DESIGN FOR HEALTH

University of Minnesota | June 2008

Key Questions:

Safety

Metropolitan Design Center

Version 3.0

DESIGN FOR HEALTH is a collaboration between the University of Minnesota and Blue Cross and Blue Shield of Minnesota that serves to bridge the gap between the emerging research base on community design and healthy living with the every-day realities of local government planning. This Safety Key Question is part of a series with a focus on identifying and interpreting evidence-based research linking public health with planning.

UNIVERSITY OF MINNESOTA

Design for Health
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Thanks to Active Living by Design for their helpful comments.

Suggested Citation: Design for Health. 2008. Key Questions: Safety. Version 3.0. www.designforhealth.net

Overview

In terms of public health, safety is a term that is employed both generously and generally, applying to safe water, roadways, air, workplaces, homes, and many other topics. Some such dimensions are covered in other aspects of the Design for Health project (namely water and air). This research summary highlights public-health aspects that directly relate to safety aspects of the built environment specifically reducing transportation-related crashes (i.e., reducing crashes between vehicle and vehicle or bike/pedestrian and vehicle) and crime and overall violence. Given the widely differing orientation of each, we review key questions in four different sections: (1) transportation-related safety, (2) pedestrian/bicycle crashes, (3) crime, and (4) violence.

Transportation-related safety

Legend has it that when the world's first road traffic death happened in 1896, the coroner was brought to the scene and exclaimed, "this must never happen again." More than a century later, such an occurrence is, unfortunately, commonplace. Statistics from the National Highway Transportation Safety Administration reveal that during 2003 in the United States:

- more than 40,000 deaths occurred as a result of car crashes,
- 4749 pedestrians were killed in traffic crashes,
- 70,000 pedestrians were injured in traffic crashes,
- 622 cyclists were killed in traffic crashes (23 percent of whom are under 16), and
- 46,000 cyclists were injured in traffic crashes.

Source: National Highway Transportation Safety Administration 2003

There are generally two elements to transportation-related safety: vehicle-to-vehicle interactions and vehicle-to-pedestrian/cyclist interactions (World Health Organization (WHO) 2004).

Things for certain (or semi-certain)

- Speed is the quintessential traffic safety issue. The risk of a fatality increases dramatically when the speed at moment of impact exceeds 30 mph (48 km/h) and is more than 50 percent likely to be fatal when the change exceeds 60 mph (96 km/h). The probability of death from an impact speed of 50 mph (80 km/h) is 15 times the probability of death from an impact speed of 25 mph (40 km/h) (Transportation Research Board 1998).

- Speed limits on roadways are established based on the context of the environment; where exceeded, drivers pose considerable risk to society. The absolute speed deviation of crash-involved vehicles from the average traffic speed is positively related to crash probability, especially for rural arterial highways and Interstate highways (Transportation Research Board 1998).

Things up in the air

- There is ample, but not unequivocal, evidence indicating crash involvement rates rise with speed of travel. Across all types of roads, however, crash involvement rates do not necessarily rise with the average speed of traffic, because the average traffic speed is highly correlated with the design speed of different road classes (and other conditions). That is, Interstates do not necessarily have a higher crash rate, largely because they are designed to accommodate fast-moving traffic.

Pedestrian-refuge island, Taree, Australia

Pedestrian/Bicycle Crashes

Pedestrian and bicycle crashes are a topic of intense interest to the Design for Health project because its attention to these non-motorized forms of travel. There are a variety of issues to consider when comprehensively addressing travel by these modes and encouraging their use.

Things for certain (or semi-certain)

- The speed of car and pedestrian/bicycle crashes is an important predictor of severity of injury. Best estimates suggest that 5 percent of pedestrians who are struck at 20 mph (30 km/h) are killed, 45 percent at 30 mph (50 km/h) and 85 percent at 40 mph (65 km/h) (Ashton and Mackay 1979).

- Intersection crashes account for more than 45 percent of all reported crashes, and 21 percent of fatalities (U.S. Federal Highway Administration).

- Marked crosswalks, particularly those well designed (e.g., raised medians) and noticeable by drivers, significantly reduce pedestrian crashes (Zegeer et al. 2001).

- When motorists and bicyclists are traveling in parallel directions, either in the same direction or opposing directions, the three most frequent categories of crashes are:

  – motorists turning or merging into the path of a bicyclist (12.1 percent of all crashes). Almost half (48.8 percent) of this type of crash involves a motorist making a left turn in front of a bicyclist approaching from the opposite direction;
  – motorists overtaking a bicyclist (8.6 percent of all crashes). Of these crashes, 23 percent appeared to involve a motorist who misjudged the space required to safely pass the bicyclist; and
  – bicyclists turning or merging into the path of a motorist (7.3 percent of all crashes). Within this category, 60 percent involved a bicyclist making a left turn in front of a motorist traveling in the same direction (NHTSA 1997).

Traffic calming is most often applied on residential streets that otherwise receive a great deal of through traffic; designing for complete streets is a close cousin to this strategy. But both strategies may also be appropriate for shopping streets where a more pedestrian-oriented realm is desired, while vehicles remain.

There are a variety of techniques for traffic calming. They include:

- altering the terrain vertically with speed bumps, speed humps, speed tables, raised crossings, undulations, or road texture/material;

- altering the terrain horizontally with traffic circles and roundabouts, curb extensions (bulb-outs, neckdowns, chokers, chicanes/lateral shifts), median or pedestrian-refuge islands or edgelines to narrow a wide roadway in order to create a bicycle lane, parking lane or shoulder; and

- altering the terrain linearly via full closures or cul-de-sac conversion, half closures (closing one direction), diverters (barriers at intersection to prohibit or require certain movements), or realignment of intersections.

Overall:

- Area-wide urban traffic-calming schemes reduce the number of injury accidents by about 15 percent on average. The largest reduction in the number of accidents is found for residential streets (about 25 percent); a somewhat smaller reduction is found for main roads (about 10 percent) (Zein et al. 1997);

- In areas with traffic-calming, drivers "read" the potential hazards of the road environment and adjust their behaviors in response, thereby resulting in fewer crashes.

Sources: County of Montgomery 1996, Dumbaugh 2005, Elvik 2001, U.S. Federal Highway Administration 2001, Zein et al. 1997

Things up in the air

Discussions about bicycle safety and crashes often turn to the merits of physically separating bicycle travel from other modes of travel versus right-of-way facilities that separate them via painting or striping or right-of-ways with little separation. Such treatments, referred to herein as separated bicycle facilities (SBFs) (but also called cycle tracks (mostly in the U.K.), sidepaths, off-street bicycle paths, and sometimes Copenhagen bicycle lanes (named after the first known city to install one) are often used to reduce interactions between cyclists, pedestrians, and motor vehicles.

Part of the difficulty in understanding the merits of separated bicycle facilities stems from the varying definitions; generally speaking, they are defined as a path within the right-of-way designed specifically for cyclists and separated physically from motor vehicles. But even within this definition there is considerable variation. Physical separation may be in the form of bollards, raised paving, medians, vehicle parking, or a completely different path, several meters from the road. The best known and widespread examples of SBFs come from the Netherlands and Denmark where such facilities are commonplace throughout downtowns and other environments.

The common argument in favour of SBFs stems from increased safety which is ironic since the role of SBFs as a safety measure is highly controversial and has even drawn point/counter-point arguments in leading transportation journals (Forester 2001; Pucher 2001). Arguments against present empirical findings demonstrating how they are not necessarily safer, when considered vis-à-vis actual crash data. Such opponents point to the fact that the majority of bicycle-auto conflicts are not from cars and bicycles travelling in the same direction. As the below figure suggests, the bulk of all bicycling oriented crashes are derived from intersections or turning movements. Separating the modes via infrastructure, many argue, exacerbates the complexity of intersections and hence leads to additional crashes and conflicts. A good number of studies suggest such.

Figure 1: Bicycle Crashes - Most frequent car-bicycle crashes by age and urban versus rural

1-Cyclist running stop sign 2-Cyclist exiting residential driveway 3-Cyclist riding on sidewalk turning to exit driveway 4-Cyclist on sidewalk hit by motorist exiting driveway 5-Cyclist running stop sign	1-Motorist turning left 2-Traffic light changed too quickly 3-Motorist turning right 4-Motorist restarting from stop sign 5-Motorist exiting commercial drive
Rural	
Child	Adult
1-Cyclist exiting residential driveway 2-Cyclist swerving about on road 3-Cyclist swerving left 4-Cyclist entering road from sidewalk or shoulder 5-Cyclist running stop sign	1-Motorist overtaking unseen cyclist 2-Motorist overtaking too closely 3-Motorist turning left 4-Motorist restarting from stop sign 5-Cyclist swerving around obstruction

Source: adapted from Forester 1994, 269

- For example, studying driver scanning behaviour in Helsinki, Summala et al. (1996) found that drivers making right turns looked to their left more often than their right, thus failing to notice cyclists on the adjacent bicycle path.

- Alternatively Räsänen and Summala (1996), in a study of bicycle-motor vehicle accidents in Finland, found that the most common accident type involved drivers turning right and a cyclist coming from the driver's right along a separated bicycle facility, a manoeuvre that has the cyclist coming from an unexpected direction.

- Furthermore, others suggest that cyclists in streets have fewer crashes. Pedler and Davies (2000) found that those cyclists who bicycled on the road had fewer interactions with motor vehicles at intersections than those who rode on the cycle tracks.

However, this finding must be taken lightly, as the skill and confidence level of cycle track cyclists was probably lower than that of on-road riders. In a study of facility safety in Ottawa and Toronto, Canada, Aultman-Hall (2000, 10) found that "the rates of injuries indicates it is safest per kilometre for travel on the road, followed by off-road paths/trails and then least safe on sidewalks." Similarly, Wachtel and Lewiston (1994), in a study of bicycle-motor vehicle accidents in Palo Alto, CA, found that cyclists on sidewalks or bicycle paths incur a risk of collision with motor vehicles that is 1.8 times as great as that for roadway travel.


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Underpass with good visability, Almere, Netherlands

Where safety research does not focus specifically on SBFs, it often addresses issues related to on-street bicycle lanes or wide curb lanes. In these cases, the available literature suggests the following. Harkey and Stewart (1997), in a study of 1,583 bicycle-motor vehicle interactions in 13 locations in six metropolitan areas in the U.S., found that bicycle lanes had the following advantages over wide curb lanes:

(1) Motorists were less likely to encroach on the adjacent lane,
(2) Motorists had less variation in their lane placement when passing, and
(3) Cyclists were more likely to ride further away from the edge of the roadway.

In addition, they found that bicycle lanes as narrow as 0.92 m (3 ft) provide enough space for motorists and cyclists to interact safely while, bicycle lanes of 1.22 m (4 ft) optimize safety conditions. Other research has supported the findings that vehicle encroachment into the adjacent lane is reduced (Hunter et al. 1999a, 2005; Hallett et al. 2006) and cyclist distance from the curb is increased (Hunter et al. 2005) on streets with bicycle lanes, as compared to wide curb lanes. Research focusing on the riding position of the cyclist found that cyclists rode, on average, further away from moving traffic where bicycle lanes were present and/or wider (Hallett et al. 2006). More general trends related to safety are discussed in the section, "General finding," below.

Clearly there are a number of factors to consider in planning for both SBFs and other on-street facilities. A poorly designed separated facility (e.g., next to a sidewalk or with inadequate attention devoted to intersections) is indeed likely to be more dangerous than riding on the roadway. Equally, a rail-trail with grade-separated intersections, easy grades and a 12-foot paved surface is likely going to be a great alternative to a parallel busy arterial street with no space for bicyclists.

Working associations to be aware of

- High travel speeds, without proper design considerations, increase the likelihood of crashes.

- Traffic calming and context sensitive design can mitigate the extent to which autos travel through environments at speeds dangerous to pedestrians or cyclists.

- Caution is needed for projects involving many intersections, requiring cyclists to turn left to access the facility, or make extensive use of off-street bicycle facilities that cross many roadways.

- The available literature does not allow one to draw direct correlations between SBFs and increased safety. Nor can we draw direct correlations between SBFs and increased use. It is extremely difficult to make more definite conclusions because studies have too seldom controlled sufficiently for confounding factors. For example, some studies have considered off-street facilities to include both specialized bicycle facilities and sidewalks. Alternatively, other studies have not controlled for skill and confidence level of the cyclist. There is, however, general consensus on the following. The belief that SBFs reduce the risk of accident is a common reason SBFs lead to increased perception of safety for cyclists across different types of users. With increased perception of safety comes increased ridership. And, in locations with higher levels of ridership, there is convincing evidence that, per capita, the cycling is safer because of a concept referred to as *safety in numbers*.

- Conventional wisdom suggests that the number of collisions varies directly with the amount of walking and bicycling. However, upon examining detailed data from a variety of settings—68 cities in California (U.S.), 14 cities in Europe, 47 towns in Denmark, and eight European counties—findings revealed the same picture: a non-linear relationship, such that collisions rates declined with increases in the numbers of people walking or bicycling (Jacobsen 2003). This means that motorists are less likely to collide with a cyclist bicycling if more people walk or bicycle and initiatives to encourage increased rates of cycling may be an appropriate strategy to increase overall safety as well. The most reliable conclusion, therefore, drawn from the available literature about the efficacy of SBFs and related bicycle treatments requires roundabout, though sound, reasoning. SBFs, however they are defined or implemented, usually lead to increased perception of safety across a wider array of users which helps induce bicycle use. Communities with higher rates of bicycle use have fewer crashes with motorists on a per capita basis and are therefore considered safer.

Crime

Crime is often considered a topic restricted to the province of the police, courts and penal system. A public-health approach concentrates on preventing violence and fear of violence, and aims to provide additional services for victims. At that point, the professions of medicine, nursing and the health-related social services come forward.

Perceptions

People avoid areas with high levels of crime or even areas with a perception/fear of high levels of crime. There is less community watchfulness (e.g., "eyes on the street") and such patterns affect people's mobility (i.e., they don't want to go there).

Things for certain

- Sensitively deployed street lighting can lead to reductions in crime and fear of crime, and increase pedestrian street use after dark (Painter 1996).

Things up in the air

- Some studies suggest that higher crime areas are also less physically active. Such findings, however, have also been refuted. Often older neighborhoods with many "urbanist" features but higher crime or perceived crime are exactly the types of urban form relied on to foster transportation-related physical activity (Hoehner et al. 2005).

Violence

Some studies suggest that higher crime areas are also less physically active. Such findings, however, have also been refuted. Often older neighborhoods with many "urbanist" features but higher crime or perceived crime are exactly the types of urban form relied on to foster transportation-related physical activity (Hoehner et al. 2005).

Working Thresholds for HIA

In terms of increasing safety, research suggests that people often avoid areas with high levels of crime or even areas where they perceive or fear high levels of crime. Crime or perceived crime may be associated with a lack of street activity and may affect people's likelihood of using the space. We suggest all circulation corridors should have adequate lighting.

Second, relative to balancing the needs of multiple users, there are a variety of remedies available to address pedestrian and bicycle crashes. Traffic-calming features may include raised medians, painted crosswalks, curb extensions (e.g., bulb-outs, chicanes, neckdowns), pedestrian refuge islands, woonerfs, roundabouts, edge lines to narrow roadway for bike or parking lane. Complete streets ensure that the entire right of way is routinely designed and operated to enable safe access for all users. We suggest that the plan or project adequately accounts for safe circulation patterns for all modes.

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