Transport Research Arena 2014, Paris

Mobility and safety of powered two-wheelers in the OECD countries

Pierre Van Elslande[a], Veronique Feypell-de la Beaumelle[b], James Holgate[c], Kris Redant[d], Hélène de Solère[e], Dimitris Margaritis[f], George Yannis[g*], Eleonora Papadimitriou[g], Saskia de Craen[h], Lars Inge Haslie[i], Juan Muguiro[j], Per-Olov Grummas Granström[k]

[a]IFSTTAR, Lyon-Bron, France, [b]OECD/ITF, Paris, France,
[c]VicRoads, Australia, [d]Belgian Road Research Centre (CRR), Belgium,
[e]CERTU, France, [f]Centre for Research and Technology Hellas (CERTH), Greece,
[g]NTUA, Athens, Greece, [h]SWOV,the Netherlands
[i]Road Directorate, Norway, [j]ATOS Consulting, Spain
[k] Swedish Transport Administration, Sweden

Abstract

The objective of this paper is the analysis of PTWs mobility and safety in the OECD countries, and the presentation of measures for the improvement of PTW mobility and safety. This research was carried out by a working group of the OECD International Transport Forum, composed of experts from several countries. PTWs use, mobility and safety figures are examined, in terms of their development over time, and their distribution per road user and vehicle characteristics. Moreover, contributory factors of PTWs road accident and injury risk are discussed, as well as PTWs accident patterns, on the basis of an exhaustive review of the international literature. On the basis of the results, a number of measures are discussed, including licensing, training & education, enforcement, traffic and speed management, vehicles and ITS, infrastructure, protective devices and conspicuity. Most importantly, improving PTW safety is compatible and should be integrated with the development of a safe system approach, and requires a toolbox of measures, which includes safer behaviour of all road users, safer infrastructure and vehicles with enhanced safety features.

Keywords: Powered two-wheelers; mobility; safety; safe systems.

Résumé

L'objectif de cet article est l'analyse de la mobilité et la sécurité des DRM dans les pays de l'OCDE, et la présentation des mesures pour l'amélioration de leur mobilité et sécurité. Cette recherche a été réalisée par un groupe de travail du Forum Transport international de l'OCDE. On présente des données concernant l'utilisation, la mobilité et la sécurité des DRM, leur évolution temporelle, et leur répartition par caractéristiques de l'usager de la route et du véhicule. En outre, les facteurs contributifs des accidents routiers des DRM sont discutés, ainsi que leurs scénarios dominants. Plusieurs mesures sont examinées, y compris les licences, la formation et l'éducation, contrôles de Police, la gestion des vitesses et du trafic, les dispositifs de protection et de visibilité etc. Plus important encore, l'amélioration de la sécurité des DRM doit être intégrée dans une approche de 'sécurité du système', et nécessite une panoplie de mesures, qui comprend l'amélioration du comportement de tous les usagers de la route, des meilleures infrastructures et des véhicules avec des caractéristiques de sécurité avancées.

Mots-clé: deux roues motorises ; mobilite ; securite routiere ; securite du systeme.

---

[*] Corresponding author information here. Tel.: +30-210-7721380; fax: +30-210-7721454.
E-mail address: geyannis@central.ntua.gr.

1. Introduction

An important growth in motorcycling has occurred during the last decades in most parts of the world (Haworth, 2012), resulting in the powered two-wheeler (PTW) gradually becoming a true mobility tool, attracting an increasingly vast and varied population. Some riders use PTWs as their primary form of transportation, others for recreation. For many it is the only affordable or practical means of individual motorised mobility. The use of PTWs continues to grow globally each year in conjunction with multiple economic and social factors contributing to their expansion worldwide, such as increased traffic congestion and inner-city parking problems, increases in gasoline prices, the development of leisure, changes in lifestyle, etc. (Shinar, 2012).

The result is that, in spite of a remarkable improvement in traffic safety for all road users (including motorcyclists) in OECD countries, motorcyclists have seen their exposure to road risk increase to the point that in some countries the number of motorcyclists who died in road crashes actually increased over the past two or three decades (Shinar, 2012), while the mortality of other road users declined significantly.

PTW riders are at far more risk than car drivers per kilometre ridden in terms of fatalities and severe injuries entailing long-term disability. The share of PTW fatalities is often much higher than their share in the vehicle fleet, especially in low- and middle-income countries.

Regardless of the countries concerned, however, PTW users are confronted with an excessive risk on the road, which has been qualified as "unfair" by Elvik (2009), insofar as for the same number of kilometres driven they have a much higher risk of being killed or severely injured than car occupants. They are clearly overrepresented among road traffic casualty figures, even when they are not overrepresented in crash occurrences.

In this context, the objectives of this paper can be outlines as follows:

- To review and synthesize the most recent knowledge dealing with motorcycling safety;
- To review and synthesize the current understanding of motorcycle crash configurations and mechanisms;
- To provide recommendations to on measures that can be implemented in the short term to improve the safety of motorcyclists.
- To progress toward the safe system approach for PTW.

This research was carried out by a working group of the OECD International Transport Forum, composed of experts from several countries. The paper starts by presenting the basic trends and figures of PTW mobility, use and safety. Then, a comprehensive review of PTW crash contributory factors is presented (user-, vehicle- or infrastructure-related). Subsequently, the integration of PTW in the Safe Systems approach is discussed, with particular focus on the challenges and particularities involved. Finally, the most promising individual measures for the improvement of PTW mobility and safety are outlined.

2. Mobility and safety figures of PTW

2.1. PTW mobility and use

It is estimated that there are 313 million powered two-wheelers in the world, with a relatively uneven distribution across regions: 77% are found in Asia, 5% in Latin America, 1% in Africa, 1% in the Middle East and 16% in North America and Europe (Rogers, 2008). This disparity is also characterized by the uses made of this mode. Primarily recreational in North America and Australia, the two-wheeler does have a much more mixed function, for example, in Europe it is increasingly used to escape the problems of urban traffic congestion; in other regions of the world it may have a mainly utilitarian use.

In most OECD countries, over the past decade (2001-2010), the motorcycle fleet grew much more rapidly than the passenger car fleet (see Table 1).

Table 1 Evolution (%) in the PTW and passenger car fleets for a selection of OECD countries 2001-2010 (Source: IRTAD)

	Passenger cars	Mopeds	Motorcycles
Australia	25%	-	88%
Czech Republic	29%	10%	35%
France	11%	-22%	48%
Great Britain	13%	-27%	28%
Greece	52%	-14%	76%
Japan	11%	-20%	14%
Spain	22%	27%	82%
Sweden	8%	84%	91%
United States (excl. SUVs)	5%	-	67%

PTWs are becoming an important component of the transport system and represent in some cities up to 30% of the motor vehicle fleet (ACEM, 2013). They present both assets for mobility, and also challenges in terms of traffic management and safety. However, only a few countries have in place a national transport strategy for PTWs (e.g. DfT, 2005; Victorian Government, 2008); though several measures may be taken at local level.

2.2. Safety development over time

While there has been important progress in most OECD countries in improving road safety and reducing road mortalities, PTW riders have not benefited at the same pace as car occupants from safety improvements over the last decade (see Figure 1).

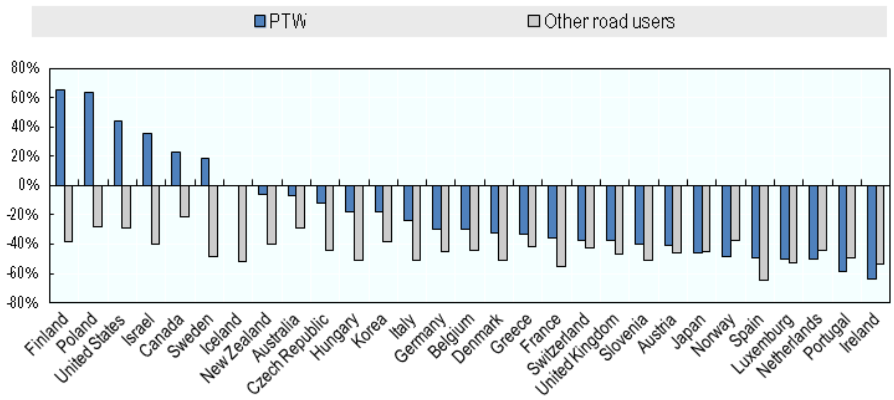

Fig. 1 Evolution in fatalities among PTW and other road users, OECD countries, 2001-2011 (Source: IRTAD, 2001-2010 data for Canada)

In fact, the situation of motorcyclists has deteriorated in the past decade if one compares with the significant progress with other road users. PTW trends are not following the overall fatalities decrease in the OECD countries; this may be explained by the high increase in PTW fleet and respective mobility, as PTW have been steadily gaining in popularity in recent years, with large gains seen in PTW ownership and ridership. PTW is the only mode of transport for which the number of fatalities has increased, significantly in some countries, over the last decade, which stresses the importance of taking immediate appropriate counter measures.

2.3. Crash characteristics and scenarios

When related to the number of kilometres travelled, a motorcyclist is between 9 to 30 times more likely to be killed in a traffic crash than a car driver (see Table 2).

Table 2. Deaths per billion veh-km in 2011 for motorcyclists and car occupants (source: IRTAD)

	Car Occupant	Motorcyclists	Mopeds (when distinction is made in statistics)	Relative risk of motorcyclists vs. car occupants
Australia	5.2	71.8		14
Austria (2010)	4.7	59.7	56.1	13 for motorcyclists 12 for mopeds
Belgium (2010)	5.9	76.9		13
Canada (2010)	4.9	62.9		13
Czech Republic (2010)	10.5	252.6		24
Denmark	4.2	49.5		12
France	4.9	72.4	64.7	15 for motorcyclists 13 for mopeds
Germany	3.3	59.5	14.6	18 for motorcyclists 4 for moped
Ireland	2.5	60.8		24
Israel (2010)	5.1	45.7	26.8	9 for motorcyclists 5 for mopeds
Netherlands (2004-08)	3.0	64	63	21
Slovenia	4.3	112.5		26
Sweden (2010)	2.2	43.9		20
Switzerland	2.3	39.2	29.6	17 for motorcyclists 12 for mopeds
United States	5.0	150.6		30

On average, in OECD countries, PTWs riders and passengers count for 16.5% of all road fatalities, while only representing 8% of the fleet. PTWs are clearly overrepresented in the road traffic casualties. The situation in developing countries is drastically worse. 90% of global deaths occur in low- and middle-income countries.

In many countries, the average age of motorcyclist killed has increased. In Europe the number of motorcyclists killed in the 40-60 years age group has doubled in 10 years (Yannis et al., 2010; NHTSA, 2010). The fatality rates for moped riders aged 15-19 and motorcycle riders aged 20-30 are notably high. It appears that being young, male and lacking experience is associated with increased PTW fatality risk (Yannis et al. 2005; Lardelli-Claret et al. 2005; Reeder et al. 1995).

A wide majority of PTW crashes are single vehicles crashes occurring on rural roads; 25% of all PTW crashes in Italy, 38% in Greece and 44% in Finland and Sweden (2BESAFE, 2010). Almost one third of all PTW fatalities occur at junctions - a proportion notably higher compared to other road users'(ACEM, 2006; Yannis et al. 2010). This stresses the importance of taking specific counter measures for junction safety improvement for PTWs.

3. Contributory factors of PTW crashes

The level of risk for PTW is influenced by many factors. A first general factor is the intrinsic difficulty to drive a PTW, due to the necessity to control the balance, its lower friction capacity and its greater sensibility to environmental perturbations (wind, gravel, any change in road surface, etc.) which may destabilize the vehicle. PTW riders also have a higher risk of injury due to their greater vulnerability, resulting from a lack of protection compared to passenger cars.

Elvik (2004) has defined some basic factors which influence the level of risk of road accidents. Among these risk factors some are considered to affect PTWs more specifically, such as low friction (as mentioned above), but also lack of visibility, road-user rationality, road-user vulnerability and system forgiveness.

Moreover, by its very nature, driving a PTW may induce a specific behaviour pattern on the road which is different from the drivers of four-wheeled vehicles. Such behaviour is not necessarily “deviant” according to the law, but may surprise other road users. Even "normal” behaviour, i.e. common to PTW riders, may be atypical for other vehicle operators (e.g. overtaking within a small space, overtaking on the right, filtering, positioning on one side of the road, intense acceleration, etc.), disturbing their normally efficient information-seeking routines. Atypical behaviour also refers to “deviant” behaviour, including stunts, wheeling, etc.

Driver and rider-related behaviour factors are much more prevalent in PTW crashes, compared to vehicle and road infrastructure / environment factors. Speeding is a bigger problem for PTW crashes, compared to other modes. On average, motorcyclists ride at higher speeds than cars and PTW crashes usually occur at higher speeds than cars’ ones (Horswill et al. 2005). Similarly, the consumption of alcohol is associated with increased risk of fatal crashes among PTWs (Kasantikul et al. 2005). Moreover, for the same BAC, the severity of the crashes is higher for the PTW than for the other road users (McLellan et al. 1993; Soderstrom et al. 1995). Operating a PTW requires more co-ordination and balance than operating a car, which explains that impaired riding (e.g. by alcohol or drugs) or inappropriate behaviour (e.g. speeding) is even more problematic for PTW riders.

Vehicle technical failures are only a minor proportion of PTW road crash contributory factors. On the other hand, road design and road environment factors have mostly an important influence on the crash severity (e.g. roadside obstacles and barriers, speed reduction installations) rather than on crash occurrence (ACEM, 2006). PTW are more sensitive to infrastructure design (e.g. alignment, curves, etc.), maintenance (holes, gravels, etc.) and interaction with other road users. Due to this sensitivity, defects on the layout are likely to create more difficulties on PTW riders than on operators of other motorised vehicles.

A large number of crashes involve a problem of perception/appraisal by the other vehicle operator. This over-representation of inappropriate perception in PTW crashes suggests a specific problem of detectability (conspicuity) for these road users (Preusser et al., 1995; Yuan, 2000). The problem of perception is complex and cannot be reduced to the simple fact that PTWs are physically less visible than other vehicles. There are many causes behind the poor detectability of PTWs and these are often connected to each other and with the general parameters of the driving context. Indeed, this problem can be explained by the visual characteristics of PTWs, by the sensory capabilities of the human perceptual system, by the atypical behaviour of PTWs and by the expectations that road users develop.

It is also noted that a more frequent combination of road crash contributory factors is found in PTW crashes, compared to other road users crashes, which results in the multiplication of the relative risk. For example, it has been found that those without a valid license have a higher probability not to wear a helmet, to drive above the speed limit, to drive under the influence of alcohol and without daytime running light, and so on (Peek-Asa et al. 1996; Reeder et al. 1996).

Although human behaviour and characteristics are the most frequently represented contributing factors in crashes, this does not mean that solution to improve safety conditions for PTWs must only focus on behaviours. A safe system approach is required; it can be more efficient to change behaviour by acting on a range of levels, including the infrastructure, the vehicle and the system as a whole. However, the integration of PTW in a safe systems approach may be challenging in several ways; these are discussed in the next section.

4. Towards an integrated road safety strategy for PTW

4.1. The safe systems approach

The safe system is variously described in a number of jurisdictions but has a single core principle: A recognition that road users will make mistakes, or inappropriate decisions, and that the system, while also minimizing errors, should accommodate these errors so that no individual road user is exposed to crash forces likely to result in death or serious injury. The system then ensures their safety by providing vehicles, road and roadside infrastructure and travel speeds that combine to ensure that any crashes that do eventuate result in crash forces that are below the level of human tolerance to physical harm

Another characteristic of safe system approaches is consideration of the interactions between the different elements of the system and between the effects of different interventions. Some aspects of this are well recognised, for example, the influence of road design on chosen travel speeds. The challenge is to optimize the protection by combining the components of the road traffic system.

According to the recommended approach of the OECD's Towards Zero – Ambitious Road Safety Targets and the Safe System Approach (OECD/ITF 2008), a strategic planning process on the basis of Safe Systems approach principles can be outlined as follows:.

- Situational analysis: conduct sufficient data collection and analysis to understand crash risks and current performance;
- Define strategic objectives: adopt a highly ambitious vision for road safety, set interim targets to move systematically towards the vision, develop a Safe System approach, essential for achieving ambitious targets;
- Determine strategies and actions: exploit proven interventions for early gains, invest in road safety;
- Establish supporting arrangements: strengthen the road safety management system, accelerate knowledge transfer, foster commitment at the highest levels of government.

4.2. PTWs in the safe system

Growing PTW traffic makes it imperative to adopt safety interventions targeting this mode of transport, while integrating it into a safe system approach. According to the above, improving the safety of PTWs should be a shared responsibility. All relevant stakeholders need to be actively involved in the process of drawing up and implementing a shared road safety strategy which includes safer behaviour of all road users, safer infrastructure and vehicles with enhanced safety features.

A strategic approach should consider the most effective combination or measures according to the specific needs of individual jurisdictions. Several OECD countries do have strategic plans for PTW safety, although not always involving specific strategic objectives, quantitative targets, specific evidence-based measures to achieve the targets etc. (e.g. DfT, 2005; DGT, 2007; Rijksoveheid, 2011; Trafikverket, 2010; Victorian Government, 2008)

Inclusion of motorcyclists into the Safe System yields two challenges. The first is the technical problem of providing protection from physical harm at the speeds at which collisions with other vehicles or fixed objects are likely. While this could be solved by ensuring travel speeds by, and in the vicinity of, motorcyclists are much lower, this then amplifies the second challenge. This is to ensure that any measures taken to improve motorcycle safety are supported both by the broader community and by motorcyclists in particular.

This leads to consideration of whether the conventional Safe System approach should be modified by recognising that, in the short to medium term, motorcycling will remain an inherently risky activity and that measures should be taken to reduce risk. This may result in, for example, strategies that focus more on avoiding crashes, rather than mitigating their effects.

A toolbox of measures is required to improve the safety of PTW riders within the traffic system. These measures must take into account the specific challenges of PTWs traffic, and also consider the variety of PTW users, insofar as some segments may be addressed with particular measures.

5. Measures for PTW safety improvement

The Safe System approach assumes that road users will enter the system competent and will take measure to ensure that they remain compliant and alert. Licensing, training, education, and enforcement campaigns are essential tools for improving riding safety.

5.1. Licensing, training & education

Access to PTWs should be gradual, with a licensing system aiming at managing novice rider risks while riders are gaining experience and maturity (Reeder et al., 1995).

Novice riders of every kind of PTW should be trained. Training should not only focus on basic manoeuvring skills and mastering traffic situations, but also address attitudes towards safety, putting a special emphasis on hazard perception and defensive riding (Kardamanidis et al., 2010).

Other road users should also be made aware of the specific risks associated with PTWs vulnerability and crash patterns. Communication campaigns addressing required behaviour change should be targeted at key groups of drivers and riders.

5.2. Enforcement and communication

Enforcement of traffic rules is an indispensable ally of other safety measures (Elvik & Vaa, 2004). PTW operators, as other operator of motorised vehicles, must comply with traffic rules and typical enforcement activities to control speeding, drink and driving, non-respect of traffic rules etc.

Traffic rules apply equally to operators of 2 and 4 wheeled vehicles and should be equally enforced. As for other motorised vehicle users, enforcement is needed to improve compliance with key safety rules like speed, drinking and driving, helmet use, proper licenses and a vehicle that meet safety standards. High-visibility enforcement accompanied by other measures, such as communication and publicity has proven to have a strong deterrent effect. Speed enforcement is key in reducing the speed and associated crash risk. Automated speed enforcement has proven its effectiveness for cars, but further adjustments are needed to make it as effective for PTW.

The combination of enforcement-communication campaigns (on speeding, riding without a helmet and other risky behaviour) has proven its effectiveness in many countries (Henkens & Hijkoop., 2008). The success of enforcement and communication strategy depends on the involvement of motorcyclists themselves and motorcyclists associations have an important role to play in diffusion communication messages, informing riders about the rules and making enforcement acceptable.

5.3. Infrastructure and traffic management

Road and traffic management have traditionally been designed for four wheel vehicles. In some cases, these are not properly adapted for PTW. Much could be done to facilitate the mobility and safety of PTWs, without compromising the mobility of other motorised vehicles.

Infrastructure should be improved with the development of self-explaining roads to guide drivers and riders to adopt appropriate speeds, traffic calming measures and PTW friendly equipment (forgiving roads), targeted at areas of highest PTW risk (ACEM, 2006).

Engineers, road designers, road safety auditors and inspectors should be trained to consider PTWs in the design, maintenance and operation of roads, and be provided with the necessary risk assessment tools to make the right decisions. Local authorities’ staff should be trained and informed on the infrastructure requirements for PTWs to compensate for the safety problems to which they are specifically subject.

Traffic management measures can have a dual purpose: facilitating PTW traffic and increasing safety. Further research is needed on the safety impact of measures such as advanced stop lines and traffic filtering. When implementing any new measure in favour of PTW mobility, caution must be paid that no new risk is induced for themselves or for any other road users.

5.4. Vehicles, ITS and protective devices

There are a number of developments within the motorcycle industry to improve the passive and active safety of motorcycles.

Anti-lock braking system (ABS) is a well proven technology which can significantly improve the safety of PTW (Rizzi et al, 2009). While it is currently offered as an option on new high-end bikes of major PTW manufacturers, with a slow penetration rate in most OECD countries, it can certainly benefit all powered-two wheelers and should become a standard. Cost is however an issue, and industry and government should work together to facilitate a quicker penetration of these technologies, which anyway will become mandatory in some regions in the coming years (expected in EU for the year 2016).Other advanced braking systems may also help reducing injury risk, but the priority today is to keep ensuring the penetration of ABS in the fleet.

There has been little advancement of intelligent transportation systems research dedicated to motorcycle safety. Motorcycle ADAS (Advanced Driver Assistance Systems) could improve the safety of the rider as well. There is however a number of obstacles that will likely lead to a slower uptake compared to passenger cars, including the challenges posed by the Human Machine Interface requirements, costs, and the required support from the motorcyclists community. In spite of these obstacles, ITS has a role to play to increase motorcycle safety in the future. e-Call, blind spot detection, curve and collision warning systems are suitable applications for the motorcycle - once sufficiently developed for them.

While research into the benefits of protective clothing is unequivocal (Rome et al., 2011; ACEM, 2006), there are rider willingness-to-pay issues with mandatory requirements for protective clothing. Further research and development into clothing and equipment with lower weight and improved ventilation should be encouraged.

The helmet is the most important source of protection against severe injuries for both motorcyclists and moped riders (Liu et al., 2007). The use of helmets and other protective equipment with adequate safety standards should be promoted and regulated where required.

6. Key messages and recommendations

The OECD/ITF group on PTW mobility and safety proposed a number of key messages and recommendations, which are summarized in Table 3, and analysed below.

Table 3. Key messages and recommendations on PTW mobility and safety

Key messages and recommendations	
1.	The powered two-wheeler population increases and plays a significant role in mobility
2.	PTW riders are at far more risk than car drivers
3.	PTW crashes are mainly due to perception and control failures
4.	A safe system approach is required to improve the safety of PTWs
5.	A toolbox of measures is required to improve the safety of PTW riders
6.	Promoting appropriate behaviours of road users is a prerequisite
7.	Self-explaining and forgiving roads contribute to lower crash risk
8.	Protective equipment and vehicles with enhanced safety features save lives
9.	It is essential to extend the knowledge on PTW mobility and crash mechanisms

Motorcycling has become an integrated part of the traffic system offering certain benefits over other modes of transport; consequently, they need to be properly integrated into mobility plans and safety strategies. As the economic costs associated with PTW crashes are significant, investing in PTW safety can bring important societal and economic benefits.

However, PTW safety figures have not followed the impressive improvement trends of the last decade that other users' safety figures demonstrate. Moreover, per kilometre driven, PTW riders have a much higher risk of being killed than car occupants, between 9 and 30 times higher. PTW riders are also more likely to be very seriously injured in a road crash with long term disabilities than other motorised road users. They are also more vulnerable to rider impairment by e.g. alcohol.

Young, inexperienced and male riders are over-represented in crashes. The most frequent PTW fatal crashes are single-vehicle crashes, due to intrinsic difficulties of riding a PTW (e.g. necessity to keep the balance) and to the higher sensitivity of riders to external perturbations (e.g.; wind or poor pavement condition). The other most frequent crash type occurs at intersections with other traffic, involving, for a large number of crashes, a problem of perception and appraisal by the driver and/or the rider.

A safe system approach is proposed for improving PTW mobility and safety in the OECD countries; it can be more efficient to change crash and injury outcomes by implementing a range of interventions, including road users, the infrastructure, the vehicle and the system as a whole, i.e. their interactions. The implementation of this approach involves dealing with a number of challenges in balancing the different objectives of the safe system design with the PTW particularities and needs. In each case, a selection of specific measures for implementing the strategy will be required.

Priorities in individual measures may include:

- Promoting appropriate behaviours of road users (licensing, training and education, enforcement of traffic rules, communication campaigns addressing required behaviour)
- Self-explaining and forgiving roads (roads to guide drivers and riders to adopt appropriate speeds, traffic calming measures and PTW friendly equipment, training of engineers and local authorities etc.)
- Protective equipment and vehicles with enhanced safety features (use of helmets and other protective equipment with adequate safety standards, enhanced safety features in vehicles, notably with the general introduction of advanced braking systems etc.).

Additional research is needed to better understand current challenges related to PTW mobility and safety problems. This involves a need to develop and apply relevant methods, tools and indicators to measure PTWs in traffic flows and analyse their mobility and behaviour (exposure data). More in-depth investigations will allow a better understanding of fatal and serious injury crash patterns and causes. Conspicuity and other perception problems deserve further study in order to identify key contributing factors and effective countermeasures.

References

2-BE-SAFE (2010). *Rider / Driver behaviours and road safety for PTW*. Deliverable D1 of the 2-BE-SAFE project. European Commission, Brussels. Available on-line at: http://www.2besafe.eu/sites/default/files/deliverables/2BES_D1_RiderDriverBehavioursAndRoadSafetyForPTW.pdf

ACEM (2009). *Motorcycle Accident In-Depth Study: In-depth investigations of accidents involving powered two wheelers*, MAIDS project Final report 2.0 - Association des Constructeurs Européens de Motocycles (The Motorcycle Industry in Europe), Brussels.

ACEM (2013). *The motorcycle industry in Europe: Statistical overview*, version 18/4/2013. The Motorcycle Industry in Europe, Brussels.

DfT (2005). *The Government's Motorcycling Strategy*, Department for Transport, London, 2005

DGT (2007). *Strategic Plan for the Road Safety of Motorcycles and Mopeds*, Direccion General del Trafico, Ministerio del Interior, Madrid, 2007.

Elvik (2004). To what extent can theory account for the findings of road safety? *Accident Analysis and Prevention* 36, 841-849.

Elvik, R. and Vaa, T. (2004)., *The handbook of road safety measures.* Amsterdam: Elsevier Science.

Elvik, R. (2009). Benefits and fairness: are the high risks faced by motorcyclists fair? In P. van Elslande (ed.), *Les deux-roues motorisés : nouvelles connaissances et besoins de recherche*. Bron: Les collections de l'INRETS.

NHTSA (2012), *Traffic Safety Facts, 2010 Data, Motorcycles*. DOT HS 811 639.

Haworth, N. (2012). Powered two wheelers in a changing world: challenges and opportunities. Accident *Analysis and Prevention*, 44(1), 12-18.

Henkens, N.C. & Hijkoop, S. (2008). *Monitoring Bromfietshelmen 2008*. In opdracht van Bureau Verkeershandhaving Openbaar Ministerie. Grontmij Verkeer en Infrastructuur, De Bilt.

Horswill, M. S., Helman, S., Ardiles, P., & Wann, J. P. (2005). Motorcycle accident risk could be inflated by a time to arrival illusion. *Optometry and Vision Science*, 82(8), 740-746.

Kardamanidis K, A. Martiniuk, R. Ivers, M. Stevenson and K. Thistlethwaite (2010). *Motorcycle rider training for the prevention of road traffic crashes: review.* Cochrane Injuries Group.

Kasantikul, V. et al. (2005). The role of alcohol in Thailand motorcycle crashes. *Accident Analysis &Prevention*, 37(2), 357-366.

Lardelli-Claret, P., Jimenez-Moleon, J. J., Luna-del- Castillo, J. D., Garcia-Martin, M, Bueno-Cavanillas, A. and Galvez-Vargas, R. (2005). Driver dependent factors and the risk of causing a collision for two wheeled motor vehicles. *Injury Prevention*, 11, 225-231.

Liu, B.C., Ivers, R., Norton, R., Boufous, S., Blows, S. & Lo, S.K. (2007). *Helmets for preventing injury in motorcycle riders*. In: Cochrane Database of Systematic Reviews 2007, nr. 4.

McLellan et al. (1993). The role of alcohol and other drugs in seriously injured traffic crash victims, *International Conference on Alcohol, Drugs and Traffic Safety-T92*, Proceedings of the 12th Conference.

OECD/ITF, (2008), *Towards Zero – Ambitious Road Safety Targets and the Safe System Approach* , OECD/ITF, Paris, 2008.

Peek-Asa, C, and Kraus, JF. (1996). Alcohol use, driver, and crash characteristics among injured motorcycle drivers. *Journal of trauma* 41 (6), 989-93.

Preusser D.F., Williams A.F., Ulmer R.G., (1995), Analysis of fatal motorcycle crashes: crash typing. *Accident Analysis and Prevention*, 27 (6), 845-851.

Reeder A.I, Chalmers D.J, Langley J.D, (1995). Young on-road motorcyclists in New Zealand: age of licensure, unlicensed riding, and motorcycle borrowing, *Injury Prevention* 1, 103–108.

Rijksoverheid, (2011). *Action plan for improving road safety for motorcyclists – Strategic approach*, Ministry of Infrastructure and Environment, The Hague, 2011.

Rizzi M., J. Strandroth, A Kullgren, C. Tingvall and B. Fildes (2013). Effectiveness of Anti-Lock Brakes (ABS) on motorcycles in reducing crashes : a multinational study. Paper presented at the *2013 ESV Conference*, Seoul, 27-30 May 2013.

Rogers, N. (2008). *Trends in motorcycle fleets worldwide*. Presentation to Joint OECD/ITF Workshop on Motorcycling safety. http://www.internationaltransportforum.org/jtrc/safety/Lillehammer2008

de Rome, L., Ivers, R., Fitzharris, M., Wei Du, Haworth, N., Heritier, S. & Richardson, D. (2011). Motorcycle protective clothing: Protection from injury or just the weather? *Accident Analysis & Prevention* 43 (6), 1893-1900.

Shinar, D. (2012). Safety and mobility of vulnerable road users: pedestrians, bicyclists, and motorcyclists. *Accident Analysis and Prevention*, 44(1), 1-2.

Sodertrom CA, P Dischinger, T Kerns and A. Triffilis (1995). Marijuana and other drug use among automobile and motorcycle drivers treated at a trauma center, *Accident Analysis and Prevention*, 27 (1), 131-135.

Trafikverket (2010), *Improved safety for motorcycle and moped riders*. Joint strategy for the period 2010–2020, Swedish Transport Administration, 2010:043, Borlange, 2010.

Victorian Government (2008). *Victoria's Road Safety and Transport Strategic Action Plan for Powered Two Wheelers 2009-2013*, Victorian Government, Melbourne, 2008.

Yannis G., Golias J., Papadimitriou E., (2005). Driver age and vehicle engine size effects on fault and severity in young motorcyclists accidents, *Accident Analysis and Prevention*, 37 (2), 327-333.

Yannis G., et al. (2010) *Basic Fact Sheet "Mopeds and Motorcycles"*, Deliverable D3.9 of the EC FP7 project DaCoTA, European Commission, Brussels.

Yuan, W (2000). The Effectiveness of the 'Ride Bright' Legislation for Motorcycles in Singapore. *Accident Analysis and Prevention* 32 (4), 559–63.