Bicycle Commuter Injury Prevention: It Is Time to Focus on the Environment

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Background: Few data exist on the risk of injury while commuting to work or school by bicycle. The proportion of commuters choosing to travel by bike is increasing in the United States, and information on injury incidence and the influences of rider characteristics and environmental factors may suggest opportunities for prevention actions.

Methods: Bicycle commuters in the Portland, OR, metropolitan area were recruited via the websites and community advertising to participate in a 1-year study. Riders completed an initial online survey along with 12 monthly surveys describing their commutes and injury events from September 2007 to August 2008. A traumatic event was considered a serious traumatic event if medical attention was sought.

Results: Nine hundred sixty-two adult bicyclists (52% men and 48% women) with a mean age of 36.7 ± 0.4 years (range, 22–70 years) commuted an average of 135 miles (range, 7–617) per month. There were 225 (23%) beginner, 256 (27%) intermediate, and 481 (50%) advanced riders. Four hundred twenty (44%) had a prior traumatic event. Over the 1-year period, 164 (18%) riders reported 192 traumatic events and 49 (5%) reported 50 serious traumatic events. The incidence rates of traumatic events and serious traumatic events were 15.0 (95% CI, 13.2–17.5) and 3.9 (95% CI, 2.9–5.1) per 100,000 miles commuted. There were no differences in age, gender, safety practices, and experience levels between commuters who experienced a traumatic event and those who did not.

Conclusions: Approximately 20% of bicycle commuters experienced a traumatic event and 5% required medical attention during 1 year of commuting. Traumatic events were not related to rider demographics, safety practices, or experience levels. These results imply that injury prevention should focus on improving the safety of the bicycle commuting environment.

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The number of people choosing to commute to work or school by bicycle in the United States continues to rise. The 2008 national bicycle commuter mode share of 0.5%, though small, represents ~720,000 commuters, an increase of almost 200,000 people in 3 years.[1] The bicycle commuter modal share in Portland, OR, a city with a population of ~600,000, rose to 6.4% in 2008, according to the US Census Bureau.[1] Although bicycle commuting is believed to be beneficial to the health of both the individual and the community, the potential for fatalities and injuries also exists. Puncher and Dijkstra[2] report that riding a bicycle is 12 times more likely to lead to mortality than riding in a car. Injuries result in costly medical bills, time off work, surgery, and permanent disability. Even events that do not lead to injury can adversely affect a cyclist's sense of safety, leading them to stop commuting by bike.[3]

Although the risk of injury while bicycle commuting is real, it has been difficult to accurately measure. Two large retrospective studies of North American bicycle commuters found the injury incidence to be between 6.0 and 18.6 per 100,000 miles commuted.[4,5] A 2-week pilot study of commuters in Nottingham, England, recorded no injuries.[6] No large prospective study of bicycle commuter injury has been published. We conducted a 1-year prospective, observational study to determine the incidence of traumatic events, defined as a cycling event leading to injury, along with the incidence of serious traumatic events, defined as a traumatic event requiring medical attention, associated with commuting to work or school by bike in Portland. We also sought to characterize the influence of rider skill, environmental factors, roadway surface conditions, and infrastructure on both traumatic and serious traumatic events.

MATERIALS AND METHODS

Bicycle commuters in the Portland metropolitan area were recruited throughout August and September 2007 via websites, including bikeportland.org and the Portland Bicycle Transportation Alliance, as well as community advertising to participate in the study. The recruitment period coincided with the Bike Commute Challenge, a month long event sponsored by the Bicycle Transportation Alliance in September of each year. This study was approved by the Institutional Review Board at Oregon Health & Science University. Subjects were required to be at least 18 years old, self identify as a bicycle commuter, complete at least part of their bicycle commute to work or school within Portland city limits, have access to the Internet, be accessible through email, and have the ability to complete surveys written in English, either alone or with assistance. An initial online survey was used to collect demographics, safety practices, experience levels, and event history as well as information regarding the current commuting route including distance, months used, and infrastructure encountered. Commuters were grouped into one of

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three skills levels, beginner, intermediate and advanced, based on responses to the initial survey. Those who reported a bike commute history of <9 months, regardless of days commuted per week, were considered beginners; those who commuted by bike ≥3 days per week for at least 9 months during 1 year were considered intermediate; and those who commuted by bike ≥3 days per week for at least 9 months per year for at least 3 years were considered advanced.

Monthly online surveys were sent via Survey Monkey on the first day of the month, beginning in October 2007 and ending in September 2008. Each survey remained open for 8 days. Reminder emails were sent to all subjects who had not completed the survey on the fifth and eighth days of the month. Surveys were used to collect information regarding the previous month's commute as well as information regarding the circumstances and outcomes of both traumatic events and serious traumatic events, including the light, weather, roadway surface condition, and infrastructure related to the event, whether or not a vehicle was involved, injuries sustained, hospital admission, length of stay, and time off from work.

Statistical Analysis

Descriptive statistics were run on the initial survey data, and values are reported as mean ± SEM except where otherwise indicated. Comparisons across skill levels were made using analysis of variance with Bonferroni post hoc tests for continuous variables and χ^2 or Fisher's exact test for categorical variables. For continuous variables without homogeneity of variances, Welch and Brown-Forsythe statistics were calculated with Games-Howell post hoc testing as needed. Monthly and yearly incidence of traumatic events and serious traumatic events per 100,000 miles were calculated from the reported number of events and the total miles commuted. Total miles commuted were derived for each commuter by multiplying the average number of days commuted per week, as reported in each monthly survey, by the roundtrip distance of the commute, as reported in the initial survey, by four; results were added to obtain total miles commuted for each month and for the year beginning September 2007 and ending August 2008. Monthly and yearly incidence rates of both traumatic and serious traumatic events were also calculated for each skill level and were then compared using analysis of variance.

To analyze commuter characteristics potentially associated with traumatic events and serious traumatic events, univariate analysis of categorical data was performed using χ^2 test. Noncategorical data were analyzed using independent samples *t* test with equal or unequal variances depending on the distribution of each set based on analysis by Levene's test for equality of variances. All differences between traumatic and serious traumatic events were calculated using χ^2 test. For all descriptions, calculations, and analyses, serious traumatic events were first included within the traumatic event data and were then recorded and analyzed separately, except for when traumatic events and serious traumatic events were directly compared. Statistical analysis was performed using SPSS version 17.0 (SPSS, Chicago, IL).

RESULTS

The initial online survey was accessed by 1043 individuals and 1034 consented to participate in the study. Nine hundred eighty individuals fully completed the initial survey. Eighteen individuals did not respond to any of the 12 monthly surveys, and their information was not included in any calculations. Another 34 commuters opted out of the study at various times during the year; their initial and monthly survey responses were included in all calculations for which they provided data. In total, we collected 9,492 months of data, an average of 9.9 months (range, 1–12 months) per commuter; the 34 commuters mentioned earlier provided an average of 4.9 months (range, 1–11 months) of data per rider. Overall, 42% of commuters provided 12 months of data, and 72% of commuters provided at least 10 months of data. There were no deaths, though a Portland bike commuter not enrolled in the study was killed in October 2007.

Commuter characteristics are listed in Table 1. Sixty-three percent (301) of the advanced commuters were men, compared with 37% (82) of the beginners ($p < 0.001$). There were no statistical differences in body mass index (BMI) between the skill levels. Advanced commuters were statistically more likely to use both lights and reflective clothing ($p = 0.001$, $p < 0.001$) but were no more likely to use helmets or mirrors. Four hundred sixty-three (48%) commuters reported using a road bike, 247 (26%) a hybrid bike, and 122 (13%) a mountain bike; more than half (52%) used clipless pedals. The average roundtrip length of commute was 11.2 ± 0.2 miles (range, 3–25 miles), with no significant difference between skill levels. Respondents reported an average bicycle commuting history of 74 ± 2.5 (range, 0–453 months) and an average of 41.1 ± 1.2 (range, 0–156 months) on the current commuting route. Two hundred twenty-four (53%) of advanced, 72 (32%) of beginner, and 90 (35%) of intermediate riders ($p < 0.001$) reported a prior traumatic event. Of the total 420 (44%) commuters who experienced a prior traumatic event, 294 (70%) said that the event occurred during their commute and 223 (53%) said that the event involved a vehicle.

TABLE 1. Bicycle Commuter Demographics

Commuter	962
Male	52%
Female	48%
Age (yr)	36.7 ± 0.4*
BMI (kg/m^2)	24.1 ± 0.1*
Skill level	
Beginner	23%
Intermediate	27%
Advanced	50%
Prior traumatic event	44%
Helmet	95%
Lights in dark	96%
Reflective clothing	60%
Mirror	19%

* Mean ± SEM.

Overall, the incidence of traumatic events and serious traumatic events were 15.0 (95% CI, 13.2–17.5) and 3.9 (95% CI, 2.9–5.1) per 100,000 miles commuted, respectively. There were no significant differences between skill levels (Fig. 1). The monthly incidence of both traumatic and serious traumatic events from September 2007 to August 2008 is illustrated in Figure 2. Of note, there were only two additional traumatic events for which medical attention would have been sought if the commuter involved had medical insurance.

Commuter characteristics and their association with traumatic events are summarized in Table 2. On univariate analysis, there were no statistical differences in gender, age, BMI, skill level, commuting history, prior traumatic event, or use of helmet, lights in the dark, reflective clothing, and mirrors between those commuters who experienced a traumatic event and those who did not. Commuters who experienced a traumatic event had a slightly longer commute than those who did not (12.1 ± 0.5 miles vs. 11.0 ± 0.2 miles; $p = 0.036$). A univariate analysis of characteristics associated with serious traumatic events is outlined in Table 3. Except for helmet use, there were no statistical differences between those commuters who experienced a serious traumatic event and those who did not. Thirteen percent (6) of commuters who did not wear a helmet experienced a serious traumatic event, compared with 5% (43) of those who did ($p = 0.023$). In an additional analysis comparing commuters who reported a traumatic event with those who reported a serious traumatic event, lack of helmet use was the only statistical difference between the two groups ($p = 0.013$).

The most common body regions injured were the skin/soft tissue, upper limbs, and lower limbs, occurring in 52%, 48%, and 42% of all traumatic events and 52%, 44%, and 52% of all serious traumatic events reported (Fig. 3). Injuries of the head, face, abdomen, and spine were more likely to be associated with a serious traumatic event ($p = 0.017$, 0.001, 0.005, and 0.001, respectively). Of the 50 serious traumatic events, 12 (24%) led to hospital admissions with an average length of stay of 1 day and 4 (8%) led to one operation each. The average time off work as a result of a serious traumatic event was 2.42 days (range, 0–20).

For each traumatic and serious traumatic event, we collected the light, weather, roadway surface condition, and infrastructure involved with the event. Most traumatic

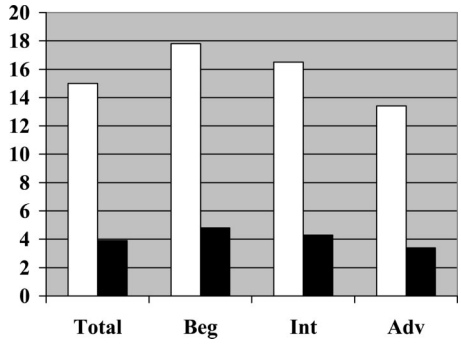

Figure 1. Incidence rates of traumatic events (*white bar*) and serious traumatic events (*black bar*) per 100,000 miles commuted, by skill level. Beg, beginner; Int, intermediate; Adv, advanced.

TABLE 2. Bicycle Commuter Characteristics Associated With a Traumatic Event

	Traumatic Event		
Variable	**Yes**	**No**	***p***
Commuter	164	798	—
Male	87	416	0.83
Female	77	382	
Age (yr)	36.6 ± 0.9	36.7 ± 0.4	0.91
BMI (kg/m^2)	23.3 ± 0.3	23.7 ± 0.1	0.29
Skill level			0.74
Beginner	31	193	
Intermediate	43	214	
Advanced	90	391	
Total commute history (mo)	76.8 ± 6.4	73.6 ± 2.7	0.64
Current commute history (mo)	38.2 ± 2.9	41.7 ± 1.3	0.27
Commute length (miles)	12.1 ± 0.5	11.0 ± 0.2	**0.04**
Prior traumatic event	79	85	0.19
Use helmet	156	761	0.89
Use lights in dark	162	764	0.06
Use reflective clothing	96	478	0.75
Use mirror	37	147	0.22

Values are presented as mean ± SEM or n. The *p* value in boldface indicates significance.

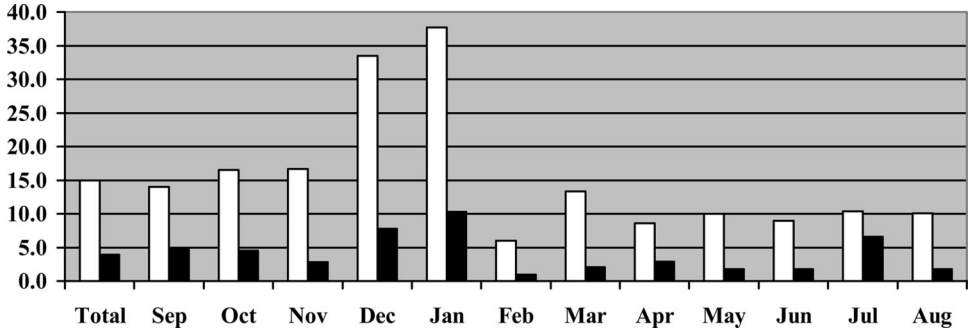

Figure 2. Incidence rates of traumatic events (*white bar*) and serious traumatic events (*black bar*) per 100,000 miles commuted, by month.

TABLE 3. Bike Commuter Characteristics Associated With a Serious Traumatic Event

	Serious Traumatic Event		
Variable	**Yes**	**No**	***p***
Commuter	49	913	—
Male	22	481	0.29
Female	27	432	
Age (yr)	35.0 ± 1.6	36.8 ± 0.4	0.28
BMI (kg/m^2)	22.7 ± 0.5	23.6 ± 0.1	0.07
Skill level			0.88
Beginner	10	214	
Intermediate	14	243	
Advanced	25	456	
Total commute history (mo)	66.9 ± 9.9	74.5 ± 2.5	0.45
Current commute history (mo)	36.3 ± 4.9	41.4 ± 1.2	0.32
Commute length (miles)	10.9 ± 0.8	11.2 ± 0.2	0.76
Prior traumatic event	26	393	0.17
Use helmet	43	874	**0.01**
Use lights in dark	49	877	0.16
Use reflective clothing	25	549	0.20
Use mirror	11	173	0.54

Values are presented as mean ± SEM or n. The *p* value in boldface indicates significance.

events (57%) and serious traumatic events (64%) occurred during daylight on a clear/dry day (40% and 54%, respectively). Poor roadway surface conditions were a factor in 40 (21%) traumatic events and 10 (20%) serious traumatic events: tracks on the road, loose gravel, and steel plates were cited most often. Fifty-six (29%) of all traumatic events and 24 (48%) of all serious traumatic events involved a motorized vehicle ($p = 0.001$). Eleven (6%) traumatic events and no serious traumatic events involved another bike (not significant).

Both traumatic events and serious traumatic events occurred mostly on bike lanes/wide shoulders and residential streets (Fig. 4). When compared with one another, traumatic events were more likely to occur on major streets with no bicycle facilities ($p = 0.028$), whereas serious traumatic events were more likely to occur on residential streets and on bicycle boulevards ($p = 0.029$ and 0.010, respectively), defined as low-traffic streets that use traffic calming features to give priority to bicycles over motor vehicles. Of note, 875 (91%) and 502 (52%) of commuters used bike lanes and residential streets, respectively, during some part of their route; 899 (94%) encountered a major street at some point.

DISCUSSION

Portland, OR, has been honored several times as America's top cycling city by Bicycling Magazine and was recently named a platinum-level bicycle friendly community by the League of American Bicyclists.[7] During the past two decades, largely under the auspices of the Bicycle Master Plan, the city has invested several million dollars in engineering, education, evaluation, and enforcement to improve both the safety and comfort of cyclists, resulting in 171 miles of bike lanes, 71 miles of bike paths, and 30 miles of bike boulevards, all of which are part of a highly integrated bicycle network.[8] Portland's active and dedicated bike community presented the opportunity to follow a large cohort through four seasons of commuting. While each of the 12 monthly surveys collected data retrospectively, commuters were never >31 days removed from any event, thereby keeping recall bias to a minimum, a problem encountered in other large studies of bike commuters.[9] The survey format also allowed us to capture many events that did not warrant an emergency department visit or police intervention; often, the fact that such events do not become part of any public record leads to both an underestimation of injury rate and an incomplete understanding of the commuter experience.[10]

Bicycle commuting has the potential to improve the health of both the individual and the community. It has been suggested that as the number of bicycles on the road increases, motorists adjust their behavior so they are less likely to collide with a bicycle.[3] Almost half of all commuting trips in the United States are 6 miles or less roundtrip, a distance that is feasible for most adults.[11] However, to safely encourage an increased bicycle commuter mode share, it is first necessary to understand who is currently commuting by bike and then attempt to determine what personal and environmental factors influence the incidence rates of traumatic and serious traumatic events.

Several large, retrospective studies have gathered demographic data on bicycle commuters. In a study of 1,360 bike commuters in Toronto and 1,604 in Ottawa, the percentages of female cyclists were 42% and 28%, respectively.[10] In a 1995 survey of 2,374 commuters from throughout North America, women comprised just 18% of the respondents; the average age of the cyclists was 39.1 years.[5] A smaller study of 150 bike commuters in Phoenix, AZ, had a female to male ratio of 1:3, with a mean reported age of 35 years.[12] Although safety practices were not collected in Toronto or Ottawa, the North American survey found that 95% of commuters wore a helmet and 79% used lights.[5] In Phoenix, 75% of commuters reported using a helmet.[12] North American commuters had a mean commuting history of 8.3 years, compared with 3.8 years and 5.8 years for the women and men of Phoenix. The average roundtrip commute length was 6.5 miles in Toronto, 14.9 miles in North America, 8.2 miles for women in Phoenix and 14.4 miles for men.[4,5,12] Finally, 52% and 54% of riders in Toronto and Ottawa experienced a prior injury while commuting by bike during the past 3 years.[10]

Demographics of bike commuters in Portland are similar to those reported in the Toronto, Ottawa, North American, and Phoenix studies. The large percentage of female commuters in our study, 48% (459), is comparable to that in Toronto but is substantially higher than reported in the literature.[13] This proportion is higher than the 30% prevalence for Portland estimated from 2008 census data and likely reflects a gender difference in choice to participate in our survey.[1,14] Even so, the Portland metropolitan area has the highest rate of women biking to work in the United States, at 1.4%.[14] This rate may be explained, in part, by the fact that women have shown a preference for cycling routes with a maximum separation

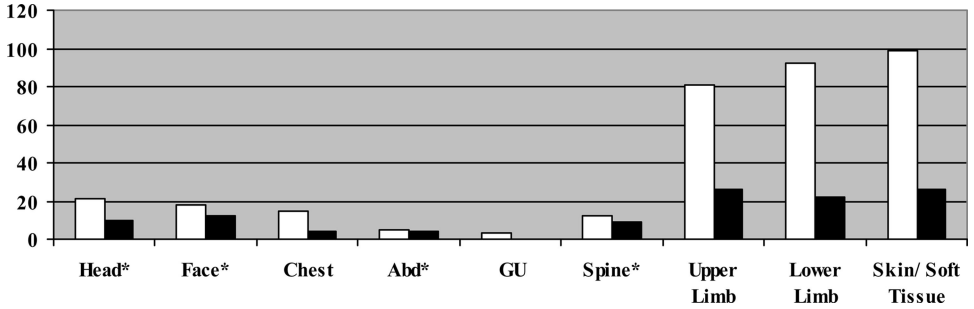

Figure 3. Number of injuries occurring as a result of traumatic events (*white bar*) and serious traumatic events (*black bar*), by body region. Abd, abdomen; GU, genitourinary system. *$p \leq 0.05$ comparing traumatic events with serious traumatic events.

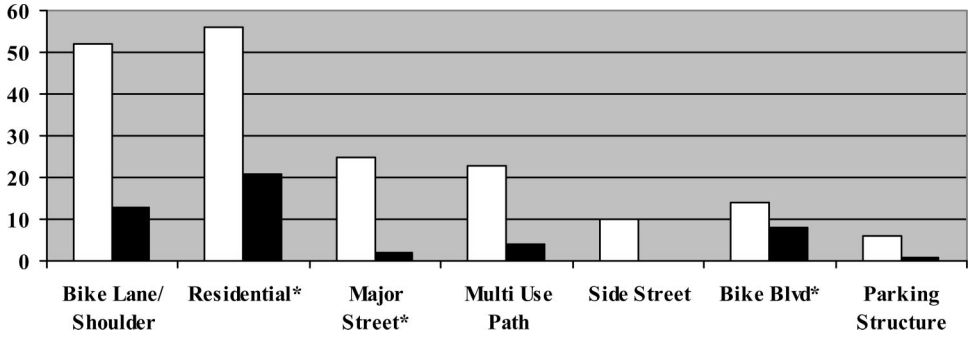

Figure 4. Infrastructure distribution of traumatic events (*white bar*) and serious traumatic events (*black bar*), by infrastructure. *$p \leq 0.05$ comparing traumatic event vs. serious traumatic event.

from motorized traffic and that Portland has >70 miles of bike paths.[15] Helmet use (95%) in Portland is identical to that reported in the North American survey, whereas the average roundtrip commute length in Portland was 3.2 miles shorter than the average in North America.[5] This shorter commute may also be explained by Portland's investment in cycling infrastructure. The city has made a concerted effort to establish bikeway networks that allow commuters to travel safer and shorter distances. Years of bicycle commuting experience is lower than that reported in the North American study but higher than that reported in Phoenix.[12] Finally, the percentages of Toronto and Ottawa commuters who reported prior injuries are comparable to the 44% of bike commuters in Portland who reported a prior traumatic event.[10]

The Toronto, Ottawa, North American, and Phoenix studies also attempt to define the rate of injury among bicycle commuters. On using 1,196 of the Toronto commuters, researchers reported an injury rate of 18.6 per 100,000 miles commuted.[4] In contrast, the North American survey described an injury rate of just 6.0 per 100,000 miles commuted.[5] Commuters were asked to report crashes they had experienced in the past 12 months only if such crashes had resulted in injury or property damage in excess of fifty dollars. This caveat most likely explains why this injury rate is so much lower than the 15.0 per 100,000 miles observed in Portland. Only 50 (26%) of the traumatic events reported in Portland required any sort of medical attention. Therefore, it is more appropriate to compare the North American injury rate with the incidence of serious traumatic events, 3.9 per 100,000 miles commuted. In summary, the injury rates of bicycle commuters in Portland are fairly similar to those in both Toronto and in North America as a whole. The fact that Portland commuter demographics and injury rates are similar to those found in Toronto, Ottawa, North America, and Phoenix suggests that one may be able to generalize some of our findings to other communities, particularly those which have invested in bicycle infrastructure.

Analysis of our study reveals two important findings that have not been previously reported. First, as discussed above, there were no statistical differences in gender, age, BMI, skill level, or prior traumatic events between those commuters who experienced a traumatic or serious traumatic event and those who did not. This suggests that with proper safety practices, adults with no bike commuting experience are no more likely to be injured than adults with years of commuting experience. Second, although the incidence rate of traumatic events is relatively low per 100,000 miles commuted, it translates into nearly 20% of commuters experiencing a traumatic event during the yearlong study period. Stated another way, Portland commuters experience one traumatic event per every 6,670 miles commuted. If these cyclists continue commuting at their current rates (1,620 miles/yr), they should experience one traumatic event every 4 years, on average.[5] It is therefore imperative that all bike commuters are encouraged to wear helmets. In our analysis, helmets were associated with a lower risk of serious traumatic event (unadjusted OR = 0.32; 95% CI, 0.12–0.89).

Given that commuter characteristics were not found to be associated with the incidence of either traumatic or serious traumatic events, we next reviewed the roadway surface

conditions and infrastructure involved in each event. As mentioned above, poor surface conditions were cited as a factor in 20% of both traumatic events and serious traumatic events. Portland has several programs and policies that allow cyclists to contact the city when cleaning or repairs or needed; this can be helpful with loose gravel. Steel plates are common during road repair; they cover dangerous potholes but are not a good substitution for thoughtful bicycle detours. Tracks on the road, although evidence of Portland's commitment to expanding its public transportation network, continue to challenge cyclists, especially during right and left turns.

Several studies have addressed the role of infrastructure in traumatic and serious traumatic events.[16–18] In both Toronto and Ottawa, major injuries, those requiring medical attention, were most likely to occur on a sidewalk, followed closely by multiuse paths.[10] The North American survey also reported a much higher incidence of events on sidewalks.[5] In contrast, in Portland, very few events, 10 traumatic events and no serious traumatic events, occurred on a sidewalk, despite the fact that 40% of commuters reported riding on a sidewalk during part of their commute. It is interesting to note that in Portland, the greatest numbers of both traumatic and serious traumatic events occurred on infrastructure, bike lanes/wide shoulders, and residential streets, with motorized vehicles. This pattern may be, in part, due to exposure, as a 2009 study of 166 regular cyclists in Portland found that a disproportionate amount of cycling occurs on streets with bike lanes.[16] In an effort to improve cyclist safety, Portland has been using colored bicycle lanes for the past 10 years. A 2000 study found that the colored lanes increased the percentage of motorists slowing or stopping before reaching the area, increased the number of motorists who yielded to bicycles in the given area, and decreased the number of conflicts between motorists and cyclists.[19]

The limitations of our study are several. We followed a very dedicated (as evidenced by the monthly response rate) and safety conscious (as evidenced by the safety practice data) group of bike commuters in a city known for both its outstanding bicycle infrastructure and its educational programs geared toward motorists. Therefore, it may be difficult to generalize our conclusions. Although the data were collected prospectively at monthly intervals, there is some potential for recall bias; however, we judge this potential to be low because of the short time frame between an event and the next monthly survey. It is also possible that an event occurred during a month when the commuter did not complete a survey, leading to a falsely low incidence rate. Exposure data for the different types of infrastructure were limited by the nature of the survey questions and the lack of technology to collect such data, thereby limiting our ability to determine and compare incidence rates on various types of facilities. Finally, although the potential to lose a subject to follow-up due to death is a possibility with this study design, we are assured that no study participant died as a result of a bicycle-related event during our study year.

In summary, we report that nearly one in five bicycle commuters will experience an event leading to injury in any given year, regardless of gender, age, BMI, or skill level. Twenty-five percent of all events will require medical attention. In an effort to increase the number of bicycle commuters and decrease the number of traumatic events, we encourage policy makers to invest in both the construction and the continued maintenance of bicycle infrastructure and to consider cyclists when planning updates to local public transportation systems.

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DISCUSSION

Ms. Giuseppina Violano (Hamden, Connecticut): Good morning, Dr. Baracco, Dr. Templeton, members, and invited guests of EAST. Dr. Hoffman and colleagues, thank you for your timely submission and for presenting a very interesting study.

The subject of bicycle safety is a timely one and one of significance in addressing a very important injury prevention topic. In 2008, in a report from the National Highway Traffic Safety Administration, it was estimated that 52,000 bicyclists were injured and 900 killed involving motor vehicle crashes,

of which 21 percent of those bicyclists, which was nearly 11,000 children, were fourteen or younger and so this topic has relevance to individuals of all ages.

Dr. Hoffman and colleagues examined the risks of injury while commuting to work or school by bicycle in the Portland, Oregon metropolitan area. The findings were interesting in that both traumatic events and serious traumatic events occurred mostly on bike lanes, wide shoulders, and residential streets.

The study also confirmed what those of us in injury prevention have been advocating for years, the important use of helmets in preventing significant traumatic events. Can you please comment on the following questions related to your study?

Did you find a correlation in injuries with clip-on pedals versus non-clip-on bike pedals? Was there any correlation of injury with the bicyclists knowledge of the route commuted? Number three, did the time of day traveled during the commute have any significant impact on the incidence of injuries? Four, what were the average posted speed limits of the roads traveled and the compliance of the bicyclists and motorists and lastly, did you identify any specific locations where there was a higher risk of accidents, whether it be pedestrian, motor vehicle, or of any kind?

Future areas of study that might be looked into include bicyclists, motor vehicle operators and pedestrian attitudes and behaviors towards each other in sharing the road and how to address the issue of non-compliance with helmet use among cyclists. I would like to thank Dr. Hoffman and colleagues for their excellent work and the Association for the privilege of the podium.

Dr. Melissa Hoffman (Portland, Oregon): Thank you for your comments and your questions. We did actually look at clipless versus non-clipless pedals and found no significant difference between those who use clipless versus non-clipless pedals.

As far as the time of day, we basically looked at – Instead of time of day, we looked at light and so dawn/dusk versus dark versus light and, again, we didn't find any statistical difference between those. I don't know the average posted speed limit of the roads that the commuters were commuting on. We did not look at that and also we did not look at the areas of highest risk as far as where the accidents were occurring.

Dr. Thomas Hayward (Indianapolis, Indiana): I have a confession to make. I'm a bicycle commuter, at 3,000 miles a year, but the question I have for you is at the conclusion, you talk about investment in infrastructure, which is a lot of money and I applaud Oregon and specifically Portland for making that investment, but your data suggests that there is a bicyclist education problem, in that only 60 percent are wearing reflective gear and it tends to be the more advanced commuters and not everybody is wearing a helmet and that is statistically correlated with that.

Wouldn't you make a much bigger impact by having better bicyclist education and basic how to drive your bike on the road and encouraging people to drive your bike and understand what it is to deal with bicyclists on the road? Education, what could do in terms of improving that, because that's essentially what the Netherlands do and they have the lowest rate of injury in the world.

Dr. Melissa Hoffman (Portland, Oregon): I agree that education is important and that is one of Portland's four things. We do evaluation, engineering, education, and enforcement. Education is definitely important and that's something that's already happening in the city.

I do think that because 20 percent of our events were occurring not so much due to poor infrastructure, but due to poor maintenance of infrastructure, we just felt that that was a place where we could definitely have some sort of impact that wouldn't cost that much money.

I also want to comment that I think that 95 percent of people wearing helmets and 96 percent of people wearing lights in the dark is a pretty good safety number and so as far as Portland, Oregon is concerned, I feel that bicycle commuters are pretty well educated.

Dr. Jeffry Kashuk (Hershey, Pennsylvania): I want to congratulate you on bringing the bicycle issue to the forefront. You may have seen a presentation we had at the American College this past fall. We evaluated bicycle injuries in Denver over ten years and compared our most recent five-year experience and we found that the frequency of abdominal and chest injuries had increased dramatically over the most recent five years and we also found that although documentation of helmet use had increased significantly, i.e., awareness of helmet use, that the actual incidence of helmet use had not changed over the past eleven years, undermining the safety issues.

Similar to Portland, in Denver, we have a very educated, athletic population that is healthy and is interested in bicycle transportation. I think our conclusion in our study was that we may be on the cusp of an injury epidemic, with the shift towards the use of bicycle for transportation, but with a lack of infrastructure nationally.

While Denver and Portland may have very advanced infrastructure, when we look at major metropolitan areas, like New York and Philadelphia, and the increased use of kiosks pushing bicycle use, we think that we have a potential disaster on our hands. I'd be interested in your comments on this and thank you.

Dr. Melissa Hoffman (Portland, Oregon): I would agree with you that infrastructure is definitely where we need to focus. Basically, our results are very similar to studies that were done in Toronto, Ontario, and then a much smaller study of bike commuters in Phoenix, all cities which are known to have good infrastructure.

Another comment is the better the infrastructure, the more people are going to ride their bicycles and there's actually a study that's called "Safety in Numbers," which shows that the more people who are riding their bicycles, the safer we all are. I agree with you that that is where it's at. Unfortunately, of course, it takes a lot of money to get there.

Dr. Peter Ehrlich (Ann Arbor, Michigan): My question is, did you correlate the type of bicycle with the type of injury, i.e., those who were riding racing road bikes as a

commuter bike versus those who were riding mountain bikes, particularly with your railroad track and steel plate injuries?

The second very quick question is your data suggested that some of the more serious injuries occurred when there actually was a bike lane and I was wondering whether you could comment on that.

Dr. Melissa Hoffman (Portland, Oregon): I did not correlate the type of bike ridden with the injury. We did look at the type of bike, comparing people who had traumatic events and serious traumatic events with those who did not and the type of bike was not statistically significant at all.

I think the bike lane question is a question of exposure, because there's another study that recently came out of Portland looking at infrastructure, using actually GPS. They found that the majority of people are riding on either bike lanes or bike paths and so in some ways, there was probably more traumatic events that occurred on those areas just because of the increased exposure on those bike lanes.

Dr. Michael Aboutanos (Richmond, Virginia): Just to follow up on that same question, have you actually looked at risk behavior with the driver? Does driving experience necessarily equal to risk behaviors? Is there any distractions that affect bicyclists behavior and did you account for that – I have seen many bicyclists who are actually answering telephones as they're biking and so is it possible that it's another risk factor to be looked at?

Again, the same question was asked before: is it just possible that because of their risk behaviors, they're actually driving faster and they feel safer on these roads that are made for bikes and therefore, you have a higher incidence of having more serious injuries than less serious injuries on dedicated bike roads? I would like your thoughts and thank you.

Dr. Melissa Hoffman (Portland, Oregon): We did not look at risk taking behaviors while someone was actually riding their bicycle, though I would assume with the cohort of people that we followed that most of them, because they are so safety conscious, as evidenced by their high rate of helmet use and reflective clothing, that they probably – I would assume the majority of them were not talking on their cell phone and unfortunately, we did not look at that second question.