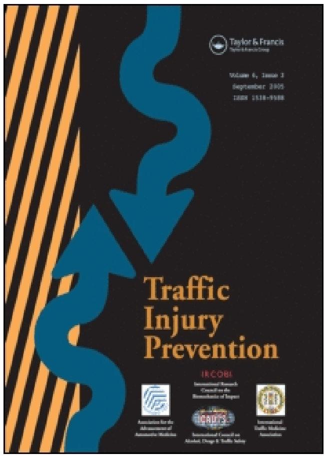

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The "Unintended Pedestrian" on Expressways

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Objective. *To explore the epidemiology of pedestrian deaths in Dallas County, Texas, and to compare factors associated with pedestrian deaths on expressways versus those that occurred on other roadways.*

Methods. *We studied all pedestrian deaths among persons 15 years of age or older in Dallas County, Texas, from 1997 to 2004 by linking data from Medical Examiner's office, the Fatality Analysis Reporting System, and local police records. Univariate and multivariate analysis compared various factors associated with death on an expressway.*

Results. *Among 437 pedestrian deaths who were 15 years of age or older, 197 (45%) occurred on expressways; the proportion that occurred on expressways was highest among 15- to 29-year-olds (65%) and was lower with advancing age group ($p < 0.01$, chi square for trend). At least 36% of these expressway-related pedestrian deaths were known to have been "unintended pedestrians," who had exited a vehicle after being on the roadway, compared with 11% of pedestrian deaths on surface streets (OR 4.6, 95% CI, 2.7–8.1), and this was also highest among younger age groups. Pedestrian deaths on an expressway, compared with deaths on surface streets, remained strongly associated with having been an "unintended pedestrian" (OR 6.2, 95% CI, 3.1–14.0), after controlling for several other variables, including age, sex, race, nighttime of crash, and alcohol involvement.*

Conclusions. *Expressways are the predominant site of fatal pedestrian crashes among young adults in this urban area. Since many of these deaths were "unintended pedestrians," procedures for management of occupants of disabled vehicles on expressways could have a large impact on pedestrian deaths in young adults.*

Keywords Injury; Pedestrian; Unintended; Expressway; Freeway; Trauma; Epidemiology; Prevention

Pedestrian injuries resulted in more than 4800 traffic deaths in the United States in 2005 with a rate of 1.7 deaths per 100,000 population, accounting for about 12% of all traffic-related deaths (Department of Transportation [DOT], National Highway Transportation Safety Administration [NHTSA], 2006). This was the highest level of pedestrian deaths since 2001 (DOT, NHTSA, 2006). More than two thirds of pedestrian deaths occurred on urban roadways, and in many cities, pedestrians account for >20% of traffic-related deaths (DOT, NHTSA, 2003). For many years, "Sunbelt" states in the southern United States have had higher pedestrian death rates than other areas (Paulozzi, 2006).

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A better understanding of the epidemiology of pedestrian deaths is essential to designing prevention efforts, both in the United States and around the world. We undertook to study pedestrian deaths for a large urban area in a Sunbelt state, with the goal of identifying patterns, circumstances, contributing factors, and potential avenues for preventive interventions for this problem. Our linked data allowed us to identify expressway-related deaths and some of the circumstances around those deaths, including the reason that the person was on the expressway, and to compare expressway-related pedestrian deaths with those that occurred on other roadways.

METHODS

Background

Dallas County, Texas, had a population of 2.2 million persons according to the 2000 census. The population 15 years of age or older was 1.7 million; 49% were white, non-Hispanic; 19% were black, non-Hispanic; 27% were of Hispanic origin; and

5% other. Greater than 90% of the city of Dallas is within Dallas County, as are several other smaller cities.

Data

All traumatic deaths in Dallas County are reviewed by the county's medical examiner (ME). We reviewed medical examiner details of every pedestrian death who was at least 15 years of age that occurred in Dallas County, Texas, for the 8 years 1997–2004. A pedestrian death was defined as a person who died within one year of being injured as a result of being struck by a motor vehicle while the person was walking or standing.

We excluded any death that was determined by the ME to have been intentional (homicide or suicide) or that was of undetermined intent. We also excluded persons who were lying on the roadway when struck by a vehicle (e.g., a motor vehicle crash in which an occupant was thrown from the vehicle and then struck by another vehicle), or who were on a bicycle or other wheeled vehicle (such as wheelchair), or those who were struck by a train.

An expressway was defined as a limited-access highway (e.g., on-ramps, off-ramps, no stoplights or stop signs, and no cross traffic). A surface street was defined as any street or road designed for public traffic that was not an expressway.

The ME records were linked to the record of the crash from the Fatality Analysis Reporting System (FARS) data and to records from the Texas Department of Public Safety (DPS), based on the age, sex, location of crash, date and time of crash, and date and time of death. If any of the data sets included an assessment that the pedestrian had exited a stopped vehicle in the road or on the roadside, the case was designated as being an "unintended pedestrian," meaning that the person had entered the roadway in a motor vehicle, then exited the vehicle and was killed as a pedestrian. Nighttime was defined as 8:00 p.m. until 5:59 a.m.; no attempt was made to determine the actual time of sunset or darkness on the day of the injury.

Denominators for rate calculations were derived from the 2000 census for Dallas County, Texas. This study was judged by the Institutional Review Board at the University of Texas Southwestern Medical Center to have exempt status.

Statistics

Data were analyzed using Epi Info version 6.02, Epi Info 2000, and JMP version 5.1.1 (SAS Institute, Cary, NC). Univariate analyses utilized chi square, chi square for trend, and odds ratios (OR) and 95% confidence intervals (95% CI). All variables with significant associations ($p < 0.05$) were among those entered into the multivariate logistic regression analysis to compare expressway deaths to other sites of death.

RESULTS

For the 8-year period (1997–2004) we identified 464 pedestrian deaths that were at least 15 years of age. Twenty-seven did not meet inclusion criteria (7 were classified as homicides, 7 as suicides, 4 as undetermined intent, 4 involved trains, and 5 died >1 year after the injury), leaving 437 cases that met the criteria for inclusion (3.2 per 100,000 persons 15 years of age or older, per year). Of these 437 cases, 433 (99.1%) were in the ME data, 399 (91.3%) in the DPS data, and 389 (89.0%) in the FARS data. Three hundred eighty-three (87.6%) cases were found in all three data sets; 32 (7.3%) were found in the ME data only, 16 (3.7%) in the ME data and DPS data only (i.e., not in the FARS data), and 4 (1%) were found in the FARS data only. The FARS data set included 92% of the cases that occurred on public roadways (expressways, frontage roads, and streets) but only 40.7% of cases that occurred in driveways, parking lots, sidewalks, and alleys ($P < 0.001$), consistent with FARS policy for collecting data for public roadways. The interval between the crash event and death was <1 day for 77% of cases, <30 days for 98% of cases, and <90 days for 99% of cases.

The majority (340 of 437, 77.8%) were male. Median age was 40.0 years. Rates per 100,000 population were highest among blacks and Hispanics (Table I).

The site of the crash event was as follows: expressways (197; 45.1%); expressway frontage roads (31; 7.1%); other surface streets (182; 41.6%); other sites (driveways, parking lots, alleys, or sidewalks, 27; 6.2%). Among the 197 pedestrian deaths on expressways, 137 (69.5%) were interstate highways, and 60 (30.5%) were non-interstate expressways (i.e., state highways, United States highways, etc.).

Alcohol test results were available from 373 (85.4%) of the 437 pedestrians deaths; 171 (45.8%) of those tested had detectable levels. The distribution of alcohol content levels was as follows (in g/dL): 0.01–0.07, 17 (9.9%); 0.08–0.15, 37 (21.6%); 0.16–0.23, 71 (41.5%); 0.24–0.31, 30 (17.5%); 0.32 and above, 16 (9.4%).

For purposes of comparing expressway-related deaths to other sites, deaths on frontage roads were combined with deaths on other types of surface streets, because speed limits and cross-traffic characteristics of frontage roads were more similar to streets than to expressways. The proportion of deaths that occurred on expressways was highest among young adults and was lower with advancing age (Table II; chi-square for linear trend = 32.9; $p < 0.001$); among the youngest age group 15–29 years old, 75 (64.7%) of 116 pedestrian deaths occurred on expressways. When comparing expressway vs. non-expressway sites of injury, expressway-related deaths were more likely to occur at nighttime (8:00 p.m.–5:59 a.m.) (76% vs. 53%, respectively; OR = 2.8, 95% CI, 1.8–4.3), among males (82% vs. 74%; OR = 1.6, 95% CI 1.0–2.6), to have alcohol detected (47%

Table I Pedestrian death rate by gender and race/ethnicity, for persons 15 years of age or older, Dallas County TX, 1997–2004. Rates are average annual deaths per 100,000 population.

Variable	Rate	95% C.I
Male	5.0	4.5–5.6
Female	1.4	1.1–1.7
White (non-Hispanic)	2.2	1.9–2.6
Black (non-Hispanic)	4.7	3.9–5.5
Hispanic	4.1	3.5–4.8
Other	2.2	1.0–3.3

Table II Number and percent of pedestrian deaths among persons 15 years of age or older that occurred on expressways,* surface streets, and other sites, and proportion that were unintended pedestrians,** by age group, Dallas County, TX, 1997–2004 (N = 437).

	All sites	Expressways*		Surface streets		Other sites	
Age group (years)	Total number of pedestrian deaths at all sites	Number on expressways (% of all Pedestrian Deaths)[3]	Number that were unintended pedestrian[2] (% of expressway pedestrian deaths)[3]	Number on surface streets (% of all pedestrian deaths)[3]	Number that were unintended pedestrian[2] (% of surface street pedestrian deaths)[3]	Number on other sites (% of all pedestrian deaths)	Number on other sites that were unintended pedestrians[2] (% of other sites pedestrian deaths)
15–29 Years	116	75 (64.7)	39 (52.0)	38 (32.8)	10 (26.3)	3 (2.6)	0
30–44 Years	167	72 (43.1)	20 (27.8)	84 (50.3)	9 (10.7)	11 (6.6)	0
45–59 Years	87	38 (43.7)	10 (26.3)	43 (49.4)	3 (7.0)	6 (6.9)	0
60+ Years	67	12 (17.9)	2 (16.7)	48 (71.6)	1 (2.1)	7 (10.4)	0
Total (%)	437 (100)	197 (45.1)	71 (36.0)	213 (48.7)	23 (10.8)	27 (6.2)	0

[1]Expressway = limited-access highway.
[2]Unintended pedestrian = person who entered roadway in a motor vehicle, then exited the vehicle and was killed as a pedestrian.
[3] $p < 0.001$ by chi square for trend, by age group.

vs. 33%; OR = 1.8, 95% CI 1.2–2.7), and to have been an unintended pedestrian (36% vs. 10%; OR = 5.3, 95% CI 3.1–9.3), but there was no significant difference in proportion related to race or ethnicity, hit-and-run status of the driver, or year of injury.

Unintended Pedestrians

For further analysis of unintended pedestrians, only those 410 (93.8%) deaths that occurred on a public roadway were included; the 27 (6.2%) deaths that occurred on driveways, parking lots, alleys, etc., were not included in this analysis. Ninety-four (22.9%) of the 410 roadway pedestrian deaths were known to have been unintended pedestrians who had exited a vehicle after it had entered the roadway. The proportion of unintended pedestrians was higher among pedestrian deaths on expressways compared with other surface streets (36.0% [71 of 197] on expressways were unintended pedestrians vs. 10.8% [23 of 213] on other surface streets [OR = 4.6, 95% CI, 2.7–8.1]).

The reasons that these 71 known unintended pedestrians had left a vehicle after entering the expressway included the following: vehicle disabled by crash, stall, etc., 51 (71.8%); assisting another disabled vehicle ("good Samaritan"), 10 (14.1%); parked or stopped for other reasons, 10 (14.1%). Among the 197 expressway pedestrian deaths, the remaining 126 (63.9%) were not known to have been unintended pedestrians, from the ME or police investigation records: 28 had entered the expressway on foot intentionally, 4 were working on the expressway or shoulder (e.g., construction worker, police), 3 had fallen or jumped from a moving vehicle, and for 91 (46.2% of the total number of expressway pedestrian deaths) the reason for the pedestrian being on the expressway was not known from any of the records reviewed.

Among the 197 expressway pedestrian deaths, the proportion of unintended pedestrians was highest among the younger age groups and was lower among older persons ($p < 0.01$, by chi square for trend, Table II); among the subset of 75 persons who were 15–29 years old and killed on an expressway, 52% (39 of 75) were known to have been unintended pedestrians. For expressway pedestrian deaths among teenage driving-age persons (16–19 years), all (9 of 9) were unintended pedestrians. Among the 197 expressway pedestrian deaths, there were no significant differences between unintended pedestrians vs. other pedestrian deaths when analyzed by race, sex, alcohol involvement, or time of day.

In the multivariate analysis, the dependent variable was the site of the pedestrian crash (expressway vs. other surface streets). Based on results of univariate analyses, seven independent variables were entered into the logistic regression: age group, race/ethnicity, gender, alcohol test result, nighttime, year of crash, and whether the case was an unintended pedestrian. In the final model, three variables were significantly associated with expressway site of pedestrian death: being an unintended pedestrian (OR 6.2, 95% CI, 3.1–14.0); age group 15–29 years (OR 1.9, 95% CI, 1.1–3.1); and presence of alcohol in the decedent (OR 1.7, 95% CI, 1.1–2.6).

Expressway site of pedestrian death was not significantly associated with race or ethnicity, gender, occurrence at nighttime, or year of crash. There was noted a significant interaction for unintended pedestrian death and nighttime of crash, with the odds ratio (for pedestrian death on an expressway vs. a surface street) associated with unintended pedestrian being much larger for daytime crashes than for nighttime crashes, despite the fact that most of the deaths occurred from nighttime crashes.

There was no difference in the results of the multivariate analysis when we limited the analysis to those cases that died within 30 days of the crash (the definition used in the FARS data set), or when the day/night variable in the FARS data set was used in place of the night time definition we had used (i.e., 8:00 p.m. through 5:59 a.m.).

DISCUSSION

Expressways may be the safest part of the roadway system for motor vehicle traffic; however, these same expressways may be the most dangerous place for a pedestrian. We were surprised that expressways accounted for a majority of pedestrian deaths among young adults in Dallas County. A recent tally of all motor vehicle–related deaths that occurred on expressways in the city of Dallas in 2003–2005 showed that 40.7% (68 of 167) were pedestrians, and 59.3% (99 of 167) were vehicle occupants (unpublished data, A. Dickason, Dallas Police Department, December 2006); this despite our anecdotal experience that it is rare to see a pedestrian on an expressway.

A recent report showed that although pedestrian deaths overall declined between 1998 and 2001, deaths that occurred on interstate highways had increased (DOT, NHTSA, 2003). But analyzing pedestrian deaths on interstate highways underestimates the role of expressways in pedestrian deaths. Thirty percent of expressway pedestrian deaths in our study occurred on non-interstate expressways. Functionally, there is little difference between an interstate highway and a non-interstate expressway. Both have higher speed limits, have multiple lanes, are designed to move large volumes of traffic rapidly, and prohibit pedestrian traffic.

Paulozzi (2006) found that Sunbelt states have the highest rates of pedestrian deaths in the United States, and that much of the excess was among 15- to 64-year-olds, on roadways with speed limits >35 mph, and with elevated blood alcohol concentrations. Our findings from Dallas County, a large urban area in the Sunbelt, are similar. In the Paulozzi (2006) study, the higher pedestrian death rate on higher-speed roadways in Sunbelt states was significant only for urban roadways, not for rural ones; there is no mention of a separate analysis of expressway deaths in his report. Pedestrian death rates are higher in urban populations than in rural populations (Baker et al., 1987; Paulozzi, 2005), and a higher proportion of the Sunbelt population lives in urban areas compared with the rest of the country (Paulozzi, 2006). Urban sprawl may be more prevalent in the South (Ewing et al., 2006), where population growth has been greatest (Lang & Rengert, 2006). Sprawl carries with it an increased risk to pedestrians (Ewing et al., 2003), which may be due to more driving on expressways and other high-speed roads (Ewing et al., 2006; Frumkin, 2002). If results from our study in Dallas County are representative of other urban areas in the Sunbelt, then some of the difference that Paulozzi (2006) observed for Sunbelt states may be due to pedestrian deaths on urban expressways, many of which are not interstate highways.

The most striking finding from our study was that more than one third of pedestrian deaths on expressways occurred among persons known to have been "unintended pedestrians," who exited a vehicle after it was on an expressway. In fact, among young adults, at least half of the pedestrian expressway deaths occurred among unintended pedestrians; among pedestrian expressway deaths in the first 4 years of driving age (16–19 years of age), all were unintended pedestrians. These numbers probably underestimate the true proportion of unintended pedestrians among expressway pedestrian deaths, because for almost half of these deaths we could not find information from the ME or police investigations about why the person was on the expressway.

There are few studies in the injury literature that have noted the connection between pedestrian deaths on expressways and being an "unintended pedestrian." Knoblauch et al. (1978) studied a sample of what they classified as freeway pedestrian deaths in five states in 1974 and found that these deaths were most common in persons in their late teens and 20s, and one third were attending to a disabled vehicle. Johnson (1997) studied police reports from pedestrian deaths on interstate highways in three states from 1991 to 1993 and found that 32% involved what he called an "unintended pedestrian," who had not set out to enter the interstate on foot.

A review of pedestrian deaths from 1994 to 1998 in four counties of the Atlanta metropolitan area revealed that 22% occurred from crashes on interstate highways, and 35.8% of those involved persons who had exited a privately owned vehicle in traffic (calculations based on raw numbers contained in report; Hanzlick et al., 1999), which proportion is similar to the finding in Dallas County. We feel that these findings support the possibility that unintended pedestrians on expressways comprise a substantial and under recognized proportion of pedestrian deaths, especially in some urban areas.

There are several limitations of our study. First, we studied fatalities, which are likely to be different epidemiologically from non-fatal pedestrian crashes. Deaths are more likely to occur at higher vehicle speeds (Anderson et al., 1997; Leaf & Preusser, 1999), and it is likely that a high proportion of the pedestrian crashes that occur on expressways are fatal, compared to crashes on surface streets, where vehicle speeds are considerably lower. Second, exposure rates for pedestrians on expressways are unknown, so that calculating rates based on denominators of foot traffic is not possible. Third, it is possible that the risk of having a disabled vehicle varies by age or socio-economic status, and the risk of a fatal pedestrian event may, in part, be determined by these factors.

Fourth, we had limited information about certain environmental and pedestrian factors, such as the color of clothing, the visibility of the person in the roadway, etc. Fifth, some race/ethnicity misclassifications may have occurred, which could have affected rate calculations. Sixth, it is possible that we have underestimated the number of persons who had exited a vehicle before being killed as a pedestrian, because this information may be missing from both police and ME reports, especially if it involved an unaccompanied victim who may have been a distance from the vehicle.

Measures to prevent deaths on expressways among unintended pedestrians will undoubtedly involve several approaches. The fact that unintended pedestrian deaths were more likely among the younger adults, especially among those in the first few years of driving age, leaves an opportunity for training of new drivers about safer behaviors for instances where vehicles become disabled on an expressway. However, at this point there are no proven measures to decrease risk in this situation. Some experts advocate remaining in the vehicle, which logically seems safer than standing on the roadway. Some countries in Europe now require that high-visibility reflective vests be kept in automobiles, in case the driver becomes an unintended pedestrian (The Automobile Association, 2006); we are aware of no data of the efficacy of this measure, as yet.

In addition, some European countries have emergency telephones located along motorways, with arrows pointing to the nearest telephone. Some jurisdictions in the United States have highway assistance programs, such as the HERO program in Atlanta (Hanzlick et al., 1999), designed to remove disabled vehicles from expressways as soon as possible to maintain traffic flow. Such an assistance program was in place in Dallas, but because of funding levels, its primary hours of operation were during the day time, whereas most pedestrian deaths on expressways occur at night. In order to have a substantial impact upon pedestrian deaths on expressways, such a program would have to function throughout the night.

There are a variety of reasons that lead a person to leave a vehicle after entering an expressway. These include a motor vehicle crash, flat tire, mechanical breakdown, or stopping to assist another stranded motorist; each circumstance places the unintended pedestrian at high risk of death on an expressway. The magnitude of this problem has been under recognized. It deserves our efforts to devise appropriate strategies for managing these circumstances, to educate people, especially young drivers, about how to deal with it safely, and to assist them to get to a safe location away from traffic. Pedestrian safety is a growing public health concern worldwide, especially as motor vehicle travel and urbanization continue to increase. Recognition of this problem may offer an opportunity for expressway designers to incorporate additional pedestrian safety features into new expressway construction.

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