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Cycling Safety

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Improving cycling safety is obviously important for reducing injuries to people riding bicycles. Moreover, safer cycling would encourage more people to cycle because risk averse and vulnerable groups are deterred from cycling by fear of injury and thus do not enjoy the health benefits of the physical activity of cycling.

As this chapter will show, cycling is not intrinsically dangerous, although it may appear so because of the risks of severe injury or death imposed by drivers. People cycle less than they would if the dangers imposed by motorized traffic were reduced. They judge the risks of injury from riding bicycles—whether accurately or not—and respond accordingly. A review of the literature from the fields of medicine, public health, city planning, public administration, and traffic engineering shows that the real and perceived danger and discomfort imposed by motor traffic discourage cycling (Jacobsen, Racioppi, and Rutter 2009). Although measuring behavioral effects is difficult, there is an inverse correlation between the volume and speed of traffic and the levels of cycling. Interventions that reduce traffic speed and volume may therefore increase cycling, with consequent improvements in public health. In addition, the risk to an individual cyclist of being seriously injured decreases as the level of cycling within an area increases (Jacobsen 2003). A climate of fear around cycling may therefore lead to lower levels of cycling, making it more risky for those who continue to cycle, and so on in a vicious circle.

Hence the most important issue in bicycle safety is that the danger posed by motorized traffic discourages cycling. Society loses not only the health benefits that cycling affords through increased physical activity but also the wider social and environmental benefits of nonmotorized transport.

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Health Risk Compared to Health Benefit

As noted in chapter 3, virtually all scientific studies show that the health benefits of cycling far offset the traffic dangers. In Copenhagen, cycling to work has been found to decrease the risk of dying by over 25 percent in any one year (Andersen et al. 2000). Copenhagen has some of the world's best cycling infrastructure, and Denmark has one of the world's lowest fatality rates per distance cycled (de Hartog et al. 2010), so it may not provide a generalizable example. In Shanghai, women who cycled to work were found to have a 35 percent reduction in risk for all-cause mortality (Matthews et al. 2007) although Shanghai provides a more dangerous cycling environment than Copenhagen. A similar level of health benefit from cycling was documented among people with type 2 diabetes in Finland (Hu et al. 2004).

A study based on cycling in the Netherlands found that people who switched their main mode of travel from driving to cycling gained nine times more years of life than they lost as a result of increased inhaled air pollution and traffic injuries. The authors repeated their calculations for the United Kingdom, where the risk of a fatal bicycle injury is about 2.5 times greater than in the Netherlands, and still found that the gain would be seven times greater than the risks. Comparing the physical activity benefit to only the injury risk (omitting the pollution factor) showed that the cyclist in the Netherlands would gain 35 times more years of life (de Hartog et al. 2010).

That the health benefits to cyclists so consistently and greatly exceed the risks of being killed in a traffic crash needs to be prominent in any discussion of bicycle safety. To avoid losing the societal health benefits of cycling, injury prevention programs should take an objective approach to the true level of danger for cyclists. Instead of overplaying the risks, they should work synergistically with activity-promotion programs to reduce the dangers created by motorized traffic.

Danger Is Imposed on Cyclists

Most of the risk of severe injury while cycling is not intrinsic to the activity; motorists impose it on cyclists. Cycling is a benign activity that often takes place in dangerous environments. The majority of injuries to

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cyclists do not involve a motor vehicle and typically do not cause severe injuries, which are far more likely to arise in the far smaller number of collisions with vehicles.

The potential for injury is related to the kinetic energy involved, which is proportional to the mass of the moving object multiplied by the square of its velocity. A 2-ton vehicle traveling at 50 km/h has more than 200 times the kinetic energy of an 85-kg male on a 15-kg bicycle traveling at 15 km/h.

Injury data support this observation. At speeds below 20 mph (32 km/h), cyclists and pedestrians are rarely killed in collision with vehicles (Kim et al. 2007, Rosén, Stigson, and Sander 2011). This physiological tolerance for injury is central to Sweden's Vision Zero road safety approach that identifies the importance of protecting pedestrians and cyclists from motor vehicles exceeding 30 km/h (19 mph) (Johansson 2009).

The important role of motor vehicles in severe injuries and fatalities for cyclists is seen in a range of injury data. As the injury severity increases, a greater proportion of injuries is attributable to motor vehicle collisions. Although only 15 percent of the injured cyclists presenting at emergency rooms were hit by motor vehicles, 36 percent of those hospitalized were (Rivara, Thompson, and Thompson 1997). A range of studies has shown that approximately 90 percent of cyclist deaths involve motorists (Nicaj et al. 2009; Rowe, Rowe, and Bota 1995; McCarthy and Gilbert 1996; Spence et al. 1993). It is clear that protecting the health of cyclists requires measures to prevent motorists from colliding with them.

Fatalities and serious injuries that result in chronic health impairment are a much more important target for prevention than minor injuries. However, because the minor injuries occur much more frequently than fatal and severe injuries, their greater numbers may overwhelm injury data. It is thus essential to separate out severity from volume of injuries, as the two are not interchangeable. Some measures, such as that of disability-adjusted life years (DALYs) used by the World Health Organization (WHO), allow equivalence between small numbers of deaths and severe injuries, and larger numbers of minor injuries. But because minor injuries to cyclists typically have no impact on long-term cycling behavior, their aggregate impact is trivial compared to serious injuries that

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prevent or dissuade people from cycling. The health benefits of cycling are so great that this can have a major impact over a person's life.

The key characteristics of cyclist collisions with motor vehicles differ for fatal and minor injuries. For example, motorist and cyclist intoxication are both associated with fatal injuries, but not with minor injuries. Because minor injuries greatly outnumber fatal injuries and alcohol intoxication is not associated with increased risk of minor injuries, the importance of alcohol may be overlooked if all injury severities are aggregated (Kim et al. 2007).

A study of cyclist injuries in Belgium that defined minor injuries as those for which hospital visits lasted less than twenty-four hours found them to be surprisingly common: 148 minor bicycle-related injuries per million kilometers (Aertsens et al. 2010). This rate is 2,000 to 7,000 times as high as the rate for fatalities, which is 0.072 fatalities per million kilometers in the United States, 0.032 in Germany, and 0.020 in the Netherlands (Pucher and Dijkstra 2003). It is important that none of the cyclists with minor injuries studied in Belgium gave up cycling permanently: 30 percent indicated greater concern about cycling but did not stop, and although 5 percent did stop cycling, this was the case for an average of only thirteen days. From a public policy perspective, if minor injuries do not discourage physical activity, they represent primarily a financial cost and should not be considered a significant health issue.

Risk Factors for Collisions

Of the three main elements determining serious cyclist injuries—the road design and condition, the motorist, and the cyclist—the cyclist is the most studied. It may be that the cyclist is simply the easiest element to study: the victim may, for example, be well documented in medical records. In contrast, studying streets often requires extensive fieldwork, based on specialist understanding of road design and operation. Studying motorist characteristics is even more difficult because such inquiry may require the use of police databases, which—due to privacy concerns—are not readily available to researchers. Also, accurately identifying the relative contributions of motorists and cyclists is skewed by the legal perspective underpinning the collection of police and other data in these circumstances. These data will reflect the requirements of law enforcement and civil liability and may be constrained both by the demands of the legal burden of proof and a particular worldview among people collecting the data. As a result of these factors, discussions of causality in motorist-cyclist crashes may be biased against the cyclist.

There is an ethical issue when comparing dangerous behavior by motorists to risky behavior by cyclists. The driver endangers the cyclist, not vice versa, and it is rare for a cyclist or pedestrian to injure another road user (Elvik 2010). The language of injury causation is often distorted, with a tendency to blame the victim. This is especially seen in injuries among children, where normal childhood behavior may incorrectly be regarded as irresponsible, rather than motorists traveling too fast for the situation (Roberts and Coggan 1994). Blame for causation of the collision is a backward-looking approach, but preventing future collisions requires a forward-looking approach, as seen in the Vision Zero philosophy, which requires adaptation and learning from crashes and injuries to build safety into the transport system (Fahlquist 2006). Some injury prevention specialists object to determining blame at all, claiming that it is uninformative and does not help analysis (Elvik 2011b). Because society tends to acquiesce in blaming children for their injuries, the real causes—dangerous neighborhood and roadway design and dangerous driver behavior are not usually addressed.

By far the biggest risk factors for cyclist deaths are motor vehicle speed and mass. Heavy-duty trucks are unwieldy in urban situations, with the driver unable to see large areas around the truck, and are especially dangerous to cyclists (Kim et al. 2007, McCarthy and Gilbert 1996).

Although popular opinion suggests that traffic injuries result from "accidents" which are unavoidable, possibly even random events, there is considerable scientific evidence that collisions between a cyclist and a motorist are both predictable and avoidable. Motorists who collide with cyclists share several distinct characteristics:

- They are overwhelmingly male: over 90 percent of the drivers who kill cyclists in London (McCarthy and Gilbert 1996) and New York City (Komanoff and Smith 2000) are men.
- They tend to be uninsured: drivers without insurance are 40 percent more likely to cause severe injuries to cyclists than insured drivers (Moore et al. 2011).

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- Those who cause deaths are disproportionately likely to be intoxicated or traveling at excessive speed (Kim et al. 2007).

Improving motorist behavior could greatly reduce severe injuries and fatalities among cyclists. It is also worth noting that the risks cyclists face from motorists are not constant but decrease as the level of cycling in an area increases (Jacobsen 2003).

Cyclist Characteristics

To identify possible approaches to improving road safety, it is helpful to divide injured cyclists into three broad groups: children, sober adults, and adults intoxicated with drugs or alcohol. The aggregation of these different categories of cyclists into a single pool disguises the important patterns of injury causation specific to each, impeding the development of truly effective injury-prevention programs.

Children

The age profile of cyclists has changed over the last forty years; they used to be mostly children, whereas today they are increasingly adults. In the early 1970s, 91 percent of injured cyclists were under the age of 20 (Williams 1976), but in a 1997 study, only 59 percent of injured cyclists were under 20 years old (Rivara, Thompson, and Thompson 1997). This shift likely reflects a decrease in bicycle use by children, rather than safer conditions for child cyclists (Jacobsen, Racioppi, and Rutter 2009).

Collision patterns vary substantially based on the age of the cyclist involved. Children on bikes are typically hit when emerging from driveways onto minor roads or when riding through intersections. Adult cyclists are often hit from behind or by an oncoming motorist turning across their path (Williams 1976).

Intoxicated Cyclists

Alcohol-intoxicated riders are considerably more likely than sober cyclists to be severely injured or killed. In one study in Portland, Oregon, although only 15 percent of killed and hospitalized adult cyclists had elevated blood alcohol levels, half of the adult cyclists with fatal injuries were intoxicated (Frank et al. 1995).

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Of 200 injured cyclists reviewed during a study at a regional trauma center in Austin, Texas, 40 either had measurably elevated blood alcohol levels or themselves reported having consumed alcohol. The intoxicated cyclists were much more likely to have been injured at night or in the rain and to have been admitted to the hospital. Only 1 of the 40 (2.6%) alcohol-consuming cyclists had worn a helmet, compared to 44 percent of the others. Both cyclists who incurred severe brain injuries were intoxicated, and the average hospital care cost of the alcohol-consuming cyclists was twice that of their sober counterparts (Crocker et al. 2010).

Nevertheless, of all road users killed in a study of over 1,000 road-traffic fatalities between 2000 and 2006 in England and Wales, cyclists were the least likely to have consumed alcohol or drugs. Of the cyclists tested, 33 percent showed the presence of alcohol and/or drugs, compared to 55 percent of drivers, 52 percent of car passengers, 48 percent of motorcyclists, and 63 percent of pedestrians (Elliott, Woolacott, and Braithwaite 2009). More cyclist fatalities are due to intoxicated motorists than intoxicated cyclists (Kim et al. 2007).

Net Health Benefits of Increasing Cycling

In an earlier section, we showed that on an individual basis, increased cycling benefits health. Does that effect hold for a large mode shift from driving to cycling?

Comparing the health burden of motorized traffic in the United States with the Netherlands shows a correlation between motor vehicle use and health. Across the developed world, road traffic injuries rank fifth as a cause of ill health across the population (Murray and Lopez 1997), but they rank third in the United States (McKenna et al. 2005) and thirteenth in the Netherlands, which has one of the highest levels of cycling in the world (Melse et al. 2000).

A shift from driving to cycling raises the question of the balance between protecting its users—where a car excels—against causing little harm to others and benefiting the rider's own health—where a bicycle excels. A heavier vehicle protects its users from injury, but the heavier and faster the vehicle, the more kinetic energy and hence injury potential it has (Elvik 2010). Determining the total burden of injury resulting from a shift in travel modes involves weighing the shift in danger that vehicles impose on other road users against the protection they afford their occupants.

Collisions between cyclists and pedestrians are rarely fatal. In a German study, ten pedestrians and two cyclists died in bicycle-pedestrian collisions, a tiny fraction (0.1%) of the total of approximately 8,000 traffic fatalities during the study period (Graw and König 2002).

The consequence of a shift from driving to cycling is further complicated because the risk to an individual cyclist of being injured is nonlinearly related to the amount of cycling: as the level of cycling increases, so do total injuries, but at a lower rate. In general, doubling cycling increases cyclist injuries by only a third (Jacobsen 2003). In contrast, halving car use approximately halves the number of single- and multiple-vehicle crashes. Although the exact nature of the relationship is unclear, the total number of crashes would probably decrease if there were a large enough shift from motor vehicles to bicycles (Elvik 2009).

A series of studies has modeled the likely health consequences of a shift from personal motor vehicles to bicycles (Austroads 2010; AVV 2006; Lindsay, Macmillan, and Woodward 2010; Stipdonk and Reurings 2010). In most cases, road traffic fatalities varied up or down by only a small amount, and adding in the physical activity benefits of active travel resulted in health benefits that far outweighed any minor increases in injuries.

Empirical observations bear out the findings of these models. A number of cities—including London, Bogotá, Berlin, Amsterdam, Copenhagen, Odense, and Groningen—have successfully developed bicycle infrastructure and other programs to encourage cycling and simultaneously reduced the levels of deaths and injuries among cyclists. Portland, Oregon, experienced an increase in reported crashes of 14 percent, but over the same period, the number of cyclists entering the downtown area increased by more than 300 percent (Pucher, Dill, and Handy 2010).

A nationally funded initiative in Odense, Denmark, allocated 20 million Danish kroner or approximately 120 kroner per person (US$25) in an attempt to increase cycling, reduce injuries, and improve health. Fifty projects were developed and implemented during the four years of the program, including physical improvements, changes to regulations, and marketing campaigns. It resulted in 20 percent more cycling trips, replacing car trips and public transit use, while reducing injuries to cyclists by 20 percent. The project was estimated to save much more money than it cost (Troelsen, Jensen, and Andersen 2004).

Helmets

Use of bicycle helmets is a central element of many campaigns intended to improve cyclist safety. But helmets do not create safety; only a safe environment, free from the dangers created by motorized traffic and poorly designed roads, can do that. Reducing danger and increasing safety are prerequisites for encouraging both cycling and walking (Gehl 2010, Jacobsen, Racioppi, and Rutter 2009). Because promoting and wearing helmets might promulgate a false perception that cycling is an unusually risky activity (Lorenc et al. 2008), which would reduce cycling (Jacobsen, Racioppi, and Rutter 2009), it may actually decrease health across a population. The risk of being injured by a motorist increases as the level of cycling decreases (Jacobsen 2003), and that increased fear might leave those who do cycle at greater risk.

Bicycle helmets were first marketed to the general population in the 1980s. An early analysis asked cyclists about their crashes and found that helmeted cyclists had a 90 percent reduced risk of death (Dorsch, Woodward, and Somers 1987). A retrospective case-control study found that helmeted cyclists had an 85 percent reduction in risk of head injury (Thompson, Rivara, and Thompson 1989). More recent evidence has, however, led to a reappraisal of the benefits of wearing bike helmets. Elvik has reported that three previous meta-analyses were in broad agreement that helmeted cyclists have a reduced risk of head injury, yet his own meta-analysis that combined the risk of injury to head, face, or neck found that helmets provide only a small protective effect. Moreover, this effect is evident only in older studies—newer studies showed no net protective effect (Elvik 2011a). The reasons for these much lower estimates of protective effect seen in the most recent studies are not known, but they may result from changes in helmet construction, as well as the methods used in the meta-analyses (Elvik 2011a).

The dramatic difference in injuries between helmeted and bareheaded cyclists reported in the earliest studies has not been seen in population-level research. In a study of six jurisdictions where cyclists were compelled to wear helmets, resulting in a large increase in the proportion of cyclists wearing them, the ratio of head injuries to other injuries did not noticeably decrease (Robinson 2006). It may be that people who choose to wear helmets are especially cautious and safety-minded (Elvik 2011a; Farris et al. 1997). Indeed, one analysis has found that bare-headed cyclists "tend to be in higher impact crashes than helmet users, since the injuries suffered in body areas other than the head also tend to be much more severe" (Spaite et al. 1991, 1515). The authors concluded that helmet use may be a "marker" for cyclists who tend to be in less severe crashes, rather than contributing to reductions in the level of injury (Spaite et al. 1991). It is also worth noting that intoxicated cyclists rarely wear helmets and tend to be involved in disproportionately severe crashes (Crocker et al. 2010, Kim et al. 2007; Spaite et al. 1995).

Analysts in observational studies must be wary of the pitfalls of selection bias—"muddling characteristics of the chooser with the benefits of the choice." (Westmont 2004). Such selection bias is clearly a risk for research into cycling helmets, especially because bareheaded and helmeted cyclists differ so much in terms of characteristics associated with the likelihood and severity of crashing.

Another possible reason for not achieving the dramatic reduction in injuries initially identified for helmets could be that cyclists take more chances as a consequence of wearing them, a phenomenon known as risk compensation (Elvik 2011a; Phillips, Fyhri, and Sagberg 2011). In addition, motorists might treat cyclists differently in response to the clothing and equipment they wear—for example, by driving closer to helmeted cyclists (Walker 2007).

Yet another possible reason could be because the studies examined different injury severity patterns. The retrospective studies examined emergency room attendances, which are dominated by minor injuries, whereas the population-level study examined hospital admissions, which are characterized by serious injuries. When the authors of the most-quoted retrospective study more closely examined cyclists' injuries, they found that hospitalizations and deaths were outnumbered by emergency room visits by 9:1, with helmets having no apparent effect on hospitalization rates (Rivara, Thompson, and Thompson 1997). They also found—as did Kim et al. (2007)—that helmeted riders had fewer deaths. Given the lack of impact of helmet use on hospitalization rates, it may be that the difference in death rates is attributable to differences in the

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cyclists (such as risk-taking behavior) rather than a protective effect of helmet wearing.

Even the best helmet provides limited protection. In the United States, a helmet is tested with a weight of 5 kilograms (11 pounds) at an impact velocity of 5.4 meters per second (12 mph) (Consumer Product Safety Commission 1998). As discussed earlier, a car colliding with a cyclist at a speed below 20 mph rarely causes a fatal injury. Because the energy transferred in the impact is a function of weight multiplied by the square of the velocity, a head hitting the ground at 12 mph involves only 37 percent of the energy of the same head hitting a motor vehicle with a combined velocity of 20 mph; at higher velocities, the disparity is even greater.

Laws requiring cyclists to wear helmets are controversial. The European Cyclists' Federation actively opposes them, as does RoadPeace, the international charity for road crash victims (ECF 2011; RoadPeace 2010). Not only have such laws failed to bring about reductions in rates of head injuries (Robinson 2006), but they also reduce the level of cycling (Robinson 1996) and the health benefits of physical activity. Because the risk that an individual cyclist will be struck by a motorist increases as the level of cycling decreases, compulsory helmet laws could have the perverse effect of increasing deaths—not just risk of death—among those who continue to cycle (Komanoff 2001).

Conclusion

The issue of safety presents a complex set of challenges for cycling. Both real and perceived dangers discourage cycling, and the safety of cycling is related to the number of cyclists on the roads. Proactively addressing cyclist safety thus creates a virtuous circle in which more safety increases the numbers of cyclists and the presence of more cyclists improves their safety.

Cyclist safety is largely an artifact of traffic safety and to a large extent out of the control of cyclists themselves. Serious injuries mostly result from collisions with vehicles; for sober adult cyclists, motorists are primarily responsible for those collisions.

Notwithstanding these difficulties, many cities and countries have managed to increase the level of cycling while simultaneously reducing

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the proportion of injuries to cyclists. By implementing a wide variety of policies to improve safety, Germany and the Netherlands have both significantly reduced cyclist deaths. These countries have greatly expanded their cycle networks, implemented traffic calming, restricted or otherwise discouraged vehicle use in urban areas, and developed traffic regulations strongly favoring pedestrians and cyclists (Pucher and Dijkstra 2003; Pucher and Buehler 2008).

An impressive range of cities has also successfully encouraged cycling while simultaneously reducing injuries. The list includes big cities (London), small cities (Boulder, Colorado), and developing cities (Bogotá). Cyclists respond to a variety of interventions to encourage them to ride and feel comfortable (Pucher, Dill, and Handy 2010). Cyclist safety is not improved through single interventions but from the accumulation of many individual and collective actions, illustrated by the activities and ideas expressed throughout this book. Improving the safety of cyclists should focus on the causes, not the victims, of danger. Although the risks should not be ignored or trivialized, it is important to emphasize that cycling is a fundamentally safe and healthy activity that not only benefits the individual cyclist but also promotes safety among other road users and a healthier environment for the entire population.

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