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THE WORLD BANK

POWERED TWO- AND THREE- WHEELER SAFETY

A road safety manual for
decision-makers and practitioners

Second edition

COOPERATIVE
PUBLISHED

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ISBN 978-92-4-006056-2 (electronic version)

ISBN 978-92-4-006057-9 (print version)

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Suggested citation. Powered two-and three-wheeler safety: a road safety manual for decision-makers and practitioners, second edition. Geneva: World Health Organization; 2022. Licence: CC BY-NC-SA 3.0 IGO.

Cataloguing-in-Publication (CIP) data. CIP data are available at <http://apps.who.int/iris>.

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Preface

Road traffic injuries are a major public health problem and a leading cause of death and injury around the world. Each year approximately 1.3 million people die and millions more are injured or disabled as a result of road crashes, mostly in low- and middle-income countries (LMICs). As well as creating enormous social costs for individuals, families and communities, road traffic injuries place a heavy burden on health services and economies. The cost to countries, many of which already struggle with economic development, may be as much as 5% of their gross national product. As motorization increases, preventing road traffic crashes and the injuries they inflict will become an increasing social and economic challenge, particularly in LMICs. If the present trend continues, road traffic injuries will increase dramatically in most parts of the world over the next two decades, with the greatest impact falling on the most vulnerable citizens.

Appropriate and targeted action is urgently needed. The *World report on road traffic injury prevention*, launched jointly in 2004 by the World Health Organization (WHO) and the World Bank, identified improvements in road safety management and specific actions that have led to dramatic decreases in road traffic deaths and injuries in industrialized countries active in road safety. Addressing the safety of powered two- and three-wheelers (PTWs), the report showed, has saved thousands of lives. The introduction of speed limits, the creation of safer infrastructure, the enforcement of limits on blood alcohol concentration (BAC) while driving, and improvements in vehicle safety are all interventions that have been tested and repeatedly shown to be effective.

The international community must continue to take the lead to encourage good practice in road safety management and the implementation of the interventions identified above in other countries in ways that are culturally appropriate. To speed up such efforts, the United Nations General Assembly has passed several resolutions urging that greater attention and resources be directed towards the global road safety crisis. These resolutions stress the importance of international collaboration in the field of road safety.

These resolutions also reaffirm the commitment of the United Nations to this issue, encouraging Member States to implement the recommendations of the *World report on road traffic injury prevention* and commending the collaborative road safety initiatives taken to date. They encourage Member States to focus on addressing key risk factors and to establish lead agencies and coordination mechanisms for road safety. These were further encouraged through the Moscow Declaration (2009), Brasilia Declaration (2015) and the Stockholm Declaration (2020).

To contribute to the implementation of these resolutions, WHO, the Global Road Safety Partnership (GRSP), the FIA Foundation and the World Bank have collaborated to produce a series of manuals aimed at policy-makers and practitioners. This manual on powered two- and three-wheeler safety is one of them. Initially published in 2017, it has been updated to include new evidence and case studies. These manuals provide guidance to countries wishing to improve road safety organization and to implement specific road safety interventions outlined in the *World report on road traffic injury prevention*.

The manuals present cost-effective solutions that can save many lives and reduce the shocking burden of road traffic crashes around the world. We encourage all to use these manuals.

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Acknowledgements

WHO coordinated the production of this manual and acknowledges, with thanks, all those who have contributed to its preparation. Particular thanks are due to the following people:

Reviewers: Alina Burlacu; Dave Cliff; Natalie Draisin; Judy Fleiter; Cristina Inclán-Valadez (GRSP); Fangfang Luo (WHO); Blair Matthew Turner (World Bank).

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Financial support

WHO acknowledges with thanks the financial support from Bloomberg Philanthropies for the production of this manual.

Abbreviations

ABS	antilock brake system
BAC	blood alcohol concentration
DRLs	daytime running lights
ECMT	European Conference of Ministers of Transport
e-PMVs	electric powered motor vehicles
GRSP	Global Road Safety Partnership
HICs	high-income countries
INS	intersection safety
ITF	International Transport Forum
ITS	intelligent transport system
LMICs	low- and middle-income countries
M&E	monitoring and evaluation
OECD	Organisation for Economic Co-operation and Development
PMD	personal mobility device
PLRT	post-licence motorcycle rider training
PTWs	powered two- and three-wheelers
PTW2V	powered two-wheeler oncoming vehicle information system
THC	tetrahydrocannabinol
UHL	universal helmet law
VBS	vulnerable road user beacon system
WHO	World Health Organization

Executive summary

Road traffic crashes kill approximately 1.3 million people every year (1) – more than two every minute – with nine in ten deaths occurring in LMICs. Globally, road traffic crashes are the leading cause of death among children and young people aged 5–29 (1).

Nearly 30% of all crash fatalities reported to WHO in 2016 involve powered two- and three-wheelers (PTWs), such as motorcycles, mopeds, scooters and electrical bikes (e-bikes) (2). Crashes involving PTWs are often predictable and preventable and should never be accepted as inevitable.

Key risk factors for motorcycle traffic injuries include the non-use of helmets, vehicle speed, alcohol use, mixed traffic conditions, a lack of protection from the vehicle in a crash and a lack of safe infrastructure for PTWs such as poor road surfaces and roadside hazards.

It is possible to eliminate or least reduce the risks faced by PTW users, yet despite the existence of proven interventions, and that the number of PTWs in use continues to rise, in many places PTW safety does not attract the attention it deserves.

It is crucial that all relevant authorities and bodies put the laws, frameworks and actions in place to reduce deaths and injuries involving PTWs. Rooted in successful actions and new evidence, this updated manual sets out what is needed. It examines the extent of PTW-related fatalities and injuries, and the importance of addressing the key risk factors.

The manual is applicable worldwide, but targets decision-makers and practitioners in developing countries. It offers key evidenced-based interventions to support countries in promoting actions with a focus on road engineering measures, standardized vehicle safety features and the introduction and enforcement of key road safety legislation combined with strong social marketing. The steps outlined for conducting a situational assessment aim to help prioritize interventions, prepare a related plan of action and help implement and evaluate PTW safety measures.

In the 5 years since the first edition of this manual, the global landscape has changed significantly. The rapid increase in PTW use, as well as e-bikes, pose new challenges. With the adoption of the United Nations Decade of Action for Global Road Safety 2021–2030 and the subsequent Political Declaration adopted by the United Nations General Assembly in July 2022, countries are adopting the Safe Systems approach, that recognizes that road transport is a complex system with interconnecting elements that all affect each other.

A Safe System can only be achieved if safety becomes a fully integrated element in how we organize, design and build out our mobility systems. It requires looking at how mobility systems are designed and organized, how they operate and how people, vehicles and infrastructure all affect the decisions made by the users of the system.

In this context, actions to ensure safety for PTW users must be part of a holistic and whole-of-government approach to road safety and safe mobility.



Introduction

Why were these manuals developed?

Since 2006, the WHO, World Bank, FIA Foundation and Global Road Safety Partnership (GRSP) have produced a series of good practice manuals, which provide guidance on the implementation of interventions to address specific risk factors in road safety, and supporting the implementation of good practices in road safety to help make the world's roads safer for all. The topics covered in the first series of manuals were: helmets (2006), drinking and driving (2007), speed management (2008), seat-belts and child restraints (2009), data systems (2010), pedestrian safety (2013), road safety legislation (2013), powered two- and three-wheeler safety (2017) and cyclist safety (2020). In addition, WHO produced a road safety technical package, Save LIVES (2017), which presents 22 evidence-based interventions related to speed management, leadership, infrastructure, vehicles, enforcement and post-crash care.

Why are these manuals being revised?

Since the series of manuals was first published, the scientific evidence base relating to various risk factors and interventions has continued to expand. Contemporary research has refined our knowledge about specific risk factors, such as distracted driving, and vehicle impact speed and risk of death for pedestrians. New issues and practices have arisen, such as a tropical helmet standard and an anti-braking control standard for motorcycles. New and existing interventions have been implemented and evaluated, with increasing application in LMICs. Research attention and policy response have also increasingly been applied to emerging road safety issues including e-bikes, drugs other than alcohol, fleet safety, urban mobility, micromobility options, air and noise pollution, public transport and technological advances.

As a result of these developments, the good practice manuals required revision so that they can continue to be key references for road safety policy implementation and research. This is particularly important, given the emphasis placed on road safety within the framework of the 2030 Agenda for Sustainable Development and because of the global impetus to reduce road deaths and injuries resulting from the declaration of the two United Nations Decades of Action for Road Safety (2011–2020 and 2021–2030). The manuals have been revised to reflect these developments as they continue to provide the evidence-based and cost-effective solutions to save lives and reduce injuries. An extensive literature review has informed the revision and updating of all the manuals, and additional information has been collated to allow more contemporary case studies to be showcased. In addition, the need to broaden the topics covered in the manuals to include aspects such as qualitative research methods and participatory approaches to designing and evaluating interventions was identified. An emphasis on shifting traditional thinking away from blaming road users towards more contemporary frameworks, such as the Safe System approach, is key in the revised manuals. An area requiring ongoing consideration is decolonizing knowledge and practice within the road safety field.

A review of the evidence on risk factors and interventions was conducted to inform revision of this manual. The review utilized text mining techniques to gather evidence on risk factors and outcomes of interventions. This technique creates computational algorithms for reading and extracting texts from a large volume of information in a short period of time. The review was limited to January 2008–December 2019, with the understanding that the previous manual had drawn on the evidence that existed before January 2008. Only papers in English, Spanish, French and Portuguese were included in the literature review. Studies excluded were those presented in conference proceedings, editorials and draft papers. The full search generated 157 abstracts relevant to PTW safety, which were screened to produce 53 full studies for review for this manual. The two experts who conducted the literature review grouped the interventions into three categories – proven, promising and insufficient evidence – based on the existing best practices in road safety. The Advisory Committee reviewed the categories and refined them based on the existing best practices in road safety policy and their expert knowledge.

Safe System approach

The Safe System approach recognizes that road transport is a complex system and places safety at its core (3). It also recognizes that humans, vehicles and the road infrastructure must interact in a way that ensures a high level of safety (Fig. 1). A Safe System therefore (3):

- anticipates and accommodates human errors;
- incorporates road and vehicle designs that limit crash forces to levels that are within human tolerance to prevent death or serious injury;
- motivates those who design and maintain the roads, manufacture vehicles and administer safety programmes to share responsibility for safety with road users, so that when a crash occurs, remedies are sought throughout the system, rather than solely blaming the driver or other road users;
- pursues a commitment to proactive and continuous improvement of roads and vehicles so that the entire system is made safe rather than just locations or situations where crashes last occurred; and
- adheres to the underlying premise that the transport system should produce zero deaths or serious injuries and that safety should not be compromised for the sake of other factors such as cost or the desire for faster transport times.

Fig.1 Safe System approach



Source: (4).



Module 1

Why is addressing powered two- and three-wheeler safety necessary?

1.1 What are powered two- and three-wheeler vehicles?

PTWs are motor-operated two- or three-wheeled vehicles, powered by either a combustion engine or rechargeable batteries. Examples of these powered vehicles are motorcycles, scooters, mopeds, e-bikes; and auto-rickshaws (5). It should be noted that self-balancing vehicles are, in some cases, classified as toys and not permitted to be used on public streets. The types of powered two-wheelers covered in this manual are motorcycles (which include scooters), e-bikes and motor or auto-rickshaws. In light of the growing international use of micro-vehicles and the difficulty in defining and categorizing them, authorities in Singapore have created a new vehicle category – personal mobility device (PMD) (6). There is a need to review the existing classification of vehicles to include these emerging vehicles.

Fig. 1.1 Range of PTW vehicles



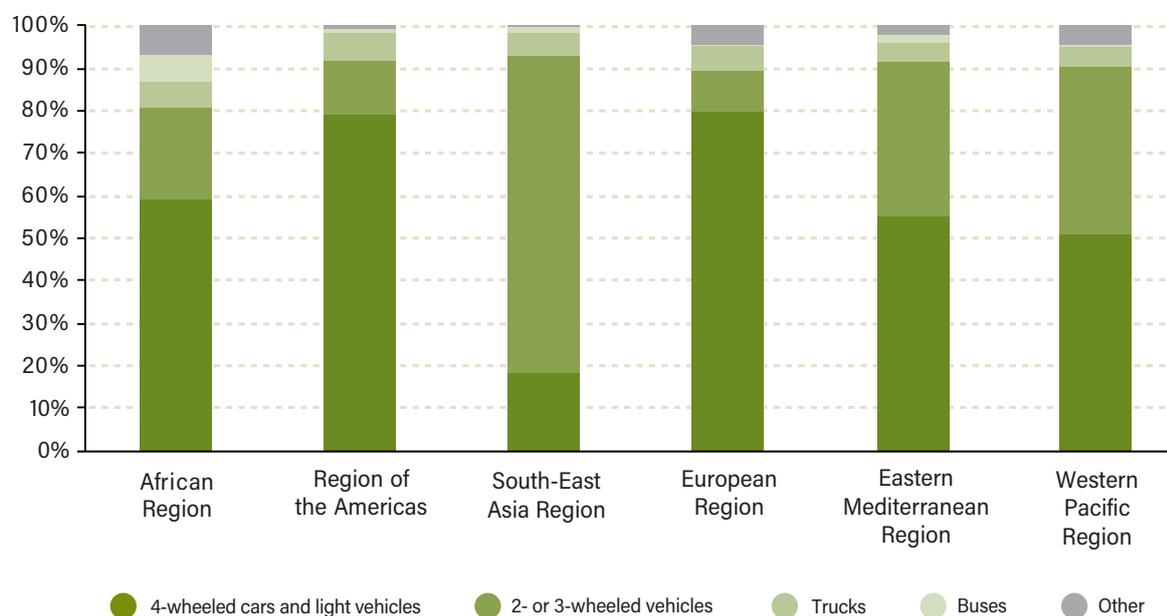
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1.2 Importance of powered two- and three-wheelers for mobility and accessibility

Accessibility refers to the ease of reaching destinations or activities located in different places. It focuses not only on access to different modes of transport but also the ability of transport to reach different destinations and activities such as educational institutions, employment places, shopping centres and residential areas. PTWs are important modes of transport, complementing, competing with and supplementing other modes like walking, bicycle, bus, train and private car. Though PTWs are increasing in importance, their use is not the same in all countries or regions. They are growing in most LMICs, partly as a solution to increasing traffic congestion in urban areas and the high cost of other forms of transportation. In addition, easy access to finance to purchase motorcycles, the convenience of parking and low cost of maintenance have contributed to their growth. Though this development responds to an unfulfilled transport demand, most of the users of this mode in LMICs are of low socioeconomic status. They are captive users, utilizing this mode largely due to limited choices. This development inevitably exposes the poor or low-income sections of society to negative consequences, such as a road traffic crashes associated with PTWs.

The use of PTWs has increased in importance in all parts of the world, representing a sizeable and varied user population (5–7). Fig. 1.2 shows that the WHO South-East Asia Region had the highest proportion of registered PTWs in 2019, followed by the Western Pacific Region and Eastern Mediterranean Region.

Fig. 1.2 Global distribution of registered motorized vehicles, WHO region, 2019



Source: Based on data collected by WHO.

Personal scooters and e-bikes are increasing in importance in high-income countries (HICs) in regions such as Europe. The bicycle has long been used for short local trips in European cities but the situation is changing with several such trips being undertaken using electric powered motor vehicles (e-PMVs) (6–7). There is growing attention being drawn to a new range of vehicles such as standing e-scooters, e-skateboards and self-balancing vehicles.

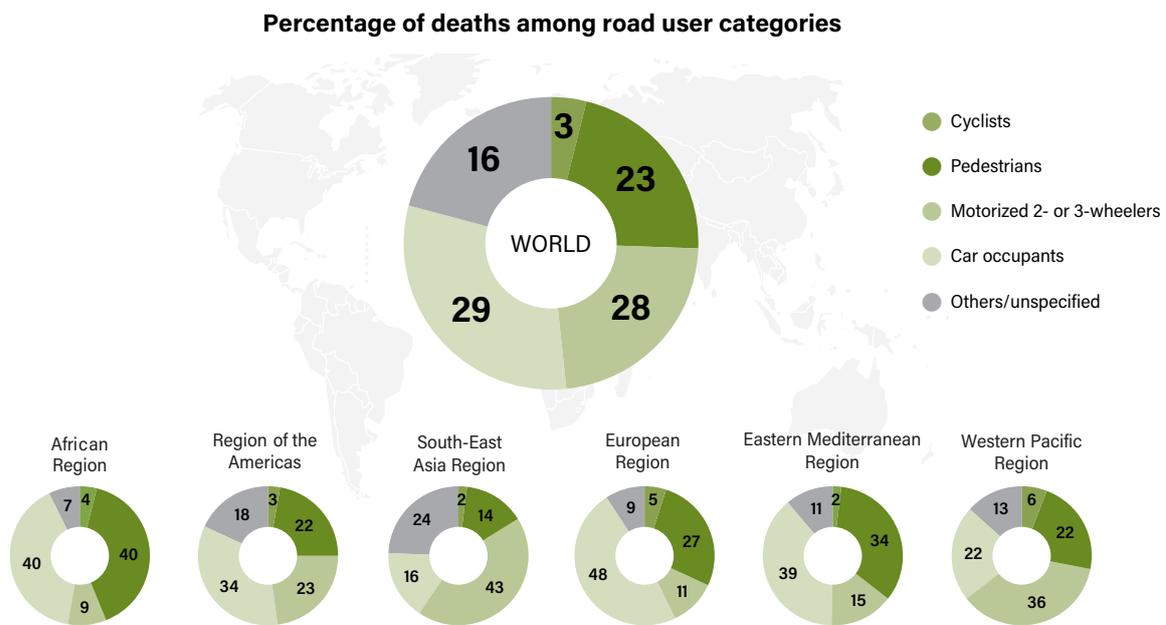
The demand for and use of PTWs show that mobility is a vital aspect of daily life. PTWs are used for activities linked with daily life, working, education, recreation and health care. These activities are often located in different places and therefore people and goods have to move from one place to another using different modes of transport (8). Several factors account for the increasing use of PTWs in different parts of the world. In some regions high motorcycle sales are associated with readily available finance and the availability of affordable, low-capacity motorcycles (9).

While PTWs meet mobility needs for different people, purposes and places, the safety of those who use them needs to be considered or ensured in transport planning. In some contexts, facilities such as parking slots and lanes for motorcycles have not been adequately provided. The growing use of scooters poses a challenge because they are not well integrated into transport planning, including inadequate allocation of road space to this mode. Further, negative perceptions towards PTW users creates problems regarding road use and their incorporation into transport planning. Traffic laws on speeding, alcohol impairment and helmet use for PTWs are yet to adequately incorporate the emerging technological adoption by PTWs. There is a need to take a fresh look at how these developments associated with PTWs are or should be reflected in transport policies.

1.3 The powered two- and three-wheeler-related injury problem

Nearly 30% of all road traffic fatalities reported to WHO involve PTWs, such as motorcycles, mopeds, scooters and electrical bikes (e-bikes) (2). The *Global status report on road safety 2018* (2) shows that globally 378 000 motorcyclists were killed in road traffic crashes in 2016. This represents more than a quarter of all road traffic deaths in that year. PTW safety is a concern to all WHO regions (see Fig. 1.3).

Fig. 1.3 Road traffic deaths by type of road user, WHO region, 2016

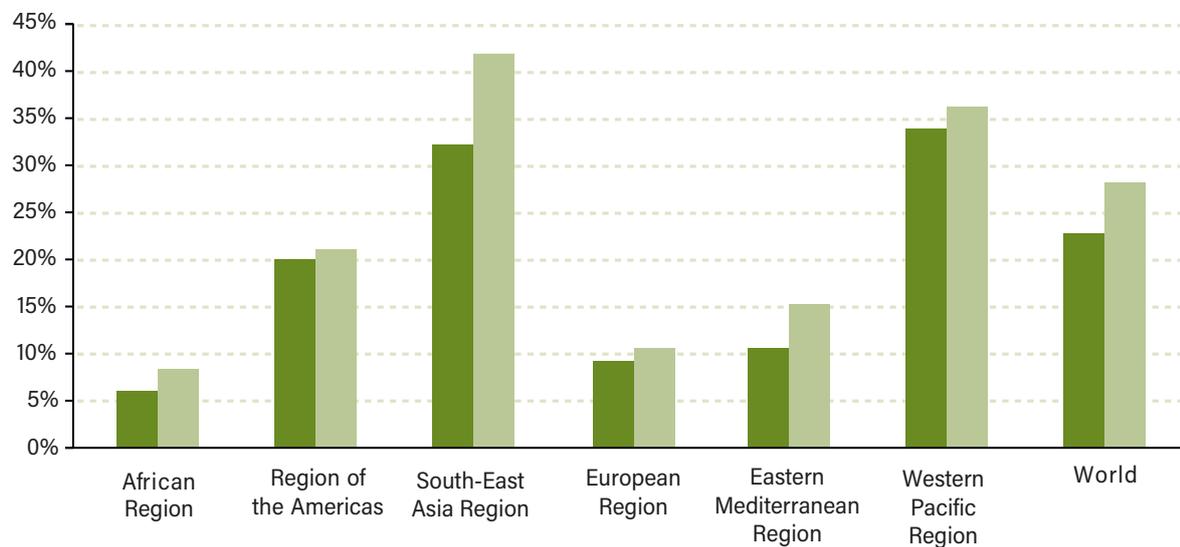


Source: Based on (2).

Between 2013 and 2016 the proportion of PTW deaths globally increased from 23% to 28% and this is observed in all regions, with the South-East Asia Region having the highest increase from 34% to 43% in 2016 (see Fig. 1.4). Fatality data for different regions, as reported in the *Global status report on road safety 2018 (2)*, indicate a large variation within regions in the proportion of PTW fatalities:

- While African countries, on average, had the lowest proportion of traffic-related fatalities among PTW users (9%), some countries in the region had a proportion of PTW fatalities as high as those of the South-East Asia and Western Pacific Regions.
- In Cambodia and Thailand, where there is a large PTW fleet, motorcycle fatalities in 2016 accounted for 73% and 74% of total road fatalities respectively, while in HICs in the same region, such as Australia and the Republic of Korea, motorcycle fatalities accounted 20% and 19% of all traffic-related deaths respectively.

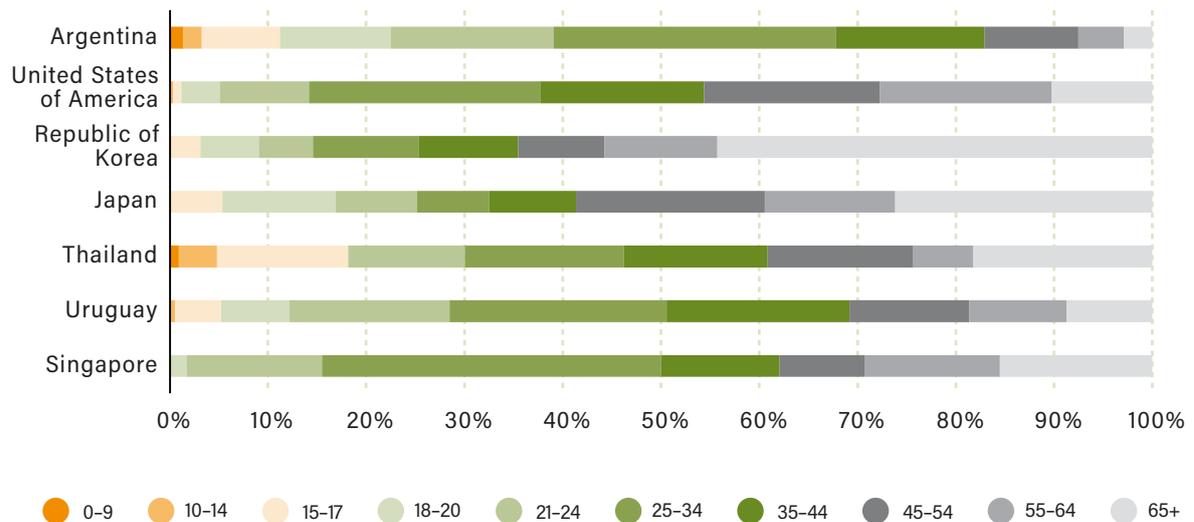
Fig. 1.4 Proportion of motorcyclist deaths by WHO region 2013–2016



Source: (2).

Fig. 1.5 shows data for the most recent year available from selected countries on the distribution of PTW-related deaths by age group. The age distribution of PTW users killed differed significantly between countries. PTW user deaths remained consistently high across the 25–34 year age group. In selected countries (Japan, Republic of Korea), the largest proportion of PTW deaths occurred among people aged 65 years and above (44% and 26%, respectively).

Fig. 1.5 Age distribution of PTW users killed, selected countries



Source: Based on data collected by WHO.

1.4 Risk factors for powered two- and three-wheeler injuries and deaths

The key risk factors that contribute to PTW-related crashes, injury and death are associated with the road environment, the vehicle, the road user and the standard of post-crash response. These factors are summarized in this module. Intervention measures to address these risk factors are described in Module 2.

1.4.1 Risk factors related to the road environment

Lack of inclusive urban planning

Transport planning is concerned with identifying transport needs and designing and implementing policies and infrastructure to meet them. It should seek to develop or provide different modes of transport such as roads, railways, air and water to meet different travel needs. In the case of road transport planning, it is necessary to consider the needs of all users including walkers, cyclists, PTW riders and four-wheeler riders as well all socioeconomic groups in the allocation of road space. Transport planning has not adequately responded to the growth in PTWs. The rapid growth of cities and urban populations has outpaced the development of urban transport infrastructures that cater to PTWs, resulting in an increase in PTW fatalities (10). Transport planning needs to respond and cater not only for infrastructure and services for PTWs but also for other modes of transport such as walking and cycling that have largely been neglected in land use and transport planning. Inclusive transport planning will not only enhance equal access to transportation or mobility options but also maximize the benefits of clean air and safety, especially in LMICs.

Mixed traffic

Operating PTWs in mixed traffic (i.e. with no segregation) significantly increases the likelihood of PTW collisions. In countries where there is a large PTW fleet, mixed driving conditions (in which interaction between PTWs and larger vehicles is frequent) result in an increased crash risk (11-12). An increase in traffic volume on both major and minor roads, as well as at junctions, increases the exposure of PTWs to other vehicles moving at different speeds and, consequently, increases the likelihood of crashes (13-14). In HICs, in particular, low familiarity with PTWs for some car drivers – as well as challenges in detecting PTWs and judging their speed – can make the mixed traffic environment dangerous for PTW users (15).

Lane sharing by PTWs and other traffic, also known as lane splitting or filtering, is common in many countries. There are reports of advantages of lane sharing in terms of reducing traffic congestion and travel time by PTW riders – with associated economic and environmental benefits (16). There are few studies available, however, that have examined the risk to PTW riders' safety posed by lane sharing. The main safety concern is associated with the movement of other vehicles into the path of the PTW rider, when drivers have not seen or are not expecting the PTW to be there (17). One review of lane sharing indicated that this practice is associated with between less than 1% and up to 5% of motorcycle crashes, although the relative risk does not appear to have been the focus of the research (18). As traffic congestion is set to increase in most urban areas of the world, there is increasing pressure for lane sharing by PTWs.

Design of road infrastructure

Road infrastructure design can influence both the likelihood and severity of a motorcycle crash (18). Studies have shown that motorcyclists are particularly vulnerable to collisions on curves, bends, slip roads (i.e. roads with a tight radius) and roundabouts. This is mainly due to acceleration or deceleration, or where stability is at stake, making loss of control likely. Intersections and roundabouts are commonly associated with motorcycle crashes involving right of way violations (19), an increase in approach speed (15) and violating traffic signals (18). However, a recent study using data from Australia and New Zealand demonstrated that the risk of motorcycle crashes on curves and other road features such as intersections or straight roads also varies by travel purpose (commuting or recreational) (20). Other studies show that a higher proportion of crashes occurred on curves during recreational times, while most of the crashes on straight roads and at intersections occurred during commuting (21-22) and demonstrated that road infrastructure design can have an impact on crash severity (23).

Specific design elements identified as contributing to increased severity include lane and shoulder width, surface friction, curve type and radius, horizontal and vertical sight distances, and turning provisions, including signal phasing at intersections (21). Other poorly designed road treatments, such as ones dedicated to lowering the speed of other road users, and the choice of location of other roadside equipment used for lighting or signage, can also have a negative impact on PTW safety (9).

In Florida, USA, results of a study showed that sharp curves (radius < 460 m) compared with flat curves (radius ≥ 1220 m) tended to increase the probability of severe injury for motorcyclists by 7.7%. Other significant factors were lighting conditions, weekends, speed, collision type, alcohol or drug impairment, rider age and helmet use (21).

In Hunan, China, a study investigated several factors (road user, environment, vehicle) linked to the severity of two-wheeler injuries and found that first-class, second-class and lower highways were

more related to severe crashes, compared with urban streets. The estimated parameters for these two variables are statistically significant (21).

Road surface conditions

The road surface condition presents a unique level of crash risk to PTW users (24). Uneven road surfaces, deterioration, potholes, unpaved curbs, manhole covers, bumps, drainage, spillages, poor road markings and debris are road surface factors that have been shown to increase the risk of PTW crashes (19, 22).

Roadside hazards

Roadside hazards can be fixed roadside objects such as trees, signposts, guardrails, utility poles and drainage structures, as well as transient objects such as parked cars, and they all present the greatest risk to PTW users. A crash involving a fixed roadside hazard is 14 times more likely to be fatal than a crash on the ground with no physical contact with a fixed hazard (24). The severity of a PTW crash with a roadside object is dependent on collision speed, impact angle, the surface area of the object and the impact absorption properties of the object (25). In a study that looked at such risk factors, combined with speed, roadside objects were the primary mechanisms by which fatal injuries were sustained by motorcyclists. Another study using data from Australia and New Zealand concluded that many of the roadside fixtures such as rails and sign posts provide protection for cars, they can be hazardous to PTW users (19). This situation is mainly due to the fact that objects like guardrails have been designed for the safety of cars and their occupants rather than for PTWs.

Limited public transport infrastructure

The lack of alternative means of transport in urban settings in LMICs limits commuter choice. The increase in the demand for and use of PTWs increases the pressure on urban infrastructure, with competition for space on roads shown potentially to further exacerbate the risks of injury and death among riders (26).

The limitations in road infrastructure highlighted earlier reveal that the design of transport systems has not adequately considered the needs of PTWs. Regions and countries that have recently witnessed an increase in the use of different types of PTWs have not at the same time seen a significant shift in road infrastructure design and development to accommodate this evolving mobility reality.

1.4.2 Risk factors related to the vehicle

PTW stability

The stability of PTWs depends on travel speed and on there being sufficient friction between the tyres and the road (27). Certain types of PTWs can become unstable when the available friction limit has been exceeded (such as on wet roads) or when acceleration or braking forces are too high. Unlike four-wheeled vehicles, motorcycles have the ability to lean during cornering. The roll angle that occurs while a rider is leaning during cornering is very sensitive to any changes in applied force, and any sharp increase or decrease in roll angle may lead to loss of control and thus to increased crash risk (28).

Lack of crash protection

The inherent lack of crash protection to PTW riders and passengers puts them at a higher risk for traffic-related injuries and deaths (29). The injuries sustained tend to be more serious in PTW users than car occupants because of this lack of protection (30–32). In addition to head injuries, the lower extremities (including the pelvic region) are the second most commonly injured part of the body among motorcyclists who have crashed (33–34). These trends are of particular concern as they might easily be applicable to numerous countries around the globe where two-wheeler use is on the rise, highlighting the urgent need for further research and intervention planning (35–36).

Braking errors

In emergency situations, riders often fail to use full braking capacity. Braking errors lead to loss of control of the PTW, putting both the rider and any passenger(s) at an increased risk of serious injury and death (27).

1.4.3 Risk factors related to the road user

Although some of the most common road user-related risk factors, such as speeding, drinking and driving, and lack of experience, apply to all road users, there are some behaviours specific to PTW users that put them at increased risk of fatal crashes or injuries. Road user-related risk factors concern the behaviour of riders as well as other road users with whom they interact in the traffic environment.

Non-use of helmets

The non-use of helmets by PTW users is an important factor influencing the risk of road traffic crash-associated head injuries and fatalities. Injuries to the head and neck are among the main causes of death, severe injury and disability among PTW users. During a PTW crash there may be two principal mechanisms of injury to the brain: through direct contact with a surface or other object, and through acceleration-deceleration forces (37). Each mechanism causes different types of injuries. The purpose of a helmet is to reduce the risk of serious head and brain injuries by reducing the impact of force to, or collision with, the head. The risk of head injury and fatality also varies according to the quality of the helmet and face coverage – while not wearing a helmet is a risk factor, it is important to point out that wearing poor quality and non-standard helmets also puts the rider at increased risk of head injury and fatality in the case of a crash.

In the USA, a study found that motorcyclists who use helmets in order to comply with mandatory helmet laws are 29.8% less likely to receive a traffic citation for risky driving behaviour (speeding, alcohol, etc.), travel at a 6 mph (10 kmh) lower average speed, and have a 47.4% reduction in the probability of severely damaging their motorcycle in a crash (38).

In California, USA, a cohort-study concluded that the estimated risk of death was greatest for novelty helmet users (5.4%), followed by users of modular helmets and half-helmets (3.1% each), open-face helmets (2.8%) and full-face helmets (2.4%). The adjusted fatal injury risk ratio for novelty helmets was almost two times more when novelty helmets were compared with full-face helmets (31–32).

Another study in the USA from 2019 on helmet type and risk-taking concluded that partial helmet coverage was associated with a lower likelihood of motorcycle crashes (by 55%) when compared with full helmet coverage likely due to the varying risk-taking attitudes of riders with different helmet types. High front tyre tread depth (5/32" [4 mm] or more) was found to decrease the chances of being in a crash by 48% (30).

Speeding

Excessive and inappropriate speed is the leading cause of road trauma in many countries (39–41). The higher the speed at which a vehicle travels, the longer the stopping distance. The lack of protection for PTW users during a collision means they are particularly vulnerable to severe or fatal injury associated with excessive speed. Speed is implicated in a higher proportion of fatal motorcycle crashes compared with other road users, which makes speed a particularly important risk factor for this road-user group (42). In the USA in 2013 for example, 34% of all motorcycle riders involved in fatal crashes were speeding, compared with 21% for car drivers, 18% for light truck drivers and 8% for large truck drivers (43). Other research has shown that motorcyclists, particularly those riding sports bikes, drive faster and engage in extreme speeding more often than other road users (44). Speeding is also reported as a factor in PTW crashes in segregated motorcycle lanes (16).

A cross-sectional study conducted in Rawalpindi city, India, in 2019, found that the probability of minor injury increases on divided streets and road segments with a posted speed limit of less than 50 kmh, involving Chinese brand motorcycles, registered motorcycles, and where at least one motorcycle and auto-rickshaw are involved. These findings suggest that there is a need to lower speed limits on roadway segments with higher motorcycle populations, separate motorcyclists from heavy vehicles, remove dangerous fixed objects such as poles and trees from roadsides, and encourage the use of low engine capacity bikes for daily commutes in an effort to lower injury severity (29).

Alcohol impairment

Alcohol impaired driving due to alcohol consumption is an important factor influencing both the risk of a road traffic crash as well as the severity and outcome of injuries that may result from it (45–46). According to the European SARTRE4 study on road safety attitudes, European motorcyclists from several countries reported drinking and riding, although there were significant regional differences in frequency between northern, eastern and southern European countries. In general, declared drinking and riding was higher among the following groups: males, those with increased exposure (amount of riding), those who tended to underestimate their risk of crashing, people who had been involved in a previous crash or had incurred a penalty for riding under the influence of alcohol (47).

Alcohol consumption is also associated with other risky PTW rider behaviours, such as speeding and not using helmets (48–49). A study in Australia in 2018 showed that motorcyclists involved in crashes due to intoxication had the highest average length of hospital admission and the longest average periods with disability before returning to their previous occupation, compared with a number of other causative factors for rider error and loss of control (50). Although limited, there is some evidence from LMICs on the impact of alcohol on driving performance. In one hospital-based study of PTW-related injury cases in Sri Lanka, the majority (67%) of night-time crashes were related to alcohol (51).

A recent study conducted in Arizona, USA, using data of 5069 young drivers injured over a 7-year period (from 2008 to 2014) suggested that drivers with an over the blood alcohol concentration (BAC) limit

or presence of alcohol BAC or tetrahydrocannabinol (THC) result were 40–90% more likely to sustain injuries than their counterparts who tested negative for the substance (52).

A study carried out in Arizona to examine associations between driving under the influence of drugs and/or alcohol and driver-related risk factors, found a risk between 4 and 6 more times for drug/alcohol-impaired drivers in comparison with sober drivers related to non-use of a seat-belt and speeding. For motorcyclists the highest risk was between four and nine more times for non-use of a helmet. The findings that shows that 39% of motorcycle riders aged 16 or 17 years were not helmeted at the time of the crash illustrates the difficulty of enforcing motorcycle helmet laws (53).

Studies that looked at the relationship between riding and drug use, other than alcohol, found that riding under the influence of a drug increases the risk of fatal crash (53). Studies that looked at the prevalence of different types of drugs used by injured riders in Organisation for Economic Co-operation and Development (OECD) member countries showed that the proportion of drivers consuming drugs was higher among PTW riders than car drivers (9).

Rider's age and level of experience

Young and older riders have a higher risk of injury. While the increased crash risk among young riders is predominantly associated with their lack of experience and greater propensity to adopt risky behaviours, the increased injury risk and injury severity among older riders tends to be associated with physical fragility and decrease in riding practice (i.e. the distance ridden every year). Riding ability and performance of older riders has been shown to decrease in riders over 60 years of age (35–36). For young riders, factors relating to their physical state and condition, motivations, riding style and awareness of other road users may also put them at increased risk of crashing (9).

In Utsunomiya, Japan, a 7-year study from 2011–2017 comparing risk factors for motorcycles and mopeds, found that moped riders were significantly older than motorcycle riders (50.7 ± 25.0 years vs 35.1 ± 18.6 years). The frequency of persons injured was significantly higher in moped riders than in motorcycle riders (21.3% vs 10.9%), and moped riders tended to have a higher likelihood of sustaining traumatic brain injuries. Mopeds are frequently utilized by elderly individuals in Japan, which may have been causally associated with the higher frequency of traumatic brain injuries in moped riders, while other causes, including the difference in helmet type, may also be involved (54).

In Fortaleza, Brazil, an analysis of injury severity in motorcycle crashes in 2017 found that motorcyclists using helmets reduced their chances of suffering severe and fatal injuries by 9%. Crashes involving motorcyclists older than 61 years had a 22% higher probability of resulting in severe and fatal injuries (36).

Failing to see PTWs

Situations in which a driver of a motor vehicle may have looked but failed to see the approaching PTWs have been documented as one of the most significant contributing factors to PTW crashes in HICs such as the United Kingdom (37). An increase in approach speed by motorcycles contributes to a higher number of "looked-but-failed-to-see" crashes at intersections, likely due to the motorcyclist being outside the other driver's field of view at the time (44).

Because of their smaller size and rapid acceleration, PTWs are often not seen in time to avoid a collision. Problems of other road users detecting approaching PTWs at junctions, and right-of-way-violations, are

some of the problems that can lead to crashes. The more conspicuous PTWs can be, the more likely they will be seen by other motorists (14).

1.4.4 Post-crash response

Lack of appropriate post-crash care increases the risk of injury and death for PTW riders when a collision occurs. The type of injuries sustained by motorcyclists who use full-face helmets, chin straps and some types of protective clothing suggest that there are a number of unique aspects of airway, circulatory and spine management for motorcycle crash casualties, and that professional training is important to be able to assess the threats to breathing versus the threat of spinal injury (32, 40).

1.5 Summary

The PTW fleet is growing in size and diversity of vehicles in most parts of the world, attracting an increasingly large and varied user population. The global registered PTW fleet increased by 10% between 2013 and 2016. PTWs are becoming one of the main means of transport used to move people and goods in many LMICs and HICs. PTW users account for more than a quarter (28%) of global road traffic deaths. There is great variation between and within regions in the distribution of deaths by road user category. While there is an exponential growth in the use of e-bikes, scooters and other light-engine mopeds as modes of transport, along with the associated risk increase and higher hospitalization costs, legislation on PTWs lags behind as compared with other vehicle types.

Key risk factors for PTW traffic injury are traffic mix, roadside hazards, vehicle instability, braking errors, non-use of helmets, use of alcohol and drugs, and speeding.



Module 2

Evidence-based powered two- and three-wheeler interventions

This module discusses specific interventions to improve PTW safety. Several specific interventions, both effective and promising, have been evaluated. These include interventions that focus on road engineering measures to minimize exposure to high-risk scenarios; interventions that promote standardized vehicle safety features; and the introduction and/or enforcement of key road safety legislation combined with strong social marketing to promote the uptake of and compliance with legislated interventions.

2.1 Overview of interventions

A summary of effective road safety interventions specific to PTW safety are summarized in Table 2.1. This includes a review of evidence from January 2008 through December 2019, resulting in an additional 53 full studies that were considered in this update. The effectiveness of interventions relates to the reduction of fatalities or injuries as well as other measurable change(s) in the behaviour of the road user targeted by the intervention. The evidence on interventions is categorized into one of three groups: proven, promising or insufficient evidence. The assessment of effectiveness and impact was made using several tools developed in evidence-based medicine and policy research. For the purpose of this document the following intervention category definitions are used:

- **Proven or effective:** Evidence from studies such as systematic reviews, experimental trials, case-control or cohort studies demonstrate that these interventions are effective in reducing PTW-related fatalities and injuries, or in bringing about desired behaviour change, combined with likely feasibility or cost-effectiveness.
- **Promising:** Evidence from studies shows that some safety benefits have resulted from these interventions, but further evaluations from diverse settings are required and thus caution is needed when implementing such an intervention.
- **Insufficient evidence:** Evaluation of these interventions has not reached a firm conclusion about their ability to reduce fatalities and injuries or bring about desired behaviour change. This may be due to a lack of quality evidence on these interventions or the evidence that exists may be equivocal.

Table 2.1 Key measures and specific interventions for improved PTW safety

Key measures	Specific interventions	Effectiveness		
		Proven	Promising	Insufficient evidence
Safer roads and mobility	Exclusive motorcycle lanes	■		
	Protected turn lanes and widened shoulders or lanes		■	
	Removal of roadside hazards		■	
	Speed limiters and traffic calming structures		■	
	Improving road surface conditions		■	
	Modifying the composition of roadside barrier building material			■
Safer vehicles	Antilock brake systems (ABS)	■		
	Headlights at night		■	
	Daytime running headlights		■	
	Configuration to enhance stability			■
	Airbags for motorcycles			■
	Intelligent transport systems			■
	Brake lights			■
Safer road users	<i>Setting and enforcing legislation</i>			
	Mandatory helmets	■		
	Helmet standards	■		
	Strengthening penalties	■		
	Demerit point system		■	
	<i>Wearing reflective and protective clothing</i>			
	Reflective clothing use		■	
	Protective clothing use		■	
	Thermal resistant shields			■
	<i>Regulating and licensing PTWs</i>			
	Mandatory registration of vehicles and licensing of PTW operators	■		
	Graduated licensing system		■	
	Age restrictions for children riding or as passengers on PTWs			■
	Restriction on multiple pillion passengers			■
	Periodic inspection for mechanical defects			■
	Minimum height for pillion passengers			■
Smaller engine size for learner riders			■	
<i>Training</i>				
Compulsory skill test for motorcycle permit	■			
Post-licence training			■	
Post-crash response	On-site helmet/collar brace removal		■	

2.2 Interventions related to safer roads

As mentioned in Module 1, an increase in traffic volume on both major and minor roads, and the presence of mixed traffic, including other vehicles moving at different speeds, increases the likelihood of PTW crashes (5, 7, 21). Low familiarity with PTWs for some car drivers – as well as challenges in detecting PTWs and judging their speed – can make the mixed traffic environment dangerous for PTW users (55). Currently, the only documented proven effective intervention in this category is that of exclusive motorcycle lanes. Other road engineering measures, such as the introduction of protected turn lanes, widened shoulders and the removal of roadside hazards, are reported as promising PTW safety interventions. These interventions need to be seen within the context of reinforcing each other and the need to integrate specific PTW road infrastructure-related interventions into the broader road space planning to cater for the modal mix in countries such as Malaysia and Viet Nam which have a high proportion of PTW users. The development of an exclusive single motorcycle lane is not adequate in such a setting. Much more needs to be done to improve infrastructure design and other measures to address the safety PTW users.

Exclusive motorcycle lanes

One of the main risk factors for PTWs in traffic is their interaction with other high-speed and heavier vehicles. Exclusive motorcycle lanes are mainly used to separate motorcycles from general traffic, and comprise a track that is separated (either by a physical barrier or a structure) from the main road or highway where other vehicles travel. The aim of providing such a lane for motorcyclists is to reduce the risk of collision or injury to motorcyclists by removing them from conditions where interaction between motorcycles and larger vehicles is frequent (56–58) and may result in a crash (12). In many settings the same roads are used by PTWs and various other types of motorized vehicle, non-motorized vehicles and pedestrians, all travelling at different speeds. Given that most roads were originally built for cars, there is a need to either regulate the use of PTWs on higher speed roads (motorways, expressways and multi-lane roads) or separate PTWs from other vehicles in order to reduce crashes and improve the road capacity (59–60).

Segregation is likely to be of benefit and be acceptable to the general public when the proportion of road users using PTWs is more than 20–30% of all vehicles on the road – as is the case in many LMIC settings (10). Segregation of motorcycles from other vehicles using exclusive motorcycle lanes is one of the extensively applied interventions in countries in the Western Pacific Region, e.g. Malaysia (61). The first exclusive motorcycle lane was built in Malaysia in the early 1970s and its effectiveness in reducing crashes has been well documented. It has reportedly contributed to an almost 40% reduction in motorcycle crashes in the areas of Malaysia where it has been implemented (59–61). Speeding is often reported as the causative factor for any PTW crashes that occur in those lanes (62).

Mandatory registration and licensing of PTW operators and vehicles

General road safety interventions that target all road users form the basis of successful road safety management in HICs (38). These include registration and licensing systems, and strict enforcement – with penalties – of road safety laws. In some LMICs, most PTWs are not registered and studies show that riders who are unlicensed tend to be involved in crashes more than those who are licensed (10). In LMICs, there is widespread illegal modification of powered two-wheeler vehicles into three-wheel vehicles in order to carry passengers and/or goods (63). While there appears to be little data about crash involvement, studies that have looked into the roadworthiness of modified vehicles show that there is

no regulation of these vehicles through any registration process, and that many of the riders of these vehicles are unlicensed. A study of crashes involving three-wheel vehicles in Sri Lanka, for example, reported that modifications made to the handle lock of these vehicles increased the turning angle for the driver – a contributing factor in almost 30% of the crashes in the study sample (57).

Road design

PTWs are at particular risk of collision on curves, bends, slip roads (i.e. roads with a tight radius) and roundabouts (due to acceleration or deceleration) or because PTW stability is at stake. Some road surface materials, including road-marking materials, provide better grip than others and this aspect of road design is important for motorcyclists. The layout of roads and intersections, alterations to existing road designs, as well as appropriate shoulder widths have been shown to have a significant impact on motorcycle collisions and injury severity.

A study of 36 intersections in Malaysia demonstrated that exclusive or protected (right hand) turn lanes may reduce rear-end crashes for motorcycles (59). This study also found that 25% more motorcycle crashes occur at intersections without a shoulder than those with a shoulder wider than 1 m, and the results suggest paved shoulders wider than 1 m may help to reduce motorcycle crashes.

Wider lanes on major and minor roads and an increase in the number of lanes on major roads are associated with a reduction in motorcycle crashes (59). Adequate visibility and signage around intersections and roundabouts also help motorcyclists manage their speeds as they approach the intersection. Appropriate signage providing motorcyclists with a clear understanding of the road conditions ahead is also important to help them be prepared. As motorcycles are relatively small vehicles, other vehicles on the road, signage, vegetation and other objects can easily obscure them, and intersection and roundabout design needs to take this into consideration.

Speed limits and traffic calming

Traffic calming measures have been effective in reducing the number of crashes for all four-wheeled vehicles. However, the design of such interventions can have a negative impact on motorcyclists. One OECD report cites obstacles placed on the road, such as speed humps and other small vertical objects designed to minimize speed, as examples of how such interventions can be hazardous for motorcyclists (9).

Motorcyclists need to be warned through the use of some other form of traffic calming such as horizontal markings on the road (with adequate grip or skid resistance). The location of these types of traffic calming features (primarily aimed at other vehicle types) also needs to consider the ability of motorcyclists to navigate them safely (9). On the other hand, a recent systematic review of effective interventions to prevent motorcycle injuries indicated that two-thirds of studies found a reduction in motorcycle crashes following the introduction of lower speed zones in urban areas (19).

Removal of roadside hazards

Impact with a roadside obstacle increases the severity of a crash (64–65). Fixed hazards in the road environment present a substantial risk to motorcyclists and result in many serious injuries and fatalities (66). Elimination of roadside hazards such as trees, posts and utility poles can significantly reduce injury severity of motorcycle crashes by creating a “clear zone” that not only minimizes the risk

of a motorcyclist impacting any hazardous object, but also provides room for motorcyclists to correct errors (9). Choice of location of roadside equipment used for lighting or signage can also impact PTW safety. Guardrails and crash barriers are often used to separate vehicles from roadside hazards, but the design of such devices needs to take motorcyclists into account. There has been much debate about the best guardrail or crash barriers for motorcyclists. Exposed posts within the guardrail system are the major cause of injury (62, 67–68). The OECD report notes that a number of solutions can be used to protect sliding motorcyclists from impacting exposed posts. Wire rope barriers are increasingly used as barriers to roadside hazards, as well as roadway dividers. One study found no significant differences in the effectiveness between wire rope and other types of discontinuous guardrails (69).

There is increasing evidence that the position of motorcyclists when they impact a guardrail may be more important than the type of guardrail (69). The OECD report provides recommendations for crash barrier designs that allow a fallen motorcyclist to slide along the surface rather than impact any specific component of the system. Importantly, there is evidence that impacts with fixed hazards, such as posts and poles, are more hazardous to motorcyclists than impacts with barriers, supporting the need for barriers to prevent impacts with such objects. The report also recommends that priority be given to improving barriers and guardrails on curves and reiterates the importance of proper installation and maintenance of guardrail and crash barrier systems (9).

Conspicuity

Two recent literature review studies found that, in terms of conspicuity aids, the majority of studies discussed conspicuity enhancement in the frontal area, particularly daytime running lights (DRLs) colour and configuration (70–71). Weather conditions prevalent in a region might also affect suitability of implementation of DRLs. Few studies have discussed rear running and brake light and motorcycle colour and there are numerous studies looking at motorcyclists' appearances in terms of their attire and helmet colour (see Section 2.4). Authors conclude that the motorcycle and motorcyclist's appearance are highly associated with the risk of motorcycle crashes. The most important part of enhancing motorcycle conspicuity is to ensure motorcycle appearance is always in contrast with the road traffic environment (70, 72–75).

2.3 Interventions related to safer vehicles

There are three interventions in this category that have been shown to be effective. These are antilock brake systems (ABS), the use of headlights during the day and headlights at night. The use of DRLs and headlights at night are reported as promising.

Antilock brake systems (ABS)

ABS on PTWs are designed to help the rider maintain control of the vehicle during an emergency braking situation. The system prevents wheels from locking during braking and may make users more confident to brake fully (27). ABS improve the stability and handling of PTWs. Almost half of all severe and fatal motorcycle crashes in vehicles above 125 cc could be avoided by using motorcycle ABS. On 1 January 2016 the European Union passed legislation for mandatory ABS installation on all motorcycles with an engine displacement greater than 125 cc (73). Details on DRLs are provided in Section 2.2.

2.4 Interventions to improve road users' safety

Setting and enforcing comprehensive helmet legislation

Enforcing helmet laws significantly reduces both fatal and nonfatal injuries, with the nonfatal injury rate decreasing by approximately 20% (74). The number of motorcycle-related head injuries in particular has been shown to decrease by up to 33% after implementation of a mandatory helmet law, alongside a decrease in the length of hospital stay and severity of injury (75). There is evidence from both high- and low-income countries that maximum compliance (i.e. over 95%) with a mandatory helmet law is attainable with active enforcement (38).

In countries where local governments have repealed or weakened existing mandatory helmet legislation, the negative effects of this action have been associated with a decrease in helmet use and a rise in overall fatalities and traumatic brain injury fatalities (54).

Implementing universal helmet laws (UHLs), applied to both drivers and passengers, increased helmet use; reduced total deaths and deaths per registered motorcycle; and reduced total injuries and injuries per registered motorcycle (38, 64). Repealing UHLs decreased helmet use; increased total deaths and deaths per registered motorcycle; and increased total injuries, and injuries per registered motorcycle. Implementing UHLs increased helmet use among young motorcyclists (aged < 21 years) by 31%, and repealing UHLs decreased helmet use (76).

Comprehensive motorcycle helmet legislation generally involves passing a mandatory helmet law requiring the use of a standard helmet by all motorcycle riders on all roads regardless of the engine size, with an effective enforcement, penalty and regulatory mechanism for its full implementation (77-78). Table 2.2 provides a checklist for assessing the comprehensiveness of legislation on motorcycle helmets.

Table 2.2 Checklist for assessing the comprehensiveness of legislation on motorcycle helmets

Does the content of current legislation address	Yes
Helmet use	
Includes compulsory helmet wearing for all riders (i.e. drivers and passengers)	<input type="checkbox"/>
Defines helmet wearing as including proper strapping and wearing of a helmet that meets national standards	<input type="checkbox"/>
Requires all riders to wear a helmet on all roads	<input type="checkbox"/>
Requires riders of all motorized two- or three-wheeled vehicles (all engine types) to wear a helmet	<input type="checkbox"/>
Sets a minimum age for riding a motorcycle	<input type="checkbox"/>
Helmet standards	
Specifies recognized helmet safety standards based on internationally recognized standards	<input type="checkbox"/>
Includes product labelling requirements and addresses tampering	<input type="checkbox"/>
Specifies requirements for child helmets (e.g. age or height) depending on the age at which children are allowed to ride on motorcycles	<input type="checkbox"/>
Enforcement	
Specifies who has authority for enforcement	<input type="checkbox"/>
Allows primary enforcement: no other traffic offence is required to stop a violator and enforce helmet wearing law	<input type="checkbox"/>
Penalties	
Specifies financial penalties	<input type="checkbox"/>
Includes provisions for motorcycle impoundment	<input type="checkbox"/>
Other regulatory measures for helmet wearing	
Establishes penalties for sale of de-specified helmets	<input type="checkbox"/>
Establishes penalties for tampering with product labelling	<input type="checkbox"/>
Sets requirements for passenger helmet wearing for public service two- and three-wheeled motorized vehicles	<input type="checkbox"/>

Helmet standards

For a helmet to be effective it needs to be of sufficient quality to provide maximum protection to the head (30). Helmet standards are used as a regulatory measure to ensure a uniformly recognized safety level for helmets on the market and used by riders.

Motorcyclists wearing standard-approved helmets have a lower risk of head and traumatic brain injury than those not wearing helmets (77-79). Proper fastening of the helmet is also important for a helmet to be fully effective. Supporting legislation and law enforcement by informing and educating the public on the importance of the proper use of standard-approved helmets has the potential to create a shared social norm, which has been shown to lead to increased helmet use (80).

While there have been relatively few studies of helmet effectiveness, specifically among children using motorcycles, studies on injured child motorcyclists that examine injury outcome by helmet status have found less head injury and/or less severe injury among children that use motorcycle helmets (81).

There is sufficient evidence that helmets are effective in preventing head injury or death in the event of a crash. In studies on injured riders and pillion passengers, injuries are more frequent and more severe among children involved in a crash not using a helmet compared with those using helmets (82–84). There is evidence that helmet-wearing rates can be much lower for children than for adults in some LMICs (85).

In countries where it is common for young children to use PTWs as riders or passengers, helmet availability and the adequacy of available helmets in terms of quality is also a safety concern. Even in places in LMICs where helmets are reported to be widely available, there is a concern about the adequacy of those helmets for children, both in terms of size and quality (85). Very few helmets include requirements for small “child-size” motorcycle helmets. Use of oversized helmets not only reduces the protection provided by the helmet but can also negatively affect the position of the helmet and chin strap on the child’s head (81). During a crash, this could increase the chance of the helmet coming off, and during riding the helmet may obscure a child’s vision. There are few countries that have local standards for child helmets, although Viet Nam has recently introduced one. The smallest helmet sizes regulated by these standards would approximate to the head size of a child aged 5 to 7 years.

Strengthening penalties

Police enforcement plays an important role in strengthening compliance with traffic rules by all road users. One of the ways governments operationalize enforcement is by setting maximum penalties for various road traffic offences. A systematic review of the literature (86) identified evidence from two studies that indicated a small but significant reduction in crashes associated with increased financial penalties, and criminalization of drink-driving and speeding offences.

Criminalizing offences

Enforcing laws that criminalize different behaviours related to speeding and alcohol consumption has consistently been an effective legal sanction in reducing road traffic fatalities (87). Little evidence is available on the broader issue of criminalizing (non-alcohol related) offences and reductions in motorcycle-related injuries. In order to create conformity and adherence to road rules by motorcycle riders, sustained media publicity and awareness campaigns are necessary to accompany enforcement activities (38).

Demerit point system

A demerit point system is a penalty system where a number of points are added to the record of a driver or a PTW rider for a traffic offence, depending on the severity of the traffic law violation (88–90). In some settings, the rules applied for assigning a demerit point could be tailored to whether a driver is a novice or is experienced with a full licence. A penalty point system using demerit points has been shown to reduce crashes, specifically among moped riders on urban roads in Spain (88–90).

Wearing reflective and protective clothing

The use of reflective and protective clothing such as jackets, trousers, boots and gloves is a promising intervention for prevention of PTW-related injuries. As described in Section 2.2, reflective clothing that improves the visibility of the rider and passenger by increasing the brightness contrast between the motorcyclists and their surroundings (91) has been consistently shown to improve motorcycle visibility and thus contribute to reduced risk of motorcycle crashes and serious injuries or deaths by almost

one-third (92–93). For effective implementation there is a need for a multifaceted approach that includes complementary helmet safety laws and educational campaigns focusing on raising awareness about PTW conspicuity (94). Regulations requiring the use of such clothing and enforcing compliance are equally important to highlight the importance of this measure.

The use of protective clothing reduces the likelihood of injury, hospitalization and disability. Motorcycle protective clothing is specifically designed to provide adequate abrasion resistance and impact protection for motorcycle use. Protective clothing is a viable measure to protect against abrasions and fractures – the most common types of PTW-related injuries in nonfatal crashes (91). Most common PTW-related injuries to arms and legs can be reduced or prevented by protective clothing, which has been shown to reduce soft tissue injury, the likelihood of hospitalization, and the likelihood of impaired function 2 months after the crash (95–97). Despite its documented effectiveness, there is limited use of protective clothing in LMICs (11). The use in HICs also varies considerably between countries and within countries, ranging from 50–81% (98–99). Promoting and enforcing compliance is key to successful implementation of this intervention.

Graduated licensing system

A graduated licensing system is a regulatory mechanism whereby a power and engine size restriction is applied to young and novice PTW riders in order to give new riders the opportunity to gain experience and skills in a lower risk manner over time. There is documented evidence that implementation of a graduated licensing system leads to a significant (up to 22%) reduction in motorcycle crash-related hospitalization (100). Although a graduated licensing system is common in HICs, the type of restrictions enforced as part of regulations varies considerably. These variations include restrictions on engine size, the age of the rider, on being allowed to carry passengers, and on night riding. Some systems set specific BAC limits for less experienced riders below a certain age, and some include tests for a motorcycle permit, driver training and longer duration of a learner's permit (101).

Training: compulsory skills test for a motorcycle permit

The introduction of compulsory training and a skills test to obtain a motorcycle permit or licence has been shown to be an effective intervention in PTW safety, although there appear to be limited benefits from post-licence training (102).

Compulsory training and skills testing prior to obtaining a licence have been shown to contribute to a reduction in both crash and mortality risk (102). Where this intervention has been implemented, it has been done through PTW operation and licensing regulations (38). The effectiveness of this intervention is well-documented in HICs, but its effectiveness in LMICs is yet to be validated. Based on evidence from HICs, the OECD/ITF Working Group on the Safety of Powered Two-Wheelers has made recommendations (summarized in Box 2.1) to its members on training.

Box 2.1 OECD/ITF Working Group recommendations on PTW training

- National (or provincial/state) authorities should consider that riding a PTW requires a certain level of personal maturity, as for all road users.
- Access to PTWs should be gradual, with a licensing system aimed at managing young and novice riders' risk as they gain experience.
- The purpose of the licensing system should be to ensure riders, regardless of age, possess the skills, knowledge and correct attitude to ride as safely as possible without unduly restricting mobility.
- Promote safe behaviours training not only PTW riders but also drivers in all other vehicle categories focusing on risk awareness, vulnerability and crash patterns.

Source: (9).

2.5 Post-crash care

Initiation of swift post-crash care minimizes the risk of severe injury and death. While general pre-hospital care standards – such as a quick response time and the application of uniform treatment protocols – are effective for minimizing the risk of severe injury and death associated with road crashes, two interventions specific to PTWs have been shown as promising: on-site helmet removal and on-site application of a cervical collar brace to the injured individual(s). Both interventions, if properly applied by a trained pre-hospital care provider, have been shown to minimize injury severity and long-term disability.

Helmet removal by trained professionals is important when it is evident that there is vomiting or obstruction of the airway (103). The application of a cervical collar brace to protect the crash victim's spine at the scene of an incident has equal priority. The type of injuries sustained by motorcyclists who use full-face helmets, chin straps and some types of protective clothing suggest that there are a number of unique aspects of airway, circulatory and spine management for motorcycle crash casualties, and that professional training is important to be able to assess the threats to breathing versus the threat of spinal injury (78).

2.6 Interventions for powered two- and three-wheeler safety with insufficient or weak evidence

In addition to the effective and promising interventions described, there are other interventions for which the evidence base is insufficient to recommend widespread implementation. These interventions tend to be limited in scope and their applicability beyond the intervention site has not been validated. Often evaluation of such interventions is unable to reach a firm conclusion about the intervention's ability to reduce fatalities and injuries, or to bring about the intended behaviour change. This is due to a variety of reasons, including insufficient time between the intervention and expected impact on injuries; small number of cases leading to lack of statistical significance; or that there are very few studies to evaluate. 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.

The list of interventions for PTW-related injuries with insufficient or weak evidence include:

- improving road surface conditions;
- modifying the composition of roadside barrier building material;
- designing the PTW to enhance stability;
- airbags for motorcycles;
- intelligent transport systems;
- installing or using brake lights and front lights at all times;
- regulating and licensing PTWs;
- wearing thermal resistant shields;
- age (or height) restriction for children as passengers or riders on PTWs;
- periodic inspection of the PTW for mechanical defects;
- setting a minimum height for pillion passengers;
- smaller engine size for learner riders;
- post-licensing and training for returning riders; and
- using on-site helmet removal/collar brace.

Adoption of these strategies (other than in trial form) in order reduce PTW-related injuries is not recommended until robust evidence of their effectiveness is available.

2.7 Summary

There are effective proven and promising interventions that are specific for improving PTW safety. Interventions that have been found effective and promising include:

- **Safer roads and mobility:** Separation of PTWs from other traffic.
- **Safer vehicles:** Advanced braking systems, such as antilock braking systems, and addressing mechanical defects in all PTWs.
- **Safer road users:** Legislation and enforcement related to alcohol use, speeding, helmet and protective clothing use; instituting a programme for graduated licensing schemes; increased conspicuity of PTWs.
- **Post-crash response:** Introduction of uniform treatment protocols and quick and accurate mechanisms for the rapid activation of emergency care systems.
- **Helmets:** Wearing a properly strapped helmet remains the most effective way to lessen the impact of a crash and to prevent severe craniofacial injuries. The type of helmet used also has a significant impact – full-face helmets being the safest.



Module 3

Implementing evidence-based powered two- and three-wheeler safety interventions

This module examines actions required to implement PTW safety interventions. It briefly discusses the cycle of improvement, assessment of the situation, challenges in implementing PTW safety interventions and evaluation of these interventions.

3.1 Cycle of improvement

Improving the PTW safety situation in a country requires continued effort of planning, executing and evaluating programmes. It is not a one-off undertaking, implying that the policy planning stages used in specifying actions required are mainly for illustrating a continuous cycle. There are opportunities as well as unexpected challenges that need to be managed as this cycle moves on. Implementing a continuous cycle of road safety improvement begins with an assessment of the existing system followed by the development, execution, evaluation and refinement of a national or a local plan of action. A plan of action will not yield improvements unless it is translated into practical solutions. In addition to identifying and prioritizing actions that should be taken, there are key ingredients that need to be considered and made available or developed: human and financial resources, sharing responsibility among different agencies, and political commitment (3).

3.1.1 Pathways to change

Applying the Safe System approach to road safety results in a complex set of interacting interventions that can make interventions quite difficult or sometimes even unethical to implement and evaluate using traditional research methods such as randomized controlled trials. For this reason, some researchers have proposed that “understanding the public health intervention’s underlying theory of change and its related uncertainties may improve the evaluation of complex health interventions” (104).

A theory of change is therefore basically the pathway(s) that will be followed to achieve the objective of a programme. It “explains how activities are understood to produce a series of results that contribute to achieving the final intended impacts. It can be developed for any level of intervention implementation – an event, a project, a programme, a policy, a strategy or an organization” (105) or the evaluation of such interventions or set of interventions (impact evaluation). It encourages “systems thinking” through the understanding of the complex social change processes, different perspectives, assumptions and the contexts needed to optimize success.

A theory of change is a systematic approach to understanding the pathway to change in order to reach a long-term goal. It should always begin with a good situational assessment to understand the causes, risk factors, opportunities and challenges in the local situation where an intervention is to be implemented. It should then be guided by a participatory approach – bringing together multiple key stakeholders, through a workshop, for example, to discuss the proposed approaches or interventions that need to be implemented to optimize impact.

Although developing a theory of change is an iterative process, and there are many ways it can be developed, it should include the following basic steps (106):

1. Identify the long-term outcome
2. Develop a pathway of change
3. Operationalize outcomes
4. Develop interventions
5. Articulate assumptions
6. Monitor and evaluate the process.

As a final output of stakeholder discussions, a visual map of the change being explored should be developed to show the relationships between proposed actions/interventions and outcomes and how these interact in order to achieve the goal. The benefits of developing a realistic and implementable theory of change are articulated in Box 3.1. In general, this process challenges the status quo and gets stakeholders to “think outside the box” so that mistakes are not made when interventions are implemented. It also forces stakeholders to think about resources and how these will be best utilized to bring about the required change. Finally, the process develops a shared understanding of the actions to be taken and expected outcomes on one hand and accountability on the other.

Box 3.1 How a theory of change would benefit your programme

It provides:

- A clear and testable hypothesis about how change will occur that not only allows you to be accountable for results, but also makes your results more credible because they were predicted to occur in a certain way.
- A visual representation of the change you want to see in your community and how you expect it to come about.
- A blueprint for evaluation with measurable indicators of success identified.
- An agreement among stakeholders about what defines success and what it takes to get there.
- A powerful communication tool to capture the complexity of your initiative.

Source: (105).

3.2 How to assess the situation

A situational assessment provides key information that will inform prioritization and help make decisions about managing, reducing or preventing PTW crashes, injuries and fatalities. A situational assessment helps to:

- **Identify the problem and the priorities for action.** Analysis of information gathered will illustrate the types of injuries common among PTW users in a given area; where the greatest need for intervention is; the cost to PTW users of compliance (and non-compliance) with a specific intervention; and the reasons why PTW users do or do not comply with road safety laws.
- **Provide evidence on why a specific intervention should be supported.** Successful PTW safety programmes need the support of all stakeholders, especially policy-makers, PTW users and the public in general. Accurate data on the burden in a given project area and the potential of the proposed intervention to reduce this burden will help show policy-makers what can be gained by implementing evidence-based, effective interventions.
- **Provide baseline data and evidence of progress on key programme monitoring and evaluation (M&E) indicators.** M&E is an integral component of any PTW safety strategy. Data from the situational assessment help define baseline M&E indicators. Such indicators range from outcome measures (such as deaths and injuries) to process measures linked to specific interventions (such as compliance with legislation and public opinion on a given PTW policy).

3.2.1 What is to be assessed?

A comprehensive situational assessment involves the systematic gathering of information on the magnitude of the problem of PTW crashes, injuries and fatalities; risk factors for these outcomes; and the prevention needs, opportunities and barriers (i.e. the context of implementing change to reduce PTW-related injuries). This information can be gathered through four types of assessment:

- **Epidemiological assessment:** provides information on the magnitude of the problem, risk and protective factors.
- **Policy assessment:** allows analysis of contributing and facilitating factors as well as identification of gaps in existing policies, laws and regulations.
- **Intervention assessment:** appraises past and current interventions.
- **Stakeholder and target group assessment:** systematically maps supportive, neutral and opposing partners and their capacity to engage in change.

3.2.2 Assessing the burden of PTW-related injury and death

Identifying the number of PTW-related injuries and deaths and their context, and how they compare with deaths among other road user groups is a starting point for any PTW safety planning. Having detailed information on the burden of PTW-related injuries and deaths provides evidence that can contribute to appropriately designed and targeted interventions that will lead to measurable outcomes. Such types of assessment, referred to as epidemiological assessments, involve a scientific study of the occurrence, distribution, causes and risk factors of PTW-related injuries and deaths in a given population.

The epidemiological assessment is done by:

- Measuring the incidence of PTW-related injuries and fatalities.
- Defining the age and sex distribution of people that suffer PTW-related injuries and fatalities.
- Describing the times and places where PTW-related injuries and fatalities occur.
- Analysing the causes, risks and protective factors involved.
- Assessing the consequences of PTW crashes.

Depending on the availability of data, the following variables can be considered for an additional assessment:

- Time: on what day of the week and at what time of day do most PTW crashes occur?
- Severity: how serious are the PTW-related injuries (types of injury by severity and fatalities)?
- Cost: how big is the PTW problem in terms of health and socioeconomic costs?
- Disability: what type of PTW crashes lead to disability or life-threatening outcomes?

The extent of the epidemiological assessment in a given setting will be limited by the availability of information. In most LMICs, the availability of data on a particular road user group (which includes the number of PTW-related injuries and deaths), the circumstances leading to them and data on intervention coverage (such as the helmet-wearing rate) are often missing. The most easily available, accessible and immediately relevant data sources tend to be used first (see Table 3.1). In settings where there are no data, or where routinely collected data sources do not provide adequate information, new information on key indicators may be collected through purpose-built surveys.

Table 3.1 Key sources of road traffic injury and incident data

Source	Type of data	Observations
Police	Number of road traffic incidents, fatalities and injuries PTWs involved, other vehicles involved Age and sex of casualties Police assessment of cause(s) of crashes Use of safety equipment (e.g. helmets) Locations and sites of crashes Prosecutions/enforcement activities	Level of detail varies from one country to another, and there are typically large in-country differences too Police records can be inaccessible Underreporting is a common problem Precise location data (e.g. map coordinates) may not be available
Health settings (hospital in-patient records, emergency room records, trauma registries, ambulance or emergency technician records, health clinic records, family doctor records)	Fatal and nonfatal injuries Age and sex of casualties Nature of injury Type of care provided Alcohol or drug use	Level of detail varies from one hospital to another Cause of injury may not be properly coded, making it difficult to extract road traffic injury data for analysis Information on the injured person may not be disaggregated by type of road user

Source	Type of data	Observations
Vital registration	Fatal injuries Age and sex of casualties Type of road user(s) involved	Completeness and comprehensiveness vary between countries Cause of death may not be properly coded, making it difficult to extract road traffic injury data disaggregated by road user for analysis Population coverage may be poor
Government departments and specialized agencies collecting data for national planning and development	Population estimates Income and expenditure data Health indicators Riding exposure data (e.g. km travelled) Pollution data Energy consumption Literacy levels	These data are complementary and important for analysis of road traffic injuries The data are collected by different ministries and organizations (although there may be one central agency that compiles and produces reports, including statistical abstracts, economic surveys and development plans). These data can be important for planning interventions and garnering support for these interventions
Special interest groups (research institutes, nongovernmental advocacy organizations, victim support organizations, transport unions, consulting firms, institutions involved in road safety activities, insurance companies and others)	Number of road traffic incidents, including fatal and nonfatal injuries Type of road user involved Age and sex of casualties Vehicles involved Causes Location and sites of crashes Social and psychological impacts Risk factors Interventions Insurance claims/costs	The various organizations have different interests and data collection and research methods may not be sound

3.2.3 Assessing existing PTW policies, laws and regulations

A policy environment assessment seeks to provide an understanding of the types, characteristics and specifics of existing road safety policies, laws and regulations (and any gaps in these), and the context within which legislative and policy changes can be made. The assessment can reveal the adequacy of existing laws and/or their enforcement and is thus a necessary step in defining the direction of future PTW policies. Enacting PTW-related laws, however, is influenced by many factors, including: the policy environment and the political will of policy-makers; the resources made available by the government for their enforcement; and the acceptability of the laws to a majority of the public. As such, planning and implementing a comprehensive policy environment assessment should be carried out in a stepwise or systematic manner, to ensure all factors are taken into account.

The scope of the task of conducting a policy assessment will vary between countries. It is important that the approach is tailored according to the context in which the new or amended policy will be adopted, and the specific objectives of the policy that serve to enhance the safety of PTW riders in that nation, region or subregion. For effective use of findings it is also important that the analysis provides some insight about the institutions primarily responsible for the formulation and enforcement of the law and regulation.

3.2.4 Assessing existing PTW interventions and programmes

An intervention or programme assessment takes stock of existing and potential PTW prevention programmes and PTW initiatives. It is important to have this information in order to inform the prioritization process and, ultimately, mobilize the support of stakeholders for maximum uptake of new initiatives. Unlike the epidemiological assessment described earlier, the intervention assessment is used for defining and prioritizing possible areas of intervention. It requires an understanding of the current situation in terms of programme implementation and is particularly important to minimize duplication of efforts and ultimately maximize the impact of any PTW-related injury prevention effort. Some of the issues that the interventions assessment can address regarding existing PTW safety intervention programmes include:

- The status of past and existing programmes and interventions: what is already being done in the country, municipality, state or province?
- The types of interventions and implementation level: which interventions have been implemented and tested in the locale? What is the level of implementation for each (i.e. national, regional or local)?
- The effectiveness of existing programmes: what is their potential effectiveness (based on available evaluation findings or latest research data)?
- Gaps in knowledge: which key information areas are lacking in relation to target groups?
- Available resources: is there an allocated government budget for road safety and, specifically, for PTW safety? Are other stakeholders (government, private sector or nongovernmental organizations) providing resources?
- Visibility of the issue: do any of the potential stakeholders provide opportunities to raise the profile of PTW safety?

3.2.5 Stakeholder and target group assessment

While the assessment of existing national laws and regulations is meant to provide planning information on the policy environment, the stakeholder and target group assessment sheds light on the social environment in which policies are being developed and implemented. Key objectives of a stakeholder and target group assessment include:

- Identifying key partners and their characteristics and examining how they will affect or be affected by a policy (e.g. their specific interests, likely expectations in terms of benefits, changes and adverse outcomes).
- Consulting with the target group to identify their concerns, motivations and issues that may impact the success of the strategy. Participatory research is an important component of the situational assessment. What are the sociocultural factors that need to be considered in selecting the intervention? How can the intervention be made equitable and accessible to those who are socially and economically disadvantaged in the target group?
- Assessing partners' potential influence on the development, approval and implementation of the policy – including possible conflicts of interest – to understand the relationship between stakeholders; the capacity of different stakeholders to participate in policy development; and to assess the likelihood of their contributing to the policy development process.

- Deciding how stakeholders should be involved in the process to ensure the policy is as strong and viable as possible; in particular, to consider whether they are a partner (such as part of a taskforce or working group) or an advisor (e.g. brought in for advice on a single or limited number of issues).

Understanding the position of key stakeholders, the relationship between different entities and clearly identifying the supporters and opponents of road safety policies (i.e. those of divergent views) is key for effective engagement of all concerned parties.

3.2.6 Using situational assessment findings for targeted action

Data gathered through the situational assessment, together with information on the effectiveness of known PTW interventions, provide the evidence to inform the process of prioritizing intervention activities. Results from the situational assessment should be used to prioritize a target group with the following attributes:

- Jurisdictions with comprehensive and effective laws and a strong enforcement culture.
- Target areas with the strongest political will.
- Communities that are supportive and fully on board.

These three factors are key to creating a favourable environment to successfully implement a given PTW intervention and achieve a positive outcome in terms of reduction in number of injuries and deaths, or reduction in risky behaviour.

3.3 Challenges in implementing interventions for powered two- and three-wheeler safety

As pointed out in Module 1, there is substantial expansion of PTWs in virtually all regions of the world. This expansion is observed in both the conventional forms such as motorcycles and new forms like scooters and e-bikes. There is a need to reassess the approach to transport infrastructure and service planning and development to adequately cater for the safety and accessibility needs of PTWs.

An example of such a response is an early effort in Malaysia to provide exclusive motorcycle lanes. This initial effort has not been developed further to identify ways of integrating infrastructure for PTW into the rest of road infrastructure. Another area of exploration is the development of intelligent transport systems (ITS) to complement other measures in decreasing the number of road traffic deaths. This effort has mainly been focused on car occupants. Motorcyclists and moped riders have received too little attention in the development of ITS. While the interventions presented in Table 2.1 in Module 2 show that there is insufficient evidence to support the adoption of ITS, there is an opportunity to evaluate the effectiveness of these strategies given the current and likely future adoption by PTW operators. An example of exploring this opportunity is indicated by a study to determine the safety impacts of the selected ITS for PTW riders in the European Union, once the systems are fully adopted and meet selected future scenarios for 2020 and 2030, which focused on three aspects that have good potential for improving the safety of PTW riders: intersection safety (INS), the powered two-wheeler oncoming vehicle information system (PTW2V) and the vulnerable road user beacon system (VBS) (107). Results revealed that the best effects were offered by PTW2V and INS, and the weakest by VBS. This type of assessment or effort needs to be fully developed with inputs from different stakeholders and decision-makers.

3.4 How to evaluate progress and utilize results for improvement of powered two- and three-wheeler safety

3.4.1 Why monitor and evaluate a PTW safety programme?

Monitoring is needed to get objective measures on what works when linking the evidence to road safety practice and action in a specific context. A well-conducted evaluation makes a significant contribution to evidence-based PTW action by focusing measurement on results and subsequently promoting results-based accountability. In road safety, monitoring or surveillance activities comprise the regular collection of key road safety information on health and other road safety performance indicators, and routine analysis of the information over time, place and between population groups, using predefined criteria (108). For public health surveillance or monitoring it also includes the regular dissemination of results to support informed policy-making (109). Monitoring is essential for early identification of implementation problems; to respond to bottlenecks or gaps in programme performance; and to adequately capture contributing factors to observed negative and positive changes in road safety performance and impact (110). Depending on programme objectives and complexity, monitoring can be directed at measuring impact, output and outcome indicators.

Evaluation determines a programme's direction (shaped by the context in which the initiative sits); utility (how useful it is in achieving a defined objective); effectiveness (a programme's performance as compared with available evidence); and strengths (aspects of the programme and lessons learned that can be used to improve public health (108). Evaluation is a critical function of programme management and is used for effective planning, budgeting and the measurement of effectiveness and efficiency.

Through evaluation, programme planners can ascertain how well programme components are functioning. Evaluation also provides clues as to why components may or may not work, aids programme accountability and transparency, and is a key part of long-term, strategic planning (110).

In road safety, programmes aim to prevent or control injury, disability and death. As this means taking account of the different elements of the Safe System framework and the differing needs of stakeholders, programmes themselves can be very complex. In addition, since most of the effective interventions involve significant and often challenging changes in road user attitudes and behaviour, it adds to the complexity of planning an effective PTW safety programme.

Posing the right questions on effectiveness is key for any evaluation. Questions about programme effectiveness require implementers to pay attention to measuring and documenting the implementation of the programme and its success as it relates to the achievement of the intended outcomes. The effective use of such information makes implementers accountable to key stakeholders.

3.4.2 What to monitor and evaluate

Once an intervention has been identified as a priority and a strategy has been developed for its implementation, the measurement "metrics" for the implementation need to be defined and regularly monitored. Metrics include indicators on inputs (resources, coordination mechanisms, plans); outputs (achievements, tasks completed, products delivered that are attributable to the initiative); and outcomes (changes sought regarding risk or protective factors, e.g. a reduction of roadside hazards in "blackspot")

areas, or increased helmet-wearing rates, or enhanced infrastructure, e.g. road design and reductions in injuries and fatalities). Areas for M&E are usually presented in a M&E plan (see Table 3.2 for an example of a M&E component of a motorcycle safety plan of action).

Table 3.2 PTW monitoring and evaluation indicators

	Inputs What is being measured	Outputs What has been achieved	Outcome Targets reached
What is being measured?	Multisectoral efforts Funds allocated	Implementation of activities related to each safe system element: roads, vehicles, speed, road users % of road safety budget allocated	% change in injuries and deaths
What shows progress?	Innovative, evidence-based planning	Each system element is becoming increasingly safer	Ongoing reduction in injuries and fatalities
How will it be measured?	Action plan implementation	Example of data sources: speed survey data Regular evaluation of road safety initiatives	Hospitalization and fatality data

Source: (110).

3.4.3 Data sources for monitoring and evaluation

PTW safety M&E data can take many different forms and be collected in a number of ways. Data sources may include routinely reported data from all facilities or sentinel sites; population-based surveys; infrastructure assessment data (such as lists of operational works that address road safety issues); surveillance data (such as police-attended crashes, hospital admissions resulting from PTW crashes); observational studies on riders to measure speeding rates or helmet-wearing rates; and periodic evaluation.

3.4.4 What do these evaluation results mean?

Evaluation results provide insights that can be used to make decisions about progress and outcomes of a PTW programme. The results should enable decision-makers and practitioners to determine a programme's direction, utility, effectiveness, and strengths and weaknesses to improve public health. Results of PTW programme evaluation should be used for effective planning, budgeting and measuring effectiveness and efficiency. Aspects of the programme performing well should be sustained and those performing poorly need to be revised or modified. An illustrative example of developing, implementing and evaluating a PTW programme is presented in Box 3.2.

Box 3.2 Developing, implementing and evaluating a motorcycle strategy in New South Wales (NSW), Australia, 2012–2021

In an attempt to address the growing number of deaths among motorcycle riders as an emerging public health issue, the Minister for Roads and Ports (the minister then responsible for road safety in NSW) introduced the NSW Motorcycle Safety Strategy 2012–2021.

As an example, research results show that between 2010–2014, there was a lack of progress in reducing crash involvement of fully licensed and older riders in NSW. Post-licence motorcycle rider training (PLRT) is often raised as one potential avenue to address this problem, but the nature and characteristics of the overall PLRT environment are poorly understood. Research was done in 2016 with the aim to investigate the extent to which existing PLRT courses target identified key rider skills and competencies to address motorcycle crashes in NSW, and to identify courses that appear likely to provide a safety benefit for participating riders. Advocacy for motorcycle rider training, including voluntary PLRT, continues among stakeholders as a key strategy for improving rider safety and reducing motorcycle crash risk.

As part of this strategy a randomized control trial of an on-road rider coaching programme was done in Victoria, Australia, with the objective to determine its effectiveness in reducing crashes in novice motorcycle riders. The primary outcome was a composite measure of police-recorded and self-reported crashes; secondary outcomes included traffic offences, near crashes, riding exposure, riding behaviours and motivations. Analyses conducted in 2014 indicated no effect on crash risk at 3 months. Riders in the intervention group reported increased riding exposure, speeding behaviours and rider confidence.

The conclusion was that there was no evidence that this on-road motorcycle rider coaching programme reduced the risk of crash, and an increase in crash-related risk factors was found. With existing evaluations of rider training showing mixed results and notable limitations, and with a wide range of PLRT options available, the need seems clear for further research examining the potential contribution of specific forms of PLRT toward achieving road safety strategy goals (111).

3.5 Summary

Improving the road safety situation in a country requires continued effort of planning, executing and evaluating programmes. It is not a one-off undertaking, implying that the policy planning stages used in specifying actions required are mainly for illustrating a continuous cycle.

Effective planning and implementation of PTW safety requires a comprehensive understanding of the risk factors involved in different settings, the nature of the problem, stakeholders, and what is in place. Implementation of such interventions should take a comprehensive approach and be related to road users, vehicles and the road environment, using engineering, enforcement and education, and be applied in an integrated manner. The continued implementation of PTW safety interventions enables decision-makers and practitioners to leverage opportunities as well as address unexpected challenges that need to be managed as this cycle moves on.

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