Bicycle Guidelines and Crash Rates on Cycle Tracks in the United States

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Objectives. We studied state-adopted bicycle guidelines to determine whether cycle tracks (physically separated, bicycle-exclusive paths adjacent to sidewalks) were recommended, whether they were built, and their crash rate.

Methods. We analyzed and compared US bicycle facility guidelines published between 1972 and 1999. We identified 19 cycle tracks in the United States and collected extensive data on cycle track design, usage, and crash history from local communities. We used bicycle counts and crash data to estimate crash rates.

Results. A bicycle facility guideline written in 1972 endorsed cycle tracks but American Association of State Highway and Transportation Officials (AASHTO) guidelines (1974–1999) discouraged or did not include cycle tracks and did not cite research about crash rates on cycle tracks. For the 19 US cycle tracks we examined, the overall crash rate was 2.3 (95% confidence interval = 1.7, 3.0) per 1 million bicycle kilometers.

Conclusions. AASHTO bicycle guidelines are not explicitly based on rigorous or up-to-date research. Our results show that the risk of bicycle–vehicle crashes is lower on US cycle tracks than published crashes rates on roadways. This study and previous investigations support building cycle tracks. (*Am J Public Health.* 2013;103:1240–1248. doi:10.2105/AJPH.2012.301043)

Bicycle riding has many positive benefits related to health[1–20] as well as to transportation[21,22] and the environment.[23,24] Because the metabolic-equivalent intensity levels for bicycling are higher than those for walking,[25] bicycling can be even more beneficial than walking with respect to weight control,[26] all-cause mortality,[27,28] and heart function[29] among adults, and with respect to physical fitness[30] and cardiovascular health[31] among children. In the United States, 68% of the population is overweight or obese,[32] and 34% of children and adolescents are overweight or at risk for being overweight.[33] Although bicycling is beneficial, US census data show that only 0.5% of US residents aged 16 years or older use a bicycle as a means of transportation to and from work, and only 24% of these bicyclists are female.[34] This low rate of cycling may be attributable in part to the lack of proper bike facilities.

In the Netherlands, where there are 29 000 km of cycle tracks,[35] 27% of trips are made by bicycle and, of total bicycle trips, 55% are made by female bicyclists.[36] In Montreal, Canada, where cycle track networks were initiated 20 years ago and there are now 63 kilometers of on-road cycle tracks along with 173 kilometers of park and riverside cycle tracks, bicycle volumes have increased tremendously.[37] In both the Netherlands[38] and Montreal,[39] detailed guidelines have long existed that support the implementation of cycle tracks. Recent research articles, reviews, and reports on bicycle facilities have noted the benefits of cycle tracks.[40–46] However, other recent articles on bicycle facilities have described only the need for separation of bicyclists from cars[47] or have not included analyses or discussions of cycle tracks.[48–52]

In the United States, the guidelines of the American Association of State Highway and Transportation Officials (AASHTO) favor bicycling on roadways, even though most women, children, and seniors prefer separation from vehicles.[36,53–60] Discouraged in these guidelines is the building of bicycle facilities resembling cycle tracks, that is, physically separated and bicycle-exclusive paths adjacent to sidewalks. Past research articles on cycle track–related facilities, such as sidewalk bikeways and road-parallel shared-use paths,[61–63] have been used to discourage creation of cycle tracks in the United States. No studies have offered precise estimates of the existence and safety of US cycle tracks.

The US Department of Transportation policy statement recommends that the design of bicycle and pedestrian facilities follow the best currently available standards and design guidelines, such as AASHTO's *Guide for the Development of Bicycle Facilities* and *A Policy on Geometric Design of Highways and Streets* and the Institute of Transportation Engineers' *Design and Safety of Pedestrian Facilities.*[64] Thus, AASHTO guidelines, commonly available and used by state departments of transportation, have primarily directed the design of US bicycle facilities.

The new National Association of City Transportation Officials bike guide[65] includes cycle tracks. However, without inclusion of cycle tracks in the commonly adopted AASHTO guide, without US-based cycle track research, and without public health and transportation policies in support of cycle tracks, it will continue to be difficult to create cycle track networks. Furthermore, in the public participation process often only a few individuals attend the evening hearings, and they include adjacent residents who are opponents of changes to the street and bicyclists who prefer the road as opposed to large numbers of potential bicyclists, including women, children, and seniors. The design is, therefore, often biased toward leaving the road virtually unchanged. As a result of these and many other historical reasons, the default bicycle facility in the United States remains a bike lane painted on a road,[66] in which many bicyclists do not feel comfortable[67] or safe.[68]

We analyzed past and current state-adopted bicycle guidelines to assess the justifications for and level of rigor applied to recommendations for the use of bicycle facilities in the United States. Also, we determined, notwithstanding the AASHTO guidelines, whether cycle tracks had been built in the United States and their characteristics. Finally, we examined whether the rate of vehicle–bicycle crashes on US cycle tracks was lower than published rates for bicyclists on roadways.

METHODS

In addition to collecting information on and analyzing state-adopted bicycle facility guidelines, we identified locations of cycle tracks, gathered data from local communities, and estimated bicycle–vehicle crash rates.

Bicycle Facility Guidelines

We studied Web sites and article bibliographies to identify US bicycle facility guidelines[69,70]; we also examined all of the AASHTO guidelines (1974,[71] 1981,[72] 1991,[73] and 1999[74]) regarding bicycle facilities. *Bikeway Planning Criteria and Guidelines*,[75] published in 1972 by the Institute of Transportation and Traffic Engineering at the University of California, Los Angeles (and later reprinted by the Federal Highway Administration), was also included. We systematically analyzed the guidelines, searching for sentences, references to research, bibliographical citations, and recommendations either favoring or discouraging the implementation of cycle tracks. Because bike facility preferences have been identified as a gender issue,[53,55,56,76] we also assessed the gender of the guideline authors.

Identification of Cycle Tracks

To be defined as cycle tracks for this study, we required that cycle tracks be paved, parallel to vehicle travel lanes, 1 or 2 way, physically separated from motor traffic (i.e., separated by curbs or barriers to deter vehicles from entering), and distinct from walking paths; that they have data available or that could be obtained on crashes and bike counts; and that they not be completely adjacent to water (i.e., drivers would not drive over a cycle track to a beach). Thus, bike lanes denoted by paint alone and shared-use paths were not included.

We first identified US cycle tracks in February 2009 through a survey administered to listserv members of the Association of Pedestrian and Bicycle Professionals, which included 656 individuals throughout the United States and Canada. As more cycle tracks were suggested and other cycle tracks were found through Web searches, other communities were contacted. Of 43 suggested facilities, we excluded 24 because they did not meet our criteria. For all suggested cycle tracks, we used Google street view maps to verify their existence and whether they were separated from traffic.

Data Collection

Between 2009 and 2012, we contacted numerous professionals (e.g., urban and bicycle-facility planners, police officers, parks and recreation coordinators, community and transportation officials) from all communities with cycle tracks to obtain information on cycle track design (e.g., configuration, type of separation, length), bicycle counts, and crashes. Data on bicycle counts (which ranged from 1-hour to monthly counts) were obtained from community reports[77–80] or the community professionals we contacted. In the 2 cases in which counts were unavailable, we paid professionals to conduct the bicycle counts.

We obtained crash data on streets with cycle tracks from police departments, transportation divisions, official reports, and other sources. Almost all crashes were known to be police-recorded crashes. Only data on crashes resulting from an interaction between a vehicle and a bicyclist were included. Information on crashes involving pedestrians, other bicyclists, or fixed objects was not included because such crashes are not consistently recorded. Data on injury severity were not available for all cycle tracks studied, and thus not considered.

Estimation of Crash Rates

As with estimations of motor vehicle traffic volumes and determinations of average annual daily traffic,[81] single bicycle counts must be adjusted for the count period and duration. Data from permanent cyclist counting stations can be used to estimate the repartition of cyclists across each month of the year, day of the week, and hour of the day. For each single bicycle count period, expansion factors were used to adjust the actual counts for time of day (f-hour), day of the week (f-day), and month (f-month), allowing an estimation of the average daily bicycle count (ADBC). We derived our expansion factors from 12-month counts taken with 24-hour continuous automatic bicycle counters on cycle tracks in Portland, Oregon, and Vancouver, British Columbia. To calculate the ADBC, we divided the hourly bike count on a given cycle track (denoted as B) by the appropriate expansion factors, as follows: $ADBC = B/(\text{f-hour} \times \text{f-day} \times \text{f-month})$. If cycle tracks had more than 1 hourly bike count on different days, we used averaged daily values from each count. The resulting ADBC was then multiplied by the length of the cycle track to derive average number of bicycle kilometers per day. This in turn was multiplied by 365 to determine average bicycle kilometers per year.

Detailed data on vehicle–bicycle crash locations, vehicle types, and bicycle movements were available only for the 5 New York City cycle tracks (from the New York State Department of Transportation). In New York City, bicyclists do not have to ride on cycle tracks; the Department of Transportation data allowed us to identify crashes occurring among bicyclists riding on roads and not on adjacent cycle tracks. We had determined that only a minority of crashes ($n = 9$; 22%) occurred on the roadway sections where the cycle tracks exist, but it was more complex to distinguish near the intersection whether the bicyclist was coming from the cycle track or riding on the road. Therefore, all reported vehicle–bicycle crashes on New York City streets with cycle tracks were included, even though some of the bicyclists may not have been riding on or coming from the cycle track.

Vehicle–bicycle crash periods (according to police records and community officials) ranged from 0.3 to 8.6 years. To estimate crash rates per million bicycle kilometers, we divided the number of vehicle–bicycle crashes by amount of bicycle exposure (average bicycle km/year × crash period).

RESULTS

We analyzed and compared the bicycle facility guidelines, listed the characteristics of the 19 cycle tracks that met the inclusion criteria, and, after applying the expansion factors to the bicycle counts, estimated bicycle–vehicle crash rates.

Analysis of Bicycle Facility Guidelines

The 1972 *Bikeway Planning Criteria and Guidelines* document was authored by

TABLE 1—Bicycle Planning Documents and Recommendations Regarding Cycle Tracks: United States, 1972–1999

Document	Year	Authors Listed, No. (Gender Details)	Pages, No.	References Cited, No.	Endorses Cycle Tracks	Justification for or Against Cycle Tracks
Bikeway Planning Criteria and Guidelines[75]	1972	46 (only initials)	178 (plus 26-page appendix)	68	Yes	"Barriers at the interfaces can range from symbolic (e.g. striping), to physical (e.g. berms, median barriers, islands, fences). Symbolic barriers may be used to indicate to cyclists, drivers, and pedestrians their separate rights-of-way. However, symbolic barriers may be easily encroached either voluntarily or involuntarily by conflicting modes at the same grade. . . .In the absence of adequate horizontal clearance between the bikeway and the adjacent motor vehicle right-of-way a physical barrier is inherently safer than a symbolic one."
AASHTO documents						
Guide for Bicycle Routes[71]	1974	22 (14 male, others only initials)	45	0	No	"A major disadvantage of this arrangement (cycle track) is that there are conflicts between the bicyclist and pedestrians wishing to enter parked vehicles, and for this reason, this type is not the preferred arrangement. . . . For the preferred arrangement . . . where the lane is between the parking lane and travelled way, the minimum width should be 3.5 feet (one-lane minimum) plus a 2 foot allowance for car door openings or a total of 5.5 feet."
Guide for Development of New Bicycle Facilities[72]	1981	0	31	0	No	"Bicycle lanes should always be placed between the parking lane and the motor vehicle lanes. Bicycle lanes between the curb and the parking lane create hazards for bicyclists from opening car doors and poor visibility at intersections and driveways, and they prohibit bicyclists from making left turns; therefore this placement should never be considered. [There should be a] 5 feet minimum for bike lane by 8-10 feet parking."
Guide for the Development of Bicycle Facilities[73]	1991	~175 (~160 male)	44	13 (only 1 research-based)	No	"Bicycle lanes should always be placed between the parking lane and the motor vehicle lanes. Bicycle lanes between the curb and the parking lane can create obstacles for bicyclists from opening car doors and poor visibility at intersections and driveways, and they prohibit bicyclists from making left turns; therefore this placement should not be considered. [There should be] 5 feet for bike lane by 8-10 feet parking."
Guide for the Development of Bicycle Facilities[74]	1999	~145 (~140 male)	78	15 (only 1 research-based)	No	"Bike lanes should never be placed between the parking lane and curb lane. Bike lanes between the curb and parking lane can create obstacles for bicyclists from opening car doors and poor visibility at intersections and driveways and they prohibit bicyclists from making left turns. . . . The recommended minimum width of a bike lane by parked cars is 5 feet."

academicians in psychology, engineering, architecture, urban planning, housing, real estate, business administration, and management (Table 1). The report endorsed cycle tracks and included 68 citations, 16 from outside the United States. Only first initials were provided for the participating investigators, consultants, authors, advisors, and staff members; as a result, no data on the gender of the report's authors were available.

By contrast, the 1974, 1981, 1991, and 1999 AASHTO guidelines did not endorse cycle tracks. The reason given in the 1974 AASHTO guide was that cycle tracks posed a conflict with pedestrians crossing to parked vehicles. Other justifications were added in 1981 (and repeated in subsequent versions of the guidelines), including conflicts at intersections or driveways, that cycle tracks prohibited cyclists from making left turns, and that opening of passenger doors created hazards. The number of references cited in the AASHTO bibliographies ranged from 0 to 15, with only 1 research-based citation. Data on author gender were available only for the 1991 (91% male) and 1999 (97% male) guidelines.

Identification of Cycle Tracks

Nineteen cycle tracks met our inclusion criteria and had vehicle–bicycle crash data available (Table 2). Of these cycle tracks, 6 were located in warmer climates (Florida and California), 6 in colder climates (Minnesota, Colorado, Massachusetts, and Vermont), and the remainder in moderate climates (Oregon and New York). Six were 2-way cycle tracks on one side of the street, 7 were 1-way cycle tracks on both sides of the street, 2 were contra-flow cycle tracks (with bicyclists traveling toward cars), and the remaining 4 were 1-way cycle tracks on one side of the street. Ten were street level, and the remainder were above street level. Cycle track lengths varied from 0.16 to 4.83 kiloometers (Table 3).

Crash Rates

Our findings showed that 55 bicycle–vehicle crashes were reported over a combined 57 years of cycle track observations. When we used our Portland expansion factors (Figure 1), the ADBC ranged from 21 cyclists (Apopka Vineland Road, Orlando, FL) to 2085 bicyclists (8th Avenue, New York City; Table 3). Eight cycle tracks had no reported crashes, whereas 8th Avenue in New York had 20 reported crashes over a period of 2.3 years. Overall, the estimated bicycle exposure (bicycle km/year × crash period) on all studied cycle tracks was 24 244 027 bicycle kilometers. Hence, with 55 crashes (and use of the Portland expansion factors), the overall crash rate was 2.3 (95% confidence interval [CI] = 1.7, 3.0) per 1 million bicycle kilometers. When the Vancouver expansion factors were applied, the crash rate was 2.1 (95% CI = 1.6, 2.8).

TABLE 2—Cycle Tracks and Their Characteristics: United States, 2002–2011

Cycle Track and Location	Configuration	Separation	Level
Calle Barcelona, Carlsbad, CA	1 way, 2 sides	Curb, planting strip	Raised
East Palomar Street, Chula Vista, CA	2 way, 1 side	Parking, curb, planting strip	Raised
Friars Road, San Diego, CA	2 way, 1 side	Raised median, curb stops	Street
Beach Street, Santa Cruz, CA	2 way, 1 side	Low rubber divider	Street
High Street, Santa Cruz, CA	1 way, 1 side, contra flow	Low rubber divider	Street
13th Street, Boulder, CO	1 way, 1 side, contra flow	Raised median	Street
Broadway, Boulder, CO	2 way, 1 side	Curb, planting strip	Raised
Apopka Vineland Road, Orlando, FL	1 way, 2 sides	Curb, planting strip	Raised
Vassar Street, Cambridge, MA	1 way, 2 sides, some blue paint	Parking, curb, planting strip	Raised
1st Avenue North, Minneapolis, MN	1 way, 2 sides	Two painted lines as buffer	Street
Loring Bikeway, Minneapolis, MN	2 way, 1 side	Curb, planting strip	Raised
1st Avenue, New York City	1 way, 1 side, green paint	Painted buffer, parking	Street
2nd Avenue, New York City	1 way, 1 side, green paint	Painted buffer, parking	Street
8th Avenue, New York City	1 way, 1 side, green paint	Painted buffer, parking	Street
9th Avenue, New York City	1 way, 1 side, green paint	Posts, painted buffer, parking	Street
Prospect Park West, New York City	2 way, 1 side, green paint	Painted buffer, parking	Street
Ayers Road, Eugene, OR	1 way, 2 sides	Mountable curb	Raised
Reed Market Road, Bend, OR	1 way, 2 sides, red	Mountable curb	Raised
Dorset Street, Burlington, VT	1 way, 2 sides	Curb, planting strip	Raised

DISCUSSION

We analyzed 5 key state-adopted bicycle guidelines published between 1972 and 1999. *Bikeway Planning Criteria and Guidelines*, published in 1972 by the Institute of Transportation and Traffic Engineering at the University of California, Los Angeles, favored cycle tracks, but the subsequent AASTHO guidelines (initially published in 1974) did not. The 1972 guidelines were subsequently disfavored by some in the biking community[69]; the AASHTO guidelines favored bike lanes and road cycling.

AASHTO recommended not building cycle tracks, or facilities on the sidewalk side of the parked cars, because of their lack of safety and movement constraints. Although it described cycle tracks as having possible conflicts with pedestrians crossing to parked vehicles or passenger doors opening, AASHTO did not cite research about such injuries on cycle tracks.

Instead of cycle tracks, the guidelines recommended bike lanes on the road side of parallel parked cars. Yet, even in the 1999 version of the AASHTO guidelines, no research was cited regarding the safety of bike lanes adjacent to parked cars. Dooring, in which a car occupant opens his or her car door when a bicyclist is passing, is associated with cyclist injuries. Dooring may be prevented or lessened with sufficient buffers between the parked cars and the cycle track or bike lane but such buffers require roadway width. With or without buffers, cycle tracks on the passenger side expose bicyclists less to opening car doors compared to bike lanes on the driver side, because not all cars have passengers but all cars have a driver. Additionally, while a bicyclist in the cycle track could swerve around or hit an opening

TABLE 3—Vehicle–Bicycle Crash Rates on Cycle Tracks: United States, 2002–2011

Cycle Track and Location	Length,[a] km	Crash Report Period,[b] Year	Vehicle Bicycle Crashes,[c] No.	Average Daily Bicycle Count[d]	Bicycle km/Year[e]	Exposure,[f] No.	Crash Rate[g]
Calle Barcelona, Carlsbad, CA	2.11	3.6	0	25	19 596	70 745	0.0
East Palomar Street, Chula Vista, CA	3.28	8.6	1	201	240 256	2 068 655	0.5
Friars Road, San Diego, CA	3.46	3.6	1	280	353 991	1 277 982	0.8
Beach Street, Santa Cruz, CA	1.22	1.0	1	695	309 627	309 627	3.2
High Street, Santa Cruz, CA	0.16	2.0	0	196	11 474	22 948	0.0
13th Street, Boulder, CO	0.34	3.5	0	1 157	143 601	502 605	0.0
Broadway, Boulder, CO	4.83	3.5	2	1 712	3 018 606	10 565 122	0.2
Apopka Vineland Road, Orlando, FL	1.93	4.0	0	21	14 630	58 522	0.0
Vassar Street, Cambridge, MA	0.32	5.0	1	564	65 911	329 555	3.0
1st Avenue North, Minneapolis, MN	1.13	1.8	4	330	136 295	249 873	16.0
Loring Bikeway, Minneapolis, MN	1.13	4.0	4	814	335 806	1 343 224	3.0
1st Avenue, New York City (1st to 34th)	2.65	0.3	3	1 854	1 793 312	597 771	5.0
2nd Avenue, New York City (34th to 1st)	2.60	0.5	5	1 620	1 537 153	768 577	6.5
8th Avenue, New York City (West 14th to West 34th)	1.57	2.3	20	2 085	1 194 847	2 787 976	7.2
9th Avenue, New York City (14th-33rd)	1.57	2.4	13	1 576	902 876	2 181 950	6.0
Prospect Park West (Bartel Pritchard Square to Union Street), Brooklyn, NY	1.51	0.8	0	1 654	911 816	683 862	0.0
Ayers Road, Eugene, OR	0.80	5.0	0	144	42 146	210 728	0.0
Reed Market Road, Bend, OR	1.19	4.0	0	109	47 438	189 752	0.0
Dorset Street, Burlington, VT	1.85	1.0	0	36	24 555	24 555	0.0
Total	34	57.0	55	. . .	11 103 935	24 244 027	2.3

Note. Totals may be rounded.
[a]Length of cycle track studied (which, as a result of limited availability of crash and count data, may have been less than the entire cycle track length).
[b]Time period during which crash data were available.
[c]Police- or community-reported crashes during the reporting period.
[d]Based on bicycle counts (adjusted, via expansion factors, for time of day, day of week, and month) and duration of counting period.
[e]Length of cycle track multiplied by average daily bike count multiplied by 365.
[f]Bicycle km/year multiplied by crash reporting period.
[g]Number of crashes divided by exposure (bicycle km/year multiplied by crash reporting period).

passenger door or in the bike lane swerve around or hit the driver door, a key difference is being beside the sidewalk versus being beside moving cars, trucks, and buses. In Toronto, there were 297 cases of dooring (11.6% of collisions, with 3.1% involving major injuries and 1 case resulting in a fatality) from 1997 to 1998, when bicyclists were riding on roads (cycle track networks did not exist).[82] In Boston, Massachusetts, where bicyclists have also been riding on roads, motor vehicles accounted for the highest percentage of collisions among the city's bicycle messengers in 2001 (29%), followed by the opening of car doors (16%).[83]

The AASHTO guidelines also did not cite research regarding preferences for bike lanes relative to cycle tracks. Recent studies have shown that female, child, and senior cyclists mostly prefer separation from vehicles[36,53–60]; the AASHTO recommendations may have been influenced by the predominantly male composition (more than 90%) of the report's authors in 1991 and 1999. Finally, AASHTO did not report design alternatives for safely turning left from cycle tracks, solutions that existed on, for example, Dutch[38,84] cycle tracks well before 1974.

The 19 US cycle tracks we examined totaled only 34 kilometers, a minuscule length compared with the 29 000 kilometers of cycle tracks in the Netherlands.[35] The overall estimated crash rate on the studied cycle tracks was 2.3 (95% CI = 1.7, 3.0) per million bicycle kilometers, which is low relative to reported crash rates on roadways in the United States and Canada. When calculated to include only vehicle–bicycle crashes on the road, published crash rates per million bicycle kilometers range from 3.75[36] to 54[83] in the United States and from 46[85] to 67[86] in Canada. The wide range in reported rates for road cycling may be due to differences in study methods, case definitions, design features and context; however, all such rates of which we are aware are greater than the cycle track rates found in our study.

We may have underestimated crash rates because not all bicycle–vehicle crashes were reported. By contrast, rates may have been overestimated because crashes occurring in New York City could have involved bicyclists on roads as opposed to cycle tracks. For comparison, a recent study of 6 cycle tracks in Montreal relied on exhaustive police crash and ambulance injury data, and the safest Montreal cycle tracks had crash rates per million bicycle kilometers of 1.9 (Brébeuf) and 3.2 (Maisonneuve).[87] The crash rate found here for US cycle tracks (2.3) is within this range.

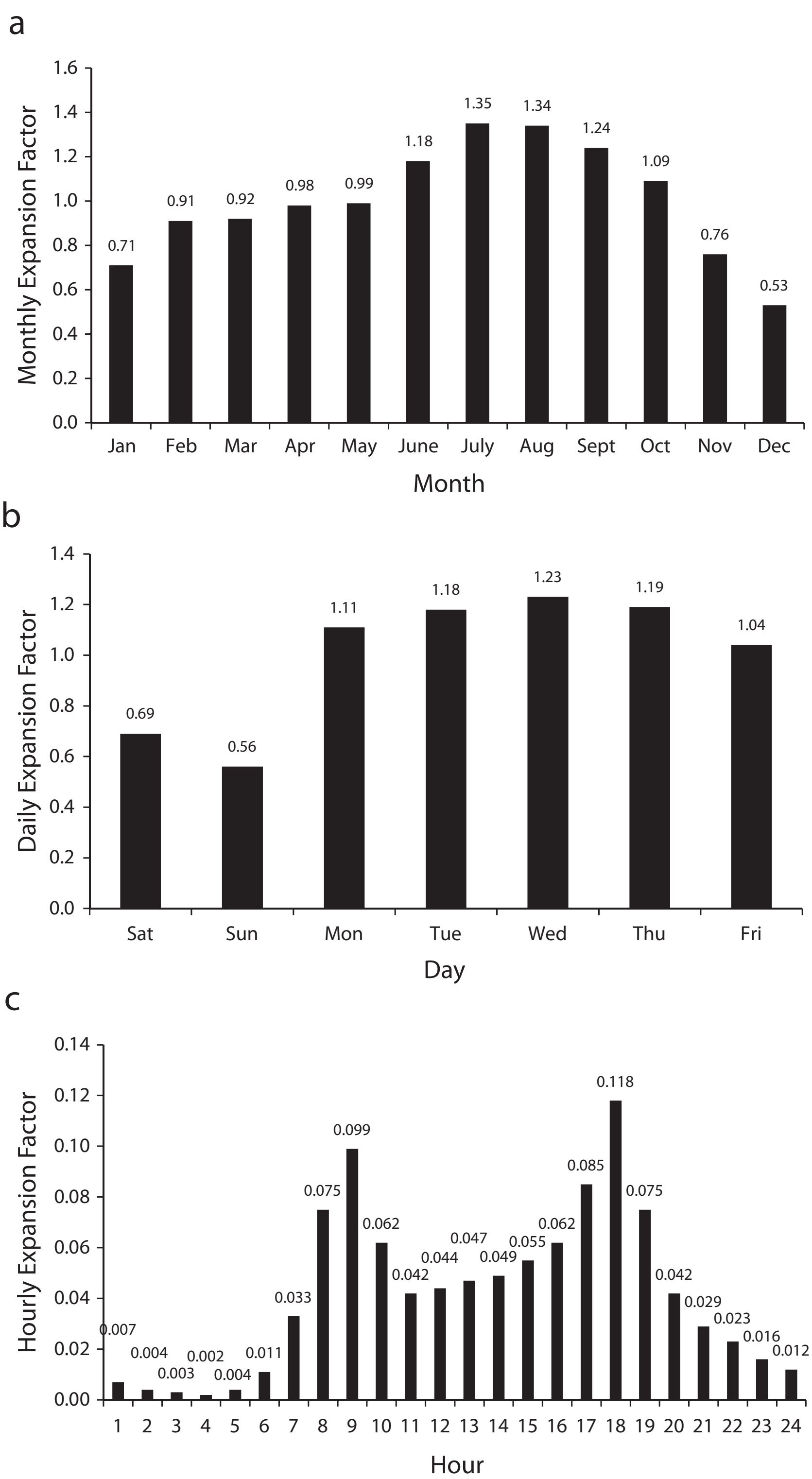

FIGURE 1—Expansion factors used to adjust bicycle counts for (a) month, (b) day, and (c) hour: Portland, OR, January–December 2010.

Two of the Montreal cycle tracks are located on major roads and had crash rates per million bicycle kilometers of 16.4 (Berri) and 19.3 (Christoph Colombo). Similarly, 2 of the US cycle tracks with the highest crash rates (1st Avenue in Minneapolis, MN, 16.0; and 8th Avenue in New York City, 7.2) are also along busy urban arterials. Overall in the Montreal urban study, there were 8.5 injuries and 10.5 crashes per million bicycle kilometers. In addition, there was a 28% lower injury rate on streets with cycle tracks than on reference streets (alternative routes without cycle tracks).

As a further comparison, data from New York City before and after installation of cycle tracks suggest that the rate of crashes with injuries decreased by 30% after installation of the 8th Avenue cycle track street section and 56% after the installation of the 9th Avenue section.[78] After implementation of the 2-way Prospect Park West cycle track, there was a 62% decrease in crashes with injuries, and the number of bicyclists riding on weekends doubled.[79] Similarly in Montreal, streets with cycle tracks had 2.5 times as many bicyclists as streets without bicycle facilities.[87]

Our results contrast with 2 earlier US studies that discussed bicycling on sidewalks (which have also been categorized as cycle tracks).[61,62] Moritz[61] used a self-report sample of 2374 riders to collect data on number of kilometers ridden, percentage of use of bike facilities, and number of crashes according to type of facility. Only 0.8% of bicycle kilometers ridden and 12 crashes (4.4%) were reported as occurring in "other" settings (most often indicated as sidewalks or parking lots, with most respondents categorizing "other" as sidewalks). The relative danger index for sidewalk cycling was 5.30, compared with 1.26 for cycling on a major street; that is, bicyclists had a 5.30 times greater risk of crashing on sidewalks. A second study by Moritz[62] involving 1956 riders revealed that only 9 crashes occurred in other settings and that 0.3% of bicycle kilometers ridden were in these settings. The relative danger index for cycling in other settings was 16.34, compared with 0.66 on major roads and 0.41 in bicycle lanes. These 2 studies are not sufficiently robust to allow conclusions about the safety of sidewalk bicycling or, by extension, the safety of cycle tracks.

In more recent research, a preinstallation–postinstallation study of cycle tracks in Copenhagen, Denmark, showed a 4% to 10% decrease in crashes and injuries occurring between intersections but an 18% increase in crashes and injuries occurring at intersections. According to the author, the latter finding was possibly due to the elimination of parallel parking and the fact that more drivers were turning to search for parking.[88] Another recent study, conducted in the Netherlands, suggested the creation of cycle tracks to reduce crash rates.[42] A recent review of infrastructure studies on bicycle injuries and crashes showed that bicyclists are safer on roundabouts with cycle tracks,[43] and in the Netherlands walking and bicycling to school have been shown to be strongly associated with the existence of cycle tracks.[40]

A review of peer-reviewed literature on bicycling and road safety conducted by authors in the Netherlands suggested that physically separated bicycle facility networks, as provided in the Netherlands (where 55% of bicyclists are female[36]), lead to reductions in risk among cyclists.[42] In Denmark, where cycle track networks are also provided, bicyclists have stated their preference for separation from vehicles and pedestrians.[89] By contrast, in the United States, where very few cycle tracks exist and bicyclists primarily have to ride with vehicles, rates of cycling have increased among men aged 25 to 64 years but have remained the same among women and decreased among children.[44]

Strengths and Limitations

There are several strengths of this research. First, our historical perspective shows that recommendations against cycle tracks in the AASHTO guidelines were mostly duplicated from previous versions of the guidelines, without references to peer-reviewed findings. Second, the territory covered included the entire United States and, probably, most actual cycle tracks at the time the data were collected. Third, we took bicycle usage into account in estimating crash rates. Bicycle counts were uniformly expanded by applying the same factors, derived from US and Canadian cycle tracks, to all studied cycle tracks. These expansion factors were based on detailed and continuous bicyclist counts. Fourth, all reported bicycle crashes on New York City streets with cycle tracks were included, even though an analysis of the crashes suggested that some occurred on the road and that some bicyclists were not riding on or coming from the cycle track.

The study involved several limitations. First, the guidelines analyzed were restricted to those most commonly adopted by states (mainly the AASHTO guidelines); however, they were the most critical guidelines with respect to implementation of cycle tracks. Second, crash data and bike counts were available for only a small number of US cycle tracks. Third, although some bicycle counts were extensive (e.g., New York City), others were 1-hour counts.

Fourth, the use of expansion factors from Portland and Vancouver may have resulted in bicycle usage being overestimated or underestimated. Fifth, although we attempted to collect data on all of the vehicle–bicycle crashes that occurred on each cycle track, reporting of crashes may have been incomplete. Sixth, for comparison crash rates on road bicycling we had to rely on studies from other contexts. Therefore, future research might estimate crash rates for bicycling on roadways in each of the US cities with cycle tracks, or another study design might be applied to compare bicycling on roads versus on cycle tracks. These limitations underscore the need for more systematic bike counts and crash data collection, as well as better descriptions of crash locations and trajectories. Our study serves as one of the many steps leading to a common understanding of bicycle facility guidelines and implementation of cycle tracks in the United States.

Conclusions

State-adopted recommendations against cycle tracks, primarily the recommendations of AASHTO, are not explicitly based on rigorous and up-to-date research. Our results suggest that, in the United States, bicycling on cycle tracks is safer than bicycling on roads. Furthermore, recent research shows bicyclists' preferences for cycle tracks. Stakeholders should consider the tremendous health benefits and safety of cycle tracks, especially given that their benefits have already been demonstrated in European and Canadian cities. Additional research on cycle tracks could identify optimal design features. ■

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This article was accepted August 17, 2012.

Contributors

A. C. Lusk acquired the data and drafted the article. W. C. Willett and J. T. Dennerlein supervised the study. All of the authors contributed to the conception and design of the study, analysis and interpretation of the data, and critical revisions of the article.

Acknowledgments

Anne C. Lusk was supported by a Ruth L. Kirschstein National Research Service Award (F32 HL083639) from the National Institutes of Health and the Helen and William Mazer Foundation. Luis F. Miranda-Moreno was supported by the Natural Sciences and Engineering Research Council of Canada.

We thank Peter Furth (Northeastern University) for his help in the early phases of the drafting of the article and Thomas Nosal (McGill University) for providing the Portland and Vancouver expansion factors. We also acknowledge Roger Geller (city of Portland) and Mark Kascha (city of Vancouver) for providing the bicycle counts.

Human Participant Protection

No protocol approval was needed for this study because publicly available data were used and no human participants were involved.

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