# Drawing the Curtain Back on Injured Commercial Bicyclists

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*Objectives.* We determined the demographic characteristics, behaviors, injuries, and outcomes of commercial bicyclists who were injured while navigating New York City's (NYC's) central business district.

*Methods.* Our study involved a secondary analysis of prospectively collected data from a level 1 regional trauma center in 2008 to 2014 of bicyclists struck by motor vehicles. We performed univariable and multivariable logistic regression analyses.

*Results.* Of 819 injured bicyclists, 284 (34.7%) were working. Commercial bicyclists included 24.4% to 45.1% of injured bicyclists annually. Injured commercial bicyclists were more likely Latino (56.7%; 95% confidence interval [CI] = 50.7, 62.8 vs 22.7%; 95% CI = 19.2, 26.5). Commercial bicyclists were less likely to be distracted by electronic devices (5.0%; 95% CI = 2.7, 8.2 vs 12.7%; 95% CI = 9.9, 15.9) or to have consumed alcohol (0.7%; 95% CI = 0.9, 2.5 vs 9.5%; 95% CI = 7.2, 12.3). Commercial and noncommercial bicyclists did not differ in helmet use (38.4%; 95% CI = 32.7, 44.4 vs 30.8%; 95% CI = 26.9, 34.9). Injury severity scores were less severe in commercial bicyclists (odds ratio = 0.412; 95% CI = 0.235, 0.723).

*Conclusions.* Commercial bicyclists represent a unique cohort of vulnerable roadway users. In NYC, minorities, especially Latinos, should be targeted for safety education programs. (*Am J Public Health.* 2015;105:2131–2136. doi:10.2105/AJPH.2015.302738)

In the United States in 2012, 726 bicyclists were killed and 49 000 were injured in motor vehicle collisions[1–3]; these fatalities accounted for 2.2% of motor vehicle–related deaths, but represented a 6.5% increase from 2011.[1,2] In New York City (NYC), there were 4207 bicycle collisions in 2012 that resulted in injury, including 20 fatalities.[4]

An estimated 185 000 people bike in NYC daily; of these, 5000 are commercial bicyclists making deliveries.[5] Although commercial bicyclists include only 2.7% of bicyclists in NYC, they account for 16% of daily bicycle trips, at an average of 22 trips per day per commercial bicyclist.[5] There are an estimated 109 375 food delivery trips made daily across NYC, covering 100 000 miles.[5] NYC businesses have been required to provide employee bicyclists with helmets and safety gear, including reflectors, since 2007 and identification cards and reflective vests since 2013.[6–9] Following a 10-month safety education initiative for business owners, the NYC Department of Transportation (DOT) increased enforcement of existing commercial bicycling safety laws in April 2013 by deploying inspectors to businesses to issue violations for missing or improper safety equipment and nonadherence to mandatory safety courses.[10–12]

Commercial bicyclists represent a unique population whose characteristics, behaviors, and injuries have not been previously documented. A comprehensive literature search yielded only 3 articles[13–15] relevant to the subject matter, emphasizing the need for more data on this population. Furthermore, current New York State and City databases do not identify injured bicyclists as commercial or noncommercial.[1,4] Previous work from our trauma center revealed that 43% of injured bicyclists involved in motor vehicle collisions were commercial.[16,17] Although commercial bicyclists provide a convenient service in many urban centers, essential information regarding their safety practices, behaviors, and outcomes in the event of injury is lacking. Our hypothesis was that commercial bicyclists represent a distinct cohort of vulnerable roadway users with a high minority representation. The objective of this study was to describe the demographic characteristics, behaviors, injuries, and outcomes of commercial bicyclists who were injured while navigating NYC's central business district.

## METHODS

Our study involved a secondary analysis of 2 prospective, hospital-based databases consisting of information on patients treated at Bellevue Hospital Center (BHC). BHC is a level 1 regional trauma center whose primary catchment area is southern Manhattan and western Brooklyn. The first database included 1075 pedestrians and 383 bicyclists who were struck by motor vehicles and evaluated at BHC between December 2008 and June 2011.[16] We excluded all pedestrian data for this study. The second database included 706 bicyclists who were treated at BHC regardless of injury mechanism (e.g., collision, fall). To optimize comparability and to minimize bias, we excluded bicyclists from the second database who were not injured by motor vehicles. We collected data for the second database between February 2012 and August 2014, except for a 3-month interruption (October 29, 2012–February 7, 2013) when BHC services were compromised as result of damage from Hurricane Sandy.

Both studies involved extensive data collection forms, which we created following the delineation of predefined variables agreed upon by all of the study investigators. We collected more than 100 distinct variables, including patient demographic characteristics, commercial status, helmet use, alcohol use, electronic device use, riding behaviors, Glasgow Coma Scale score, computed tomography imaging studies, Injury Severity Score, hospital length of stay, and outcomes (including mortality). Commercial bicyclists were defined as business employees operating bicycles (including electric bicycles) for delivery purposes.

Electronic device use included listening to music via ear buds, talking on a mobile phone, texting, or playing games on a handheld device.

We collected demographic characteristic and incident-related data primarily from the patients (i.e., self-report), which was supplemented by first responders when available. Data collection was performed by a dedicated study coordinator, attending trauma surgeons, emergency medicine physicians, physician assistants, and the trauma program coordinator. All patients presenting to BHC within 24 hours of injury were included. Patients were interviewed only when they were able to give informed verbal consent. Prehospital care reports were reviewed, if available.

Injury Severity Score was calculated after final radiology reports became available. Length of stay and disposition data were added soon after a patient's discharge. All patients were asked to self-report alcohol use; in addition, a blood alcohol concentration was obtained as part of the workup in many cases. A blood alcohol concentration of 0.01 grams per deciliter or greater was the primary determinant for alcohol use, with self-report considered next if a level was not drawn.

We analyzed data using Stata version 13.0 statistical software (StataCorp, College Station, TX). We performed a multivariable logistic regression, looking at Injury Severity Score as a 4-category outcome stratified into mild (0–8), moderate (9–15), severe (16–24), and critical (≥ 25). We calculated confidence intervals (CIs) using the exact binomial method.

## RESULTS

There were 383 bicyclists struck by motor vehicles in the first data set. Of the 706 bicyclists in the second data set, 246 were excluded for injury mechanisms other than motor vehicles, whereas 24 additional patients were excluded for unknown working status, leaving 436 for analysis. Of the 819 patients included in this study, 284 (34.7%) were working at the time of injury and labeled as commercial bicyclists (Table 1) . During the study, commercial bicyclists were between 24.4% and 45.1% of injured bicyclists treated at BHC annually. Overall, 98.6% of injured commercial bicyclists were men (95% CI = 96.4, 99.6) compared with 76.6% of injured noncommercial bicyclists (95% CI = 72.8, 80.2). Commercial bicyclists were more likely to be between 18 and 65 years old (92.3%; 95% CI = 88.5, 95.1 vs 85.4%; 95% CI = 82.1, 88.3). Injured commercial bicyclists had a greater proportion of minority patients, with significantly more Latinos (56.7%; 95% CI = 50.7, 62.6 vs 22.7%; 95% CI = 19.2, 26.5), and were less likely to report English as their primary language (27.5%; 95% CI = 22.4, 33.1 vs 77.9%; 95% CI = 74.2, 81.4).

With regard to mechanism of injury, commercial bicyclists were more likely to be injured by an open car door (21.9%; 95% CI = 17.1, 27.3 vs 13.1%; 95% CI = 10.3, 16.3) and to collide with a taxicab (46.3%; 95% CI = 40.5, 53.0 vs 35.9%; 95% CI = 31.5, 40.4; Table 2). Commercial bicyclists were less likely to be using electronic devices (5.0%; 95% CI = 2.7, 8.2 vs 12.7%; 95% CI = 9.9, 15.9) or to have consumed alcohol (0.7%; 95% CI = 0.1, 2.5 vs 9.5%; 95% CI = 7.2, 12.3). At the time of injury, 14.2% of commercial bicyclists were riding an electric bicycle (95% CI = 8.4, 21.7 vs 1.2%; 95% CI = 0.3, 3.1).

Following the implementation of NYC DOT's safety education initiative (data stratified for patients treated after May 1, 2013), 46.0% of injured commercial bicyclists were wearing helmets, 40.8% were carrying identification cards, and 51.0% were wearing vests depicting the business' name. Although commercial and noncommercial bicyclists did not differ in overall helmet use, differences between the groups were apparent when helmet use was analyzed over time by logistic regression analysis (data available as a supplement to the online version of this article at http://www.ajph.org). Injured commercial bicyclists had a statistically significant increase in helmet use by 5% annually between 2009 and 2014 ($P = .002$), whereas noncommercial bicyclists showed no change ($P = .137$). However, the difference in slopes was not statistically significant ($P = .089$).

**TABLE 1—Patient Demographics Among Injured Commercial Bicyclists: New York City, 2008–2014**

| | Commercial Bicyclists (n = 284) | | Noncommercial Bicyclists (n = 535) | |
|---|---|---|---|---|
| Categories | No. (%) | 95% CI | No. (%) | 95% CI |
| Gender | | | | |
| Male | 280 (98.6) | 96.4, 99.6 | 410 (76.6) | 72.8, 80.2 |
| Age, y | | | | |
| < 18 | 12 (4.2) | 2.2, 7.3 | 23 (4.3) | 2.7, 6.4 |
| 18–65 | 262 (92.3) | 88.5, 95.1 | 457 (85.4) | 82.1, 88.3 |
| > 65 | 10 (3.5) | 7.8, 13.2 | 55 (10.3) | 7.8, 13.2 |
| Race/ethnicity[a] | | | | |
| Non-Latino White | 21 (7.5) | 4.7, 11.2 | 300 (56.2) | 51.9, 60.4 |
| Black | 41 (14.5) | 10.6, 19.2 | 57 (10.7) | 8.2, 13.6 |
| Latino | 160 (56.7) | 50.7, 62.6 | 121 (22.7) | 19.2, 26.5 |
| East Asian | 41 (14.5) | 10.6, 19.2 | 37 (6.9) | 4.9, 9.4 |
| South Asian | 11 (3.9) | 2.0, 6.9 | 7 (1.3) | 0.5, 2.7 |
| Other | 8 (2.8) | 1.2, 5.5 | 12 (2.2) | 1.2, 3.9 |
| Primary language | | | | |
| English | 78 (27.5) | 22.4, 33.1 | 417 (77.9) | 74.2, 81.4 |
| Spanish | 138 (48.6) | 42.6, 54.6 | 69 (12.9) | 10.2, 16.0 |
| Chinese | 38 (13.4) | 9.7, 17.9 | 16 (3.0) | 1.7, 4.8 |
| Other | 30 (10.6) | 7.2, 14.7 | 33 (6.2) | 4.3, 8.6 |

*Note.* CI = confidence interval. CI calculated using exact binomial method.
[a]One noncommercial and 2 commercial bicyclists excluded.

**TABLE 2—Incident Description and Bicyclist Behaviors Among Injured Commercial Bicyclists: New York City, 2008–2014**

| Category | Commercial Bicyclists (n = 284) | | Noncommercial Bicyclists (n = 535) | |
|---|---|---|---|---|
| | No. (%) | 95% CI | No. (%) | 95% CI |
| Incident description | | | | |
| Against flow of traffic[a] | 27 (9.9) | 6.6, 14.1 | 36 (7.5) | 5.3, 10.2 |
| Riding in bike lane/path[b] | 75 (29.8) | 24.2, 35.8 | 143 (29.7) | 25.6, 34.0 |
| Crossed intersection against signal[c] | 28 (10.6) | 7.4, 14.9 | 57 (11.8) | 9.0, 15.0 |
| Cut off by motor vehicle[d,e] | 28 (24.6) | 17.0, 33.5 | 74 (25.3) | 20.5, 30.7 |
| Collided with open car door[f] | 59 (21.9) | 17.1, 27.3 | 68 (13.1) | 10.3, 16.3 |
| Riding on the side walk[d,g] | 2 (1.7) | 0.2, 5.9 | 5 (1.6) | 0.5, 3.6 |
| Electronic device use[h] | 14 (5.0) | 2.7, 8.2 | 66 (12.7) | 9.9, 15.9 |
| Alcohol involvement | 2 (0.7) | 0.1, 2.5 | 51 (9.5) | 7.2, 12.3 |
| BAC level drawn | 86 (30.5) | 25.2, 36.2 | 211 (39.4) | 35.3, 43.7 |
| Bicyclist gear use | | | | |
| Helmeted[i] | 108 (38.4) | 32.7, 44.4 | 163 (30.8) | 26.9, 34.9 |
| Reflective vest[d,j] | 7 (5.8) | 2.4, 11.7 | 3 (0.9) | 0.2, 2.7 |
| Working cyclist required gear[k] | | | | |
| Carrying ID card provided by business[l] | 20 (40.8) | NA | NA | NA |
| Wearing vest with business name[m] | 25 (51.0) | NA | NA | NA |
| Type of bicycle[d,n] | | | | |
| Normal bicycle | 97 (80.8) | 72.6, 87.4 | 306 (93.9) | 90.7, 96.2 |
| Electric bicycle | 17 (14.2) | 8.5, 21.7 | 4 (1.2) | 0.3, 3.1 |
| Fixed gear bicycle | 3 (2.5) | 0.5, 7.1 | 11 (3.4) | 1.7, 6.0 |
| Pedicab | 1 (0.8) | 0.02, 4.6 | 1 (0.3) | 0.01, 1.7 |
| Other | 2 (1.7) | 0.2, 5.9 | 4 (1.2) | 0.3, 3.1 |
| Motor vehicle type[o] | | | | |
| Passenger vehicle[p] | 95 (36.7) | 30.8, 42.9 | 212 (46.1) | 41.5, 50.8 |
| Yellow taxicab | 121 (46.3) | 40.5, 53.0 | 165 (35.9) | 31.5.40.4 |
| Commercial vehicle[q] | 43 (16.6) | 12.3, 21.7 | 83 (18.0) | 14.6, 21.9 |

*Note.* BAC = blood alcohol content; CI = confidence interval; ID = identification; NA = not applicable; SUV = sport utility vehicle. CI calculated using exact binomial method.
[a]Twelve commercial bicyclists and 53 noncommercial bicyclists excluded.
[b]Thirty-two commercial bicyclists and 53 noncommercial bicyclists excluded for nonapplicable or unknown status.
[c]Nineteen commercial bicyclists and 50 noncommercial bicyclists excluded.
[d]Includes data collected between 2012 and 2014; data from 2009 to 2011 did not collect this variable.
[e]Commercial bicyclist n = 114, noncommercial bicyclist n = 292.
[f]Fourteen commercial bicyclists and 17 noncommercial bicyclists excluded.
[g]Commercial bicyclist n = 119, noncommercial bicyclist n = 323.
[h]Two commercial bicyclists and 15 noncommercial bicyclists excluded.
[i]Three commercial bicyclists and 6 noncommercial bicyclists excluded.
[j]Commercial bicyclist n = 120, noncommercial bicyclist n = 326.
[k]Only includes commercial bicyclists injured after May 1, 2013.
[l]Commercial bicyclist n = 49.
[m]Commercial bicyclist n = 48.
[n]Commercial bicyclist n = 120, noncommercial bicyclist n = 326.
[o]Commercial bicyclist n = 259, noncommercial bicyclist n = 460.
[p]Includes limousines, SUV, and vans.
[q]Includes trucks, buses, and access-a-ride vehicles.

External and environmental factors were examined (data available as a supplement to the online version of this article at http://www.ajph.org). Commercial bicyclists were more likely to be injured in the borough of Manhattan (96.1%; 95% CI = 93.1, 98.0 vs 78.3%; 95% CI = 74.5, 81.7). Commercial bicyclists were more likely to be injured in winter (20.4%; 95% CI = 15.9, 25.6 vs 8.8%; 95% CI = 6.5, 11.5), on a wet road surface (16.0%; 95% CI = 11.9, 20.8 vs 7.8%; 95% CI = 5.7, 10.5), and on an avenue, defined as a wider, more considerable thoroughfare (10.3%; 95% CI = 7.0, 14.4 vs 19.1%; 95% CI = 15.8, 22.7), compared with noncommercial bicyclists.

Categorical Glasgow Coma Scale score was not found to be different between groups. Injury severity was greater for noncommercial bicyclists, with 14.0% having a moderate Injury Severity Score (95% CI = 11.2, 17.3 vs 4.9%; 95% CI = 2.7, 8.1; Table 3). Commercial bicyclists were less likely to be admitted to the hospital (13.4%; 95% CI = 9.7, 17.9 vs 28.8%; 95% CI = 25.0, 32.8) and had shorter mean hospital length of stay (0.65; 95% CI = 0.30, 0.99 vs 2.01 days; 95% CI = 1.30, 2.72). Commercial bicyclists were less likely to require surgery (3.9%; 95% CI = 2.0, 6.8 vs 10.8%; 95% CI = 8.3, 13.8). No commercial bicyclist died (95% CI = 0, 1.3); 5 noncommercial bicyclists died (0.9%; 95% CI = 0.3, 2.2).

Multivariable logistic regression showed that commercial bicycling was associated with less severe injury (odds ratio [OR] = 0.412; 95% CI = 0.235, 0.723; Table 4). Adults aged 65 years or younger (OR = 0.541; 95% CI = 0.325, 0.899) and Black bicyclists (OR = 0.344; 95% CI = 0.154, 0.768) sustained less severe injury. Collision with an open car door, compared with other injury mechanisms, was associated with less severe injury (OR = 0.412; 95% CI = 0.196, 0.864). Alcohol use was associated with more severe injury (OR = 3.036; 95% CI = 1.671, 5.517).

## DISCUSSION

Beginning in 2012, the DOT deployed inspectors to businesses throughout NYC to provide safety education outreach to employers and employees, with inspectors visiting 4092 businesses of which 2891 were in Manhattan.[10] The DOT also hosted 33 Delivery Cyclist Forums for business owners and bicyclists distributing bells, vests, and lights.[10] Commercial bicyclists in NYC are required by law to review a commercial bicyclist safety course,[18] whereas business owners are required to post a Commercial Bicyclist Safety poster for their staff on site.[19] NYC businesses

**TABLE 3—Injuries and Outcomes Among Injured Commercial Bicyclists: New York City, 2008–2014**

| Categories | Commercial Bicyclists (n = 284) | | Noncommercial Bicyclists (n = 535) | |
|---|---|---|---|---|
| | No. (%), Mean ±SD, or Range | 95% CI | No. (%), Mean ±SD, or Range | 95% CI |
| GCS score[a] | | | | |
| 15 | 269 (95.4) | 92.3, 97.5 | 478 (90.7) | 87.9, 93.4 |
| 13–14 | 11 (3.9) | 2.0, 6.9 | 38 (7.2) | 5.2, 9.8 |
| 9–12 | 1 (0.4) | 0.01, 2.0 | 3 (0.6) | 0.1, 1.7 |
| ≤ 8 | 1 (0.4) | 0.01, 2.0 | 8 (1.5) | 0.7, 3.0 |
| Loss of consciousness[b] | | | | |
| Yes | 57 (21.9) | 17.1, 27.4 | 153 (31.2) | 27.1, 35.5 |
| No | 203 (78.1) | 72.5, 82.9 | 337 (68.8) | 64.5, 72.9 |
| ISS | | | | |
| 0–8, mild | 263 (92.6) | 88.9, 95.4 | 421 (78.7) | 75.0, 82.1 |
| 9–15, moderate | 14 (4.9) | 2.7, 8.1 | 75 (14.0) | 11.2, 17.3 |
| 16–24, severe | 4 (1.4) | 0.4, 3.6 | 19 (3.6) | 2.2, 5.5 |
| ≥ 25, critical | 3 (1.1) | 0.2, 3.1 | 20 (3.7) | 2.3, 5.7 |
| Initial CT imaging | | | | |
| Head | 107 (37.7) | 32.0, 43.6 | 237 (44.3) | 40.0, 48.2 |
| Cervical spine | 109 (38.4) | 32.7, 44.3 | 224 (41.9) | 37.6, 46.2 |
| Chest | 47 (16.6) | 12.4, 21.4 | 96 (17.9) | 14.8, 21.5 |
| Abdomen/pelvis | 60 (21.1) | 16.5, 26.3 | 123 (23.0) | 19.5, 26.8 |
| ED disposition | | | | |
| Admitted or died in ED[c] | 38 (13.4) | 9.7, 17.9 | 154 (28.8) | 25.0, 32.8 |
| Length of stay | | | | |
| Mean days | 0.65 ±2.96 | 0.30, 0.99 | 2.01 ±8.36 | 1.30, 2.72 |
| Min–max days | 0–38 | | 0–120 | |
| Required ICU stay | 6 (0.2) | 0.8, 4.5 | 31 (5.8) | 4.0, 8.1 |
| Required intubation | 2 (0.7) | 0.1, 2.5 | 19 (3.6) | 2.2, 5.5 |
| Required tracheostomy | 0 (0) | 0, 1.3 | 6 (1.2) | 0.4, 2.4 |
| Required surgery | 11 (3.9) | 2.0, 6.8 | 58 (10.8) | 8.3, 13.8 |
| Died | 0 (0) | 0, 1.3 | 5 (0.9) | 0.3, 2.2 |
| Hospital disposition | | | | |
| Home | 278 (97.9) | 95.5, 99.2 | 499 (93.3) | 90.8, 96.2 |
| Rehabilitation facility | 6 (2.1) | 0.8, 4.5 | 21 (3.9) | 2.5, 5.9 |
| Other[d] | 0 (0) | 0, 1.3 | 15 (2.8) | 1.6, 4.6 |

*Note.* CI = confidence interval; CT = computed tomography; ED = emergency department; GCS = Glasgow Coma Scale; ICU = intensive care unit; ISS = Injury Severity Score. CI calculated using exact binomial method.
[a]Two commercial bicyclists and 8 noncommercial bicyclists excluded.
[b]Twenty-four commercial bicyclists and 45 noncommercial bicyclists with possible or unknown loss of consciousness were excluded.
[c]One noncommercial bicyclist died in the ED; all other patients were admitted.
[d]Other includes morgue, prison, nursing home, psychiatric unit, or transfer to an acute care facility.

are also required to equip bicycles with bells, reflectors, working brakes, headlights, and taillights.[11] Commercial bicyclists are also required to wear helmets; the only other group in NYC mandated as such is children younger than 14 years.[11,12] Based on all of these initiatives, it is clear that the city views commercial bicyclists as a vulnerable population.

In our study, commercial bicyclists constituted between 24.4% and 45.1% of injured bicyclists treated at BHC annually from 2009 to 2014. Because commercial bicyclists make up only 2.7% of bicyclists in NYC, this inconsistency might be partly attributed to the fact that BHC's catchment area in the dense city center is not representative of the city as a whole.

The anonymity of bicycle deliverymen in NYC is unfortunate because they provide a service that many "New Yorkers take for granted."[20] In our study, injured commercial bicyclists were predominantly young adults, mostly Latino men, whose primary language is Spanish. Recognizing the multilingual and multicultural aspect of this population, the NYC DOT offers its Commercial Bicyclist Safety Course in English, Spanish, and Chinese, whereas the Commercial Bicyclist Safety Poster is available in English, Spanish, Chinese, Greek, Italian, Korean, Russian, and Haitian Creole.[18,19] Safety materials and education provided in a variety of languages are required to effectively accommodate this diverse group.

Current literature on commercial bicyclist helmet use is limited to 2 studies. Dennerlein and Meeker[15] analyzed 113 Boston, Massachusetts–based messenger bicyclists and found that 24% reported wearing helmets on a regular basis. Internationally, Kulanthayan et al.[13] analyzed helmet use in Malaysia, where delivery bicyclists commonly ride motorcycles and standardized motorcycle helmets are required. Although compliance was not noted, they found that half of the workers wore helmets that did not meet safety requirements.[13] Our study showed an increase in helmet use among injured commercial bicyclists from 2009 to 2014. Safety education and enforcement initiatives should continue because there is room for improved compliance, not only with donning helmets, but also with carrying required identification cards and wearing reflective vests.

Most research regarding the impact of socioeconomic status and race/ethnicity on helmet use was conducted on children and suggested that helmet use is directly correlated with education level and socioeconomic advantage.[21–24] A study on pediatric helmet use found that recent immigrants were less likely to wear helmets.[25] Other studies suggested that minority bicyclists (e.g., Latino, Black) were less likely to wear helmets.[17,23,26] Because more than 85% of injured commercial bicyclists in our study were Latino, East Asian, or Black, our data suggested that these minority groups

**TABLE 4—Multivariable Logistic Regression Among Injured Commercial Bicyclists: New York City, 2008–2014**

| Outcome: Four Category ISS[a] | Odds Ratio (SE) | *P* | 95% CI |
|---|---|---|---|
| Commercial bicyclist | 0.412 (0.118) | .002 | 0.235, 0.723 |
| Aged 18–65 y | 0.541 (0.153) | .018 | 0.325, 0.899 |
| Race/ethnicity | | | |
| Non-Latino White (Ref) | 1.000 | | |
| Black | 0.344 (0.141) | .009 | 0.154, 0.768 |
| Latino | 0.830 (0.209) | .459 | 0.506, 1.360 |
| Other | 1.084 (0.326) | .788 | 0.601, 1.955 |
| Riding in bike lane/path | 1.333 (0.325) | .239 | 0.825, 2.152 |
| Riding against flow of traffic | 1.513 (0.540) | .246 | 0.751, 3.050 |
| Collided with open car door | 0.412 (0.156) | .019 | 0.196, 0.864 |
| Helmet use | 0.824 (0.188) | .396 | 0.527, 1.288 |
| Electronic device use[b] | 0.786 (0.274) | .49 | 0.397, 1.558 |
| Alcohol involved | 3.036 (0.925) | < .001 | 1.671, 5.517 |
| Motor vehicle type | | | |
| Passenger vehicle (Ref) | 1.000 | | |
| Taxicab | 0.616 (0.153) | .051 | 0.379, 1.002 |
| Commercial vehicle | 1.449 (0.337) | .155 | 0.869, 2.414 |
| Icy or wet roadway | 1.147 (0.393) | .688 | 0.586, 2.247 |

*Note.* CI = confidence interval; ISS = Injury Severity Score.
[a]ISS categories defined as: mild: ISS 0–8, moderate: ISS 9–15, severe: ISS 16–24, critical: ISS ≥ 25.
[b]Electronic device use includes listening to music, talking on phone, texting, or playing handheld game.

should continue to be targeted from a safety education standpoint.

With regard to riding behaviors, the majority of commercial and noncommercial bicyclists rode with the flow of traffic and denied crossing the intersection against the light signal. Commercial bicyclists were less likely to be distracted by an electronic device or to have consumed alcohol. Less than one third of commercial and noncommercial bicyclists were riding in a bike lane or path at the time of injury; we did not design the present study to answer whether this indicated a protective effect for bike lanes or merely represented unavailability of bike lanes at the time of the incident.

Taxicabs were involved in nearly half of all collisions with commercial bicyclists, presenting an opportunity for targeted education. Educational campaigns aimed at passengers exiting vehicles should continue, and further insight into this high-risk interaction is warranted.[27]

Nearly 15% of commercial bicyclists were injured while riding electric bicycles. These bicycles are considered more dangerous because of their greater weight and the higher speeds they can generate, which might contribute to increased injury to a pedestrian in the event of a crash.[28] Because of this and the inability to register electric bicycles, they are illegal in NYC.[29] Likely, increased enforcement might play an important role in eliminating their use.

The majority of injuries were minor and involved skin or soft tissue injuries (i.e., contusions and lacerations) followed by bony fractures. This was consistent with the study by Dennerlein and Meeker,[15] who found that the most common type of injury in their Boston commercial bicyclist cohort was bruising or contusions, and the most common cause for lost days of work was fractures. Our study found that commercial bicyclists sustained milder injuries overall.

Our study found that commercial bicyclists were less likely to require hospital admission or surgery, thereby contributing to reduced hospital resource use compared with noncommercial bicyclists. Although injured commercial bicyclists might utilize less inpatient resources, they nonetheless represented a large proportion of the injured bicyclist population seeking hospital care.[5] Dennerlein and Meeker found that 70% of messenger bicyclists lost at least 1 day of work per year because of injury, with 55% requiring a doctor or hospital visit.[15]

## Strengths and Limitations

Our study had several strengths. We collected data prospectively, and the data sets included descriptive variables not typically found in large administrative databases. In addition, patients discharged from the emergency department were included. Finally, existing literature on this population was very limited.

Our study is subject to a number of limitations. Our data were based on a case series from a single trauma center and represented, in part, the trauma registry of that institution. Trauma registry data are important sources of information about injury patterns and associations, but their main role is to inform quality assurance and patient care.[30] As such, they are subject to a number of important potential biases. Trauma registry data are usually based on a narrow set of inclusion and exclusion criteria and may differ from population-based data on characteristics, such as cause of injury, anatomic location, and injury severity.[31] In general, it is expected that trauma registries represent patients who are more severely injured, and more likely to be transported by emergency medical services.[32] Because we only included bicyclists injured within the unique catchment area of BHC, our data were not generalizable to bicyclists navigating other areas of NYC. Reporting bias was also a concern because the accuracy of our behavioral data relied on self-report. Commercial bicyclists might have been more concerned with admitting to certain behaviors for fear of losing their job or sustaining a fine for the business. Recall bias was a limitation because the collected information relied heavily on patients' memories of events. Our population only represented bicyclists who sustained injuries severe enough to require hospital care, who agreed to come or to be brought to a hospital, and who were not declared dead at the scene.

## Conclusions

Commercial bicyclists represent a unique cohort of vulnerable roadway users who have

received little attention in the scientific and epidemiological literature. In NYC, minorities, especially Latinos, should continue to be targeted by safety education programs. Educational and enforcement efforts aimed at commercial bicyclists should continue. ■

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P. Ayoung-Chee, D. Slaughter, S. Jacko, S. G. Frangos, and S. P. Wall conceptualized and designed the study. J. H. Heyer, M. Sethi, P. Ayoung-Chee, D. Slaughter, S. Jacko, S. G. Frangos, and S. P. Wall collected the data. J. H. Heyer, M. Sethi, P. Ayoung-Chee, D. Slaughter, S. Jacko, S. G. Frangos, S. P. Wall, and C. J. DiMaggio analyzed and interpreted the data. J. H. Heyer, M. Sethi, P. Ayoung-Chee, D. Slaughter, S. Jacko, S. G. Frangos, S. P. Wall, and C. J. DiMaggio drafted, revised, and approved the final version of the article.

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## Human Participant Protection

Both the New York University School of Medicine and the Bellevue Hospital Center institutional review boards approved the study.

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