THE SAFETY OF URBAN CYCLE TRACKS: A REVIEW OF THE LITERATURE

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Note: This presentation is for academic informational purposes only and is not intended as a statement of official policy or existing standards of the California Department of Transportation.

What Is a Cycle Track?

- Bikeway along a city street that is physically separated from motorized vehicle traffic lanes and also separate from the sidewalk
- Generally placed between auto lanes and sidewalk
  - Separated from auto traffic by raised curb, planting strip or on-street parking
- 1-way on each side of street
  or 2-way on one side of street

Long Beach. Source: Orange20bikes.com

Why Is This Review Needed?

- Catch 22 of Cycle Tracks in the US
  - Lack of examples → lack of studies → lack of safety data → reluctance to build them
- Literature poorly understood in the US
  - Most studies from Northern Europe
    - Many not published in journals or peer reviewed
    - Some not published in English

Methods

- 22 papers dating since 1987 were located
  - 13 on safety of cycle tracks compared to riding in the street
  - 9 on effectiveness of intersection safety measures
- All from Northern Europe with exception of one from Canada
- Caution should be used in applying exact crash modification factors to US situation
- Instead direction and magnitude of effect provide general guidance

Studies Not Controlling for Exposure

- Major limitation in not accounting for the amount of cycling
  - Did not develop crash rates or assess relative risk
  - Cycle tracks that increased cycling at a higher rate than crashes looked worse even if cyclist risk went down
  - If absolute # of crashes were the only factor, no roads would be built for cars
- Mainly an issue in earlier studies
- West Berlin Police Dept. (1987), Bach et al. (1988), Larsen (1994), Eilert-Petersson and Schelp (1997), Agerholm (2008) (Agerholm also excluded far-side intersection crashes)
- Only Larsen (1994) and Eilert-Petersson & Schelp (1997) are published, peer reviewed studies

Early Dutch Studies & Mopeds

- Wegman & Dijkstra and Welleman & Dijkstra (1988)
  - Published in government reports
  - Findings:
    - Moped riders: relatively many crashes with cyclists and peds
    - Cycle tracks safer between intersections but with increased crash rate at intersections
  - Recommendations:
    - Prohibit moped riders on cycle tracks
    - End cycle tracks before intersection

Utrecht, Netherlands. Source: Molly Marie, 2wheels2feet

Early Dutch Studies & Mopeds

- Changes in Dutch Practice
  - Dec 1999: moped riders prohibited from using cycle tracks in urban areas except where speed limit $\geq$ 70 kph (45 mph)
  - Raised crossings at many intersections rather than forcing cyclists into traffic

Source: nl-bike

Groningen, Netherlands. Source: Cambridge Cycling Campaign

Studies Limited to Intersections

- Expert Opinion Model: Garder et al. (1994)
  - Locations in Sweden
  - Bayesian method combined opinion survey with field results from 4 previous studies
  - Recommended ending cycle track before an intersection
  - Limitations
    - Results of previous studies varied widely
    - Survey respondents not randomly sampled; basis for expert opinion not given
    - Excluded crashes between intersections, not giving overall safety effect

Gothenberg, Sweden. Source: Reading Toronto

Studies Limited to Intersections

- U.S. Sidewalk Riding Study: Wachtel & Lewiston (1994)
  - Studied sidewalks designated as bikeways in Palo Alto, California
  - Not cycle tracks, but included here due to influence in US
  - Excluded crashes between intersections
    - Lusk et al. re-analyzed data (2011)
      - Relative risk of sidewalk riding 1.07 when all crashes included
      - When only including cyclists going in same direction as nearest traffic lane, relative risk is 0.87 for intersections and 0.53 overall

Study Using a Prediction Model

- Jensen (2007)
  - From conference proceedings, but not published or peer reviewed
  - Before-after study with a comparison group
  - Locations in Copenhagen
  - Prediction model based on:
    - Cycling/moped traffic volume
    - Motorized traffic volume
    - Historical trend in collisions, injuries of comparison group

Copenhagen. Source: Will Sherman, CityPhile

Study Using a Prediction Model

- Jensen (2007) (cont.)
  - Results suggest that introducing cycle tracks reduces some collision types while raising others
    - Fewer:
      - Rear-end crashes and injuries
      - Crashes with left-turning bicycles/mopeds
      - Crashes with parked vehicles
    - More:
      - Crashes with right-turning vehicles
      - Crashes between bicyclists, mopeds and pedestrians

Copenhagen. Source: livablestreets.info

Study Using a Prediction Model

- Jensen (2007) (cont.)
  - Limitations
    - Model not adjusted after it underpredicted crashes in test comparing before-before to before
      - In testing, observed 5% more crashes & 9% more injuries than predicted
      - When applied, the 9% and 12% "increase" in crashes and injuries could be partially or largely explained by imprecision in model
    - Question of similarity of comparison group to test group
      - Major routes targeted for cycle tracks
      - Traffic volume of comparison group not reported
    - "Many of the studied roads/intersections are in the far end of the traffic volume axis, i.e. much trafficked, and we are therefore close to or outside the boundaries of the possible crash model's valid area" (page 4)
    - Before and after crashes were not divided by cyclist volume to assess change in relative risk

Studies of Two-Way Cycle Tracks

- Finnish Studies
  - Found increased risk of collisions due to intersection conflicts
  - Primary cause is driver looking to left while cyclist came from right
  - Limitations
    - Did not account for injury severity
      - Cycle tracks have reduced risk of overtaking collisions
      - Overtaking collisions have highest fatality rate
  - Rasanen and Summala (1998), Pasanen and Rasanen (unpublished, 1999), Pasanen (unpublished & undated)

Helsinki. Source: Veloartisanbread.com

Studies of Two-Way Cycle Tracks

- Lusk et al. (2011)
  - Compared 6 cycle tracks with reference streets in Montreal
  - Found a lower relative risk of injury riding on cycle tracks
  - Controlled for exposure
  - Included all collision types
  - Used hospital data to focus on injury collisions
  - Limitations
    - Did not account for injury severity
    - Not a before-after study

Montreal. Source: Price Tags (Gordon Price)

Studies of Intersection Safety Measures

- All published and peer reviewed
- All controlled for exposure or reported cyclist volume*
- None analyzed injury severity**
- Early Swedish and Danish study recommendations
  - Placing cycle crossing less than 3 meters (10 feet) from intersection, or
  - Ending cycle track or converting to bike lane 20-30 meters (65-100 feet) before intersection
    - Unpopular with cyclists due to feeling less safe

* Garder (1998) reported change in cyclist volume along with change in crashes without analyzing them simultaneously Jensen (2008) included cyclist volume in model, but did not assess change in relative risk.

** Jensen (2008) did not analyze severity for specific configurations of colored (blue) intersection crossings.

Studies of Intersection Safety Measures

- Early Swedish and Danish study recommendations (continued)
  - Providing advance motor vehicle stop bar 3-5 meters (10-16 feet) behind where cyclists wait
    - In combination with converting cycle track to bike lane on intersection approach
    - Improves perception of safety
    - 35% reduction in observed cyclist collision risk
  - Linderholm (1992)

Source: Flickr (Anonymous)

Studies of Intersection Safety Measures

- Later Swedish and Dutch studies recommended
  - Raised cycle crossings
    - 20-33% overall reduction in cyclist crashes*
    - Greater reduction in cyclist risk given more than 50% increase in cyclist volume
    - 50% cyclist risk reduction at intersections
    - 40% reduction in vehicle turning speeds
  - Garder (1998), Leden (2000), Schepers (2011)

Source: NL-2011-Transpo

*33% based on empirical data; 20% when "expert opinions" combined with results

Studies of Intersection Safety Measures

- Blue cycle crossings in Copenhagen
  - Fewer collisions and injuries with 1 blue crossing
    - 19% reduction in injuries
    - 10% reduction in crashes
  - Fewer collisions with 2 blue crossings if intersection with $\leq$ 3-legs
  - More effective at smaller intersections and ones with a lower traffic volume
  - Hypothesized that driver's focus is too dispersed when multiple crossings are marked in blue
  - Jensen (2008)

Source: nerdyplanner.blogspot.com

Studies of Intersection Safety Measures

- Finnish studies of measures for 2-way tracks
  - Studied intersection scanning behavior of drivers
  - T-intersections with cycle track on major street
  - Effective measures
    - Speed humps and elevated cycle crossings
    - Stop signs placed in advance of intersection
    - Red cycle crossings combined with advance on-road bicycle warning stencils
      - Proportion of drivers looking right increased by 30%
      - Proportion of drivers looking only to left reduced by 10-50%
  - Summala et al. (1996), Rasanen and Summala (1998)

Conclusions

- Studies comparing cycle tracks to riding in street had several limitations
  - A number did not control for exposure (mainly early studies)
  - Use of cycle tracks by moped riders confounded early Dutch studies
  - Some studies excluded crashes between intersections, not giving overall safety effect
  - Results of studies using a prediction model should be used with caution
  - None of the studies accounted for injury severity

Conclusions

- Preponderance of evidence is that cycle tracks reduce injury severity
  - Reduction in motorized vehicles overtaking cyclists between intersections*
    - = reduction in most severe crash type
- Cycle tracks associated with increase in intersection crashes if no treatments employed

* McCarthy, M. and K. Gilbert, 1996

Conclusions

- Intersection treatments found to be effective
  - Raised cycle crossings
  - Convert cycle track to bike lane 20-30 meters (65-100 feet) in advance of intersection with bike box
  - Colored crossings* at minor, low traffic volume intersections
  - One colored crossing* if major intersection
  - Colored crossings** with in-pavement bicycle warning stencil in advance of intersection
    - At T-intersections with 2-way cycle track on major through-street and motorist approaching from minor street

- Bike signals another option at major intersections

* Tested blue color ** Tested red color

Conclusions

- Bigger Picture
  - Countries with a developed network of urban cycle tracks and other physically separated bikeways
    - Much higher cycling mode share
      - Sweden, Finland, Denmark and Netherlands range from 10%-27% compared to 1% in US*
    - Much lower fatality rates per kilometer cycled
      - Per 100 million km cycled, Netherlands, Denmark and Sweden range from 1.1 to 1.5 compared to 5.8 in US*

* Pucher and Buehler (2008)
Photo Source: cycling-embassy.dk

Conclusions

- Bigger Picture
  - As Jensen acknowledged (2007),
    "On the other hand, making these bicycle facilities resulted in more cycling and less motor vehicle traffic. This must have contributed to benefits due to more physical activity, less air pollution, less traffic noise, less oil consumption, etc. A recent study shows that an extra pedal cycled kilometer in Copenhagen gives an average gain in health and production solely due to more physical activity of rather more than 5 DKK, which equals about 1 US$*. The positive benefits may well be much higher than the negative consequences caused by new safety problems." (pg 14)

* City of Copenhagen Traffic Dept. Bicycle Account 2006

Recommendations for further study

- Analyze change in collision type distribution and resulting severity
  - Separate fatal and disabling injuries from minor ones
  - Separate more minor bike-bike/ped and low speed auto collisions from more severe crashes
- Control for exposure
  - Analyze relative risk
- Analyze effectiveness of intersection treatments in US context

QUESTIONS?

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