injury prevention by retrospective analysis of these injuries to in order to highlight cause, mode and type of injury as well as physical sequelae and post-traumatic behavioural disturbances of pedestrian injuries close to bus or tram stops.

2. Patients and methods

The study was performed in the Department of Paediatric Surgery, Graz which serves the County of Styria (Steiermark) as the central paediatric trauma unit treating approximately 50% of all paediatric injuries registered in this area. A computerised database was used for searching pedestrian injuries [10].

The records of children who attended the department after a tram or bus stop related pedestrian injury between January 1995 and December 2000 were reviewed retrospectively. Age, gender, type of injuries, and outcome were considered. The Injury Severity Score (ISS) was calculated [4]. Children who died on the scene were excluded from this investigation. The estimated vehicle speed at impact was reconstructed from reports of witnesses and/or police reports.

A standardised questionnaire was completed for all children in order to obtain information on physical sequel and post-traumatic behavioural disturbances, action of the child, circumstances of the injury, location, road characteristics, presence or absence of zebra crossings or traffic lights, weather, sign-posted speed limit, speed and position of vehicle, type of vehicle, traffic density, presence of accompanying persons, such as other children, parents or other adults at the scene, obstruction of view for driver or child and the wearing of reflecting clothes. No questionnaires were sent to parents whose children had died. All injuries were analysed in a workshop by paediatric surgeons, paediatric radiologists, police members, road safety technicians, vehicle

* Corresponding author. Tel.: +43-316-385-3762; fax: +43-316-385-3775.
E-mail address: johannes.mayr@kfunigraz.ac.at (J.M. Mayr).

0020-1383/02/$ – see front matter © 2002 Elsevier Science Ltd. All rights reserved.
PII: S0020-1383(02)00051-7

safety technology engineers and Citizen Advice Bureau members.

The data are presented as median (range).

3. Results

Thirty injured children were treated within a 5.5-year period. The median age of the 15 boys and 15 girls was 9.5 years (2.7–15.3). Sixteen children (53.3%) were injured on their way to school, 3 children (10.0%) on their way to kindergarten and 11 children (36.7%) were injured during leisure time activities. Eighteen children had received road traffic safety instructions at some point in the past before the injury (60.0%), the average number of those lessons being 2.8 h (range 1–12 h). Twenty-two children were wearing bright coloured light reflective clothes at the time of the injury (73.3%). Fourteen out of 30 children were alone at the time of the injury (46.7%), 12 were accompanied by parents or other adults (40.0%) and 4 by other children (13.3%). In 26 cases there was a high traffic density (86.7%), in 3 cases there was a moderate traffic density (10.0%) and in 1 case there was a very low traffic density (3.3%). Twenty-eight children knew the location of the injury (93.3%) and only 2 had never been there before (6.7%). Traffic lights and zebra crossings (crosswalks) were present at the injury site in 4 out of 30 cases (13.3%), zebra crossings in 10 (33.3%) and none of these in 16 cases (53.4%). The time of the injury shows a peak around lunch time. Seven injuries (23%) had occurred between 7:00 and 10:00 a.m., 14 (47%) between 11:00 and 14:00 h, 7 (23%) between 15:00 and 18:00 h, and 2 (7%) after 19:00 h. Cause and mode of injury are shown in Table 1. In 17 cases (56.7%) the visibility for the driver and/or the child was obstructed.

The type of injury shows a predominance of head and lower extremity injuries and is displayed in Table 2. The median ISS [4] was 4.5 (1–75) (Fig. 1) and the mortality rate 6.7% ($n = 2$) (Fig. 1). Both died of very severe head and neck injuries (ISS 75). In both cases the impact point at the car causing the main injury was the bonnet at impact speeds between 75 and 80 km/h, the location being a bus stop alongside a country road.

Nine out of 28 (32%) children surviving suffer from minor physical sequel, 4 of them suffer from pain and mild impairment of range of motion, 4 suffered scars and 1 suffered tooth damage. Six (21%) children showed post-traumatic behavioural disturbances, two of them are very anxious of crossing the street, two of motorised vehicles, one has increased fear of hospitals and one suffers from nightmares and learning problems at school.

Table 1
Cause and mode of injury

Cause of injury	Obstruction of view	Injured by	n
Injuries caused by bus ($n = 5$)			
Clothing drawstring or school bag entrapment in bus door	Out of visual range	Rear tyre	2
Lost balance during a snowball game	Out of visual range	Front tyre	1
Crowding at the bus stop (300 children)	Blinded driver, bad weather	Front tyre	1
Stop towards the one-way street, crossing at red light	None	Side of bus	1
Injuries caused by tram ($n = 6$)			
Child was carried by an adult/child while crossing the track	None	Front	2
Distracted child crossed the track	None	Side of tram, vertical metallic edge	1
Child ran against the tram	Waiting-room	Side of tram	1
Crossing at crosswalk	Parking cars	Side of tram	1
Child looked at wrong traffic light	None	Front	1
Injuries caused by passing car or truck at bus stops ($n = 15$)			
Child ran away from the adult, crossed street from behind the bus	Bus	Car or truck	2[a]
Child crossed street in front of the bus	Parking car/bus	Car	5
Child crossed street in order to reach the bus, red traffic light	None	Car	1
Child crossed the street from behind the bus	Bus	Car	4[a]
Car passed group of children slowly	Group of children	Car	1
Child crossed the street behind the bus, after being teased	Driver dazzled by bus front reflectors	Car	1
Child crossed the street between buses; person waiting at opposite side of street	Parking buses	Car	1
Injuries caused by passing car or truck at tram stops ($n = 4$)			
Child crossed the street from behind the tram	Tram	Car	2
Child got off tram in the middle of street, car passing too fast	Out of visual range of driver, bad weather	Car	1
Child ran after leaving tram	Fence	Car	1

[a] One child each died in this group.

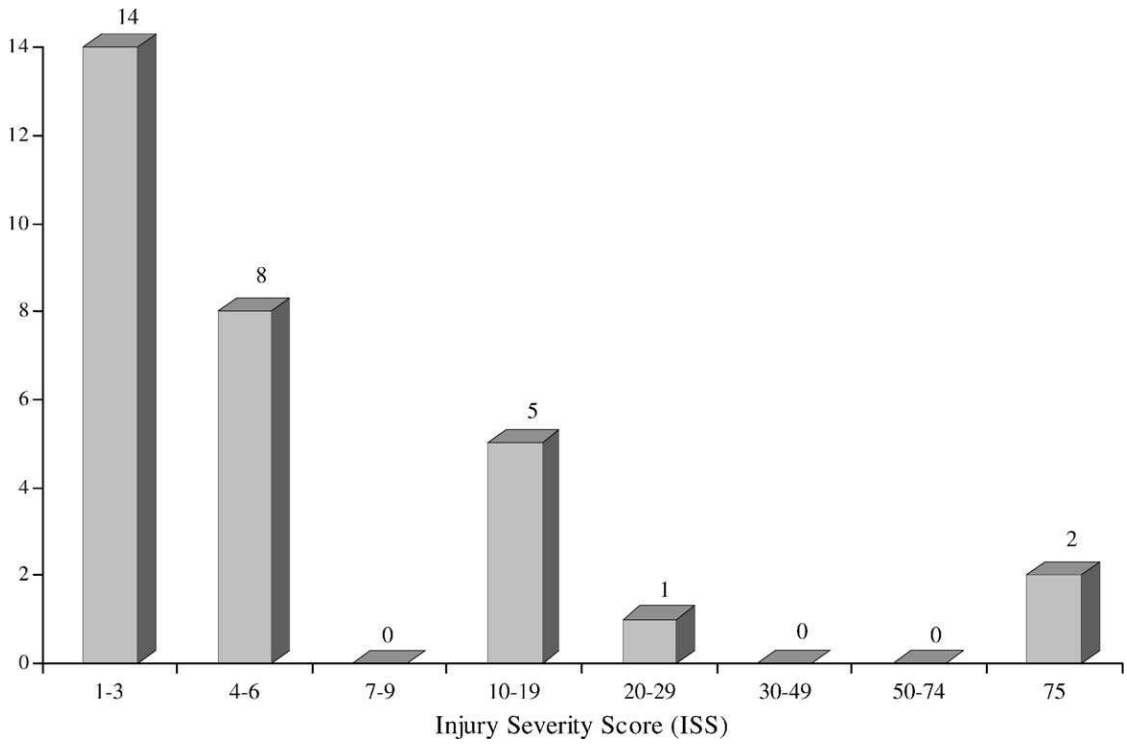

Fig. 1. ISS distribution ($n = 30$ children).

Table 2
Type and localisation of injury ($n = 30$ children)

Region of injury	Type of injury	n
Head, face	Intracranial haemorrhage	3
	Vault or base of skull fracture	4
	Minor closed head injury	13
	Abrasion, contusion, skin laceration, tooth lesion	10
Spine, trunk, pelvis	Fracture dislocation cervical spine	2
	Lung contusion/pneumothorax	2
	Pelvis or multiple rib fractures	3
	Skin abrasion, contusion, sprain	12
Upper extremity	Long bone fracture	2
	Crush injury	1
	Skin abrasion/laceration, contusion, sprain	9
Lower extremity	Long bone fracture, fracture of patella/calcaneus	4
	Crush injury	3
	Skin abrasion/laceration, sprain, contusion	17

4. Discussion

More than half of the children were injured on their way to school and approximately two out of three had received road traffic safety instruction lessons at school and/or kindergarten at some point in the past before the injury occurred. It must be kept in mind, that single interventions are known to lead to poor results, when compared to a multimode approach, using both community/environmental road safety intervention and a school based road/pedestrian safety intervention [9,16]. It has been demonstrated, that young children up to about 9 years are often at considerable risk as they do not have the ability to recognise a location as dangerous, even if they had attended road traffic safety instructions [3].

Therefore, accompanying of children on their way to school by adults seems to be a rewarding option to prevent these injuries. Our retrospective study, based on a number of 30 cases, shows that bus stops at country roads are very dangerous for children getting off buses. On the one hand there are no effective speed limits in the area of these bus stops (posted speed limits in most Austrian country roads: 100 km/h), and on the other there are hardly any safe crosswalks and/or continuous pavements or sidewalks. Many school children are transported to school by public buses instead of specially labelled school buses. Some drivers of passing cars fail to consider the possibility of children suddenly appearing from behind a bus at a bus stop. It is of urgent necessity to set initiatives for a better recognisability of buses transporting school children and better school bus safety standards (e.g. folding stop-signs at the left side of the school bus, standardised colouring, extra mirrors, use of entrapment sensors at bus doors, . . .). Safety recommendations for school buses carrying school-children, kindergarten-children or handicapped children which have already been worked out in some studies, must be considered further [1,2]. Children often force their way through a

Table 3
Possible injury prevention intervention strategies for reduction of paediatric injuries at bus or tram stops

(1)	Sign-posted speed limits (≤50 km/h) at bus stops alongside country roads
(2)	Crosswalks in front of incoming bus
(3)	Continuous pavement in area of bus or tram stop
(4)	Folding stop signs at the left side of the school bus
(5)	Standardised colouring of buses transporting school children
(6)	Extra mirrors/video monitoring for school bus back doors
(7)	Entrapment sensors for back doors of school bus
(8)	Impact absorbing tram front design
(9)	Avoidance of vertical metallic edges at the side of the tram
(10)	Front safety catch system for trams
(11)	Barriers at bus or tram stops to prevent children from crossing behind the vehicle
(12)	Avoidance of clothing drawstrings
(13)	Parking restrictions combined with regular controls at bus or tram stops
(14)	Regular road traffic safety training for school children
(15)	Adult supervision at bus or tram stops for children up to 11 years

crowd at bus stops, which can cause severe injuries trying to get a free seat, even though there is only standing room for most passengers. By installing automatic door controlling sensors or video related monitoring of the area of the back doors clothing drawstring entrapment injuries can be avoided (drawstring of the jacket, hood, cords of schoolbag, . . .). Parts such as drawstrings or cords on children's clothes should be abandoned, as these devices can cause strangulations, which has also been reported for playground injuries (slide and climbing frame injuries) and when children are using these devices while climbing trees or taking a ski-lift [8].

Crossing the street from behind the bus or the tram in the area of the stop is one of the main causes of these injuries. Warning ideograms on the inner side of the bus/tram doors and on the rear of the vehicle could help to prevent such injuries. Barriers to separate the stop from the street can be used to prevent children from crossing the street unexpectedly in the area of the bus/tram stop. The very hard and massive construction of the front of the tram leads to serious head injuries in pedestrian–tram-front collisions. But it must be mentioned that one boy—after having been knocked down by the tram—was caught by the safety-catch and thus protected from being run over and survived although with severe injuries. Non-impact absorbing parts at the side of the trams, especially vertical metallic strips, (e.g. door-frames) lead to serious head injuries even at low speed impacts. Impact absorbing front and side constructions, well-rounded strips, or elimination of vertical strips at the side of the tram could reduce child pedestrian injury severity. In order for the children to have free view it would be necessary to make sure that no cars park in the area of bus or tram stops. This surveillance system is expensive and requires a lot of staff, but this prevention program is just possible at daytimes with the highest injury-rates, e.g. rush-hour, lunch time or dawn. The mortality rate of 2 out of 30 children indicates an urgent need for intervention. Injury prevention recommendations are listed in Table 3.

5. Conclusion

Crossing the road from behind a bus or a tram in the area of a bus/tram stop is extremely dangerous. It is mandatory to increase the safety at bus stops along country roads.

References

[1] American Academy of Pediatrics. Committee on Injury and Poison Prevention. School bus transportation of children with special health care needs. Pediatrics 2001;108:516–8.
[2] American Academy of Pediatrics. Committee on school health and committee on injury and poison prevention. School Transportation Safety 1996;97:754–7.
[3] Ampofo-Boateng K, Thomson JA. Children's perception of safety and danger the road. Br J Psych 1991;82:487–505.
[4] Baker SP, O'Neill B. The Injury Severity Score: an update. J Trauma 1985;16:882–5.
[5] Burke GS, Lapidus GD, Zavoski RW, et al. Evaluation of the effectiveness of a pavement stencil in promoting safe behavoir among elementary school children boarding school buses. Pediatrics 1996;97:520–3.
[6] Cameron IC, Harris NJ, Kehoe NJ. Tram-related injuries in Sheffield. Injury 2001;32:275–7.
[7] Cass DT, Ross F, Lam L. School bus related deaths and injuries in New South Wales. Med J Aust 1996;165:134–7.
[8] Drago DA, Winston FK, Baker SP. Clothing drawstring entrapment in playground slides and school buses: contributing factors and potential interventions. Arch Pediatr Adolesc Med 1997;151:72–7.
[9] Durkin MS, Laraque D, Lubman I, Barlow B. Epidemiology and prevention of traffic injuries to urban children and adolescents. Pediatrics 1999;103:e74.
[10] Gell G. Routine documentation of medical texts. Methods Inform Med 1983;22:63–8.
[11] Hedelin A, Bjornstig U, Brismar B. Trams-a risk factor for pedestrians. Accid Anal Prev 1996;28:733–8.
[12] Milgram N, Toubiana YH. Children's selective coping after a bus disaster: confronting behavior and perceived support. J Trauma Stress 1996;9:687–702.
[13] Miller TR, Spicer RS. How safe are our schools? Am J Public Health 1998;88:413–8.
[14] Österreichisches Kuratorium für Verkehrssicherheit. Verkehrsunfallstatistik 2000—Kinder. Vienna. 2001;1–16 (http://www.kfv.or.at).
[15] Skjoth-Rasmussen J, Rasmussen SW. Tilskadekomst blandt buspassagerer i en region i kobenhavn. Ugeskr Laeger 1999;161:5803–6.
[16] Stevenson M, Iredell H, Howat P, et al. Measuring community/environmental interventions: the Child Pedestrian Injury Prevention Project. Inj Prev 1999;5:26–30.