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Summary

Road safety for cyclists

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The present report contains updated versions of four chapters of the Handbook of Road Safety Measures about bicycles and cyclist safety. The report presents results of systematic literature surveys and meta-analyses. Cyclists have far higher crash and injury risk than occupants of motor vehicles, except motorcyclists. The number of killed or seriously injured cyclists has increased in recent years in Norway. Crash risk increases when cyclists are under the influence of alcohol, are inexperienced or are older. On pedelecs, older cyclists have far higher risk than comparable cyclists on other bicycles. Dedicated bicycle infrastructure has often, but not always been found to reduce crash risk. Bicycle lanes and unidirectional bicycle paths are among the crash reducing types of bicycle infrastructure, provided a safe design at intersections and sufficient clearance to parked cars and pedestrians. On bidirectional bicycle paths, shared paths and sidewalks crash risk for cyclists is usually far higher than on other types of infrastructure, especially at intersections. On roads without bicycle infrastructure crash risk for cyclists depends amongst other things on traffic volume, speed, on-road parking, and train tracks. Effective winter maintenance and other maintenance can reduce crash risk for cyclists and is essential for making cycling attractive throughout the year. Using bicycle lights and reflective clothes reduces both night- and daytime crash risk for cyclists. Bicycle helmets about halve the risk of serious head or brain injuries among crash involved cyclists. Helmet laws were also found to reduce head injury risk.

The present report contains updated long versions of the following chapters of the Handbook of Road Safety Measures (http.tsh.toi.no and Elvik et al., 2009):

- Bicycle infrastructure (chapter 1.1)
- Maintenance of bicycle and pedestrian infrastructure (chapter 2.7)
- Bicycles, bicycle equipment, cyclist clothing, and transporting children on bicycles (chapter 4.25)
- Bicycle helmet and helmet laws (chapter 4.10).

In total over 400 empirical studies were found and summarized qualitatively or with meta-analysis.

Bicycle infrastructure

Bicycle infrastructure is meant to make cycling safer and more attractive. General road characteristics that are related to crash risk for cyclists are traffic volumes, speed limits, train tracks, roadside parking, and road lighting.

Cycle lanes have been found to have lower crash risk for cyclists than cycling in mixed traffic or on bicycle paths. Additionally, they allow higher speeds for cyclists than other bicycle infrastructure.

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Unidirectional bicycle paths can also have lower crash risk than mixed traffic on midblock sections, and they may allow equally high speeds as cycle lanes. However, the effects are highly dependent on the design, especially at intersections. At intersections cyclists are often not well visible for motorists and motorists assume often that cyclists from cycle paths have to give way, regardless of the actual priority rules. Other important safety features are sight conditions, the proximity to parked cars, and effective separation from pedestrian areas.

Bidirectional bicycle paths have been found to be less safe than unidirectional bicycle paths, especially at intersections were cyclists cycling in the "wrong" direction often come unexpected for other road users.

Shared paths (which are a common design in Norway, mainly outside urban areas, in parks etc.) were found to have far higher crash risk for cyclists than other bicycle infrastructure. On shared paths there are many potential conflict points between cyclists and pedestrians, while safety problems at intersections are comparable to bidirectional bicycle paths. Additionally, cyclists are required to slow down in the presence of pedestrians which makes such paths inappropriate for commuter cyclists.

For ***bicycle expressways*** empirical evaluations of the effects on crash risk were not found, but the design of such paths is likely to contribute to relatively low crash risk. The main aim of bicycle expressways is to allow cycling over longer distances at higher speed, separated from other road users and with a minimum of yield situations.

Contraflow cycling on one-way streets has been found to reduce bicycle crashes and cycling on sidewalks.

At ***intersections***, designs that provide a high level of safety for cyclists, often slow down cyclists, while designs that allow high speed often are unsafe. Examples of intersection designs that provide high levels of both safety and speed are cycle boxes, bicycle lanes between through and right-turn lane, and priority cycle paths combined with speed humps for traffic from side roads.

In ***roundabouts***, cycling in mixed traffic or segregated bicycle paths provide highest safety, depending on motor vehicle volumes and speed, as well as intersection design for segregated cycle paths. Bicycle lanes in roundabouts are associated with large increases in crash risk.

Maintenance of bicycle and pedestrian infrastructure

Crash and injury risk for cyclists and pedestrians increase when roads are covered by snow or ice. Leaves, sand, gravel, uneven or damaged road surfaces increase risk as well. Additionally, slippery or snow covered roads are important obstacles against cycling and walking in winter, especially for older cyclists/pedestrians. Winter maintenance can reduce crash and injury risk if road conditions are improved and slipperiness reduced. Combined sweeping and salting is an effective method for maintaining good cycling and walking conditions in winter, except under some specific circumstances (e.g. thick layers of ice). Warm sand can be effective as well (especially on icy roads), but leaves sand on the roads which may increase risk after the melting of snow and ice. Snow ploughing can be effective as well, but may under some circumstances make roads mode slippery (compressed snow). Warming up the road surface is the most effective measure, but also quite costly.

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In winter and under unfavorable cycling conditions the number of cyclists decreases. There are several general differences between cyclists that continue or stop cycling under such conditions. Those that are older and more vulnerable tend to be among the first to stop cycling, while those that continue to cycle under all kinds of conditions on average are most sporty and safety oriented (e.g., they use more often helmets and light in the dark).

Bicycles, bicycle equipment, cyclist clothing, and transporting children on bicycles

Different types of bicycle are associated with differences in crash risk. However, those differences are mostly related to differences between cyclists and how (especially where and how fast) they are cycling.

Pedelecs have become very popular in recent years. Older users of pedelecs, especially women, have far higher crash risk than other cyclists of comparable age and gender. The high risk is due to the combination of often inexperienced cyclists and bicycles that are both heavy and fast. Users of bikeshare schemes are also likely to have higher crash risk because of a far higher prevalence of high-risk behavior and nonuse of helmets.

A common contributing factor in collisions between bicycles and motor vehicles is drivers not seeing or not noticing the bicycle. Cyclist conspicuity is often poor, in many situations motorists do not expect cyclists and cyclists are often behaving unpredictably. Bicycle lights and reflective or other high-visibility clothes were found to reduce collision involvement, both in the dark and in daylight. However, the effects are difficult to quantify empirically.

Defects on brakes or tires can increase crash risk. Passengers on bicycles are also likely to increase crash involvement.

There is only very little empirical evidence about how child passengers on bicycles affect crash risk. Child seats on bicycles impair the stability of the bicycle. Trailers for children on the other side are easily overlooked by other road users.

Bicycle helmets and helmet laws

Bicycle helmets and helmet laws have in a large number of studies been found to reduce head injuries. In a meta-analysis of 53 empirical studies of bicycle helmets a statistically significant reduction of serious head injury among cyclists by 60% was found. For other head and brain injuries large reductions were found as well. Neck injuries are not likely to increase. In a meta-analysis of 20 empirical studies of bicycle helmet laws statistically significant reductions of head injury among cyclists by about 20% was found. Helmet laws were found to be more effective in preventing more serious head injuries (-35%) and they are more effective - also for children - if helmet wearing is mandatory for all cyclists, as compared to children only.

Supplementary analyses do not indicate that the estimated effects of bicycle helmets or helmet laws are affected by publication bias, biases in the crash and injury data, or a lack of control for confounding factors.

The hypothesis that bicycle helmets lead to more high-risk behavior is not empirically supported. On the contrary, several studies show that helmeted cyclists show less high-risk behavior than unhelmeted cyclists.

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Bicycle helmet laws may deter some cyclists from cycling. However, these effects are not inevitable and not usually large or long-lasting. There are many other factors that are far more important for the choice of means of transport than helmet laws (such as how far bicycle infrastructure is regarded as safe and attractive).

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