THE ASSOCIATION OF LIGHT TRUCKS AND VANS WITH PEDIATRIC PEDESTRIAN DEATHS

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ABSTRACT

We investigated the hypothesis that relative to cars, light trucks and vans (including sports utility vehicles) are more likely to result in fatal pediatric pedestrian injury. 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 pedestrian aged 5 to 19 years old was injured or killed. Frequencies and case fatality ratios for each vehicle body type were calculated. We conducted a logistic regression analysis with light truck or van versus 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 (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). We conclude that vehicle body type characteristics play an important role in pediatric pedestrian injury severity and may offer engineering-based opportunities for injury control.

Keywords: vehicle, pediatric, pedestrian, injury

2,028 words, 2 figures, 4 tables, 37 references

INTRODUCTION

Pedestrian injury is a frequent cause of childhood morbidity and mortality. (1-4) Research has often focused on the pre-crash phase of injury, in particular the complex interaction between a child's behavior 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.(3, 5-9) While early studies of the relationship between vehicle type and pedestrian injury sometimes differed in their conclusions.(10-12) evidence is accumulating that larger, heavier vehicles known as light trucks and vans pose and increased risk of severe injury.(13-15)

In this study, we investigate whether pediatric pedestrian injuries involving light trucks and vans like sport utility vehicles and minivans are more likely to result in fatality. We further investigate whether any such increased risk is mediated through head injuries.

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. We reviewed 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. 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 (16). Light trucks and vans consisted of “pickup trucks, minivans, full-size vans and sport utility vehicles”. Additionally, we assigned vehicles to 3 weight categories. Vehicle weights of 1,500 to 3,999 pounds were characterized as ‘light’; weights of 4,000 to 6,999 were characterized as ‘medium’; weights greater than 7,000 pounds were characterized as ‘heavy’.

An injured child was defined as an individual between the ages of 5 and 19 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. (17) Based on prior descriptive analyses, the children were divided into three age categories: 5 to 9, 10 to 14 and 15 to 19. (18)

Children under the age of 4 were excluded from the study. These children are frequently injured in “rollovers” that often involve light trucks and vans and occur on private driveways for which police accident reports are not required.(19) This population is, therefore, biased by being both systematically underrepresented in the database and associated with the primary risk factor of interest.

Mortality frequency, case-fatality rates and odds ratios 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 truck/trailers and buses, compared light truck or van body type to car body type with fatal versus 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)* and *(*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. (20, 21) Adjusted estimates are presented.

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

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, though, 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, 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) Odds ratios 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 odds ratio for the association of light trucks and vans with fatality did not differ from the odds ratio 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).

DISCUSSION

A number of studies and reports have documented the aggressivity of light trucks and vans (LTVs) in motor vehicle crashes. (22, 23) This paper adds to the growing literature on their consequences for pedestrians.(24, 25) 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.(26)

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 an LTV contradicts at least one engineering-based prediction of less severe injury for young pediatric pedestrians when struck by SUVs at residential speeds. (27).

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 result in more severe injuries such as head trauma. It may also be due to driver behavior such as speeding, or perhaps the high carriage of these vehicles affects driver visibility.   It is likely some combination of these factors.

We found evidence 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. (12, 28) 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 or her head onto the top of the hood. There are also anatomical differences between children and adults that predispose children to head injuries (29-32)

The study was subject to several limitations. There was no acceptably accurate estimate for vehicle speed. While the structural properties of LTVs may be more important, the combination of vehicle speed (which is at least in part a function of driver behavior) and vehicle mass might also affect the smaller body surface of the youngest pediatric 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.(33) This might account, at least in part, for the stronger association of LTVs 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 which could be expected to bias the results toward the null.

There were a large percentage of cases missing vehicle information. This was due primarily to hit-and-run incidents. The Insurance Institute for Highway Safety estimates that 17% of pedestrian fatalities nationwide occur in hit-and-run crashes.(34) The latest available figures from the New York City Department of Transportation place the figure closer to 26%. (35) 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 one percent for any given category. Occurrence at an intersection and presence or absence of traffic signals differed by 2 to 3 percent. 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” (23) than they are by the US Environmental Protection Agency for evaluation of fuel economy and emissions standards. (36) 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 (37), even small increases in the risk of pedestrian injury due to light trucks and vans have important implications for injury prevention and control. While, this study has demonstrated such a risk, the mechanics of the relationship between light trucks and vans and fatal pediatric 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.(31)

FIGURES AND TABLES

Table 1: Frequency of Vehicle Body Types in Fatal and Non-Fatal Pedestrian Injuries and Their Associated Case Fatality Rates and Odds Ratios (New York City, Pedestrians Ages 5-19), 1991-1997

	FATALITY FREQUENCY (%)	**ALL INJURIES FREQUENCY (%)**	**CASE FATALITY RATE (%)**	**ODDS RATIO (95% CI)**
Cars	64 (61.5%)	14,944 (81.9%)	0.4	1 (Referent Category)
Light trucks and vans	32 (30.8%)	3,049 (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 Pediatric Pedestrian Injuries, Ages 5 to 19, NYC, 1991-1997. Buses and Trucks excluded.

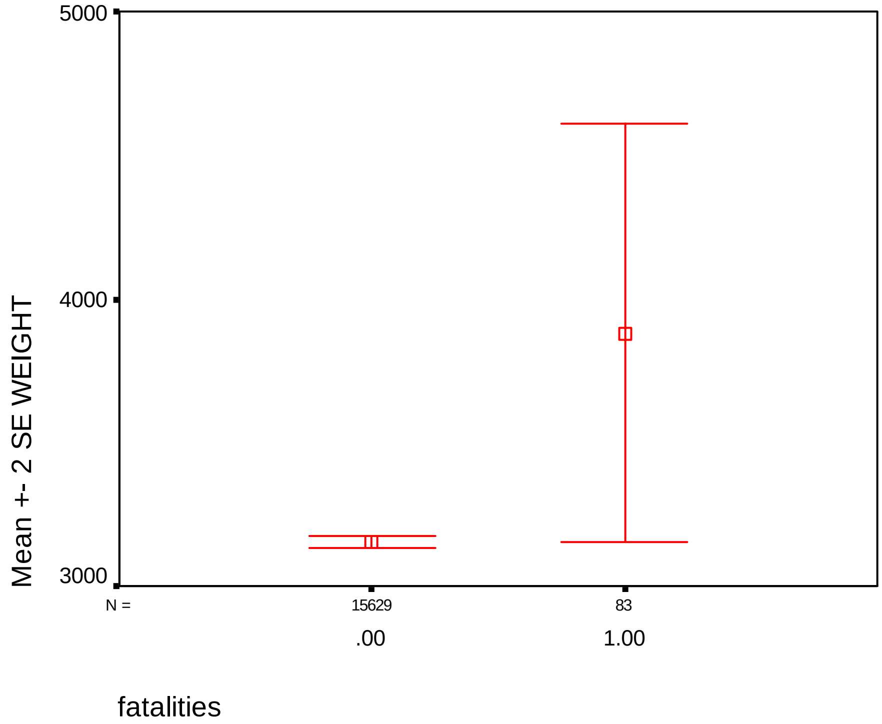

Figure 2: Case-Fatality Ratios and Standard Errors by Vehicle Weight Categories. Pediatric Pedestrian Injuries, Ages 5 to 19, NYC, 1991-1997. Buses and Trucks excluded. (n=83 fatalities).

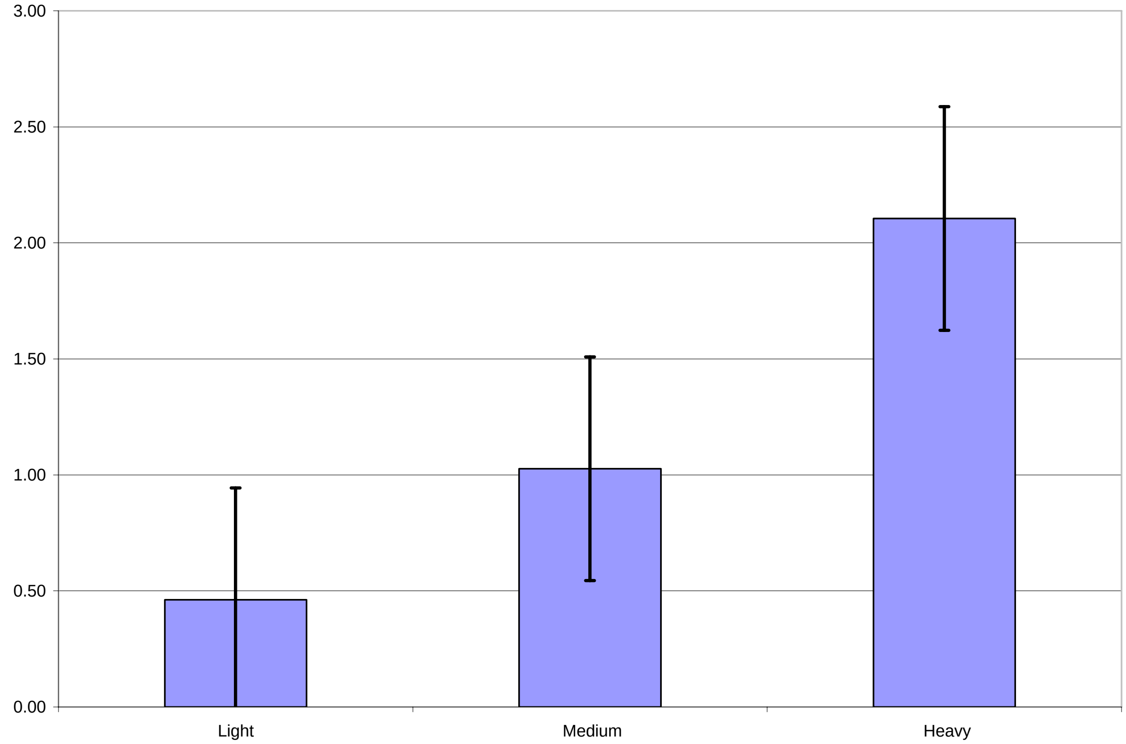

Table 2: Unadjusted Odds Ratios for Association of Predictor Variables with Fatality. Pediatric Pedestrian Injuries, Ages 5 to 19, NYC, 1991-1997:

Variable	**Indicator**	**Fatal**	**Nonfatal**	**OR (95% CI)**
LTV vs Car	LTVs	32	3017	2.5 (1.6, 3.8)
	Cars	64	14880	
Driver Gender	Male	73	11725	2.2 (1.1, 4.3)
	Female	10	3539	
Driver Age	< 25 Years	24	2578	2.0 (1.2, 3.1)
	> 25 Years	72	15319	
Head Injury	Present	42	4304	2.5 (1.6, 3.7)
	Absent	54	13593	
Road Surface	Wet	9	2603	1.6 (0.8, 3.3)
	Dry	87	15294	

Table 3: Results of Multiple Logistic Regression for Association of Fatality with LTV 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	**ODDS RATIO (95% CI)**
5 TO 9	**4.2 (1.9, 9.5)**
10 TO 14	**1.0 (0.3, 2.9)**
15 TO 19	**2.5 (1.0, 6.5)**

Table 4. Univariate Odds ratios for association of ‘car’ body type with fatality stratified by age group. Pediatric Pedestrian Injuries, Ages 5 to 19, NYC, 1991-1997:

AGE GROUP	**ODDS RATIO (95% CI)**
5 TO 9	**0.3 (0.2, 0.5)**
10 TO 14	**0.7 (0.3, 1.5)**
15 TO 19	**0.4 (0.2, 0.7)**

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