A recent published study titled "**<u>Vulnerable roadway users struck by motor vehicles at the center of the safest, large US city"</u>** was funded by the National Highway Traffic Safety Administration with a grant from the New York State Governor's Traffic Safety Committee: October 1, 2008, to September 30, 2011. Grant awards per fiscal year are as follow: Federal Fiscal Year (FFY) 2009, $122,242, FFY 2010, $129,748; FFY 2011, $130,670. This is a hospital- based study of pedestrians and bicyclists struck by motor vehicles. Bellevue's catchment area is southern Manhattan and western Brooklyn.

Bellevue Hospital Center (BHC) is a Level 1 regional trauma center in Manhattan. Data was collected from December 22, 2008, to June 22, 2011. Inclusion criteria for this study is as follows: A**ll** pedestrians or bicyclists presenting to BHC after being struck by a motor vehicle within 24 hours of the incident; walk-ins and transfers; patients treated in the emergency department (ED) not requiring admission; and patients who arrived at BHC with cardiopulmonary resuscitation. The definition of **''Pedestrians''** included patients who may have been in a wheelchair, mobility scooter, or infant stroller because these individuals adhere to the same traffic safety regulations.

Most crashes occurred in Manhattan (899 pedestrians and 319 bicyclists), followed by Brooklyn (166 pedestrians and 60 bicyclists). The remainder included Queens, Staten Island and New Jersey.

A total of 1,471 patients met the inclusion criteria: 1,075 pedestrians and 382 bicyclists. Again, this study looked at pedestrian and bicyclists who were struck by motor vehicles and treated at BHC. Patients and first responders were interviewed and the data collection looked at patient demographics, Sex, Age, Ethnicity and Disabilities; Patient behaviors; and External and Environmental factors.

Findings:

- Pedestrians sustained more severe injuries than bicyclists and were more likely to be admitted

- 15 pedestrians (1.4%) and 3 bicyclists died (0.8%)

- 923 pedestrians and 363 bicyclists were older than 17 years of age. Of those, 138 (15.0%) pedestrians and 39 (10.7%) bicyclists had used alcohol

- 81 pedestrians (7.7%) and 29 (7.8%) bicyclists were using electronics
- 81 pedestrians and 29 bicyclists were between the ages of 7 years-17 years. Of those, 11 pedestrians (10.4%) and 5 bicyclists (29.4%) were using electronic devices

- 975 pedestrians were struck while in the street. 751 (77.0%) were crossing, and of those, 426 (43.7%) were in the crosswalk with a signal when struck. 288 (67.6%) of those struck in the crosswalk with the signal reported the vehicle was turning. Pedestrians crossing with a green light were commonly struck by vehicles failing to yield

- 134 bicyclists were struck by taxicabs (40.1%)
- 249 pedestrians were struck by taxicabs (24.8%)

- 49.8% of pedestrians struck involved private vehicles
- 44.9% of bicycle collisions were with private vehicles

- Young walking adults are most frequently injured by motor vehicles
- Bicyclist injured were predominantly young adult men
- Working bicyclists injured were Latino (98), black (28) and East Asian (19)

- Ethnic minority groups and persons of lower socioeconomic status are disproportionally represented in these crashes

- Weekday incidents, between the hours of 9am-6pm were common for both pedestrian and bicyclists. Working cyclists were injured during the afternoon (12pm-3pm) and evening (6pm-midnight)

In summary the author recommends that these two vulnerable roadway users represent two distinct entities. Therefore, countermeasures need to be specifically geared towards each user.

For further information, please read the attached study.

Vulnerable roadway users struck by motor vehicles at the center of the safest, large US city

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BACKGROUND: Road safety constitutes an international crisis. In 2010, 11,000 pedestrians and 3,500 bicyclists were injured by motor vehicles in New York City. This study aims to identify the demographics, behaviors, injuries, and outcomes of vulnerable roadway users struck by motor vehicles in New York City's congested central business district and surrounding periphery.

METHODS: A prospective, descriptive study of pedestrians and bicyclists struck by motor vehicles and treated at a Level I regional trauma center was performed. Data were collected between December 2008 and June 2011 by interviewing patients and first responders supplemented with imaging and outcomes variables. Main outcome measures included patient demographics, behavior patterns, scene-related data, Injury Severity Score (ISS), and outcomes including mortality. Multivariate ordinal logistic regression modeling was performed to isolate effects of predictor variables on outcome of ISS categories.

RESULTS: Injured pedestrians (n = 1,075) and bicyclists (n = 382) differ by age ($p < 0.001$), sex ($p < 0.001$), ethnicity/race ($p < 0.001$), and involved motor vehicle type ($p < 0.001$). Pedestrians sustain more severe/critical injuries ($p < 0.001$) and hospital admissions ($p < 0.001$). Bicyclists are more commonly struck by taxis ($p < 0.001$) and infrequently wear helmets (29.6%). Variables associated with low ISS include bicycling (adjusted odds ratio [AOR], 0.43; 95% confidence interval [CI], 0.29–0.63), above normal body mass index (AOR, 0.73; 95% CI, 0.54–0.99), Latino (AOR, 0.65; 95% CI, 0.46–0.94) or black (AOR, 0.63; 95% CI, 0.41–0.96) ethnicity/race, and struck by a taxicab (AOR, 0.50; 95% CI, 0.33–0.76) or turning vehicle (AOR,0.49; 95% CI, 0.34–0.70). Variables associated with high ISS include alcohol (AOR, 2.71; 95% CI, 1.81–4.05), age less than 18 years (AOR, 1.73; 95% CI, 1.05–2.86), hearing impairment (AOR, 2.24; 95% CI, 1.24–4.03), and struck by a truck or bus (AOR, 1.91; 95% CI, 1.18–3.10). Mortality was 1.2%.

CONCLUSION: Injured pedestrians and bicyclists represent distinct entities. Prevention modalities must be tailored accordingly with a focus on high-risk subgroups and compliance with traffic laws. Studying fatality or admissions data fail to capture the extent of the epidemic. (*J Trauma Acute Care Surg*. 2013;74: 1138–1145. Copyright © 2013 by Lippincott Williams & Wilkins)

LEVEL OF EVIDENCE: Prospective epidemiologic study, level II.

KEY WORDS: Pedestrian; bicyclist; motor vehicle.

Road safety constitutes an international crisis with severe health and economic impacts.[1,2] Road traffic injuries are currently among the three leading causes of death for individuals 5 years to 44 years of age and predicted to become the fifth leading cause of death globally accounting for 2.4 million annual deaths.[1] The United Nations General Assembly and governments and agencies from more than 100 countries recently launched Decade of Action for Road Safety 2011 to 2020[3]—a plan designed to reduce the level of road traffic fatalities globally by 2020.

In the United States, progress has been made during the last two decades, with national traffic fatalities dropping significantly. In no large city has this been more pronounced than in New York City (NYC), where as of 2008, fatality rates per 100,000 residents were less than one third of the national average (3.5 vs. 12.2).[4] NYC's success in traffic safety has led to it being dubbed the safest, large US city.[4]

Despite New York's progress, pedestrians and bicyclists struck and injured by motor vehicles remains a significant public health concern. In 2010, 149 pedestrians and 18 bicyclists were killed in NYC.[5] Fatality data can be misleading as supported by the high number of individuals struck but nonfatally injured; in 2010, more than 11,000 pedestrians and 3,500 bicyclists were nonfatally injured by motor vehicles in NYC.[5]

Road traffic injuries are preventable. The objective of this study was to determine the demographics, behaviors, injuries, outcomes, and contributing environmental factors of pedestrians and bicyclists who are struck by motor vehicles in the central business district and surrounding periphery of the US city at the forefront of traffic safety, NYC.

PATIENTS AND METHODS

Using prospective data, we conducted a hospital-based, descriptive study of pedestrians and cyclists who are struck by motor vehicles. The study was conducted at Bellevue Hospital

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Center (BHC), a Level I regional trauma center whose primary catchment area is southern Manhattan, followed by western Brooklyn. The institutional review boards of both New York University School of Medicine and BHC approved this study.

Collected variables included patient demographics, body mass index (BMI), alcohol use, scene-related data, admission Glasgow Coma Scale (GCS) score, initial imaging studies including computed tomographic scans, Injury Severity Score (ISS), hospital length of stay (LOS), mortality, and disposition. Alcohol use was defined as blood alcohol concentration greater than 0.01 g/dL or history of use before the incident (if blood alcohol concentration was not obtained). BMI was categorized as unhealthy (<18.5), healthy (18.5–25), or overweight (>25). ISS was categorized according to the National Trauma Data Bank's (NTDB) definitions of mild (1–8), moderate (9–15), severe (16–24) and critical (≥25). Data were collected regarding pedestrian street-crossing patterns and bicyclist behaviors.

Data were collected from December 22, 2008, to June 22, 2011. Inclusion criteria were all pedestrians or bicyclists presenting to BHC after being struck by a motor vehicle within 24 hours of the incident. Walk-ins and transfers were included. Patients treated in the emergency department (ED) not requiring admission were included. Patients who arrived at BHC with cardiopulmonary resuscitation in progress were included. "Pedestrians" included patients who may have been in a wheelchair, mobility scooter, or infant stroller because these individuals adhere to the same traffic safety regulations.

Most patient demographics and scene-related variables were obtained by interviewing patients. Available first responders, including emergency medical technicians, New York Police Department, or Fire Department of New York were interviewed to corroborate data related to the incident. Patients were interviewed when they were alert and able to answer questions in an unaltered fashion based on the discretion of the interviewer. Ambulance records were reviewed from patient records if prehospital providers were involved.

A team member logged the data onto a six-page collection form. Verbal informed consent was obtained before enrollment. Data collection began upon patient arrival. Findings on imaging studies were incorporated into the forms and ISSs were determined (by a single attending trauma surgeon) after official radiology attending imaging reports became available. Hospital LOS and disposition data were added soon after discharge.

ED staff was informed of the study ahead of time. Informational fliers were also hung throughout the ED. Data collection was performed primarily by a dedicated study coordinator, a trauma coordinator, attending trauma surgeons, and emergency medicine attendings. A 24-hour study pager was made available to the ED staff and activated whenever a patient was triaged.

Data were collected on patients not able to give verbal consent on arrival (e.g., unresponsive or intoxicated); however, formal enrollment was delayed until the patient or a surrogate was able to consent. Hearing impairment was defined as any current history of decreased auditory ability. Vision impairment was defined as uncorrected visual acuity including not wearing corrective lenses at the time of injury. To validate the study's ability to capture patients, ED records were retrospectively reviewed for missed patients. Because the number of missed patients was deemed acceptably low, retrospective review was discontinued after 6 months. During the second half of the study, institutional review board approval was granted to telephone any missed patients discharged from the ED within 24 hours of the incident.

Data were entered into a Microsoft Excel 2010 (Redmond, WA) spreadsheet with predetermined categories in dropdown menus as defined from the paper data collection instruments. Data were double entered to ensure accuracy of transcription and stored in a password-protected network with identifying information removed. Appropriate multiple imputation methods were used to impute missing data.

SPSS version 18 software (IBM) and STATA version 12 (College Station, TX) were used for statistical analyses. Where applicable, Pearson's χ^2, Fisher's exact or independent Student's t test was performed with $p \leq 0.05$ representing statistical significance. Multivariate ordinal logistic regression modeling was used to isolate effects of predictor variables on the outcome of ISS categories. We used a Markov Chain Monte Carlo method for multiple imputations and generated 20 multiply imputed data sets, each analyzed independently and combined using Rubin's rules to appropriately account for within– and between–data set variance. The multiple-imputation model included all relevant variables in the data set for which there were no missing data, the primary and secondary outcomes, and demographic variables including age, sex, and mechanism of injury. Means with 95% confidence intervals (CIs) were reported for continuous data, and proportions and 95% exact CIs for categorical data. Multivariate ordinal logistic regression modeling was used to isolate effects of predictor variables on the ordinal outcome of ISS categories (uninjured or ISS of 1–8, ISS of 9–15, ISS of 16–24, ISS of >24). Candidate variables were included based on the known epidemiology of traffic injuries or hypothesized associations between the candidate variables and outcomes. Odds ratios and 95% CIs adjusted for the multiply imputed data were reported.

RESULTS

A total of 1,471 patients met inclusion criteria including 1,075 pedestrians and 382 bicyclists (Fig. 1). Fourteen additional patients who had been traveling on wheels were grouped as "other" and removed from analysis because these cyclists generally do not adhere to either pedestrian or bicyclist traffic safety patterns or rules. Missed patients were tracked during the initial 6 months of the study with eight missed patients per month during the first 3 months and 3.3 patients per month during the subsequent 3 months. During the 6-month tracking period, there were three refusals to participate.

Consistent with BHC's location and catchment area, most incidents occurred in the borough of Manhattan (899 pedestrians, 83.6%; 319 bicyclists, 83.5%) followed by Brooklyn (166 pedestrians, 15.4%; 60 bicyclists, 15.7%). The remainder occurred in Queens, Staten Island, or New Jersey. Emergency medical technicians brought in 1,011 pedestrians (94.0%) and 350 bicyclists (91.6%), while 47 pedestrians (4.4%) and 26 bicyclists (6.8%) walked in. The rest were brought in by New York Police Department or Fire Department of New York or were transferred to BHC.

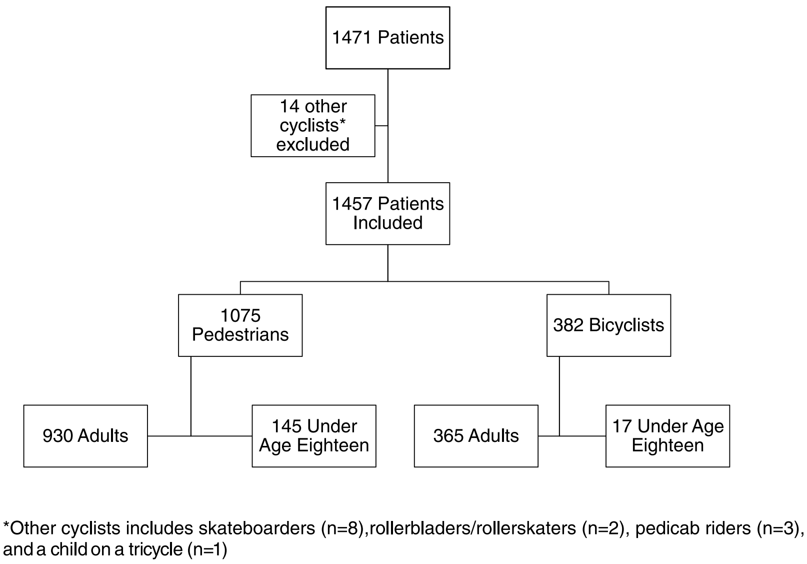

Figure 1. Patient population.

Sex, age, and ethnicity or race of pedestrians and bicyclists are presented in Table 1. There were significant differences between the two groups in each of these demographic variables ($p < 0.001$). Rates of hearing and vision impairment also differed between cohorts.

Eighty-one pedestrians (7.7%) and 29 bicyclists (7.8%) were using electronic devices (Table 2). Stratified for patients' age 7 years to 17 years, 11 pedestrians (10.4%) were using electronic devices, while 5 bicyclists (29.4%) were using electronic devices. Of the 923 pedestrians and 363 bicyclists who were older than 17 years, 138 (15.0%) and 39 (10.7%), respectively, had used alcohol.

Most pedestrians (90.7%) were struck while in the street (Table 2). Of those pedestrians struck while in the street (n = 975), 751 (77.0%) were crossing; of those, 426 (43.7%) were in the crosswalk with the signal when struck. Of those pedestrians in the crosswalk with the signal, 288 (67.6%) reported that the vehicle was turning when they were struck.

Table 2 presents the circumstances of bicyclist collisions and further stratifies the data by working bicyclist status. Most working bicyclists who were injured were Latino (n = 98; 59.4%), followed by black (n = 28; 17.0%) and East Asian (n = 19; 11.5%).

There were differences between pedestrian and bicyclist cohorts in hit-and-run rates ($p = 0.01$), motor vehicle involved ($p < 0.001$), road surface ($p = 0.003$), season ($p < 0.001$) and weekday time of day ($p = 0.01$) of collision (Table 3). Bicyclists are more commonly struck by taxicabs (n = 134; 40.1%) compared with pedestrians (n = 249; 24.8%). Private vehicles were involved in 49.8% of pedestrian incidents (308 cars [30.7%] and 192 sports utility vehicles [SUVs] [19.1%]) and in a lower percentage (44.9%) of bicyclist collisions (111 cars [33.2%] and 39 SUVs [11.7%]).

TABLE 1. Patient Demographics

Categories	Pedestrians (n = 1,075)	Bicyclists (n = 382)	p
Sex			<0.001
Male, n (%)	588 (54.7)	329 (86.1)	
Age, n (%), y			<0.001
0–6	39 (3.6)	0 (0)	
7–12	49 (4.6)	4 (1.0)	
13–17	57 (5.3)	13 (3.4)	
18–29	290 (27.0)	183 (47.9)	
30–39	176 (16.4)	87 (22.8)	
40–49	142 (13.2)	52 (13.6)	
50–59	149 (13.9)	26 (6.8)	
60–69	89 (8.3)	13 (3.4)	
70–79	44 (4.1)	3 (0.8)	
80–89	37 (3.4)	1 (0.3)	
≥90	3 (0.3%)	0 (0)	
Ethnicity/race, n (%)			<0.001
White	460 (42.8)	141 (36.9)	
Black	182 (16.9)	54 (14.1)	
Latino	245 (22.8)	143 (37.4)	
East Asian	115 (10.7)	30 (7.9)	
South Asian	43 (4.0)	8 (2.1)	
Other	30 (2.8)	6 (1.6)	
Disabilities			
Hearing impaired	65 (6.2)*	6 (1.6)†	<0.001
Legally deaf	6 (0.6)*	1 (0.3)†	0.68
Vision impaired	77 (7.4)‡	15 (4.0)§	0.03
Legally blind	3 (0.3)‡	0 (0)§	0.57

*Twenty-eight unknown removed.
†Eight unknown removed.
‡Thirty-one unknown removed.
§Nine unknown removed.

TABLE 2. Patient Behaviors

Categories	Pedestrians (n = 1,075)	Bicyclists (n = 382)	*p*
Electronic device use, n (%)			
Mobile phone	37 (3.5)*	3 (0.8)†	0.01
Hand-held game	1 (0.1)*	0 (0)†	1.00
Music/movie device	43 (4.1)*	26 (7.0)†	0.03
Alcohol use (excludes <18 y)			0.05
Yes, n (%)	138 (15.0)‡	39 (10.7)§	
Location of pedestrian collision, n (%)			NA
In street	975 (90.7)	—	
Sidewalk	64 (6.0)	—	
Other	22 (2.0)	—	
Unknown	14 (1.3)	—	
Circumstances of pedestrian collisions, n (%)‖			NA
Crossing with signal	426 (43.7)	—	
Crossing midblock	226 (23.2)	—	
Crossing against signal	88 (9.0)	—	
Crossing at stop sign	11 (1.1)	—	
Vehicle backing up¶	75 (7.0)	—	
Darted into the street#	37 (3.8)	—	
Standing in road waiting to cross	27 (2.8)	—	
Getting in/out of vehicle	23 (2.4)	—	
Traffic cop	13 (1.3)	—	
Vehicular assault/aggression	10 (1.0)	—	
Loading/unloading vehicle	9 (0.9)	—	
Playing in street	7 (0.7)	—	
No stop light, no stop sign	7 (0.7)	—	
Hailing service vehicle	6 (0.6)	—	
Construction worker	5 (0.5)	—	
Jogging	4 (0.4)	—	
Getting in/out of school bus	3 (0.3)	—	
Walking in street owing to construction	3 (0.3)	—	
Miscellaneous**	9 (0.9)	—	
Unknown	61 (6.3)	—	
Circumstances of bicyclist collisions, n (%)			NA
Riding with flow of traffic	—	312 (81.7)	
Riding against flow of traffic	—	33 (8.6)	
Other††	—	3 (0.8)	
Unspecified or unknown	—	34 (8.9)	
Versus open car door	—	59 (15.4)	
Surfing‡‡	—	0 (0)	
Riding in bike lane	—	82 (21.5)	
Working	—	165 (43.2)	
Wearing helmet	—	113 (29.6)	
Wearing elbow, knee pads, or wrist guards	—	26 (6.8)	
Demographics of working bicyclists and circumstances of collisions (n = 165), n (%)			NA
Male	—	163 (98.8)	
Latino	—	98 (59.4)	
Black	—	28 (17.0)	
East Asian	—	19 (11.5)	
White	—	13 (7.9)	
Riding with flow of traffic	—	140 (84.8)	
Riding against flow of traffic	—	16 (9.7)	
Collided with open door	—	36 (21.8)	
Wearing helmet	—	52 (31.5)	

*Twenty-one unknown removed.
†Ten unknown removed.
‡Seven unknown removed.
§Two unknown removed.
‖Includes only those in the street during collision (n = 975).
¶The number for this category was all pedestrians, that is, n = 1,075.
#All were younger than 18 years; 27 were struck midblock, 6 ran out into crosswalk against signal, and 4 were unknown.
**Includes patients who were selling newspapers in the street (n = 1), repairing car (n = 1), walking beside parallel-parked cars (n = 2), pushed into traffic by someone (n = 1), saving another pedestrian from being struck (n = 1), chasing someone into the street (n = 1), attempting suicide (n = 1), and sleeping in the street (n = 1).
††Two were entering street between parked cars; 1 was on sidewalk
‡‡"Surfing" was defined as holding onto a moving motor vehicle.
NA, not applicable.

Weekday incidents were more common in both groups. Among weekday incidents involving pedestrians, 61.0% occurred between 9:00 AM and 6:00 PM. Bicyclists showed a similar pattern, with 60.3% of weekday collisions occurring between 9:00 AM and 6:00 PM with a slower downtrend into the evening hours (6:00 PM to 12 midnight) (Table 3). Working bicyclists were more likely to be injured (vs. noncommercial) during the afternoon hours (12 noon to 3:00 PM) (35.3% vs. 22.0%) and evening (6:00 PM to 12 midnight) hours (34.6% vs. 20.0%).

Pedestrians sustained more severe injuries ($p < 0.001$) compared with bicyclists and were more likely to be admitted (32.7% vs. 22.8%; $p < 0.001$) (Table 4). After adjusting for important clinical and socioeconomic predictors, multivariate modeling revealed variables associated with lower ISS (Table 5), including bicyclist as a mechanism (adjusted odds ratio [AOR], 0.43; 95% CI, 0.29–0.63), above normal BMI (vs. normal BMI; AOR, 0.73; 95% CI, 0.54–0.99), Latino ethnicity (AOR, 0.65; 95% CI, 0.46–0.94) or black race (vs. non-Latino whites; AOR, 0.63; 95% CI, 0.41–0.96), and struck by a taxicab (vs. non-SUV private vehicles; AOR, 0.50; 95% CI, 0.33–0.76) or a turning vehicle (AOR, 0.49; 95% CI, 0.34–0.70). Variables associated with higher ISS include alcohol (AOR, 2.71; 95% CI, 1.81–4.05), age less than 18 years (vs. adults; AOR, 1.73; 95% CI, 1.05–2.86), hearing impairment (AOR, 2.24; 95% CI, 1.24–4.03), and struck by a truck or bus (AOR, 1.91; 95% CI, 1.18–3.10) or on a two-way street (AOR, 1.37; 95% CI, 1.02–1.83).

Fifteen pedestrians (1.4%) and three bicyclists (0.8%) died. Twelve of these patients died within 24 hours, while 8 died 4 days to 53 days later. The ISSs of these patients ranged from 18 to 75.

DISCUSSION

Pedestrians and bicyclists are vulnerable roadway users. Their identities and behaviors are less well described than those

TABLE 3. External and Environmental Factors

Categories	Pedestrians (n = 1,075)	Bicyclists (n = 382)	p
Hit and run*			0.01
Yes, n (%)	131 (13.6)	65 (19.6)	
Vehicle type, n (%)†			<0.001
Car	308 (30.7)	111 (33.2)	
SUV	192 (19.1)	39 (11.7)	
Motorcycle	15 (1.5)	0 (0)	
Taxi	249 (24.8)	134 (40.1)	
Bus	49 (4.9)	7 (2.1)	
Truck	46 (4.6)	27 (8.1)	
Van	134 (13.3)	16 (4.8)	
Other	11 (1.1)	0 (0)	
Road surface, n (%)‡			0.003
Normal	840 (79.5)	331 (87.8)	
Icy	5 (0.5)	1 (0.3)	
Wet	204 (19.3)	45 (11.9)	
Icy and wet	8 (0.8)	0 (0)	
Season, n (%)§			<0.001
Winter	105.3 (24.6)	20 (12.8)	
Spring	113.3 (26.5)	48 (30.7)	
Summer	103 (24.1)	50 (31.9)	
Fall	106 (24.8)	38.5 (24.6)	
Day of the week, n (%)			0.22
Monday	158 (14.7)	46 (12.0)	
Tuesday	175 (16.3)	74 (19.4)	
Wednesday	167 (15.5)	52 (13.6)	
Thursday	179 (16.7)	73 (19.1)	
Friday	175 (16.3)	61 (16.0)	
Saturday	132 (12.3)	36 (9.4)	
Sunday	89 (8.3)	40 (10.5)	
Time of day of collision (Monday-Friday), n (%)‖			0.01
12:00 midnight to 3:00 am	26 (3.2)	8 (2.8)	
3:00 AM to 6:00 AM	34 (4.2)	8 (2.8)	
6:00 AM to 9:00 AM	90 (11.0)	21 (7.2)	
9:00 AM to 12:00 noon	159 (19.5)	41 (14.1)	
12:00 noon to 3:00 pm	169 (20.7)	83 (28.6)	
3:00 PM to 6:00 PM	170 (20.8)	51 (17.6)	
6:00 PM to 9:00 PM	112 (13.7)	46 (15.9)	
9:00 PM to 12:00 midnight	56 (6.9)	32 (11.0)	
Time of day of collision (Saturday to Sunday), n (%)¶			0.90
12:00 midnight to 3:00 am	29 (13.9)	13 (18.3)	
3:00 AM to 6:00 AM	24 (11.5)	6 (8.5)	
6:00 AM to 9:00 AM	14 (6.7)	3 (4.2)	
9:00 AM to 12:00 noon	24 (11.5)	8 (11.3)	
12:00 noon to 3:00 pm	22 (10.5)	10 (14.1)	
3:00 PM to 6:00 PM	40 (19.1)	11 (15.5)	
6:00 PM to 9:00 PM	25 (12.0)	8 (11.3)	
9:00 PM to 12:00 midnight	31 (14.8)	12 (16.9)	

*One hundred twelve pedestrians and 50 bicyclists with unknown status removed.
†Seventy-one pedestrians and 48 bicyclists with unknown status removed.
‡Eighteen pedestrians and five bicyclists with unknown status removed.
§Average of annual values for pedestrians and bicyclists struck from December 22, 2008, to June 21, 2011. Excludes one patient struck on June 22, 2011.
‖Thirty-eight pedestrians and 16 bicyclists who were struck on weekdays were excluded owing to unknown time.
¶Twelve pedestrians and five bicyclists who were struck on weekend days were excluded owing to unknown time.

of injured drivers. Although the core outcome measured for traffic safety is fatalities,[6] deaths represent only the grim "tip of the iceberg," and the scope of the problem remains inadequately defined.

Young walking adults are the group most frequently injured by motor vehicles in this study. Our findings do not support the notion that higher death rates among older pedestrians are a function of more crashes involving the elderly.[7] Our results indicate that bicyclists injured within BHC's catchment area are predominantly young adult men, many of whom are delivery workers—a traditionally male profession in most urban centers including NYC. Injured children and teenagers younger than 18 years had a higher likelihood of being distracted

TABLE 4. Injuries and Outcomes

Categories	Pedestrians (n = 1,075)	Bicyclists (n = 382)	p
ISS, n (%)*			<0.001
No injuries	172 (16.0)	55 (14.4)	
1–8	625 (58.2)	274 (71.7)	
9–15	166 (15.5)	31 (8.1)	
16–24	57 (5.3)	9 (2.4)	
≥ 25	54 (5.0)	13 (3.4)	
Hospital length of stay, n (%), d			
Admitted	351 (32.7)	87 (22.8)	<0.001
1–2	143 (40.7)	42 (48.3)	
3–4	53 (15.1)	14 (16.1)	
5–6	32 (9.1)	6 (6.9)	
7–8	35 (10.0)	7 (8.0)	
9–10	30 (8.5)	3 (3.4)	
11–12	11 (3.1)	3 (3.4)	0.86
13–14	9 (2.6)	2 (2.3)	
15–16	8 (2.3)	2 (2.3)	
17–18	8 (2.3)	1 (1.1)	
19–20	2 (0.6)	0 (0)	
21+	20 (6.0)	7 (8.0)	
Mortality			0.54
Death (%)	15 (1.4)	3 (0.8)	
Patient disposition from hospital, n (%)†			0.10
Home	198 (56.4)	62 (71.3)	
Rehabilitation	116 (33.0)	17 (19.5)	
Nursing home	3 (0.9)	0 (0)	
Prison	1 (0.3)	0 (0)	
Other	33 (9.4)	8 (9.2)	

*One pedestrian with code 9 injuries was excluded from analysis.
†Includes only those who were admitted (351 pedestrians and 87 bicyclists).

TABLE 5. Multivariate Analysis by Injury Severity

Categories	OR	SE	*t*	P > |*t*|	95% CI
Low BMI	1.86	0.70	1.63	0.10	0.88–3.90
High BMI	0.73	0.11	2.04	0.04	0.54–0.99
Distracted	0.66	0.18	1.57	0.12	0.39–1.11
Intoxicated	2.71	0.55	4.87	0.00	1.81–4.05
Car turning	0.49	0.09	3.90	0.00	0.34–0.70
Age < 18 y	1.73	0.44	2.14	0.03	1.05–2.86
Female	0.90	0.14	0.67	0.51	0.67–1.23
Black	0.63	0.14	2.13	0.03	0.41–0.96
Latino	0.65	0.12	2.31	0.02	0.46–0.94
Asian	0.91	0.24	0.38	0.71	0.54–1.51
Bicyclist	0.43	0.09	4.25	0.00	0.29 – 0.63
Taxi	0.50	0.11	3.23	0.00	0.33–0.76
Two-way street	1.37	0.20	2.12	0.03	1.02–1.83
SUV	1.27	0.27	1.12	0.26	0.84–1.93
Van	1.13	0.29	0.47	0.64	0.66–1.87
Bus/truck	1.91	0.47	2.63	0.01	1.18–3.10
Other vehicle	1.28	0.34	0.90	0.34	0.75–2.17
Hearing impairment	2.24	0.67	2.69	0.01	1.24–4.03
Visual impairment	1.32	0.39	0.95	0.34	0.74–2.36

Multiple-imputation estimates.
Ordered logistic regression.
df adjustment for large sample
Model F test, equal Fraction Missing Information.
Within Variance Covariance Estimator type, Observed-Information-Matrix Method
df = 20.83 minutes
average = 785,983.06
maximum = 4,403,170.62
$F_{19,382794.3} = 6.33$
Probability > *F* = 0.0000
Imputations = 20
Number of observations = 1,284
Average Relative Variance Increase Due to Nonresponse = 5.7423
Largest Fraction Missing Information = 0.9588

potentially contributing to these incidents. They also seem to be more vulnerable to injuries compared with adults as judged by injury severity.

Sex and ethnic differences among pedestrian fatalities have been reported.[8–10] Our study adds to the evidence for the disproportionate nonfatality injury burden of ethnic minority groups and persons of lower socioeconomic status. Latino bicycle delivery men are especially vulnerable, while uncommonly adhering to NYC helmet laws, which state that commercial bicyclists must wear a properly fitted helmet; less than a third did so in our study.

Above normal BMI may be protective of severe injury. Although our population is not readily comparable to previous blunt trauma reports, which suggest no difference or an increased injury severity,[11–15] it is not implausible that a greater proportion of torso and extremity fat may protect against injury. In contrast, the reported poor outcomes of hospitalized obese blunt trauma patients[13] presumably relate to preexisting comorbidities. The low mortality rate in this study precludes an accurate assessment of the role of BMI on outcomes.

For pedestrians in the crosswalk with the green light, vehicular failure to yield while turning was a common and concerning finding and was higher than previous reports.[4] However, turning vehicles, presumably secondary to lower speeds, cause less severe injuries. It has been estimated that overall 27% of crashes that kill or seriously injure pedestrians involve driver failure to yield.[4] Although distracted walking is a pedestrian traffic safety hazard that is difficult to quantify, lawmakers have been looking to restrict the use of cell phones and music players.[16]

Few studies have evaluated cyclists' adherence to traffic laws or engagement in risky behaviors. One NYC observational study[17] of 5,275 bicyclists, which encompassed much of our own catchment area, revealed the evident sex disparity of riders (91% male), infrequent helmet use (29.8%), common riding against traffic (13.2%), and use of electronic devices (8.9%). These findings were consistent with our own findings. Safe bicycling behaviors in NYC must be monitored because this will contribute to the success or failure of NYC's ambitious bike-share program[18] intended to rival ones in London and Paris.

Our group has previously shown that intoxicated pedestrians are more likely to cross the street in an unsafe manner and sustain more serious injuries.[19] Our current analysis, which includes all vulnerable roadway users reinforces our previous findings and better quantifies alcohol's risks. Motor vehicle–related fatalities involving intoxicated pedestrians are well documented.[20] Alcohol use while cycling has also been associated with increased risk of serious injury or fatality.[21]

As opposed to pedestrians, a greater percentage of bicyclists are injured by taxicabs. This may relate to competition for the side of the road and to the swinging doors of exiting passengers. Recently installed protected bike paths may help prevent against "door-ing." Taxi collisions seem to result in milder injuries.

Our mortality rate (1.2%) is the lowest reported for vulnerable roadway users as previous studies have ranged between 3% and 30%.[22–27] One reason relates to our methodology of capturing all-comers rather than just admissions. Improvements in prehospital care and inpatient critical care within an advanced urban trauma system may also play a role. In addition, motor vehicles in Manhattan travel at lower speeds. Our low mortality rate reinforces that studying fatality data alone as previous studies have done[7,20,28–30] fails to capture the true magnitude of the problem.

Pedestrians and bicyclists struck by motor vehicles represent two distinct entities. Therefore, solutions for vulnerable roadway users need to be distinct, and lumping these two groups together as part of an injury prevention strategy would be imprudent. Retrospective analyses of hospital admissions databases fail to capture a substantial percentage of the injured as our work suggests that as many as 70% of all patients are treated and released. These patients are invisible in studies but certainly strain already scarce health care resources including emergency medical service use and overcrowded EDs. Days lost from work and traffic crash costs to a city's economy must also be factored in to better understand the consequences of this underappreciated majority on a societal scale. The costs of dedicated inpatient rehabilitation, which was required of 33.0% and 19.5% of pedestrian and bicyclist hospital inpatients, respectively, and the effects of short- and long-term disabilities may also be unrecognized or underreported if only hospital admissions data are scrutinized.

We do acknowledge certain weaknesses of this study and that the results of this study are representative of our catchment area and are not generalizable to NYC as a whole. The first is reporting bias, which may have occurred for fear of liability. To combat this issue, we gathered data from several sources including medical records, witnesses, and first responders to minimize this bias. Review of police accident reports may have additionally added objectivity, but confidentiality rules limited our abilities to recover them. Second, recall bias is a limitation because information collected relies heavily on patients' memories of events. To minimize this, all intoxicated or patients with head injury were interviewed only when their level of consciousness was deemed reliable. Third, as a hospital-based study, selection bias exists as, for example, scene fatalities may have bypassed BHC and gone directly to the medical examiner.

Missed patients were an additional limitation. Our rate of missed patients declined during the tracking period, which we attribute to improved awareness of our study. As BHC's ED sees more than 100,000 patients annually, 100% capture would have been impossible. Furthermore, our use of telephone surveys in an attempt to minimize missed patients who were discharged within 24 hours (during the latter portion of the study) is an additional consideration in recall limitations or bias.

Our research has several strengths. First, this is the largest prospective study identifying injured roadway users without limiting inclusion to admissions. A prospective methodology minimizes missing or incorrect data points, which is a weakness of many administrative data sets, which also too often lack comprehensiveness. Second, extending inclusivity to all individuals who are struck serves to more accurately delineate the true "denominator" by adding to it those "treated-and-discharged" patients who are normally unaccounted for. Third, great efforts were made to triangulate patient-provided collision information and to strengthen results by interviewing available first responders and witnesses and reviewing ambulance records.

NYC has made notable progress in reducing traffic fatalities,[5] but challenges persist. Safety education including public awareness activities, community safety projects, and public health strategies focusing on minorities and children must continue. Compliance with traffic laws relating to vulnerable roadway users must be encouraged. As NYC pushes its ambitious bicycling agenda forward, improved enforcement of helmet laws and cyclist traffic safety violations should continue. For their part, researchers must continue to delineate the nature and scope of the problem and to heighten awareness to the vulnerabilities of the injured.[6]

This study represents a comprehensive assessment of the identities and behaviors of vulnerable roadway users. The intrinsic health benefits and obvious environmental advantages of walking and bicycling within our motor vehicle–dominant culture must not be disregarded. Behaviors may be improved across all parties—pedestrian, cyclist, and driver—so as to fulfill the ultimate goal of a healthy, injury-free coexistence.

AUTHORSHIP

S.G.F. had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. S.G.F., G.F., D.A.L., and R.S. contributed in the study concept and design. S.G.F., G.F., D.A.L., D.S.-L., S.J., M.M., R.S., O.B., L.A.D., and N.E.G. performed the acquisition of data. S.G.F., G.F., D.A.L., D.S.-L., R.S., L.H.P., L.A.D., and S.P.W. performed the analysis and interpretation of data. S.G.F., L.A.D., N.E.G., and S.P.W. drafted the article. S.G.F., G.F., D.A.L., D.S.-L., S.J., M.M., R.S., O.B., L.H.P., and S.P.W. provided critical revision of the article for important intellectual content. S.G.F., L.A.D., N.E.G., S.P.W., G.F., D.A.L., D.S.-L., S.J., M.M., R.S., O.B., and L.H.P. provided final approval of the version to be published. S.G.F., D.S.-L., L.A.D., and S.P.W. performed the statistical analysis. S.G.F., G.F., R.S., D.A.L., and S.J. obtained funding.

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