Cyclist safety

AN INFORMATION RESOURCE FOR DECISION-MAKERS AND PRACTITIONERS

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An information resource for decision-makers and practitioners

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Cyclist safety: an information resource for decision-makers and practitioners

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Preface

Cycling has many health and environmental benefits. Yet every year 41 000 cyclists die in road traffic-related crashes worldwide. Many leave their homes as they would on any normal day – for school, work, worship, or meeting friends – never to return. Millions more people are injured in road traffic-related crashes while cycling, some of whom become permanently disabled. These incidents cause much suffering and grief, as well as economic hardship for families and loved ones.

However, the growing focus on sustainable mobility – an increasing effort to shift more travel from motorized transport to the use of public transport, walking and cycling – makes cyclists' safety an increasingly important component of road safety efforts. Cyclist collisions, like other road traffic crashes, are predictable and preventable and therefore should not be accepted as inevitable.

Cyclist safety: an information resource for decision-makers and practitioners describes the magnitude of cyclist death and injury, the key risk factors, and effective interventions. The document stresses the importance of a comprehensive, holistic approach that includes legislation, enforcement and behavioural measures specifically for cyclists; design of the built environment; as well as integrating cyclist safety into overall road safety and transport strategies. It also draws attention to the benefits of cycling, which should be promoted as an important mode of transport given its potential to improve health and preserve the environment.

We hope that this resource, which is designed for a multidisciplinary audience including engineers, planners, law enforcement officers, public health professionals and educators, will contribute towards strengthening national and local capacity to implement cyclist safety measures in various settings worldwide. We encourage all to bring this resource to the attention of those who will use it to save the lives of cyclists.

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Introduction

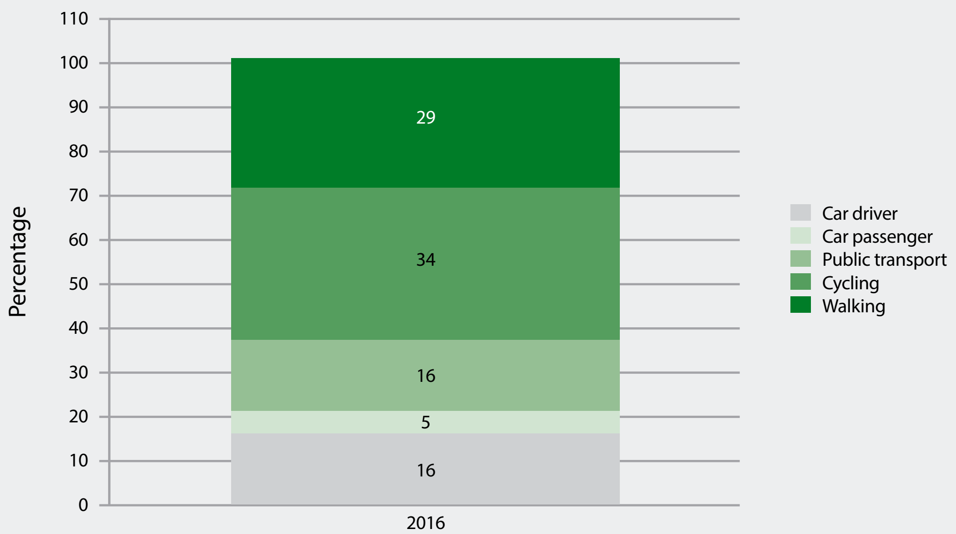
Introduction

Every year about 41 000 cyclists are killed while cycling to school, work, a shopping centre, or home *(1)*. This represents 3% of global road traffic deaths. Unlike cars, bicycles can easily become unbalanced and provide no protection in the event of a crash, allowing riders to come into direct contact with the road and other road users. Also unlike cars, bicycle use very rarely results in the death or injury of other road users.

A shift away from motorized transport towards sustainable transport – cycling, walking and public transport – is a commitment of Sustainable Development Goal 11, Target 11.2. It calls for cycling to be promoted and prioritized as an accessible means of transport for many people (for whole or parts of trips) and to improve the infrastructure for cycling, walking and public transport around the world. Such a shift means that cyclist safety must be placed at the heart of global road safety and be considered a key part of any transport and land-use planning framework. Such a framework must accommodate the needs of different modes of transport and address risk factors related to the road, vehicles and users.

While there are many barriers to cycling, people fear the risk of being in a crash and suffering an injury or death *(2)*. Thus, reducing the totality of road traffic danger is important because the perception of risk on the roads can deter people from taking up cycling *(3, 4)*. An integrated transport and land-use planning framework can achieve this by enabling the design of a total system of safe cycling infrastructure. This approach has been taken in cities like Freiburg-im-Breisgau, Germany – a move that has resulted in cycling becoming the most common mode of transport (Figure 1) *(5, 6)*.

Figure 1 **Proportion of trips by mode of transport, Freiburg-im-Breisgau, Germany**



Source: reproduced with permission from reference *(6)*.

The COVID-19-related reduction or closure of public transport services amid concerns about the proximity of passengers has resulted in a growing interest in cycling for different purposes in cities such as Bogotá, New York City and Paris *(7)*. Bogotá and Paris responded to this challenge by allocating more space to cycle lanes and if this response is sustained beyond the pandemic it will represent a positive policy development.

This document provides an overview of the risk factors for cyclist safety, and interventions available to decision-makers and practitioners as they plan for cyclist and overall road safety programmes in different settings around the world. It complements other information resources and good practice manuals developed by the World Bank, the World Health Organization (WHO), the FIA Foundation and the Global Road Safety Partnership (GRSP) *(8–15)*. This current resource was developed by an advisory committee of experts from the four collaborating agencies – FIA Foundation, GRSP, the World Bank and WHO. Countries can use this resource to review, adapt and promote cyclist and road safety policy in the most efficient way for varying political, ecological, economic, and social contexts.

1

Why is addressing cyclist safety necessary?

1

LIKE WALKING, cycling is an important means of transport for making a part of a trip or a whole trip to work, school, or to shops and markets. Yet every year 41 000 cyclists die in road traffic-related incidents worldwide. Efforts to promote an increase in bicycle use – and its many health and environmental benefits – therefore need to include measures to reduce road traffic danger caused by motorized transport. Prioritizing cyclists' needs in transport and land-use planning is critical for making the shift from reliance on private cars to increased use of public and active modes of transport (cycling, walking). This section explains the need to address cyclist safety by describing the importance and the magnitude of cyclist-related injury and death. It is important to note that the focus of this document is on human-powered bicycles and not electric bicycles.

Cycling, health and the environment

Around the world people use bicycles for work, education, health and leisure trips, and to transport goods. Cycling, which enables people to engage in regular physical activity, is one of the activities included in WHO's global action plan on physical activity 2018–2030 *(16)*. Regular physical activity is associated with reduced risk of heart disease, stroke, obesity, diabetes, breast and colon cancer, and with improved mental health and quality of life *(16)*.

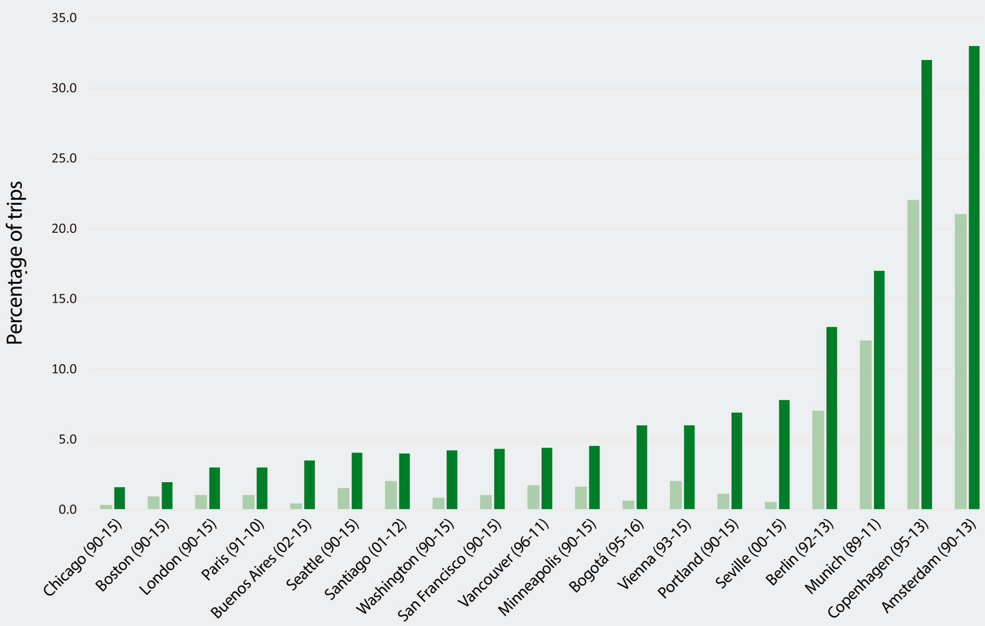
The transport sector contributes 23% of global energy-related greenhouse gas emissions *(17)* and is a major contributor to air and noise pollution, particularly in urban areas. About 3.7 million deaths each year are attributable to outdoor air pollution *(18)*. In contrast to motorized transport, cycling is associated with very little or no pollution. This means that increasing bicycle use, along with walking, public transport and other measures to reduce transport-related pollution and traffic congestion, will contribute to creating a livable environment with clean air and improved accessibility for all road users. Such a shift would also reduce noise pollution – an under-acknowledged contributor to negative mental and physical health outcomes *(19, 20)*. Conservative estimates from noise maps attribute 654 disability-adjusted life years (DALYs) to noise pollution for the population living in towns with more than 50 000 inhabitants in the European Union *(20)*.

Growth in the number of cars and the frequency of their use around the world – as well as the general neglect of cyclists' needs in road design, land-use planning and traffic law enforcement – mean that cyclists are increasingly susceptible to road traffic crashes and injuries *(21)*. Cycling and other non-motorized transport safety is largely neglected in low- and middle-income countries, despite an increasing need to address high fatality rates, traffic congestion and air pollution *(22)*. Policies and programmes that promote the use of bicycles for transport also need to address barriers that discourage cycling, such as fear of a road traffic collision.

There are no comprehensive global studies on bicycle use but case studies show variation in the use of this mode in different parts of the world. For example, in collaboration with universities in South Africa, Tanzania and Kenya, the African Centre of Excellence for Studies in Public and Non-Motorised Transport conducted travel behaviour analyses on cycling and walking in three African cities in 2010. In Dar es Salaam, cycling accounted for only 3% of the overall modes of transport. Cycling is also rare in Nairobi, with many participants being deterred from cycling by a fear of road traffic crashes. In Cape Town, bicycle use is highest among commuters from low-income households where financial constraints limit access to other modes of transport. This places people with lower incomes at a higher risk for injury.

A different situation emerges from an analysis of data for 19 cities in Western Europe, North America and South America between 1990 and 2015 that revealed that cycling levels had risen following the strengthening of cycling infrastructure, policies and programmes *(23)*. This included cities with already high bicycle use such as Copenhagen and Amsterdam, whose rates rose by 10% and 12% respectively during this period. However, cities with low rates of bicycle use also showed significant increases, such as Seville (6%), Bogotá (5%), Buenos Aires (3%), and Portland in Oregon, USA (5%) (Figure 2).

Figure 2 **Increasing rates of bicycle use in large cities in Europe and the Americas, 1990–2015**



Source: reproduced with permission from reference *(23)*.

The physical and economic costs of cycling injuries

This section outlines the types of injury, crash and economic costs associated with cyclist road traffic crashes.

Types of injuries incurred by cyclists

Most cyclists' injuries occur to the upper or lower extremities and the head *(24)*, but injuries can also occur to the face, abdomen or thorax, and (rarely) the neck *(25)*. Head injuries occur in 22–47% of cyclists' injuries (often because of a collision with a motor vehicle) and are responsible for over 60% of all cyclist-related deaths and most of the long-term disabilities *(25)*. Injuries to the facial region include eye trauma from airborne objects such as dust, insects, or debris, as well as soft tissue injuries and fractures.

Crash types

The most serious crashes resulting in cyclist injury or death are those involving a motor vehicle. Studies on collisions between cyclists and car doors (as they are opened by occupants) are infrequently undertaken, which suggests that injuries sustained in this way are underrepresented in the data. However, a Swedish study found that these crashes are the third most frequent category of cycling injury, and account for more than 25% of moderate injury. Fatal crashes were also reported when cyclists were thrown off the bike by colliding with a vehicle at a very high speed. These crashes become more problematic when cyclists go downhill or are passing parked cars on narrow city roads *(26)*.

Studies from the United States of America (USA) and Australia show that males are more likely to be involved in crashes than females, but this could be the result of more males cycling *(27, 28)*. An Australian study also indicates that cyclists aged 50 years or over were twice as likely to be severely injured compared to riders aged under 50 years *(29)*. Most cyclist crashes and fatalities occur between 6 am and 9 am, and between 3 pm and 9 pm (peak-travel times with high volumes of traffic) *(30)*.

Economic costs

While data on the economic costs of cyclist-related injury and death are scarce, a recent study on the impact of road traffic crashes on national gross domestic product (GDP) in five countries estimated that halving road crash mortality and morbidity would (after 24 years) increase GDP by as much as 7.1% in the United Republic of Tanzania, 7.2% in the Philippines, 14% in India, 15% in China, and 22.2% in Thailand *(17)*. This revenue would be gained by these countries investing in road safety, thereby saving the costs to the economy that result from road traffic crashes.

2

Risk factors for cyclist-related injuries and fatalities

2

RISK FACTORS for cyclist-related injuries and fatalities are well documented. Though there are generic risk factors, it is important to note that they vary in relation to the trip purpose, traffic mix, and type of road. It is important to note that specific risks interact with each other.

Speed of motorized vehicles sharing the roads with cyclists

In mixed traffic settings where cyclists share the road with other motorized vehicles, the speed of motorized traffic is an important factor for both crash risk and crash consequences *(8, 9)*. Speeding vehicles in a mixed-traffic environment are a major risk factor associated with serious injury and fatal crashes generally *(31*, 32) and among cyclists in particular *(33, 34)*. As the average traffic speed increases, so too does the likelihood of a crash *(9)*. For example, an increase of 1 km/h in mean vehicle speed can result in a 3% increase in the incidence of crashes resulting in injury and an increase of 4–5% in the incidence of fatal crashes *(35)*. The higher the speed, the greater the stopping distance required, and hence the increased risk of a road traffic crash. The likelihood of a fatal injury to a cyclist increases 11 times with vehicle speeds above 64.4 km/h and 16 times at 80.5 km/h *(36)*.

Alcohol impairment

Alcohol impairment among cyclists and other vehicle drivers is another important risk factor for cyclist injuries and deaths *(37–39)*. Cyclists riding with a blood alcohol concentration (BAC) level higher than 0.05 g/dl have higher rates of head injuries *(40)* as well as a strong correlation with injury severity, longer hospitalization, and higher health care costs *(41–43)*.

Non-helmet use

Cyclists not wearing a helmet at the time of a collision experience more severe head injuries than those who are wearing a helmet. The first large, case-control study of helmet effectiveness estimated 85% and 88% reductions in head and brain injury, respectively, for helmeted cyclists relative to unhelmeted cyclists *(44)*. Subsequent studies have confirmed this difference, though not often to the same extent *(45, 46)*.

It is important to note that the effectiveness of bicycle helmets in preventing head injury in a crash may be limited by incorrect use *(47)*. Helmets that rest too high on the forehead, have improperly fitted straps, or move excessively from front to back could result in a greater risk of head injury *(48)*.

Cycling against the traffic, and other risk factors

Another contributing factor to crashes is the practice of cycling against the traffic – often in the belief that it improves cyclist visibility. However, this practice adds to the risk of collision and severity of injuries. Counter-traffic cycling resulted in 3.6 times the risk of those travelling with the traffic flow and 6.6 times the risk for riders aged under 17 years *(49)*.

Furthermore, emerging risk factors such as distracted driving are associated with increased risk of injury. In the USA, a cyclist attitude and behaviour survey revealed that 21% of cyclists use electronic devices on at least some of their trips, with 9% indicating use of such devices on nearly all their trips *(50)*.

Lack of visibility and non-use of bicycle lights

Poor visibility due to inadequate illumination during afternoon peak periods or at nighttime is a major risk factor associated with cyclist collisions *(51)*.

3

Measures to improve cyclist safety

3

Overview

Cyclist safety interventions are presented and discussed in this section under four broad and interrelated groups: safer speeds, safer roads, safer vehicles, and safer road users. The effectiveness of the interventions is examined with respect to their contribution to a reduction in road traffic fatalities and serious injuries, as well as change in behaviour (Table 1). Each intervention was assessed for effectiveness as follows:

- **Proven**: evidence from robust studies such as randomized controlled trials, systematic reviews, or case-control studies shows that these interventions are effective in reducing road traffic fatalities and injuries, or in bringing about a desired change in behaviour.
- **Promising**: evidence from robust studies shows that some road safety benefits have resulted from these interventions, but further evaluation from diverse settings is required and caution is needed when implementing them.
- **Insufficient**: evaluation of an intervention has not reached a firm conclusion about its effectiveness because of a lack of evidence. The lack of evidence does not necessarily mean that interventions are not relevant or good. It just means that they have not been studied or the intervention is still being developed.

It is important to note that the designations of "proven", "promising" and "insufficient" refer to the quality of the existing scientific evidence on the use of the interventions in a range of settings. Interventions should be prioritized depending on the context. For example, in some settings with a long cycling tradition, vehicle speed may not be a key issue because the prevailing culture has incorporated cyclists into road design and user behaviour.

Table 1 **Key measures and specific interventions for preventing cyclist deaths and serious injuries**

Key measures	Specific interventions	Effectiveness in reducing deaths and serious injuries of cyclists: Proven	Promising	Insufficient evidence	References
Safer speeds	Reduce other vehicle travel speed to 30 km/h	■			*(30) (52-58)*
Safer roads	Segregated bike lanes with intersections	■			*(5) (53) (59-68)*
	Off road, non-motorized transport shared paths			■	*(69-74)*
	On-road bicycle lanes		■		*(62) (75, 76)*
	On-road shared bicycle boulevards		■		*(70-74)*
	Wide shoulders			■	*(77)*
	Bike box/advance stop line			■	*(55) (78-80)*
	Two-stage turn queue box			■	*(81)*
	Bicycle signals at intersections			■	*(55)*
	Raised bicycle crossings			■	*(82)*
	Overpasses and underpasses		■		*(83)*
	Traffic circles			■	*(53)*
	Roundabouts		■		*(76) (84, 85)*
	Bicycle network development		■		*(86-89)*
	Street lighting		■		*(36) (57) (90-92)*
Safer vehicles	Mandatory bicycle lights	■			*(30) (93)*
	Truck enhanced-mirror systems			■	*(94)*
	Truck side guards		■		*(94, 95)*
	Vulnerable road user airbags		■		*(96, 97)*
	Autonomous emergency braking		■		*(98-100)*
	Automated vehicles			■	*(101, 102)*
Safer road users	Bicycle helmet	■			*(44, 45) (47) (103-114)*
	Bicycle helmet legislation		■		*(107) (112) (115-121)*
	Enforcement of helmet wearing		■		*(112) (117)*
	Helmet standards		■		*(122, 123)*
	Non-legislative strategies to increase helmet wearing		■		*(107) (124)*
	Minimum passing distance law			■	*(125)*
	Law banning mopeds from bicycle paths		■		*(58)*
	Use of protective clothing			■	*(57) (91) (121) (126-129)*
	Education and/or training of cyclists			■	*(130-133)*
	Communication programmes			■	*(134, 135)*

Proven and promising interventions

Safer roads and urban design

The environment in which cyclists ride, and their potential exposure to motorized traffic, is one of the biggest factors for the overall risk for crash, injury, and death.

Segregated bike lanes with well-designed, safe intersections physically separate cyclists from motorized traffic and pedestrians. Bike lanes can be designed with one-way or two-way lanes, with the former offering greater safety in terms of reduced crashes and injury severity, especially when there is an increased number of possible turning conflicts and/or a lack of signalized intersection control *(59, 60)*. Bike lanes are safer than paths that are shared by different users *(61)* and provide 10% lower risk of injury than a main road with on-street parking and no bicycle infrastructure *(53, 62, 63)*. In general, the effectiveness of bike lanes may be limited at intersections where bicycle networks and general highway networks meet *(64, 65)*. Countries such as Germany, the Netherlands, New Zealand and the United Kingdom have a policy to provide segregated bike lanes where traffic speed, volumes and movements are high *(5, 67, 68)*.

On-road bicycle lanes, coloured or not coloured, designate a portion of the roadway for exclusive use by cyclists (*62,75*). A statistically significant 4% reduction in injury crashes is reported with the implementation of bicycle lanes *(62, 76)* but the results for the effectiveness of bike lanes are mixed in terms of fatal crash reductions *(136)*.

On-road shared bicycle boulevards indicate a shared lane environment for bicycles and motorized traffic through the use of lane markings or sharrows (bicycle markings but no lane markings). Signs for speed and traffic control measures are used to prioritize bicycle travel over motorized traffic *(69)*. Sharrows may benefit cyclist safety by influencing cyclist positioning and wayfinding on roadways *(70–73, 137)*. Reduction in injury crashes had been reported but the reduction was found to be larger for bike lanes (27.5 fewer injury crashes per year per 100 bicycle commuters) than for sharrows on their own (6.7 fewer) *(74)*.

Overpasses and underpasses enable cyclists to cross distributor roads without mixing with motorized vehicles. They can be associated with reduced likelihood of fatal and serious bicycle-motor vehicle crashes *(83)*.

Roundabouts circulate traffic around a centre island where entering traffic must give way to traffic already in the roundabout. Roundabouts typically improve road safety by controlling speeds and by reducing the number and severity of conflict points *(10, 84)*, but evaluation results for cyclist safety vary greatly with the various design features of roundabouts. Roundabouts produce a reduction in fatal crashes, non-fatal crashes, and crash severity for all road traffic crashes *(85)* but data specifically for cyclist safety is unavailable.

Bicycle network development consists of a mixture of interconnected treatments that consider survivable speed, visibility between road users, and separation of road users with vastly different levels of kinetic energy, especially at sites and on routes that attract busy or complex traffic movements. A bicycle network provides cyclists with a continuous route without disruption. The expansion of bicycle infrastructure in Boston between 2007 and 2014 increased cyclist commuters by 1.5% and reduced bicycle injury crashes by 8.1% *(86)*. Other cities such as New York City, Minneapolis, Mexico City, and Bogotá (Box 1) have also seen decreases in the rate of cyclist death and injury with the development of a bicycle network *(87)*. Evidence from pro-cycling countries, such as Denmark and the Netherlands, shows that networks of fully segregated, totally safe bike paths and 30 km/h speed limits reduce danger and eliminate fear as a barrier to cycling uptake *(5)*.

BOX 1: **Bogotá's CicloRuta cuts cyclist injury and death**

In 2000, Bogotá, Colombia, began the construction of a comprehensive bicycle network. It now extends over 340 km and is used by over 83 500 individuals every day. An estimated US$ 40 million is saved annually by citizens on fuel expenditure. CicloRuta has three networks, connecting educational and work areas, popular residential areas, and parks and recreational areas. From 2000 to 2007 bicycle use increased from 0.2% to 4%, significantly reducing CO_2 emissions and increasing access to the city for the lowest income groups. There was a 34% decrease in the number of cyclist-related fatalities, and an 8.8% decrease in cyclist-related injuries, despite the substantial increase in bike use.

Based on references *(88, 89)*

Street lighting increases nighttime visibility for road users. Though not specific to injury and fatal crashes involving cyclists, research shows that street lighting can reduce the total number of road traffic crashes, injuries and fatalities *(57, 92)*.

Safer speeds for motorized traffic

The key solutions for managing speed for all road users include the establishment and enforcement of speed limit laws as well as speed management measures in roadway design, and the installation of intelligent speed-adaptation technology in vehicles *(8)*. A comparison of cyclist fatalities before and after the introduction of 32 km/h zones in London showed reductions of 49.6% for cyclists overall, as well as for child cyclists *(52)*. Similarly, reduced risk of cyclist injury was found with motor vehicle speeds less than 30 km/h in Vancouver and Toronto, Canada *(53)*.

Safer vehicles

There are several types of vehicle that are used on the road. They include bicycles, motorcycles, cars, buses, and lorries. This section focuses on vehicle safety measures that enhance the safety of cyclists.

Mandatory bicycle lights could reduce the number of cyclist deaths and injuries by 3% if all new bicycles were sold with lighting equipment, and by 10% if all cyclists use bicycle lights in the dark *(93)*. However, many new bicycles are sold without lights and both cyclists and sales staff have little knowledge about legal requirements for bicycle lights *(93)*. Many countries require cyclists to use lights while travelling. For example, Australia requires riders at night and in hazardous weather that may restrict visibility to have a flashing or steady white light visible for 200 metres from the front and rear of the bicycle, and a red reflector visible for at least 50 metres on the rear of the bicycle. In addition, dealers are required to sell bicycles with lights and a bell attached *(30)*.

Truck side guards, also known as lateral protective devices (designed to keep pedestrians and cyclists from being run over by rear wheels of a large truck), may be effective in reducing the severity of crashes between trucks and cyclists. For example, the probability of death in side-impact truck-bicycle crashes was reduced by 20% following a national truck side guard requirement implemented between 1983 and 1986 in the United Kingdom. A 63% lower fatality rate was found among cyclists in left-turn bicycle crashes with side guard-equipped trucks compared to trucks exempted from the side guard mandate *(94, 95)*.

Vulnerable road user airbags are airbags that deploy on the side of a car in the event of a crash. They are capable of protecting pedestrians and cyclists in a crash and are being developed *(96)*. However, these measures may only be equipped on newer vehicles and are likely to take a number of years before full benefits can be realized *(97)*. Bike helmets with airbags have also been developed in Sweden and have been found to significantly reduce the risk of severe head injury in laboratory settings *(138)*. However, these devices require the accurate detection of a potential crash and have yet to be tested for their effectiveness in real-world settings.

Autonomous emergency braking (AEB) is an advanced technology designed for collision prevention and crash severity reduction and is a promising intervention to improve cyclist safety. AEB technology uses optical sensors, cameras, and radar, or a combination of these, to detect obstacles *(98)*. This technology was designed to prevent crashes between vehicles, but vehicle manufacturers are beginning to add the capability for vehicles to recognize cyclists as well. The addition of cyclist detection systems is anticipated to prevent crashes, injuries and fatal crashes *(99)*. The limitations of AEB systems include the variability of effectiveness due to daylight and weather conditions, the difficulties in optimizing these systems for relatively low speeds, and the inability to predict dangerous or distracted human behaviour *(100)*.

Safer road users

Bicycle helmets reduce the odds of head injury by 50%, and the odds of head, face, or neck injury by 33% *(108)*.

Bicycle helmet legislation refers to the laws or regulations requiring the use of a helmet while cycling. Depending on country context, bicycle helmet legislation can be enacted at national level and/or at subnational level (e.g. at state, provincial, and city level). A helmet requirement can be set for all cyclists or be limited to a specific age group, such as children. Other aspects covered by bicycle helmet legislation include helmet standards and penalties for non-use. Bicycle helmet legislation has been found to be associated with an increase in helmet use and decrease in bicycle-related head injuries (*135–141*).

It is also important to note that while there are studies showing the benefits of cyclists wearing a helmet, there are also studies suggesting that helmets could be linked to a decline in cycling *(139, 141)*. This latter group of studies is used by those who oppose mandatory bicycle law. Though bicycle helmet use is opposed by some groups, this does not imply that the benefits of helmet use should be ignored or underrated as there is evidence that strongly supports these benefits *(44–46, 108, 143)*. A systematic review conducted in 2008 concluded that high quality evaluative studies measuring the outcomes of bicycle helmet legislation did not report data on possible declines in bicycle use (*144*). While helmet wearing can help to reduce the seriousness of head injuries, it is not a substitute for system-wide changes in speed limits, driver behaviour, strict liability laws and a new engineering approach to total safety at junctions and roundabouts and well-funded networks of safe, segregated cyclist paths.

Enforcement of helmet wearing laws. The enactment of bicycle helmet legislation will not automatically lead to an increase in helmet use – enforcement is also needed, depending on context, to support compliance with such legislation and achieve the corresponding decrease in related head injuries. Legislation that is enforced can reduce bicycle-related head injuries by as much as 45% *(107)*. Strategies to enforce bicycle helmet legislation vary across countries, but the confiscation of bicycles for riders not wearing a helmet – a strategy deployed by a local authority in Georgia, USA – was effective in increasing helmet use *(145)*.

A comprehensive approach to bicycle safety is most effective in ensuring sustainable helmet use. A study looking at the long-term effects of a comprehensive approach (education, legislation, and enforcement on all-age bicycle helmet use) found that such an approach meant helmet use was sustained throughout the post-legislation period, from 75.3% in the year the legislation was enacted to 94.2% 14 years post-legislation, among all age groups and genders *(118)*.

Helmet standards. For a bicycle helmet to be effective in reducing the risk of head injury it must meet several product safety standards. Not all helmets provide equal protection *(123)*. Adequate safety levels for helmets can be achieved through mandatory safety requirements or standards intended to reduce the risk of cyclist injury and death by monitoring the production and distribution of bicycle helmets. Safety standards can be set at national or regional level. Some examples of institutions that have enacted helmet standards are the British Standards Institution, Canadian Standards Association, European Committee for Standardization, Standards Australia/Standards New Zealand, Swedish Board for Consumer Policies, and the United States Consumer Product Safety Commission *(124)*.

Non-legislative strategies to increase bicycle helmet wearing can include community interventions, school-based interventions, or free helmet distribution. Non-legislative helmet promotion activities have been found to produce a significant increase in observed helmet wearing, self-reported helmet wearing and self-reported helmet ownership among children and youth *(108)*. A non-legislative intervention employing bicycle safety education and free helmets increased observed helmet use from 38% to 46% among elementary school students *(125)*.

Laws banning mopeds from cycle paths in urban areas in the Netherlands have been shown to save lives and reduce injuries among moped riders and cyclists *(58)*.

Interventions with insufficient or weak evidence

In addition to effective and promising interventions, there are other interventions for which the evidence base is insufficient to recommend widespread implementation. As already noted, the lack of evidence does not necessarily mean that interventions are not relevant or good. It means that they have not been rigorously studied or that the intervention is still being developed. The interventions with insufficient or weak evidence for cyclist safety measures include the following:

- **Off road, non-motorized shared paths** that separate motorized traffic from cyclists, pedestrians, in-line skaters, and other non-motorized users who all share the path.
- **Wide paved highway shoulders** that are marked by line markings but with no bicycle markings, most often located on rural roadways.
- **Bike boxes or an advance stop line** that designate an area ahead of motor vehicles but behind pedestrian crossings at signalized intersections in which cyclists can wait during the red signal phase. Bike boxes are particularly helpful at intersections with high volumes of bicycles and where bicycle and motorist turns come into conflict. Reduction *(78)* or little change *(79)* in bicycle-motor vehicle conflicts, as well as an increase in bicycle crashes with motor vehicles *(80)* has been reported. Research evidence in terms of crash severity reductions is limited *(55)* but reductions in cyclist injury severity in crashes have been reported *(77)*.

- **Two-stage turn queue boxes** that enable the making of left turns in right-side direction countries or right turns in left-side direction countries at multilane signalized intersections without the need to merge across traffic.
- **Bicycle signals at intersections** that separate the crossing movements between cyclists and motor vehicles at complex intersections with a high volume of cyclists.
- **Raised bicycle crossings** that provide a continuation of raised cycle tracks across intersecting side streets and driveways.
- **Truck-enhanced mirror systems** that reduce blind spots.
- **Automated vehicles** that respond to external stimuli and support the task of driving.
- **Minimum passing-distance laws** that set a minimum distance that a vehicle must leave when overtaking a bicycle.
- **Use of protective clothing,** including wearing reflective or brightly coloured clothing.
- **Education and/or training cyclists** through programmes that aim to teach safe cycling skills.
- **Communication programmes** that aim to promote bicycle safety equipment and riding techniques.
- **Traffic circles** are small roundabouts that circulate traffic around a raised island in the middle of an intersection, which is typically controlled by stop or give way signs. This measure seeks to slow drivers by impeding the straight-through movement at an intersection.

These interventions tend to be limited in scope and their applicability beyond intervention sites has not been validated. Evaluations of such interventions have often been unable to reach a firm conclusion about the intervention's ability to reduce fatalities and injuries, or to bring about the intended behaviour change. Although such interventions cannot be promoted as effective or promising, they may be considered for local adaptation and further evaluation to confirm efficacy and define areas for modification. Adoption of these strategies (other than in trial form) to reduce cyclist-related injuries is not recommended until robust evidence of their effectiveness is available.

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Conclusion

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Conclusion

GLOBALLY, BICYCLES are used every day for commuting, leisure, health, tourism, work, school, sport, trade, emergency services, and policing. Modes of "active travel", such as walking and cycling, can reduce noncommunicable diseases including obesity, cardiovascular diseases and diabetes. Cycling provides numerous benefits to individuals and to society, such as physical exercise, enhanced access to places and services, a reduction in traffic congestion, flexibility with timetables and routes, reduced consumption of fossil fuels (and expenditure on these fuels), and reduced air and noise pollution.

However, almost half of all deaths on the world's roads are among those with the least protection – cyclists, pedestrians and motorcyclists. Cyclists are particularly vulnerable in the road environment, partly due to their physical lack of protection, perceptions of drivers about the rights of cyclists, and a lack of infrastructure provision to optimize their safety. Currently, road traffic danger and the fear of injury and death in the road traffic environment deter people from cycling.

To achieve significant health, accessibility, and environmental benefits, policies that support an increase in the number of cyclists should be accompanied by risk-reduction actions.

Improving cyclist safety requires a fundamental, system-wide approach. This underscores the importance of integrated land-use and transport planning that ensures accessibility using different modes of transport – as well as equity – in the allocation of road space and resources for transport systems.

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