A Review of the Evidence on Cycle Track Safety

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This memo reviews the evidence on cycle track safety. As used by bicycling advocates in North America in recent years, the terms "cycle track" or "protected bike lane" refer to a segregated path for bicyclists adjacent to an urban roadway with a curb or raised object between the bicycle path and the portion of the road used by vehicular traffic and, in some cases, also between the portion used by pedestrians. Scandinavia, Germany, and the Netherlands have the most experience with urban bicycle paths adjacent to roads, the best data, and the most comprehensive studies. In addition to a review of the best of these studies, the memo includes a review of all of the studies of cycle tracks in North America that have been conducted in the past five years.

The Netherlands

A 1988 Dutch study analyzed 5,763 injury crashes recorded by police between 1973 and 1977 in 14 municipalities of more than 50,000 people.[1] The share of cyclists and moped users from road traffic counts was compared to the share of cyclist and moped user injuries in police reports, according to location (intersection or road segment) and according to facility type (bike lane, cycle track, or mixed traffic). The traffic counts were multiplied by road length for the segments and by the number of intersections for the intersections. For bicyclists using bicycle paths, there was a 24% **reduction** in risk along segments, but a 32% **increase** in risk in intersections, compared to bicyclists in mixed traffic (with no separate bicycle facilities). For moped riders, there was a 28% **increase** in risk on segments and a 66% **increase** in risk at intersections.

Because most urban bicycle ~~coalitions~~ happen at intersections, the reduction in crashes on segments is outweighed by the increase at intersections. For mopeds, there was an increased crash rate both at intersections and on segments. The additional risk with mopeds is due to their higher speeds. As a result of this and similar studies, the Dutch prohibited faster moped (45 kph – 28 mph max) use on bicycle paths, but slower mopeds are still allowed. Although the slower mopeds are restricted to a maximum speed of 25 kph (15.5 mph), most go faster, and their use on bicycle paths is highly controversial. There has been a large increase in both moped use and electric bicycle use in the Netherlands in recent years.[2] In 2014, a national

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[1] The complete study, in Dutch, is Welleman, A.G. and A. Dijkstra. 1988. *Veiligheidsaspecten van Stedelijke Fietspaden [Safety Aspects of Urban Cycle Tracks*], Institute for Road Safety Research (SWOV), The Hague, Netherlands, and the key results are summarized in English in Wegman, F. and A. Dijkstra, 1988. *Safety Effects of Bicycle Facilities: the Dutch Experience*, Institute for Road Safety Research (SWOV), The Hague, Netherlands (http://www.swov.nl/rapport/R-88-21.pdf).

[2] http://www.aviewfromthecyclepath.com/2014/06/being-member-of-out-group-little.html

prohibition on "slow" mopeds on bicycle paths was proposed, but instead it was decided to allow local governments to enact such restrictions.[3]

Electric bicycles (with a battery-powered helper motor) are becoming increasingly popular in Europe, and are typically operated at higher speeds than European utility bicycles. They are also becoming popular in the U.S. Many bicyclists in Boston already travel faster (both mean and peak speed) than most Dutch bicycle riders, who generally ride heavy three-speed bicycles and who tend to take short trips. In addition, most Dutch and Danish cities are flat, whereas U.S. cities can have significant grades. Given these three factors that could increase the speed of U.S. bicyclists (at least some of them, and in at least some places) compared to Dutch and Danish bicyclists, the safety effects of cycle tracks in the U.S. context may be more shifted towards the moped results.

In Massachusetts, motorized bicycles (mopeds) are allowed to use bicycle lanes (on the roadway) but not bicycle paths. The legal status of a "cycle track" is not clear (whether it is part of the "roadway" or not, and whether it is a "bike lane" or "bike path"). It is also unclear whether electric bicycles are considered "bicycles," "motorized bicycles," or "motorized scooters," in Massachusetts.

Despite its status as a role model for urban bicycling, experts in the Netherlands are still investigating ways to make urban cycle tracks safer, particularly to reduce turning hazards at intersections. The Dutch Ministry of Infrastructure and Environment released a report in 2010 on "Crossing Accidents involving cyclists: The effect of infrastructure characteristics priority junctions."[4] The research looked at cycle tracks at unsignalized (priority-controlled) intersections. There was no calculation of the risk with and without a cycle track. However, the study found (confirming earlier studies) that bicycling the wrong way on a one-way cycle track, or the "wrong" (but lawful) way on a two-way cycle track, creates an elevated crash risk, estimated at 4-to 5-times greater compared to operating with the flow of traffic. The risk of intersection accidents was 5-10 times greater when they were sight obstructions so that motorists had trouble seeing cyclists on the path. Cyclists turning left, which must be done in two-steps (pedestrian-style) from the cycle track, were also at elevated risk compared to those not turning.

In recent years about 10 bicyclists per year have been killed in the Netherlands by right-turning trucks. The Dutch have attempted to reduce the crash problem with right-turning trucks in various ways, as described in a fact sheet from the Dutch Institute for Road Safety Research on "blind spot crashes."[5] According to the fact sheet, "the characteristic - blind spot crashes occur at junctions in urban areas when a lorry wants to turn right from stationary and a cyclist riding to the right of or diagonally in front of the vehicle wants to go straight ahead. This frequently happens at junctions with traffic lights where cyclists get the green light simultaneously with

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[3] http://www.dutchnews.nl/news/archives/2014/06/mopeds_on_bike_lanes_ban_on_th.php
[4] http://www.fietsberaad.nl/library/repository/bestanden/100130_Oversteekveiligheid_van_fietsers_definitief.pdf
[5] http://www.swov.nl/rapport/Factsheets/UK/FS_Blind_spot_crashes.pdf

other traffic. In principle the cyclist has the right of way, but is overlooked by the lorry driver. ... the problem is often caused by a cyclist who has approached from the rear and wants to continue just ahead of the lorry." Trucks in the Netherlands have been required to have a curb mirror (since the 1980s) and a blind spot mirror (as of 2002). European regulations effective from 2007 require new trucks to have a wide angle mirror, a curb mirror, and a front view mirror. According to the Institute for Road Safety Research, "The adjustment of the mirrors on a lorry is very important, but difficult to perform if the lorry driver is alone in the vehicle. At various places in the Netherlands special mirror adjustment stations have been set up where lorry drivers are able to adjust their mirrors in accordance with guidelines." The Dutch are also investigating automatic blind spot detection and warning systems, but have not yet found them practical. They admit that "[c]ollisions between lorries turning right and cyclists continue to happen, despite various measures to enlarge the lorry driver's field of vision and to increase the awareness of cyclists by means of public information campaigns."

Denmark

Danish studies going back to at least 1985 have shown that creating bicycle paths along roads results in an increase in crashes. Two comprehensive studies of the subject were independently conducted by different teams in 2006 for Copenhagen and other Danish cities, as described below.

Trafitec Copenhagen Study

This study commissioned by the City of Copenhagen examined cycle tracks constructed in Copenhagen (1976-2003) for which consistent before and after data were available, a total of 20.6 km of one-way paths. [6] Danish cycle tracks are generally 6 to 8 feet wide and separated from the roadway by a low mountable curb. After-construction crash data was compared to a predicted number of crashes that adjusted the "before" numbers based on observed changes in bicycle and motor vehicle traffic on the specific routes and based on citywide trends.

The study found an overall 24% increase in crashes involving bicyclists and 10% increase in bicyclist ~~injurires~~ after the creation of bicycle paths.[7] (This study combined bicycles and mopeds

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[6] The study is summarized in English here: http://trafitec.dk/sites/default/files/publications/bicycle%20tracks%20and%20lanes.pdf The full study is: Jensen, Søren U. (2006): Effekter af cykelstier og cykelbaner: Før-og-efter evaluering af trafiksikkerhed og trafikmængder ved anlæg af ensrettede cykelstier og cykelbaner i Københavns Kommune.[Effects of cycle paths and cycle lanes: a before and after evaluation of traffic safety and traffic volumes on one-way cycle paths and cycle lanes in the City of Copenhagen.] Trafitec, Kgs. Lyngby.
https://subsite.kk.dk/Nyheder/2009/April/~/media/EB0E8FA263124929B7516A7272F901DF.ashx

[7] The 24% increase represents a simple percentage increase in all crashes involving bicyclists based on "before" and "predicted" figures in the study; the 10% increase, and all other figures cited, are based on a *weighted* average calculated by Jensen that takes into account the heterogeneity of different sites. (Jensen does not provide the weighted percent increase in all bicycle/moped *crashes*; he does however report that *total crashes* increased 10% among *all* road users, including motorists and pedestrians.) Copenhagen police apparently only consider major visible injuries; they counted **62%** of bicyclists involved in crashes (in the before period) as **uninjured**. Moreover,

together in all results, but bicyclists represent 90-95% of the total.) The study details the specific types of bicycle crashes that were affected. Three types of car-bike collisions decreased:

- rear end collisions with cars **declined** 63%
- collisions where the bicyclist was attempting to turn left[8] and was hit by a car **declined** 41%
- collisions involving parked cars **declined** 38%

However, there were more than offsetting increases in the following collision types:

- collisions with cars making right turns **increased** 129%
- collisions with cars making left turns **increased** 48%
- collisions with pedestrians **increased** 121% (particularly collisions with bus stop users)
- collisions with other bicycles or mopeds **increased** 148%
- single-bicycle collisions or falls **increased** 22%.[9]

Overall, there was a 15% increase in car-bicycle crashes, and a more than **doubling** of bicycle crashes not involving motor vehicles. The study concludes that "Bicyclists' safety has worsened due to these facilities." Although mopeds were combined with bicyclists in the study report, elsewhere Jensen provides separate results: Intersection injuries increased 22% for bicyclists but 37% for moped riders[10].

One might think that even though the number of collisions increased, their severity did not, given the additional protection from same-direction motor traffic. This was not the case. Although after building the cycle tracks there were no deaths relating to collisions with motor vehicles overtaking or parking (compared to a before case of 2 overtaking and 2 parking-related) , that was more than countered by 6 recorded fatalities due to right-turning traffic (compared to 1 before) and 2 fatalities related to collisions with another bicycle or moped. There were thus a total of 8 deaths on these facilities in the after period compared to 5 previously. These figures make sense because urban overtaking collisions are rare, especially on streets with 25 mph speed limits (as is common in Danish cities), and bicyclist collisions with right-turning trucks and buses can easily be fatal.

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only about 10 percent of cyclists who visit an emergency department after a crash are counted as "injured" by the police (Jensen, personal email).

[8] Denmark prohibits bicyclists using the roadway from merging to the center of the road to turn left. Instead, left turns must be made in two steps. Since this involves additional delay, it is likely that some bicyclists attempt the turn in one step, but from the right side of the road. A cycle track makes this (unlawful) maneuver more difficult.

[9] These percent changes appear on either Table 12 of the full report or in a summary produced by the author, "Road Safety and the Perceived Risk of Cycle Facilities in Copenhagen," http://www.vehicularcyclist.com/copenhagen1.pdf.

[10] See "Road Safety and the Perceived Risk of Cycle Facilities in Copenhagen."

Aalborg University Study

A second Danish study of cycle tracks was completed around the same time by a separate team.[11] The study included 46 sections (total of 40 km) located in 17 towns (excluding Copenhagen), on larger roads in urban areas with one-way bicycle paths on both sides. The bicycle paths were constructed between January 1989 and December 2000. The comparison group was roads with no changes in the facilities for bicycle users in urban areas in the 19 municipalities which were initially part of the study. Police-reported accidents that occurred from the beginning of 1986 to the end of 2004 were included.

The study found that the number of bicyclist injury accidents **increased overall 21%** compared to the expected number, with a slightly greater percentage increase at intersections. The number of moped injury accidents increased overall 51%, and at intersections increased 94%. The number of pedestrian injury accidents also increased by 41%.

The researchers wrote that "Data on ADT for motorized vehicles were available for most sections while it was only available in a few cases for cyclists and moped riders. No clear change in ADT was found for motorized vehicles nor for cyclists and moped riders. Consequently, there is nothing to indicate that implementing bicycle paths results in an increase in the number of cyclists and moped riders in medium sized and large towns in Denmark. As there has been no increase in the number of users, this cannot be the reason for the increase in the number of accidents." This finding is contrary to the Copenhagen study, which found an average 20% increase in bicyclists and 10% decrease in motorists, although the results varied considerably among the different facilities. ~~The study cannot determine if~~ the change in bicycle and motor traffic volumes represents a shift in mode or a shift in routes chosen.

Danish Lessons

The negative safety findings of these two Danish studies from the 2000s are particularly notable given that Denmark has decades of experience with cycle tracks, that both car and bicycle speeds are lower than in North America, and that Danish drivers, most of whom are also cyclists, are used to looking for bicycle traffic to their right when turning right, and are legally required to yield in this situation, unlike in the U.S. As in the case of the Dutch studies, the negative impacts were worse for moped users than for bicyclists. Given the higher speeds of some U.S. cyclists, and the potential for high speeds for all bicyclists where there are downhill grades, the impacts on U.S. bicyclists could be expected to be worse.

Moreover, the problem of right-turn conflicts with cycle tracks has not been solved in Denmark. In 2011 the Ministry of Transport produced a national design guide specifically addressing the

[11] Agerholm, N., S. Caspersen and H. Lahrmann, 2008. Traffic Safety on Bicycle Paths: Results from a New Large-Scale Danish Study. http://vbn.aau.dk/files/14344951/agerholm_et_al._bicycle_paths.pdf. The complete study is: Agerholm, N.; Caspersen, S.; Lahrmann, H.; *Cykelstiers trafiksikkerhed en før-efterundersøgelse af 46 nye cykelstiers sikkerhedsmæssige effekt [Cycle track safety: a before-and-after study of the safety effect of 46 new cycle tracks.]* Dansk Vejtidsskrift; no. 12, 2006; Denmark; 2006

topic of right-turn dangers where there are bicycle paths at signalized intersections.[12] This guidance says that "Right turning drivers - including truck drivers - must be able to see far enough back on the right side. They should be able to see 70 meters (210 ft) back to the right. This ensures that a driver in a right-turning truck and trailer can see far enough behind to cross the cycle path without coming into conflict with cyclists." The guidance offers three cycle track design options:

- a signal phase for straight through bicyclists and a separate one for turning cars (or in some cases just an early green for bicyclists)
- the cycle track becomes shared bicycle and right-only lane at intersections
- the cycle track becomes a bike lane directed to the left of a right-only lane at intersections

In addition, if there is no separate signal for bicyclists the stop line for bicyclists is placed ahead of the one for motorists.

Denmark requires side guards and special mirrors on trucks. However, these have been insufficient to solve the problem. The Denmark Road Directorate has taken several additional measures in recent years to reduce collisions between cyclists and right-turning vehicles:

- In 2009, they reviewed all signalized intersections on the state road network with regard to the right-turn problem and made intersection improvements where needed.
- In 2011, they carried out a campaign targeting cyclists and truck drivers, and set up a website as part of the campaign.
- After a spike in serious and fatal injuries involving right-turning trucks and cyclists, in late 2013, the Danish ministries began a "Strategy for the prevention of right-turn accidents between trucks and cyclists," published in March 2014.[13] The study included representatives of the National Police, the Public Transport Authority and the Danish Road Directorate, and included a fact-finding tour of authorities and research institutions in the Netherlands, Germany, the U.K. and Sweden "in order to gain experience from these countries on the prevention of right-turn accidents." According to the project website, "The strategy reviewed and assessed a number of possible solutions, partly familiar road engineering, vehicle technical and regulatory solutions and new solutions." The study concluded that "efforts are needed across the board with a mixture of known and new approaches." They are hoping that additional education for truck drivers, and adding "bicycle boxes" (larger advanced stop areas) will help.

[12] Danish Ministry of Transport, Road Directorate. Undgå Højresvingsulykker [Prevent Right-Turn Accidents: Measures to prevent accidents between right-turning trucks / cars and straight-through cyclists in traffic signal-regulated intersections] August 2011. http://www.vejdirektoratet.dk/DA/viden_og_data/publikationer/Lists/Publikationer/Attachments/9/2011_Undg%C3%A5%20h%C3%B8jresvingsulykker.pdf

[13] There is more information in this blog post: http://www.ubmfuturecities.com/author.asp?section_id=242&doc_id=526000. The official website is here: http://www.vejdirektoratet.dk/DA/viden_og_data/temaer/trafiksikkerhed/hojresvingsulykker/Sider/default.aspx#.VDVAzPldV8E

Two-Way Cycle Tracks

Unlike Denmark and the Netherlands, several cities in Finland, Sweden, and Germany commonly use two-way cycle tracks. A number of studies of two-way urban cycle tracks have shown that the risk of cycling on a path opposite the flow of traffic (even where legal) is extremely elevated, as much as 11 times that of riding on the road in the direction of traffic.[14] Although these results are not directly applicable to one-way cycle tracks, it is likely that there will be a certain amount of wrong-way cycling on cycle tracks, perhaps more than in bike lanes, because cyclists are less concerned about motor traffic.

North American Cycle Track Studies

Until recently, there were very few urban bicycle paths adjacent to roads in North America, in part because AASHTO and state design guidelines strongly discourage their use where there are frequent intersections, based on the known risks of these designs. However, in the past four years several studies have been published claiming that urban cycle tracks in the U.S. and Canada improve safety, despite the results of European studies.

UBC Cycling in Cities Study

A team of public health researchers at the University of British Columbia ~~have~~ produced a number of papers based on their "Cycling in Cities Study," which included a project called "Bicyclists' Injuries and the Cycling Environment."[15] The study collected data from 690 injured adult bicyclists treated in Toronto and Vancouver hospitals between May 2008 and November 2009. The authors interviewed the bicyclists and collected information on the location of the injury and the route they took on the day of the injury. The study design compares the characteristics of the location of the injury to the characteristics of random points along the bicyclist's trip. For example, if 20% of the injury locations were on a downhill grade, but only 10% of the random points were downhill, the authors would conclude that there is a two-fold

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[14] See for example, Eero Pasanen, The Risks of Cycling, Helsinki City Planning Department, Finland. http://www.bikexprt.com/research/pasanen/helsinki.htm
and Linderholm, L (1984) Signalized intersection functioning and accident risk for unprotected road users. Lund, Sweden: University of Lund.
http://alt.argus.or.at/transdanubien/downloads/sonstiges/lth1984acc_cycles_hires.pdf

[15] The study website is: http://cyclingincities.spph.ubc.ca/injuries/the-bice-study/. The most important published paper is *Route infrastructure and the risk of injuries to bicyclists: A case-crossover study*. Teschke K, Harris MA, Reynolds CCO, Winters M, Babul S, Chipman M, Cusimano MD, Brubacher J, Friedman SM, Hunte G, Monro M, Shen H, Vernich L, Cripton PA. American Journal of Public Health 2012;102:2336-2343

greater risk of riding downhill. Although this methodology is not perfect (for example, it assumes that the cyclists' trips on the day of injury are representative of all their trips), it does provide a way to control for exposure that has proved elusive in many other bicycle safety studies.

This authors conclude that "Cycle tracks had the lowest injury risk, about one ninth the risk of the reference route type." However this conclusion is not supported by their own data. Only four facilities, all in Vancouver and none in Toronto, were categorized as "cycle tracks.[16] Two of these four are portions of Vancouver's Seaside Bicycle Route, a bike path *with no intersections*, in places where it happens to be near a roadway (which was why they considered it a "cycle track"). The longest "cycle track" segment included in the study (1 km) was the Burrard Street Bridge, which only has intersections at each end. Only the Carrall Street Greenway, with five intersections over its 0.6 km length, is a true cycle track, and it accounts for only 30% of the total length of the four segments that the authors considered to be "cycle tracks."[17] Moreover, because the Burrard Street Bridge is a heavily used commuter bicycle route (there are few other crossings into central Vancouver) and because the Seaside Bicycle Route is also popular, the Carrall Street Greenway probably accounted for much less than 30% of the distance traveled by bicyclists in the study. The reported risk reduction, based on data from a single short cycle track commingled with intersection-free bike paths, provides no evidence about the safety of cycle tracks.

The authors did not provide information on how many collisions were expected, based on cyclist exposure, on Carrall Street, but only 10 were expected on all four segments they designated as "cycle tracks." In addition, **two-thirds** of the injuries in the study did **not** involve a collision with a motor vehicle. Since cycle tracks are intended to increase safety by reducing collisions with motor vehicles, a more robust analysis would separate the crash effects into the type of collision (fall, with car, with other road user) and by type of maneuver (motorist turning right, overtaking, etc), as was the case in the Danish Trafitec study.

The strong findings from the study were that:

- **Downhill grades** have a relative risk of 2.3 times flat roads
- **Streetcar tracks** increase risk 3.0 times
- **On-street parking** increases risk 1.4 times compared to no parking

These results are not surprising given that injuries not related to cars were 2/3 of the total (often caused by tracks and other road defects and exacerbated by higher speeds of downhill cyclists) and "dooring" collisions are one of the most common urban bicycling injury

[16] Private correspondence with lead author Kay Teschke.

[17] Actual cycle tracks have subsequently been constructed in both cities.

mechanisms related to motor vehicles. However, these were not the findings emphasized by the authors or by the subsequent media coverage of the study.

Montreal Study

A team of researchers examined two-way "cycle tracks" in Montreal and concluded that these facilities reduce the risk of injury by 28%.[18] This statistic has been widely cited, even though it contradicts numerous European studies showing that two-way cycle tracks are particularly risky. It is not the case that two-way cycle tracks happen to be safer in Montreal than in Europe. A much simpler explanation for the discrepancy is that the study used a flawed methodology.

The authors selected six segments of cycle tracks ranging from 1.0 to 3.7 km in length. Their estimates show that two of the six cycle track segments had 1.9 and 3.2 police-reported crashes per million bicycle km whereas the other four segments had 13.9 to 19.3 police-reported crashes per million bicycle km. These estimated crash rates vary by **a factor of 10 among cycle tracks**. The authors provide no explanation for this enormous difference, but it is likely that roadway characteristics (other than just the number of bicyclists) are highly significant. In addition, the Montreal police reports include only a small fraction of bicyclist injuries, so random variations in reporting may be part of the explanation.

Instead of comparing the crash situation before and after installation of cycle tracks, or comparing the total amount of cycling and injuries on cycle tracks compared to roads without them, the authors picked a single "reference street" (or in two cases, two roads combined) to create a series of matched pair comparisons. In selecting reference streets, they chose those that could be used as alternatives, rather than choosing roads that match key characteristics such as traffic speed and volume, number and type of intersections, number of trucks, grades, and on-street parking.

As with the calculation of crash risk for each cycle track segment, the paired comparisons show an inconsistent pattern. For three of the six comparisons, the crash rate on the cycle track was *higher* (but statistically insignificant). For the remaining segments, the cycle track crash rate was significantly lower. The authors provide no explanation as to why, if cycle tracks are protective against bicyclist injuries, only three of the tracks were protective and three were not. However, their own data help explain the inconsistency.

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[18] *Risk of injury for bicycling on cycle tracks versus in the street.* Anne C Lusk, Peter G Furth, Patrick Morency, Luis F Miranda-Moreno, Walter C Willett,Jack T Dennerlein Inj Prev 2011;17:2 131-135

Two of the three paths that were safer than their reference streets, Brebeuf and de Maisonneuve, were the same two that were found to be up to 10 times safer than **other** cycle tracks. The study data show that **motor vehicle occupant** injury rates on these two segments are only 9% and 22% as great as their "reference streets," whereas bicycle crash rates are 42% and 32% of the reference streets. In other words, based on the study data, driving on these streets is much safer than driving on the reference streets; bicycling is also safer than on the reference street, but less safe than it would be if it had the same relative risk as driving. An examination of the road environment provides the explanation: Both segments are one-way, low traffic residential streets with a posted speed limit of 30 kph (**19 mph**). Most of the intersections on the de Maisonneuve segment have four-way stops.[19] The reference streets carry more and faster traffic.

Berri Street was the only other cycle track which was reported to have a lower crash rate than its reference street (St. Denis Street). However, over the same distance Berri has 7 intersections whereas St. Denis has 12. Berri has either no on-street parking, or parking separated from the bike path by a 1 m raised curb, meaning that it is not possible for bicyclists to get "doored." By contrast, St Denis has on-street parking on both sides almost everywhere, and has insufficient lane width for a cyclist to ride outside the door zone and leave enough room for a motorist to pass comfortably in the same lane, and so bicyclists using this street frequently ride in the door zone. As with the other two cases where the cycle track streets had a lower crash rate, the reference street cannot be expected to have the same crash risk as the cycle track street.

The authors provide no information about the type of incidents leading to bicyclist injuries. For the comparisons they use EMS data, which is more likely to have incidents not related to motor vehicles than police data, but they do not have any detail on the crash circumstances.

In a published response, the authors say, "We acknowledge that we did not control for all of the differences in road geometry and building typologies because there are no ideal matched streets."[20] The above discussion makes clear that they did not even come close to controlling for significant differences. Since their methodology depends on selecting comparable streets, one cannot have confidence in the results. The results are also internally inconsistent, given that the chosen measure of safety varies as much as 10:1 *among cycle tracks* but no more than 3:1 between cycle tracks and their reference streets. Moreover, a convincing demonstration of the increased safety of cycle tracks needs to show a reduction in crashes plausibly related to the cycle track (e.g. motorist overtaking), without an offsetting increase in crashes potentially

[19] There is a more urban segment of the de Maisonneuve cycle track that opened in 2007 but it was not included in the study.

[20] http://injuryprevention.bmj.com/content/17/2/131.full/reply#injuryprev_el_9408

caused by the cycle track (e.g., turning movements at intersections or driveways and crashes involving pedestrians and other bicyclists).

Second Lusk et al. Paper

The same group that produced that Montreal study also published a study of cycle tracks in the U.S.[21] The study identified 19 projects claimed to be "cycle tracks" and collected data on use and police-reported injuries. However, the study has major flaws:

- Only 5 of the projects were actually urban cycle tracks (First Avenue North in Minneapolis[22], and First, Second, Eighth, and Ninth Avenues in New York City). The majority of facilities studied (14 segments) were suburban and rural sidepaths, or urban paths with very few intersections (as currently permitted under AASHTO bicycle guidelines). The real cycle tracks averaged 11.3 intersections per km whereas the 14 other segments averaged only 1.7 intersections per km.[23]
- Using the authors' own figures, the bicycle crash rate for the real cycle tracks averaged 7.0 per million km traveled compared with only 0.6 per million km for the remainder of the sample.
- The authors claim that the cycle tracks have a lower risk when compared to published estimates of bicyclist crash risk per distance traveled. However, 3 of the 4 comparisons they cite are based on self-reports of **all injuries** (bicycle messengers in Boston, MA; bicycle commuters in Toronto or Ottawa), not on **police reports of car-bicycle collisions**. Since most bicyclist injuries are never reported to police, it is simply incorrect to compare police data and self-reported data. The fourth crash rate incorrectly cited the **UK** figure of 3.6 rather than the correct figure of 5.8 injuries per million km in the source.
- Even with a "correct" benchmark of a national average crash rate, it is inappropriate to assume that the crash rate on any particular street or facility would match a national average since there is no control for confounding factors such as traffic speed and volume, number of intersections, etc. Moreover, the cited crash rate only applies to police-reported car-bike collisions, and does not take into account the likely impact of cycle tracks on single-bicycle, bike-bike, and bike-ped collisions, which account for most bicyclist injuries.

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[21] Lusk AC, Morency P, Miranda-Moreno LF, Willett WC, Dennerlein JT. Bicycle guidelines and crash rates on cycle tracks in the United States. Am J Public Health. 2013 Jul; 103(7):1240-8. http://ajph.aphapublications.org/doi/pdf/10.2105/AJPH.2012.301043

[22] This very short segment of cycle track had a bicyclist fatality (due to right-turning truck) shortly after it opened.

[23] For the calculation of these figures, see my published comment on this paper, P. Schimek, Cycle track safety remains unproven. Am J Public Health. 2013 Oct;103(10):e6-7. doi: 10.2105/AJPH.2013.301476. Epub 2013 Aug 15.

“Lessons from the Green Lanes”

In June 2014 the National Institute for Transportation and Communities released a $160,000 study of “protected bike lanes.”[24] One purpose of the study was to evaluate the safety of these facilities. However, the study did not look at any crash data. Instead, the researchers evaluated “conflicts” at signalized intersections along the facilities. There was no comparison to a control group (nor a before-and-after comparison).

The “conflict” evaluation was by means of video review. The definition of conflict was based on instances of braking or changing direction. This definition does not match our understanding of how car-bike collisions occur. There are numerous situations in which road users are required to yield (e.g., changing lanes, turning left, overtaking) and may need to brake or turn. Most of these do not lead to collisions because drivers are following rules, and their behavior is expected. Actions that are unexpected such as overtaking on the right of a right-turning vehicle, changing lanes without yielding, or operating against the flow of traffic, are likely to produce collisions. The researchers did not measure these behaviors.

The intersections studied in the video review either had combination bicycle/right-turn only lanes at intersections (averaging 200 feet to allow room for “mixing”) or had separate bicycle signals so that right turns and through bicycle movements were not permitted at the same time. The data collection did not include intersections where motorists turn right across the bikeway without a mixing zone or separate signal, even though this design is used on some of the facilities included in the study (especially at minor intersections and driveways). At the only intersection of this type where the researchers surveyed motorists, 53% **disagreed** with this statement: “When I want to turn right, I am able to adequately see if there are any approaching cyclists in the bike lane.”

The study observed 12,900 bicyclists going through intersections and found that “no collisions or near collisions were observed.” The authors concluded that there were no “notable safety problems” and that “concerns about safety should not inhibit the installation and development of protected bike lanes.” These conclusions were based entirely on the finding that bicyclists

[24] Evaluating Protected Bike Lanes in the U.S. NITC-RR-583 National Institute for Transportation and Communities June 2014. http://bikeportland.org/wp-content/uploads/2014/06/NITC-RR-583_ProtectedLanes_FinalReportb.pdf

felt safer (although this has no bearing on actual safety) and that there were few "conflicts" (although conflicts were not defined in a way relating to crash risk).

The authors did not consider the likelihood of observing a collision over the 144 hours of video ~~taping~~ they conducted. However, this can be easily estimated. The City of Chicago reported 4,813 bike-car collisions citywide at intersections between 2005 and 2010, averaging 802 intersection collisions per year or 2.2 per day.[25] Chicago also reports an average of 320,000 miles of bicycling per day within the city limits. With about 8 intersections per mile, Chicago bicyclists collectively pass ~~through 2.56 million intersections~~ per day. Therefore one would need to observe more than **one million** bicycle intersection crossings to expect to see at least one car-bike collision in Chicago. The Lessons from the Green Lanes study looked at 8,445 bicyclists going through intersections in Chicago; this is a large number, but it is several orders of magnitude less than the number needed to conclude that a facility has no negative impact on safety.

Perhaps the most useful portion of this research project with regard to safety impacts ~~were~~ the interviews conducted with bicyclists using the cycle tracks (see Tables 8-6 and 8-7). More than 60% of bicyclists using the two-way path in Chicago (Dearborn Avenue) reported that they had had a near-collision of some kind, mostly with pedestrians, *even though the facility had been open only five months when the survey was conducted*. Similar numbers (63%) said that pedestrians waiting on the cycle track were a "major problem." On the one-way Chicago cycle track (Milwaukee Avenue), *which had been open only four months*, nearly half (48%) reported that they had had a near-collision. The most common potential collision partners were a turning car, another bicyclist, or a pedestrian. These results mirror those found in the European studies, including the finding that two-way cycle paths are much more conflict-prone that one-way paths.

Speed, Mobility, and Safety

In summary, the recent U.S. and Canadian papers claiming that urban bicycle tracks improve bicycle safety do not survive close scrutiny, whereas several comprehensive, well-designed European studies have persuasively shown that adding bicycle paths adjacent to urban roads increases the risk of both crashes and injuries for bicyclists, and even more so for moped riders. The particularly elevated risk for faster path users (whether moped riders, electric bike riders, or ordinary bicycle riders) might suggest that the problem lies with users who deliberately choose to go faster than conditions permit. However, the increased risk of using urban sidepaths is seen even among the generally slow bicyclists of the Netherlands and Denmark. In

[25] https://www.cityofchicago.org/content/dam/city/depts/cdot/bike/general/BikeCrashReport2012.pdf

fact, the most dangerous collision type – hitting the side of a right-turning truck or bus – could happen when the bicyclist is moving slowly or even stationary.

The goal of road design is neither to produce the fastest possible travel nor the safest possible travel, but a balance of both needs. When considering bicycling, the goals should be the same. To take an extreme, eliminating bicycling (or motoring) would eliminate bicycle (or motor vehicle) crashes, but neither is a desirable goal given the many benefits of both modes.[26] Designing bicycle facilities that are safe only at speeds well below what many riders can comfortably and safely attain currently on the road system reduces mobility. It reduces safety as well, because at least some riders will not adjust their speeds, putting both themselves and others at risk. Bicyclists riding 20 mph on a city street are well within the design speed of the facility, but the same 20 mph on an adjacent path may be reckless. It is a common assumption that bicyclists are "slow," but in dense urban areas, it is frequently possible to complete trips in less time by bicycle than by car, in compliance with the traffic laws, at safe and reasonable speeds for the existing conditions. A reduction in average speed from 15 mph to 10 mph may not sound like much, but it can make the difference between a commute of 30 minutes and one of 45. Creating bicycle paths adjacent to city streets effectively forces bicyclists to use the paths either because there is a law requiring the use of bike facilities (as in California, New York, and Florida)[27], or because motorists ~~(and often police)~~ will enforce the use of the facilities with threats of violence, particularly because travel lanes are narrowed (or bike lanes eliminated) when urban sidepaths are created. Nor is accepting the higher crash risk and reduced mobility of urban sidepaths a necessary trade-off, since there are numerous other methods available to reduce bicycling injuries, improve bicyclist mobility, and increase bicycle use.

[26] Nor should it be the goal, because even if the crash rate per mile is higher when bicycling than motoring, as it is everywhere, including in Europe, there are health benefits to bicycling that outweigh the increased risk. Also, if more bicycling means less driving, there is a reduced social burden from crashes caused by car drivers.

[27] Laws requiring use of bike *lanes* are much more common than laws requiring use of bike *paths*; however, the legal status of "protected bike lanes" / "cycle tracks" is unclear, and it is likely that many jurisdictions will claim that their use is mandatory, either because of laws requiring the use of bike lanes, or laws requiring bicyclists to use the right-most portion of the "roadway."