*International Journal of Injury Control and Safety Promotion*, Vol. 13, No. 2, June 2006, 95–99

Taylor & Francis
Taylor & Francis Group

# The association of light trucks and vans with paediatric pedestrian deaths

CHARLES DIMAGGIO*†, MAUREEN DURKIN‡ and LYNNE D. RICHARDSON§

†Department of Epidemiology, Columbia University Mailman School of Public Health, 722 West 168 Street, New York, NY 10032, USA
‡Department of Population Health Sciences, University of Wisconsin School of Medicine and Public Health, 610 Walnut Street, Madison, WI 10029, USA
§Department of Emergency Medicine, Mt. Sinai School of Medicine, One Gustav L. Levy Place, New York, NY 10029, USA

(*Received 23 November 2004; in final form 2 March 2005*)

The hypothesis that relative to cars, light trucks and vans (including sports utility vehicles) are more likely to result in fatal paediatric pedestrian injury was investigated. It was further hypothesized that this increased risk is a result of head injuries. The study sample consisted of 18 117 police records of motor vehicles involved in crashes in which one or more pedestrians aged 5 to 19 years old was injured or killed. Frequencies and case fatality ratios for each vehicle body type were calculated. A logistic regression analysis was conducted, with light truck or van vs. car as the exposure variable and fatal/non-fatal pedestrian injury as the outcome variable. After controlling for driver age, driver gender, vehicle weight, road surface condition and presence of head injury, 5 to 19 year-olds struck by light trucks or vans were more than twice as likely to die than those struck by cars (odds ratio (OR) 2.3; 95% CI 1.4, 3.9). For the 5 to 9 year-old age group, light trucks and vans were four times as likely to be associated with fatal injury (OR 4.2; 95% CI 1.9, 9.5). There was an association between head injury and light trucks and vans (OR 1.2; 95% CI 1.1, 1.3). It was concluded that vehicle body type characteristics play an important role in paediatric pedestrian injury severity and may offer engineering-based opportunities for injury control.

*Keywords*: Vehicle; Paediatric; Pedestrian; Injury

## 1. Introduction

Pedestrian injury is a frequent cause of childhood morbidity and mortality (Rivara 1990, Roberts *et al.* 1995, National Safety Council 1998, Durkin *et al.* 1999). Research has often focused on the pre-crash phase of injury, in particular the complex interaction between a child's behaviour and exposure to traffic. Investigations into environmental variables have frequently been concerned with housing density, traffic volume and socio-cultural variables such as race, ethnicity and socio-economic status (Rivara and Barber 1985, Retting 1988, Mueller *et al.* 1990, Braddock *et al.* 1991, Agran *et al.* 1994, Roberts *et al.* 1995). While early studies of the relationship between vehicle type and pedestrian injury sometimes differed in their conclusions (Robertson and Baker 1976, Malek *et al.* 1990, Pitt *et al.* 1990), evidence is accumulating that larger, heavier vehicles known as light trucks and vans pose an increased risk of severe injury (Mizuno and Kajzer 1999, Starnes and Longthorne 2003, Ballesteros *et al.* 2004).

This study investigated whether paediatric pedestrian injuries involving light trucks and vans, such as sport utility vehicles (SUVs) and minivans are more likely to result in

*Corresponding author. Email: cjd11@columbia.edu

*International Journal of Injury Control and Safety Promotion*
ISSN 1745-7300 print/ISSN 1745-7319 online 
http://www.tandf.co.uk/journals
DOI: 10.1080/17457300500310038

fatality and whether any such increased risk is mediated through head injuries.

## 2. Materials and methods

When a motor vehicle crash occurs on a public road and results in death, personal injury or property damage, New York State Vehicle and Traffic Law, sections 600, 601, 602, 603 and 604, requires the police to investigate and file a report MV-104AN with the New York State Department of Motor Vehicles. An electronic database of 693 283 such reports of motor vehicle crashes occurring in the five boroughs of New York City between 1991 and 1997 was reviewed. A total of 27 377 involved injuries to pedestrians aged 5 to 19 years old. Of these, 18 117 (66.2%) contained sufficient data from vehicle identification numbers, as well as driver, pedestrian and environmental information, to form the basis for study.

Vehicle body type classifications were assigned based on definitions developed by the US National Highway Traffic and Safety Administration (1997). Light trucks and vans consisted of 'pickup trucks, minivans, full-size vans and sport utility vehicles'. Additionally, vehicles were assigned to three weight categories. Vehicle weights of 1500 to 3999 lbs were characterized as 'light'; weights of 4000 to 6999 were characterized as 'medium'; weights greater than 7000 lbs were characterized as 'heavy'.

An injured child was defined as an individual between the ages of 5 and 19 years who either resided in or visited New York City during the period under study and for whom a police report was completed and filed indicating injury or death sustained as a result of a pedestrian crash. The presence of a head injury as noted on the police report was also noted (Department of Motor Vehicles 1997). Based on prior descriptive analyses, the children were divided into three age categories: 5 to 9; 10 to 14; and 15 to 19 years (DiMaggio and Durkin 2002).

Children under the age of 4 years were excluded from the study. These children are frequently injured in 'rollovers', which often involve light trucks and vans and occur on private driveways, for which police accident reports are not required (Brison *et al.* 1988). This population is, therefore, biased by being both systematically under-represented in the database and associated with the primary risk factor of interest.

Mortality frequency, case-fatality rates and odds ratios (ORs) were calculated for each body type with sedans, referred to as cars, as the referent vehicle type. Descriptive analyses were conducted for driver and environmental variables. A logistic regression, excluding trucks/trailers and buses, compared light truck or van body type to car body type with fatal vs. non-fatal pedestrian injury as the outcome variable.

Covariates for the regression were chosen based on *a priori* considerations of possible confounders or interaction variables and included: (1) driver age (less than 25 years vs. older than 25 years); (2) driver gender; (3) road surface condition (dry vs. wet); (4) head injury (present or absent); (5) vehicle weight (light, medium, heavy). Crude estimates of the association between light trucks and vans and fatality were compared to estimates adjusted for potential confounders (Kleinbaum and Klein 1994, Kleinbaum *et al.* 1998). Adjusted estimates are presented.

Statistical calculations were conducted using SPSS version 11.5 and SAS version 9.0.

## 3. Results

Between 1991 and 1997 there were 27 377 pedestrian injuries among 5 to 19 years olds in New York City. The mean age for this group was 11; the mode was 8. There were a total of 149 fatalities, with 37 (35.6%) among 5 to 9 year olds, 33 (31.7%) among 10 to 14 year olds and 34 (32.7%) among 15 to 19 year olds. Vehicle body type information was available for 104 of the 149 fatalities. Weight information was available for 86 of these vehicles.

The largest body types, such as tractor-trailers were 41 times more likely to result in fatality (table 1) These vehicles, however, were involved in relatively few injuries over the study period. Large trucks and trailers accounted for 0.1% and buses for 0.6% of incidents. By contrast, light trucks and vans were involved in 16.7% ($n = 3049$) of injuries and 30.8% ($n = 32$) of fatalities during the study period. Excluding the largest body types, vehicles involved in fatal injuries weighed more than those involved in non-fatal injuries (figure 1). The risk of fatality increased with weight, with case fatality rates for heavier vehicles four times greater than those for lighter vehicles (figure 2).

In univariate analyses, body type, drivers younger than 25 years, male drivers and the occurrence of head injury were all associated with an increased risk of fatality among 5 to 19 year old pedestrians (table 2).

There was no statistically significant interaction between vehicle weight and light truck van status. The final regression equation indicated that, after controlling for driver age, driver gender, vehicle weight and road surface, children struck by light trucks and vans were 2.3 (95% CI 1.4, 3.9) times as likely to die from their injuries as were children struck by cars.

In age-stratified analyses, 5-to-9 year olds were 4.2 (95 % CI 1.9, 9.5) times more likely to die when struck by a light truck or van than when struck by a car (table 3). There was no similar statistically significant increased risk for the other age groups. The univariate association of fatality with car body types varied in a similar, but inverse, fashion (table 4). ORs for the association of other body types with fatality were similar across age groups.

There was a small statistically significant association between head injury among 5 to 19 year olds and light truck van body type (OR 1.2; 95% CI 1.1, 1.3). This result did not differ when stratified by age group. The univariate

Table 1. Frequency of vehicle body types in fatal and non-fatal pedestrian injuries and their associated case fatality rates and odds ratios (ORs) (New York City, pedestrians ages 5–19 years, 1991–1997).

| | Fatality frequency | | All injuries frequency | | Case fatality rate | |
|---|---|---|---|---|---|---|
| | n | % | n | % | (%) | OR (95% CI) |
| Cars | 64 | 61.5 | 14 944 | 81.9 | 0.4 | 1 (referent category) |
| Light trucks and vans | 32 | 30.8 | 3049 | 16.7 | 1.1 | 2.5 (1.6, 3.8) |
| Bus | 5 | 4.8 | 104 | 0.6 | 4.8 | 11.7 (4.6, 29.8) |
| Trailer/Other | 3 | 2.9 | 20 | 0.1 | 15 | 41.0 (11.7, 143.4) |
| Total | 104 | 100 | 18 117 | 100 | 0.6 | |

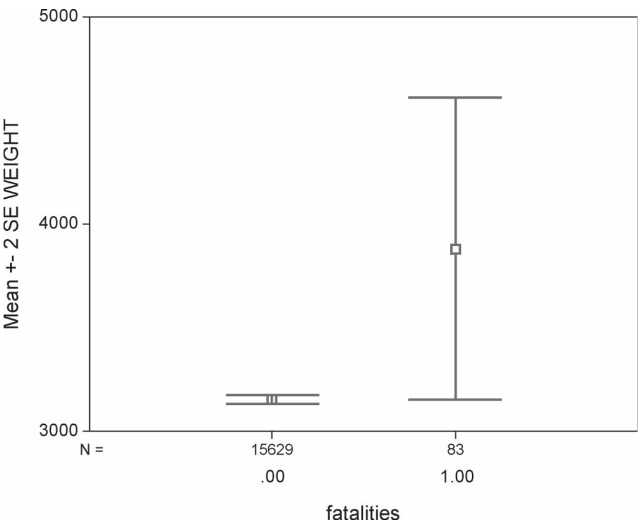


Figure 1. Mean vehicle weights and standard errors, fatal vs. non-fatal paediatric pedestrian injuries, ages 5 to 19 years, New York City, 1991–1997. Buses and trucks excluded.

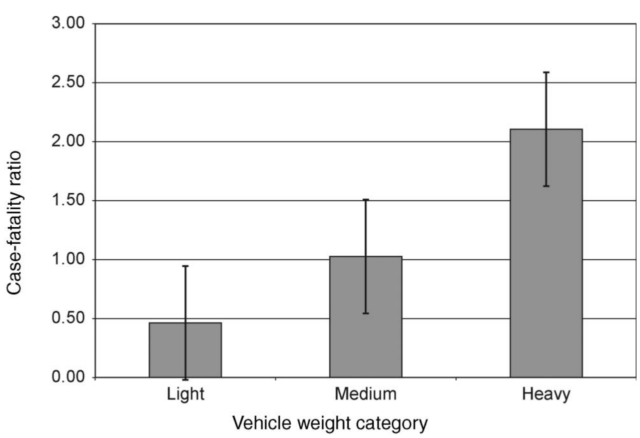


Figure 2. Case-fatality ratios and standard errors by vehicle weight categories. Paediatric pedestrian injuries, ages 5 to 19 years, New York City, 1991–1997. Buses and trucks excluded (83 fatalities).

Table 2. Unadjusted odds ratios (ORs) for association of predictor variables with fatality (Paediatric pedestrian injuries, ages 5 to 19 years, New York City, 1991–1997).

| Variable | Indicator | Fatal | Non-fatal | OR (95% CI) |
|---|---|---|---|---|
| LTV vs. car | LTVs | 32 | 3017 | 2.5 (1.6, 3.8) |
| | Cars | 64 | 14 880 | |
| Driver gender | Male | 73 | 11 725 | 2.2 (1.1, 4.3) |
| | Female | 10 | 3539 | |
| Driver age | $<25$ years | 24 | 2578 | 2.0 (1.2, 3.1) |
| | $>25$ years | 72 | 15 319 | |
| Head injury | Present | 42 | 4304 | 2.5 (1.6, 3.7) |
| | Absent | 54 | 13 593 | |
| Road surface | Wet | 9 | 2603 | 1.6 (0.8, 3.3) |
| | Dry | 87 | 15 294 | |

LTVs = light trucks and vans.

Table 3. Results of multiple logistic regression for association of fatality with light trucks and vans vs. car body type stratified by pedestrian age group (Controlling for driver age and gender, road surface, vehicle weight and presence of head injury; New York City, 1991–1997).

| Age group (years) | Odds ratio (95% CI) |
|---|---|
| 5–9 | 4.2 (1.9, 9.5) |
| 10–14 | 1.0 (0.3, 2.9) |
| 15–19 | 2.5 (1.0, 6.5) |

Table 4. Univariate odds ratios (ORs) for association of car body type with fatality stratified by age group (Paediatric pedestrian injuries, ages 5 to 19 years, New York City, 1991–1997).

| Age group (years) | OR (95% CI) |
|---|---|
| 5–9 | 0.3 (0.2, 0.5) |
| 10–14 | 0.7 (0.3, 1.5) |
| 15–19 | 0.4 (0.2, 0.7) |

OR for the association of light trucks and vans with fatality did not differ from the OR adjusted for head injury.

Although younger age (5 to 9 years old) was associated with the occurrence of head injuries (OR 1.6; 95% CI 1.5, 1.7), this association did not differ when restricted to either light trucks and vans (OR 1.7; 95% CI 1.4, 2.0) or passenger cars (OR 1.6; 95% CI 1.5, 1.7). In addition, although there was an association between the occurrence of head injuries and fatality (OR 2.3; 95% CI 1.6, 3.4), the association of head injury with fatality also did not differ by vehicle type, (OR for light trucks and vans 2.5; 95% CI 1.2, 4.9 vs. OR for passenger cars 2.4; 95% CI 1.4, 3.9). The association of head injury with fatality did not differ by age group (OR for 5 to 9 year olds 2.5; 95% CI 1.3, 4.8 vs. OR for 10 to 19 year olds 2.3; 95% CI 1.4, 3.7).

## 4. Discussion

A number of studies and reports have documented the aggressivity of light trucks and vans in motor vehicle crashes (Hampton and Hollowell 2000, Wald 2001). This paper adds to the growing literature on their consequences for pedestrians (Lefler and Gabler 2004, Roudsari *et al.* 2004). That crashes involving these vehicles are more than twice as likely to be fatal to children, and that this risk is further increased for younger children, is a cause for public health concern (Wald 2002).

Why light trucks and vans are more likely to kill 5 to 9 year olds remains to be explained, although the OR of 4.2 for fatal injury among 5 to 9 year olds struck by a light truck or van contradicts at least one engineering-based prediction of less severe injury for young paediatric pedestrians when struck by SUVs at residential speeds (ABC News 2000).

There is an element of collinearity between weight and body type, but this study indicates that the risk posed by light trucks and vans may not be due solely to vehicle weight. Increased risk may be due in part to the stiffness of the front of these vehicles compared to sedans, which results in more severe injuries, such as head trauma. It may also be due to driver behaviour, such as speeding, or perhaps the high carriage of these vehicles affects driver visibility. It is likely some combination of these factors.

Evidence was found of an increased risk of head injury when children are struck by these vehicles. The US National Highway Traffic and Safety Administration Pedestrian Impact Program and others have found vehicle design an important factor in the occurrence of cranial injury (Ashton 1982, Pitt *et al.* 1990). Higher leading edges may strike the relatively shorter child directly on the head or bumpers may strike the child on the lower extremities and pivot his/her head onto the top of the hood. There are also anatomical differences between children and adults that predispose children to head injuries (Pless *et al.* 1987, Hall 1994, Mazurek 1994, Christoffel and Schofer 1996).

The study was subject to several limitations. There was no acceptably accurate estimate for vehicle speed. While the structural properties of light trucks and vans may be more important, the combination of vehicle speed (which is at least in part a function of driver behaviour) and vehicle mass might also affect the smaller body surface of the youngest paediatric pedestrians more severely than other age groups. Given the average weight difference between cars and light trucks and vans, small differences in average speed between light trucks and cars can result in vast differences in force (Robertson 1998). This might account, at least in part, for the stronger association of light trucks and vans with fatalities among the youngest pedestrians.

Clinical designations were taken from police assessments, not medical reports. It likely resulted in errors in head injury assessments that could be expected to bias the results toward the null.

There was a large percentage of cases missing vehicle information. This was due primarily to hit-and-run incidents. The Insurance Institute for Highway Safety (2000) estimates that 17% of pedestrian fatalities nationwide occur in hit-and-run crashes. The latest available figures from the New York City Department of Transportation place the figure closer to 26% (Department of Transportation 1993). Assuming a higher number if injuries are included, the 33% of cases with missing data is consistent with most sources.

Cases that were excluded due to missing vehicle data were compared with cases that had full information. The ages of pedestrians differed less than 1% for any given category. Occurrence at an intersection and presence or absence of traffic signals differed by 2–3%. If the drivers of light trucks and vans were less likely to hit and run, these vehicles would be over-represented in the study and associations would be inflated. If light trucks and vans were under-represented, the opposite could be expected.

Finally, the designation of vehicles into categories is necessarily an approximation. For example, 'light trucks and vans' are defined differently by the US National Highway and Traffic Administration for purposes of 'vehicle aggressivety' (Wald 2001) than they are by the US Environmental Protection Agency for evaluation of fuel economy and emissions standards (Yacobucci 2000). Such non-differential classification errors, should, again, be expected to bias results toward the null.

Given their ubiquity both in the United States and Europe (Lyall 2004), even small increases in the risk of pedestrian injury due to light trucks and vans have important implications for injury prevention and control. Whilst this study has demonstrated such a risk, the mechanics of the relationship between light trucks and vans and fatal paediatric pedestrian injuries remain to be elucidated. Engineering studies are needed to determine whether adjustment of bumper heights, re-designing leading edges and front-end geometry, use of different materials and increasing the space between the more forgiving, thinner hood and front grill in relation to the rigid, unforgiving engine block may reduce the severity of light truck and van-related pedestrian injuries (Christoffel and Schofer 1996).

## References


ABC News, 2000, Dangerous Streets. In *ABC News 20/20*. (New York: ABC News).

Agran, P.F., Winn, D.G. and Anderson, C.L., 1994, Differences in child pedestrian injury events by location. *Pediatrics*, **93,** 284–288.

Ashton, S., 1982, Vehicle design in pedestrian injuries. In *Pedestrian Accidents*, A.J. Chapman (Ed.), pp. 169–202 (Chichester: John Wiley and Sons).

Ballesteros, M.F., Dischinger, P.C. and Langenberg, P., 2004, Pedestrian injuries and vehicle type in Maryland, 1995–1999. *Accident Analysis and Prevention*, **36,** 73–81.

Braddock, M., Lapidus, G., Gregorio, D., Kapp, M. and Banco, L., 1991, Population, income, and ecological correlates of child pedestrian injury. *Pediatrics*, **88,** 1242–1247.

Brison, R.J., Wicklund, K. and Mueller, B.A., 1988, 78 Fatal pedestrian injuries to young children: a different pattern of injury. *American Journal of Public Health*, **7,** 793–795.

Christoffel, K.K. and Schofer, J.L., 1996, Evaluation of a systematic approach for identifying injury scenarios. Kids 'n' Cars Teams. *Injury Prevention*, **2,** 221–227.

Department of Motor Vehicles, 1997, *Summary of Motor Vehicle Accidents: New York City, January*. (Albany: State of New York Department of Motor Vehicles).

Department of Transportation, 1994, *Traffic Fatalities in New York City 1993*. (New York: New York City Department of Transportation, Bureau of Traffic Division of Safety Programs).

DiMaggio, C. and Durkin, M., 2002, Child pedestrian injury in an urban setting: descriptive epidemiology. *Academic Emergency Medicine*, **9,** 54–62.

Durkin, M.S., Laraque, D., Lubman, I. and Barlow, B., 1999, Epidemiology and prevention of traffic injuries to urban children and adolescents. *Pediatrics*, **103,** e74.

Hall, S.C., 1994, Pediatric trauma in the 90s: an overview. *International Anesthesiology Clinics*, **32,** 1–9.

Hampton, C.G. and Hollowell, W.T., 2000, *The Aggressivity of Light Trucks and Vans in Traffic Crashes*. (Washington, DC: US National Highway and Safety Administration).

Insurance Institute for Highway Safety, 2000, *Safety Facts: Pedestrians*. (Arlington, VA: IIHS).

Kleinbaum, D.G. and Klein, M., 1994, *Logistic Regression: A Self-Learning Text*. (New York: Springer-Verlag Inc).

Kleinbaum, D.G., Kupper, L.L., Muller, K.E. and Nizam, A., 1998, *Applied Regression Analysis and Other Multivariable Methods*. (Pacific Grove: Brooks/Cole Publishing Co.).

Lefler, D.E. and Gabler, H.C., 2004, The fatality and injury risk of light truck impacts with pedestrians in the United States. *Accident Analysis and Prevention*, **36,** 295–304.

Lyall, S., 2004, American icon: big, bad SUVs are spreading to Europe. *The New York Times*, 14 November, Section A3.

Malek, M., Guyer, B. and Lescohier, I., 1990, The epidemiology and prevention of child pedestrian injury. *Accident Analysis and Prevention*, **22,** 301–313.

Mazurek, A., 1994, Pediatric injury patterns. *International Anesthesiology Clinics*, **32,** 11–25.

Mizuno, K. and Kajzer, J., 1999, Compatibility problems in frontal, side, single car collisions and car-to-pedestrian accidents in Japan. *Accident Analysis and Prevention*, **31,** 381–391.

Mueller, B.A., Rivara, F.P., Lii, S.M. and Weiss, N.S., 1990, Environmental factors and the risk for childhood pedestrian-motor vehicle collision occurrence. *American Journal of Epidemiology*, **132,** 550–560.

National Highway Traffic Safety Administration, 1997, *FARS Analytic Reference Guide 1975 to 1997*. (Washington DC: Department of Transportation).

National Safety Council, 1998, *Accident Facts:* 1997 edition. (Itasca, IL: National Safety Council).

Pitt, R., Guyer, B., Hsieh, C.C. and Malek, M., 1990, The severity of pedestrian injuries in children: an analysis of the Pedestrian Injury Causation Study. *Accident Analysis and Prevention*, **22,** 549–559.

Pless, I.B., Verreault, R., Arsenault, L., Frappier, J.Y. and Stulginskas, J., 1987, The epidemiology of road accidents in childhood. *American Journal of Public Health*, **77,** 358–360.

Retting, R.A., 1988, Urban pedestrian safety. *Bulletin of New York Academy of Medicine*, **64,** 810–815.

Rivara, F.P., 1990, Child pedestrian injuries in the United States. Current status of the problem, potential interventions, and future research needs. *American Journal of Diseases of Children*, **144,** 692–696.

Rivara, F.P. and Barber, M., 1985, Demographic analysis of childhood pedestrian injuries. *Pediatrics*, **76,** 375–381.

Roberts, I., Norton, R. and Jackson, R., 1995, Driveway-related child pedestrian injuries: a case-control study. *Pediatrics*, **95,** 405–408.

Robertson, L.S., 1998, *Injury Epidemiology: Research and Control Strategies*, 2nd ed. (New York: Oxford).

Robertson, L.S. and Baker, S.P., 1976, Motor vehicle sizes in 1440 fatal crashes. *Accident Analysis and Prevention*, **8,** 167–175.

Roudsari, B.S., Mock, C.N., Kaufman, R., Grossman, D., Henary, B.Y. and Crandall, J., 2004, Pedestrian crashes: higher injury severity and mortality rate for light truck vehicles compared with passenger vehicles. *Injury Prevention*, **10,** 154–158.

Starnes, M. and Longthorne, A., 2003, *Child Pedestrian Fatality Rates by Striking Vehicle Body Type: A Comparison of Passenger Cars, Sport Utility Vehicles, Pickups and Vans. US National Highway Traffic and Safety Administration Research Note*. Available online at: http://www.nrd.nhtsa.dot.gov/pdf/nrd-30/NCSA/Rnotes/2003/809-640/RN_Ped_Fatal.pdf (accessed 20 December 2005).

Wald, M., 2001, Safety issue assessed as Congress considers raising mileage standards. *The New York Times*, 14 July, Section 11.

Wald, M., 2002, Automakers block crash data recorders that could save lives, critics say. *The New York Times*, 29 December.

Yacobucci, B., 2000, *RS20298: Sports Utility Vehicles, Mini-Vans and Light Trucks: An Overview of Fuel Economy and Emissions Standards*. (Washington, DC: National Council for Science and the Environment).