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A Single Urban Center Experience with Adult Pedestrians Struck by Motor Vehicles

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Abstract

Background—Pedestrian-vehicle crashes are a significant problem in public health. Understanding contributing factors within a specific community helps recognize and target key intervention points.

Methods—Trauma registry analysis included all of the patients treated at a Level I trauma center following pedestrian-motor vehicle collisions from January 1, 2000 to December 31, 2010. Variables examined included patient demographics, timing of collision, abbreviated injury scale score, injury severity score (ISS), hospital and intensive care unit (ICU) length of stay (LOS), and emergency department and hospital disposition.

Results—A total of 945 pedestrians were reviewed within the study period. Average age was 46.4 ± 19.4 years. One hundred seventy-seven (18.7%) patients were elderly and of the elderly group, 69 (39%) were 80 years of age or greater. The median ISS score was 12, average hospital LOS was 10.8 days and average ICU length of stay was 6.0 ± 7.5 days. More elderly patients required admission to the ICU than the nonelderly (61.6% vs 40.2%; $P < 0.001$), and more elderly patients required admission to a skilled nursing facility than nonelderly (42.1% vs. 9%; $P < 0.001$). The mortality rate for elderly patients was more than double that of nonelderly patients (20.9% vs 9.1%; $P < 0.001$). Pedestrian-motor vehicle collisions occurred disproportionately between the hours of 6 PM and midnight ($P < 0.0001$).

Conclusion—Elderly patients struck by a motor vehicle have a mortality rate twice that of the non-elderly and a higher rate of discharge to a skilled nursing facility, despite having a similar injury severity score on admission. This highlights the need for aggressive prevention efforts targeted at the elderly population.

INTRODUCTION

Pedestrian-vehicle crashes are a significant problem in public health. Although the overall risk to pedestrians has not significantly changed over the past decade, the risk of fatality after being struck by a motor vehicle has increased by more than one-third over the past 5 years. Deaths from pedestrian-vehicle crashes rank 3rd behind motorcycle riders and vehicle occupants, and constitute 11% of total crash fatalities nationally.[1]

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Locoregional analysis is important to augment national analysis of pedestrian-vehicle crashes. Understanding contributing factors within a specific community helps determine the appropriate effectiveness measures, recognize key intervention points, and target interventions. Local analysis also reveals unique situations not seen at the national level that are subsequently addressed with community-level interventions.

The number of pedestrian fatalities varies significantly from state to state. In 2009, California, Florida, Texas, and New York accounted for 41% of the nation's pedestrian fatalities, while the 25 states with the fewest pedestrian fatalities accounted for only 12%. In Wisconsin, pedestrian fatalities make up approximately 8% of all traffic-related deaths.[2] Although Wisconsin has a low incidence of pedestrian crashes relative to national rates, improvement of pedestrian safety remains an active state policy goal.

Previous studies examining patterns in pedestrian-vehicle crashes have been largely single-center series examining smaller sample populations and have focused primarily on injury types,[3–8] geographic foci,[9–18] and environmental factors.[19–23] Over 10 years ago, Peng and Bongard conducted the largest study to date examining pedestrian motor vehicle collisions in Los Angeles County. They found that hospital length of stay, injury severity score, revised trauma score, Glasgow coma scale and mortality all increased with age.[24] Demetriades and colleagues added to this foundation in 2004 with their subsequent analysis of the LA County database, showing a higher incidence of severe trauma and higher mortality in patients older than 65.[25]

The purpose of our study was to examine pedestrian-vehicle crashes in Southeast Wisconsin attempting to characterize the populations, injury pattern, and timing of pedestrian-vehicle trauma. We also compared our findings to prior studies to see if the injury patterns in our region were different or similar.

METHODS

Froedtert Memorial Lutheran Hospital (FMLH) is an American College of Surgeons designated Level I adult trauma center providing care to trauma victims in the Milwaukee metropolitan area. It also is a referral trauma center for the state, receiving patients from the southeast region of Wisconsin, northern Illinois, and the Upper Peninsula of Michigan. We reviewed the FMLH trauma registry for pedestrian-vehicle crashes from January 1, 2000 to December 31, 2010. All entrants in the trauma registry are patients who have been admitted to the hospital because of their injury; ie, patients seen in the emergency department (ED) and discharged home will not appear in the trauma registry. Variables examined included patient age and gender; day, month, and time of the crash; abbreviated injury scale (AIS) score, injury severity score (ISS) score on admission, hospital and intensive care unit (ICU) length of stay (LOS), and ED and hospital disposition. The AIS is a whole number assigned by a trauma registrar to each injury and ranges from 1 (superficial) to 6 (nonsurvivable). ISS divides the body into 6 regions: head or neck, face, abdominal, chest, extremities, and external. ISS is computed by taking the top 3 largest AIS scores from each of the 3 most severely injured regions of the body and summing their squares. A patient with any AIS score of 6 is automatically given an ISS of 75. Otherwise, the ISS score will range from 1 to 75. Although ISS has limitations, it correlates with mortality and is the most common anatomic trauma scoring system. Approval was obtained by the Medical College of Wisconsin and Froedtert Hospital Institutional Review Board prior to any data collection. The association of age group with covariate was analyzed using the *t* test (hospital and ICU LOS), the chi-square test (death and discharge disposition), and Wilcoxon rank-sum test (ISS). Odds ratios (OR) with 95% confidence intervals were calculated. Logistic regression analysis was used to analyze the effect of age on ICU admission, mortality, and disposition.

Elderly was defined as ≥ 65 years old, nonelderly was defined as < 65 years old. Multiple regression analysis was used to analyze the effect of age on hospital LOS and ICU LOS. A *P*-value < 0.05 was considered statistically significant.

For purposes of analyzing the time of day that incidents occurred, a day was divided into daytime (8 AM–6 PM), evening (6 PM–midnight), and night (midnight–8 AM). These time periods were chosen because that is what was used in previous research and will allow comparison.[3] The chi-square goodness-of-fit test was used to determine if crashes were equally distributed across these time categories. Specifically, we tested whether the proportion of crashes during daytime, evening, and night was in a 10:6:8 ratio corresponding to the length of these periods.

RESULTS

Over the study period, 945 pedestrians were seen at FMLH after being struck by a motor vehicle. Table 1 shows the patient demographics and age distribution. The average age was 46.4 ± 19.4 years, and males made up the majority (61.3%). One hundred seventy-seven (18.7%) patients were elderly (age ≥ 65); 87 (49.2%) elderly patients were male and 69 (39%) were 80 years of age or greater.

Table 2 shows the injury severity of patients treated after pedestrian-vehicle crashes. The overall median ISS score was 12, with no significant difference between elderly and nonelderly. Average hospital LOS was 10.8 (± 16.7) days and average ICU LOS was 6.0 ± 7.5 days, with no significant difference between elderly and nonelderly. However, more elderly patients required admission to the ICU than the nonelderly (61.6% vs 40.2%; $P < 0.001$). At the time of discharge, more elderly patients required admission to a skilled nursing facility than the nonelderly (42.1% vs 9%; $P < 0.001$). The overall mortality rate was 11.3%. These patients had an average ISS of 25.0 (± 18.0). Elderly patients had a significantly greater mortality rate than nonelderly patients (20.9% vs 9.1%; $P < 0.001$).

The most common injury was to the extremities in both elderly and nonelderly patients (Table 3). There was little difference between groups for the next most common injury category: external (skin and soft tissue) and head/neck.

Logistic regression analysis was used to examine if age predicted hospital mortality and disposition. Controlling for ISS score and gender, we found that elderly patients were 3 times more likely to die in the hospital (OR 2.91; 95% CI = 1.72–4.90; $P < 0.0001$) and 7 times more likely to be transferred to a skilled nursing facility after hospital discharge (OR 7.40; 95% CI = 4.78–11.44; $P < 0.0001$) than non-elderly patients (Table 4). Controlling for age and gender, for 10 units increase in ISS, we observed a 250% increase in the odds of death in hospital ($P < 0.0001$) and 50% increase in the odds of being transferred to SNF ($P = 0.0001$) (Table 4).

Figure 1 shows the distribution of pedestrian-vehicle crashes by time of day. Incidents were not distributed evenly ($P < 0.0001$) throughout the day, with more incidents in the evening (36.7% from 6 PM to midnight) and fewer during the night (39.5% from midnight to 8 AM) (Table 5). Incidents were spread throughout the week (Figure 2) and the year (Figure 3).

Disposition out of the ED was divided between floor (39%), ICU (38%), and operating room (21%), with a 2% mortality rate in the ED (Figure 4). Fifty-one percent of patients were discharged home from the hospital, 16% went to a rehabilitation hospital, 13% went to a skilled nursing facility, 11% died, and 6% went home with visiting nurse assistance (Figure 5).

Multiple regression analysis was applied to see among those who were discharged alive if age, ISS, and gender affect length of stay in hospital and in ICU. The result shows that for 10 units increase in ISS, the hospital LOS increased 6 days (*P* value < 0.0001) and the ICU LOS increased about 3 days (*P* value < 0.0001) (Table 4).

DISCUSSION

Pedestrian injuries represent an important aspect of travel and road safety. Analyzing patterns in pedestrian-vehicle crashes allows for development of interventions aimed at protecting pedestrians and reducing their risk on roadways; this is one of the main goals of transportation safety. However, the problem is multifactorial. No single cause of pedestrian-vehicle crashes has been identified, and no definitive countermeasure will definitively solve the problem. States with significant numbers of fatalities as a result of pedestrian-vehicle crashes have used environmental, educational, and enforcement measures to improve pedestrian safety.[26–28] Proximity to bars[9,10] and crosswalk markings in absence of a traffic signal have both been associated with increased pedestrian injury.[29] Interventions that have proven to be the most effective include single-lane roundabouts, sidewalks, exclusive pedestrian signal phasing, pedestrian refuge islands, and increased intensity roadway lighting.[27] How these interventions will lower the rate or alter the severity of injury, especially among elderly patients, is not clear. What is clear is that a better understanding of the reasons pedestrians are struck is sorely needed.

Pedestrian motor vehicle crashes contribute significantly to the Milwaukee area trauma system. In 2001, the Wisconsin Department of Transportation released the Wisconsin Pedestrian Policy Plan 2020. One of the 3 primary goals outlined in the plan was to reduce the number of pedestrian crashes and fatalities.[30] Strategies for achieving this include education, improved enforcement of existing laws, and planning that accommodates pedestrians better. One example is making changes to the areas along busy state trunk highways as they come into small and medium-sized towns. The plan proposes the use of wider median islands, longer pedestrian signals at traffic lights, and pedestrian overpasses. Our study characterizes the populations affected by pedestrian-vehicle crashes, as well as the timing with which they occur, and the outcomes of hospitalization.

The median ISS of 12 and observed overall mortality rate of 20.9% reflects the substantial force imparted on pedestrians when struck by vehicles. This is consistent with prior major studies, where overall ISS for patients ranged from 8.9 to 20 and overall mortality rates ranged from 8 to 22%.[3,25,31] The ICU and hospital LOS, as well as hospital disposition, reinforce what we already know about severity of the pedestrian trauma. We found no difference between the elderly and nonelderly patients in regards to ISS, hospital LOS and ICU LOS. This may be due to an increased rate of deaths in elderly patients before even getting to the hospital. Despite the nonsignificant difference in ISS, elderly patients suffered higher rates of ICU admission, mortality, and discharge to a skilled nursing facility. Disposition out of the hospital in particular shows the toll that is taken on pedestrians who are struck by motorized vehicles, with only 51% of patients able to return home. This is consistent with results seen in prior studies and highlights the increased burden of illness and mortality suffered by elderly patients after sustaining pedestrian trauma.[12,24,30,32–35]

Our injury distribution was similar to previous reports in that injury to the extremities was number 1 for both nonelderly and elderly.[3,4,24,31] Our study does not include pediatric patients, where head and neck injuries are more common.[24] Our study confirms previous findings that pedestrian-vehicle crashes occur disproportionately between 6 PM and midnight.[3,31] The June 2008 National Highway Traffic Safety Administration report showed that more than one-third of pedestrian crash deaths occurred on Fridays and Saturdays, and our data confirm that weekend days are high risk for pedestrian-vehicle incidents.[1,19]

Implications of our research are two-fold. First, pedestrian-vehicle crashes remain a significant source of morbidity and mortality in Wisconsin, particularly for elderly patients. Future interventions that aim to reduce the incidence and severity of pedestrian-vehicle crashes should be targeted toward this population. Further research is needed to explore the environmental factors contributing to the disproportional occurrence of pedestrian injury in the evening hours. Second, the data shows that for a given ISS score, the elderly patient has a higher mortality rate than the nonelderly patient. This highlights the need for a nontrauma hospital to transfer a patient to a trauma center even for injuries that do not seem life-threatening. A practical example is an elderly patient struck by a motor vehicle resulting in 4 rib fractures. Optimum care for this patient may require thoracic epidural placement and aggressive pulmonary toilet with the help of respiratory therapists. A nontrauma hospital may not be able to provide these interventions, and the patients like this who remain at a nontrauma center may suffer higher mortality rates than those who are transferred to a trauma center. It is important to anticipate poor outcomes and transfer patients early instead of transferring when the patient is doing poorly and may be in an irreversible downward spiral.

Limitations of our study include a relatively small patient number and an inability to capture all pedestrian-vehicle crashes because we used data from our own trauma database and not from government (ie, police, department of motor vehicles) or insurance sources. Our analysis also included only pedestrians struck by motor vehicles that were admitted to FMLH. It does not include those who died at the scene, died at other hospitals prior to transport, were treated at other hospitals, or did not report for medical treatment. However, with FMLH being the only Level I trauma center in southeastern Wisconsin there is an assumption that a patient with any type of a serious injury would be transported to FMLH either immediately or after initial care at another hospital.

CONCLUSION

Pedestrian-vehicle collisions have a high rate of morbidity and mortality and occur disproportionately between the hours of 6 PM and midnight. Elderly patients have a mortality rate that is twice that of the nonelderly and have a higher rate of discharge to a SNF, despite having the same ISS. This highlights the need for aggressive prevention efforts to mitigate the number of factors that contribute to the problem of pedestrian vehicle crashes.

Acknowledgments

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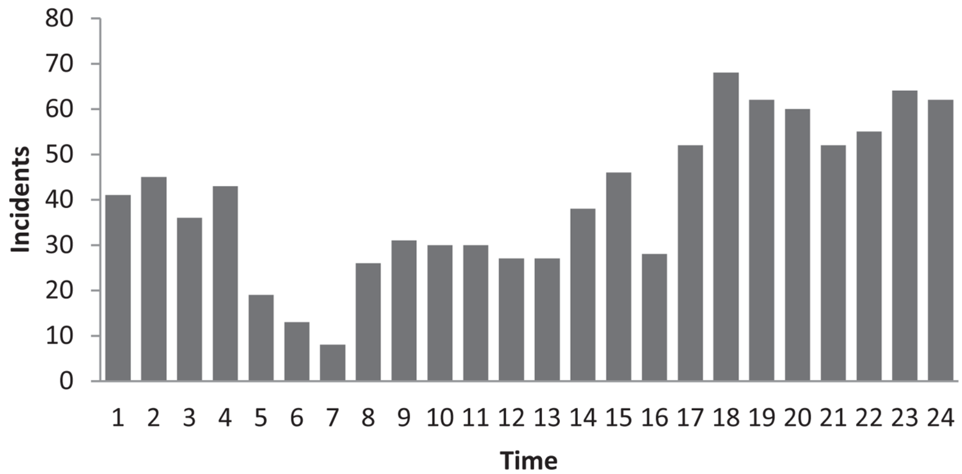

Figure 1.
Time of Pedestrian-Vehicle Crashes.

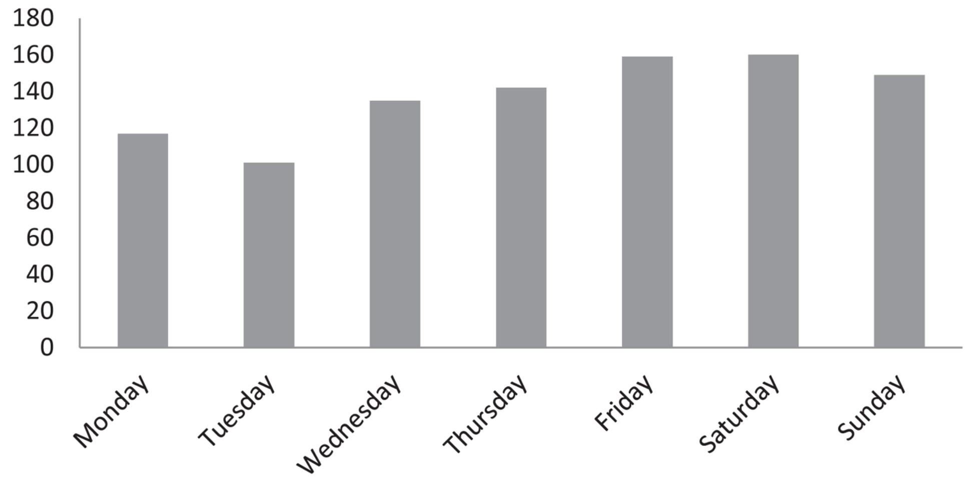

Figure 2.
Day of Pedestrian-Vehicle Crashes

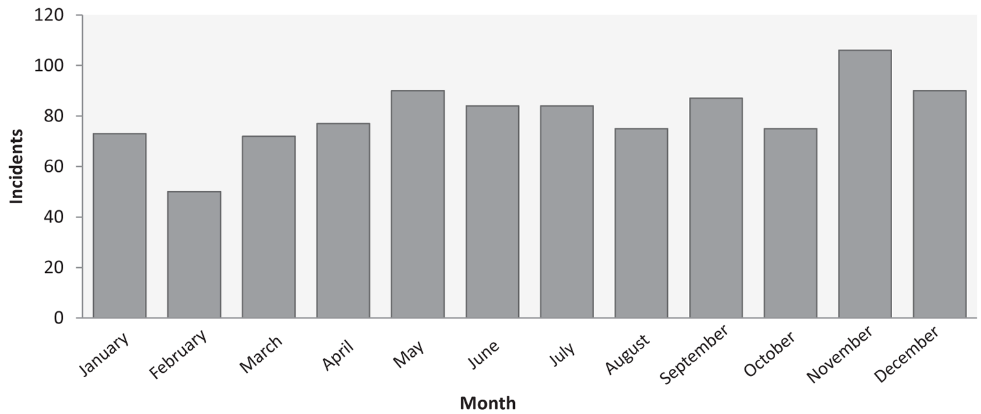

Figure 3.
Month of Pedestrian-Vehicle Crashes.

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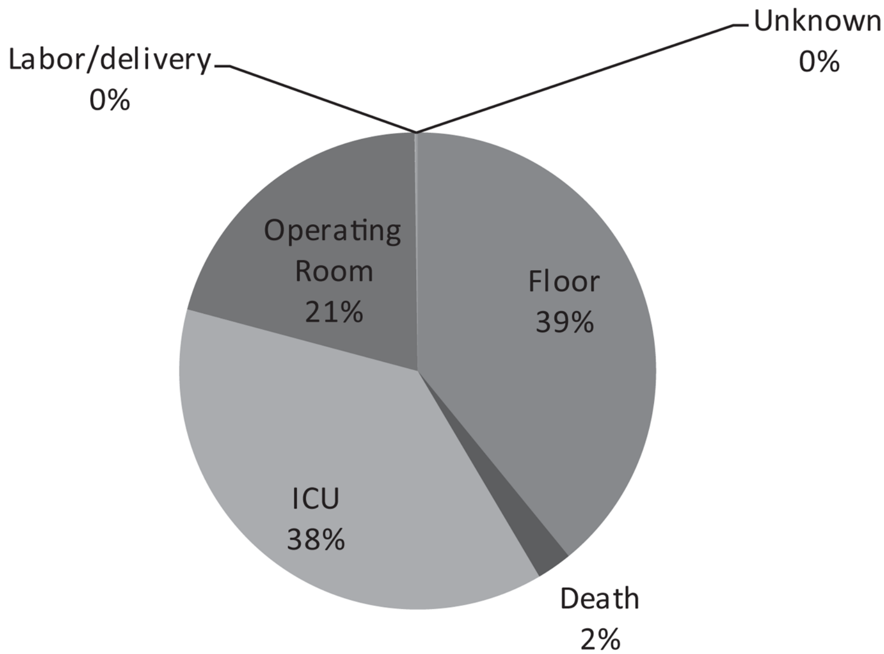

Figure 4.
Emergency Department Disposition Following Pedestrian-Vehicle Crashes.

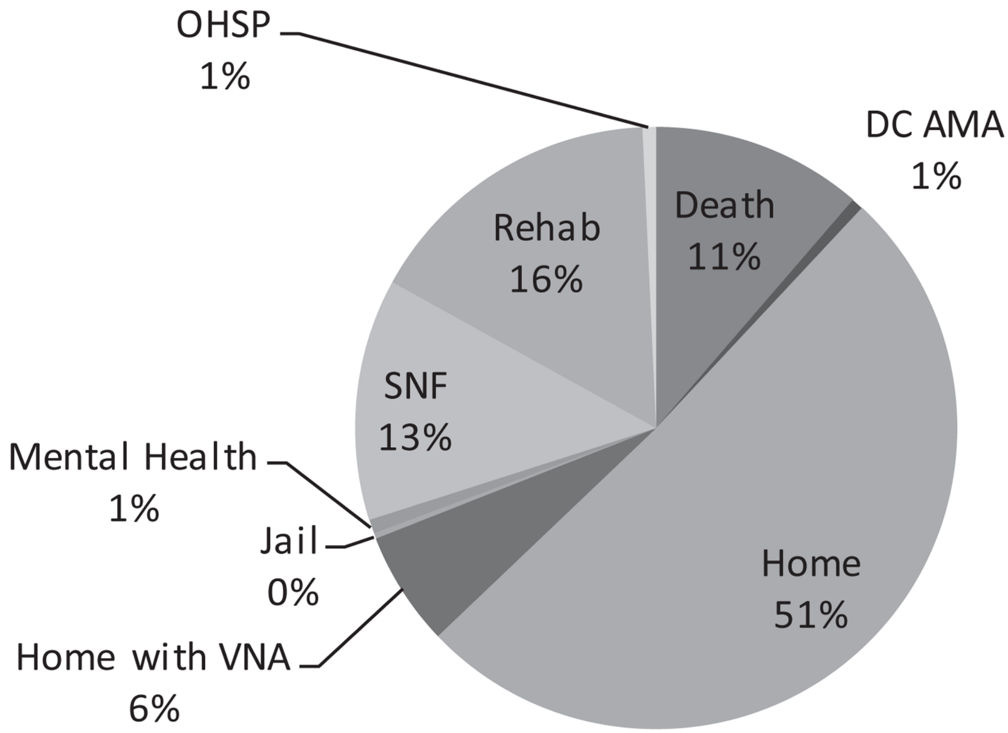

Figure 5.
Hospital Disposition Following Pedestrian-Vehicle Crashes.

Table 1

Demographics of Patients Seen at Froedtert Memorial Lutheran Hospital Following Pedestrian-Vehicle Crash.

Characteristic	n	%
Average age (±SD) (y)	46.4 (19.4)	—
Gender		
Male	579	61.3
Female	366	38.7
Age Group		
18–24	167	17.7
25–34	140	14.8
35–44	172	18.2
45–54	170	18.0
55–64	119	12.6
65–79	108	11.4
≥80	69	7.3
Age Subgroups		
Nonelderly (18–65 years old)	768	81.3
Elderly (≥65 years old)	177	18.7

Table 2

Injury Severity of Patients Treated at Froedtert Memorial Lutheran Hospital After Pedestrian-Vehicle Crashes.

Measure	Total	Nonelderly (<65 years old)	Elderly (≥65 years old)	*P*-value
Median ISS (q25–q75[a])	12 (6–21)	11 (6–20)	13 (6–24)	0.136[b]
Hospital length of stay (LOS)	10.8 ± 16.7	10.7 ± 17.3	11.8 ± 13.1	0.470[c]
Intensive care unit (ICU)				
Percent ICU admission	44.2%	40.2%	61.6%	<.001[d]
ICU LOS	6.0 ± 7.5	6.0 ± 8.0	6.0 ± 5.9	0.949[c]
Discharge to skilled nursing facility	14.6%	9.0%	42.1%	<.001[d]
Mortality	11.3%	9.1%	20.9%	<.001[d]

Abbreviations: ISS, injury severity score.

[a] 25th percentile – 75th percentile

[b] Wilcoxon rank-sum test

[c] *t* test

[d] Chi-square test

Table 3

Injury Distribution in Pedestrian-Vehicle Crashes.

	Nonelderly (<65 years old)		Elderly (≥65 years old)		Total	
Location	**n**	**%**	**n**	**%**	**n**	**%**
Head and neck	501	17.3	164	18.1	665	17.5
Abdomen	324	11.2	98	10.8	422	11.1
Chest	446	15.4	156	17.3	602	15.9
Extremity	921	31.8	254	28.1	1175	31.0
Face	204	7.05	44	4.87	248	6.53
External	496	17.2	188	20.8	684	18.0
Total	2892	100	354	100	3796	100

Table 4

Predictors of Injury Severity in Pedestrian-Vehicle Crashes.

	Parameter estimates (95% CI)	*P*-value
Hospital Length of Stay (LOS) (≥ 65 vs < 65)	Δ=1.15 days (−1.75,4.05)	0.446[a]
Intensive care unit (ICU) LOS (≥ 65 vs < 65)	Δ=1.13 days (−0.63,2.90)	0.209[a]
ICU admission (≥ 65 vs < 65)	Δ=3.70 days (2.29–5.98)	<.0001[a]
Discharge to skilled nursing facility (SNF) (≥ 65 vs < 65)	OR=7.40 (4.78–11.44)	<.0001[b]
Mortality (≥ 65 vs < 65)	OR=2.91 (1.72–4.90)	<.0001[b]
Hospital Mortality		
Injury severity score (ISS) (10 units increase)	OR=3.48 (2.80–4.32)	<0.0001[b]
Sex (m vs f)	OR=0.84 (0.52–1.37)	0.49[b]
Discharge to SNF		
ISS (10 units increase)	OR=1.53 (1.24–1.89)	<0.0001[b]
Sex (m vs f)	OR=0.71 (0.47–1.09)	0.11[b]
ICU Admission		
ISS (10 units increase)	OR=8.54 (6.31–11.55)	<0.0001
Sex (m vs f)	OR=1.29 (0.88–1.87)	0.19
Hospital LOS		
ISS (10 units increase)	Δ=5.97 (4.77,7.18)	<0.0001[a]
Sex (m vs f)	Δ=−0.13 (−2.37,2.10)	0.907[a]
ICU LOS		
ISS (10 units increase)	Δ=3.16 (2.37,3.94)	<0.0001[a]
Sex (m vs f)	Δ=−1.38 (−2.94,0.18)	0.084[a]

Abbreviations: OR is odds ratio.

Δ is mean difference

[a]multiple regression

[b]logistic regression

Table 5

Incidents of Pedestrian-Vehicle Crashes by Time of Day.

Time	Frequency	Percent (%)	Expected Ratio (%)
Daytime (8 AM to 6 PM)	373	39.5	10/24 (41.7%)
Evening (6 PM to midnight)	347	36.7	6/24 (25%)
Night (midnight to 8 AM)	225	23.8	8/24 (33.3%)[a]

[a] $P < 0.0001$; ie, more than expected incidents in the evening and fewer than expected during the night.