Chapter 3. Powered two-wheeler crash characteristics

This chapter reviews the safety issues of powered two-wheelers (PTWs). It highlights the relative crash risk for motorcyclists and describes PTW crash characteristics in terms of recent crash trends, typical injuries, and crash scenarios.

Introduction

The rapid growth in the variety, sales, registrations, and activity of powered two-wheelers (PTWs) - motorcycles, scooters, mopeds - observed in recent years in most countries has been accompanied by growth in crashes, injuries, and fatalities involving them. Such growth is likely to accelerate as world populations grow and more people recognise the potential economic, mobility, and environmental sustainability benefits of powered two-wheelers. This chapter analyses the safety issues associated with powered two-wheelers.

Data issues

Crash data

Crash data presented in this chapter are mainly based on fatality data from the following sources:

- The IRTAD database, which presents aggregated data for 32 countries;
- The CARE database, which gathers disaggregated data for most EU countries;
- National databases, such as FARS for the United States.

Analysing *serious injuries* is also essential to understand safety issues of motorcyclists, because motorcyclists are more exposed to very serious injuries with long-term handicap, due to their lower mass and occupant protection, which are significantly different from injuries of other road users. In addition, recent work (ITF/OECD, 2011) has shown that reducing the number of seriously injured may require a different approach than reducing the number of fatal crashes.

However, one must be aware of the challenge of analysing injury data because:

- There is no universal definition of serious injuries among countries, despite the recent recommendations from IRTAD and the European Commission to define serious injuries on the basis of the Maximum Abbreviated Injury Scale.
- Data on injuries are largely underreported and biased in the source of information described above. Only a very limited number of countries have systematic exchange of information between police and health data to allow a more complete picture of the situation.[1]

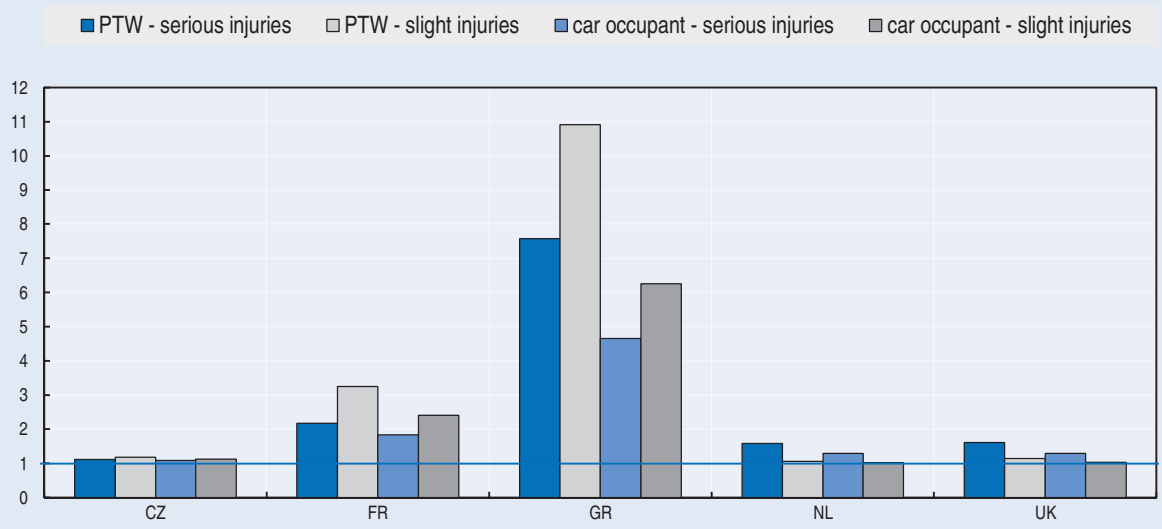
Box 3.1. **The issue of underreporting**

Results of a pilot European study

Within the SafetyNet Integrated European project, a pilot study was carried out in eight European countries, aiming to estimate road accident injury under-reporting coefficients on the basis of linking Police and Hospital data for different road user types, and to propose a common definition of injury severity in Europe (Broughton et al., 2010).

In this study, underreporting coefficients were defined as the ratio of the estimated actual number of injuries of a given severity, to the number of related injuries recorded by the Police.

Figure 3.1. **Underreporting coefficients for PTW riders and car occupants per injury severity in five European countries**



Source: Broughton et al., 2010.

Underreporting coefficients for PTW riders (namely motorcyclists) and car occupants were estimated in five European countries (see Figure 3.1). The extent of the injury underreporting problem for motorcyclists is equal (CZ), slightly higher (FR, NL, UK) or significantly higher (GR) than for car occupants. Serious motorcyclist injuries appear to be less underreported by the Police than slight ones in Greece, France and the Czech Republic, while the opposite is the case for the Netherlands and the UK. The underreporting of motorcyclists' injury is strikingly high in Greece, and the difference compared to car occupants is also more pronounced in that country, a country where motorcyclists' casualties are over-represented in the total road accident casualties.

Despite some limitations of the above European pilot study (e.g. few countries, different sample study area sizes), the results can be considered to be indicative of the overall extent of the injury underreporting problem in the examined countries and in Europe as a whole. The findings from this study confirm that motorcyclists' injuries are more often underreported (Amoros and Laumon, 2006).

Exposure data

To understand PTW crashes, crash data must be analysed and compared with exposure data. Without detailed PTW exposure information, it is difficult to determine risk trends from the available fatality and injury data.

There are various indicators to measure exposure to assess the risks of transport modes:

- Vehicle –kilometres
- Passenger-kilometres
- The number of circulating motorised vehicles
- Total travel time

Using the number of vehicle kilometres travelled by PTWs gives a good proxy of their actual exposure to assess the level of risk. However, very few countries collect this type of data on a regular basis.

More complex information is ideally required such as quantitative and qualitative variations in the activity of particular registered vehicles and drivers, activity of unregistered drivers, changes in the prevalence of driving or riding, types of travel and relevant vehicle characteristics (such as power to weight ratio) in a given population or subpopulation, etc.

Relative crash risk for motorcyclists

As already mentioned in Chapter 1, there is a worldwide pattern that PTW riders experience a greater risk of being severely injured, but contribute less risk for other road users due to the lesser "aggressivity" of PTW vehicles as compared to cars and trucks.

In 2011, there were more than 12 000 PTW fatalities in OECD countries (excluding Chile, Estonia, Slovak Republic, Mexico, Turkey), representing between 8% and 30% of total fatalities. This percentage has to be compared with the percentage of travel by PTWs or the proportion of motorised vehicles that are PTWs. For example, in 2011, in France, PTWs represented 2% of the traffic, 6% of the motor vehicle fleet but 25% of total fatalities.

Table 3.1. **Percentages of PTWs in the motorised fleet and in total fatalities**

2001 and 2011

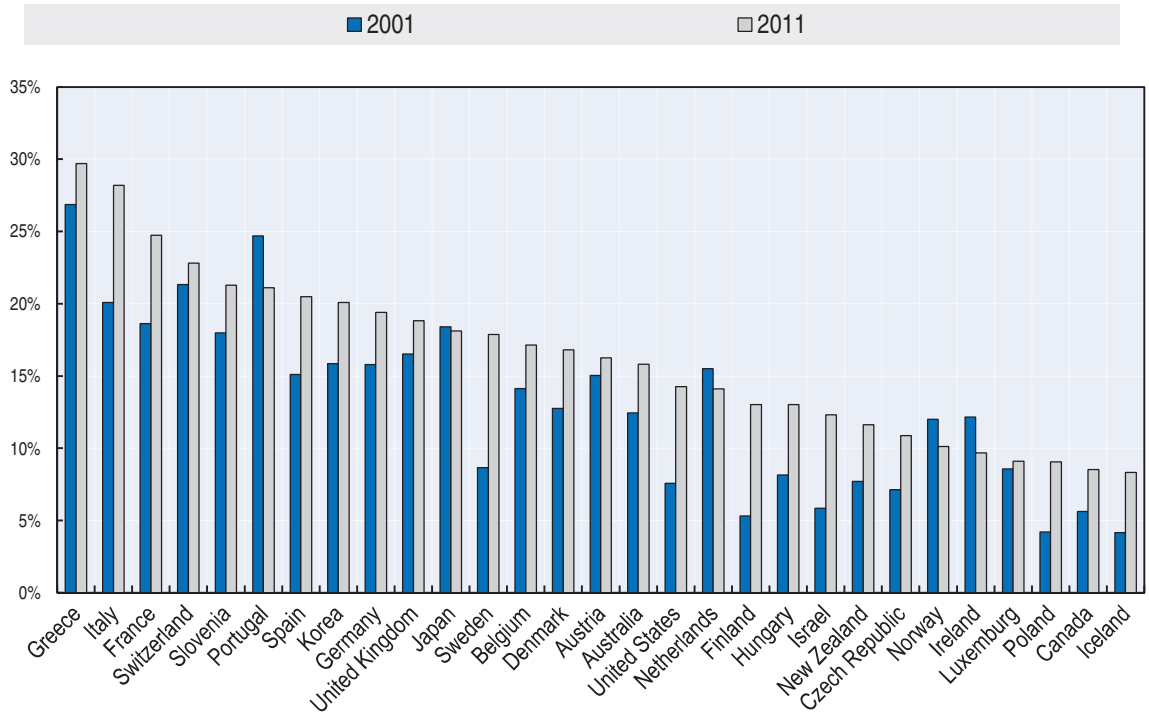
Country	Fatalities PTW	Fatalities-all	% PTW in fatalities	% PTW fleet	Fatalities PTW	Fatalities-all	% PTW in fatalities	% PTW fleet
	2001				2011			
Australia	216	1 737	12%	3%	202	1 277	16%	4%
Austria	144	958	15%	11%	85	523	16%	12%
Belgium	210	1 486	14%	5%	147	858	17%	6%
Canada	155	2 756	6%	2%	190	2 227	9%	
Czech Republic	95	1 334	7%	16%	84	773	11%	15%
Denmark	55	431	13%	3%	37	220	17%	5%
Finland	23	433	5%	7%	38	292	13%	13%
France	1 519	8 160	19%	7%	980	3 963	25%	6%
Germany	1 102	6 977	16%	9%	778	4 009	19%	11%
Greece	505	1 880	27%	35%	339	1 141	30%	31%
Hungary	101	1 239	8%	3%	83	638	13%	4%
Iceland	1	24	4%	1%	1	12	8%	4%
Ireland	50	411	12%	2%	18	186	10%	2%
Israel	31	531	6%	-	42	341	12%	4%
Italy	1 426	7 096	20%	18%	1 088	3 860	28%	17%
Japan	1 854	10 071	18%	16%	997	5 507	18%	14%
Korea	1 284	8 097	16%	12%	1 050	5 229	20%	9%
Luxemburg	6	70	9%	3%	3	33	9%	4%
Netherlands	154	993	16%	11%	77	546	14%	12%
New Zealand	35	455	8%	2%	33	284	12%	3%
Norway	33	275	12%	3%	17	168	10%	4%
Poland	232	5 534	4%	5%	379	4 189	9%	
Portugal	456	1 847	25%	13%	188	891	21%	
Slovenia	50	278	18%	1%	30	141	21%	3%
Spain	833	5 517	15%	13%	422	2 060	20%	
Sweden	48	554	9%	5%	57	319	18%	8%
Switzerland	116	544	21%	15%	73	320	23%	15%
United Kingdom	594	3598	17%	3%	369	1 960	19%	4%
United States	3 197	42 196	8%	2%	4 612	32 367	14%	3%

Source: IRTAD.

Table 3.1 and Figure 3.2 show the trends in the percentages of total fatalities that were PTW riders for the period 2001-2011. For all countries for which data are available, with the exception of Portugal, the Netherlands, Norway and Ireland, the percentages increased. This may reflect increases in PTW fatalities, decreases in other motor vehicle fatalities, or both.

Figure 3.2. **Share of PTW fatalities in total fatalities**

2001 and 2011



Source: IRTAD

There are several different ways of expressing the risk of travelling by a particular mode (e.g. car or motorcycle) and the relative level of risk of different modes depends on which way of expressing risk is chosen. While the number of people killed or injured is generally known to a reasonable level of certainty, the distance travelled value is commonly less precise. Very often, countries do not have good data on the occupancy of vehicles, and so can only use the distance travelled by that type of vehicle. Thus, they are unable to compare the risk of one person travelling a given distance by motorcycle versus the risk of one person travelling the same distance by car. Their data can show fatality (or injury risk) per vehicle-kilometre, but not per person-kilometre.

When related to the number of kilometres travelled, a motorcyclist is, depending on the country, between 9 to 30 times more likely to be killed in a traffic crash than a car driver (see Table 3.2). The relative risk for a PTW rider of being seriously injured is even higher (Martin et al., 2011). Given that a car commonly has more occupants than a motorcycle, the difference in risk per passenger-kilometre between PTW riders and car occupants is probably even greater.

Table 3.2. **Deaths per billion vehicle-kilometres in 2011**

Motorcyclists and car occupants

	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 Kingdom (Great Britain) (2012)	2.1	72		34
United States	5.0	155.0		31

Source: IRTAD.

Characteristics of PTW fatal crashes

Recent trends in fatal crashes

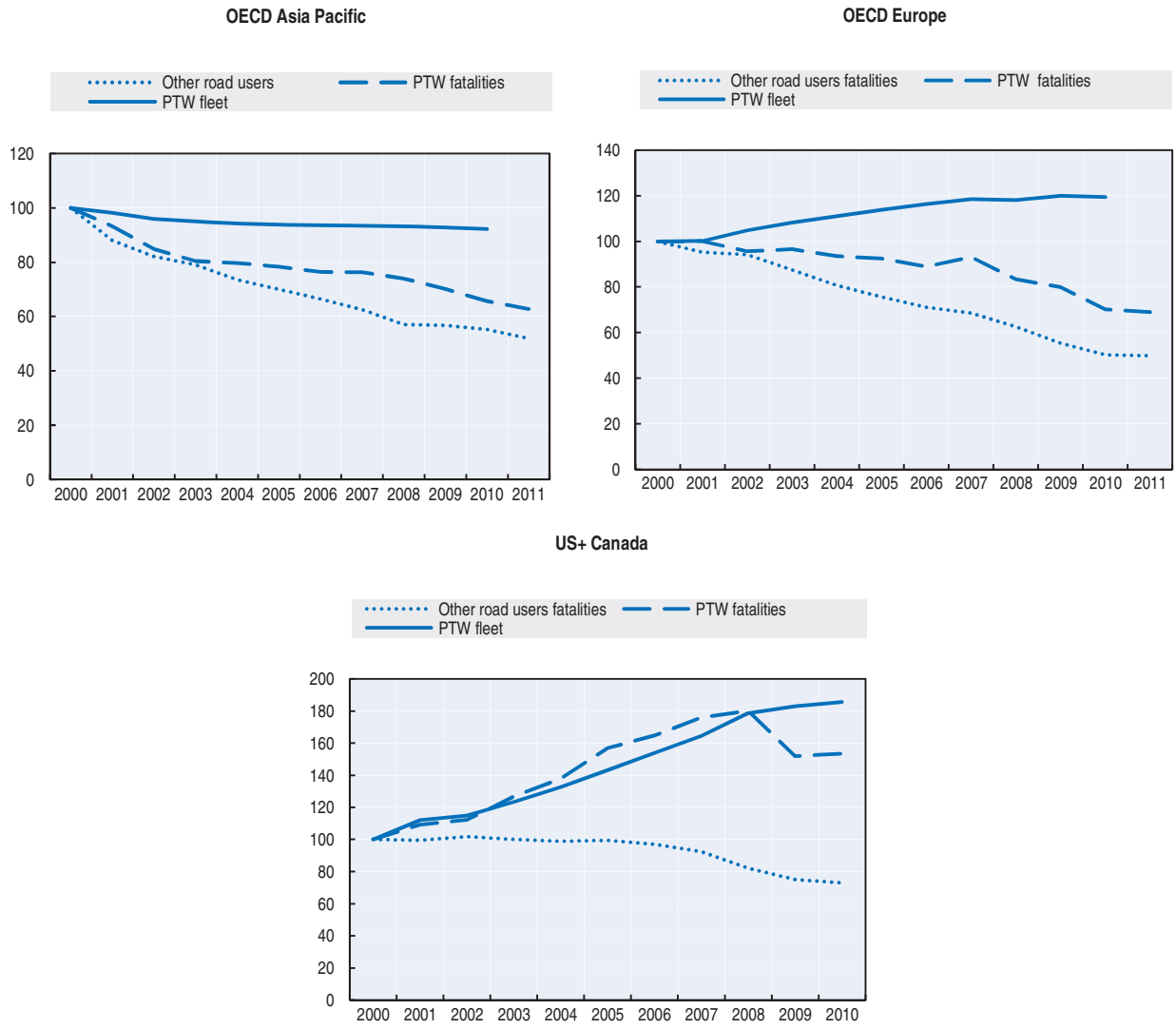
The following sections are based on fatality data; which are the most reliable information for the purpose of comparisons. Descriptive information on PTW injuries is also provided.

Figure 3.3 compares the recent trends in the number of motorcyclists killed and other road users killed in the three main regions of the OECD. A sharp increase in the number of motorcyclists killed is observed in North America and a moderate decrease in the other regions. While on average, OECD countries have seen a reduction of about 36% in the number of persons killed in traffic crashes in 2000-2010, the number of motorcyclists killed decreased only by 13% in total. The discrepancy is particularly obvious in North America.

In the United States, the number of motorcyclists killed increased by 83% between 2000 and 2008, while the number of passenger car occupants decreased by 29% (NHTSA, 2009). The relative deterioration of motorcyclist's safety in North America has to be seen in the context of a significant increase in the PTW fleet during the same period, which has almost doubled (Paulozzi, 2005) and the repeal of the helmet laws in some states. In 2009, motorcycle fatalities dropped sharply (16% decrease), but only for that one year. Fatalities resumed the increase from that point on; however, the rate of increase is smaller. From 2009 to 2011, motorcycle fatalities increased by 3%.

Figure 3.3. **Trends in PTW fatalities, other road user fatalities and PTW fleet in the three main OECD regions**

2000-2011, Index 100 = 2000



Note: OECD Asia Pacific includes: Australia, Japan, Korea and New Zealand

Source: IRTAD

Trends in PTW crashes compared to other modes

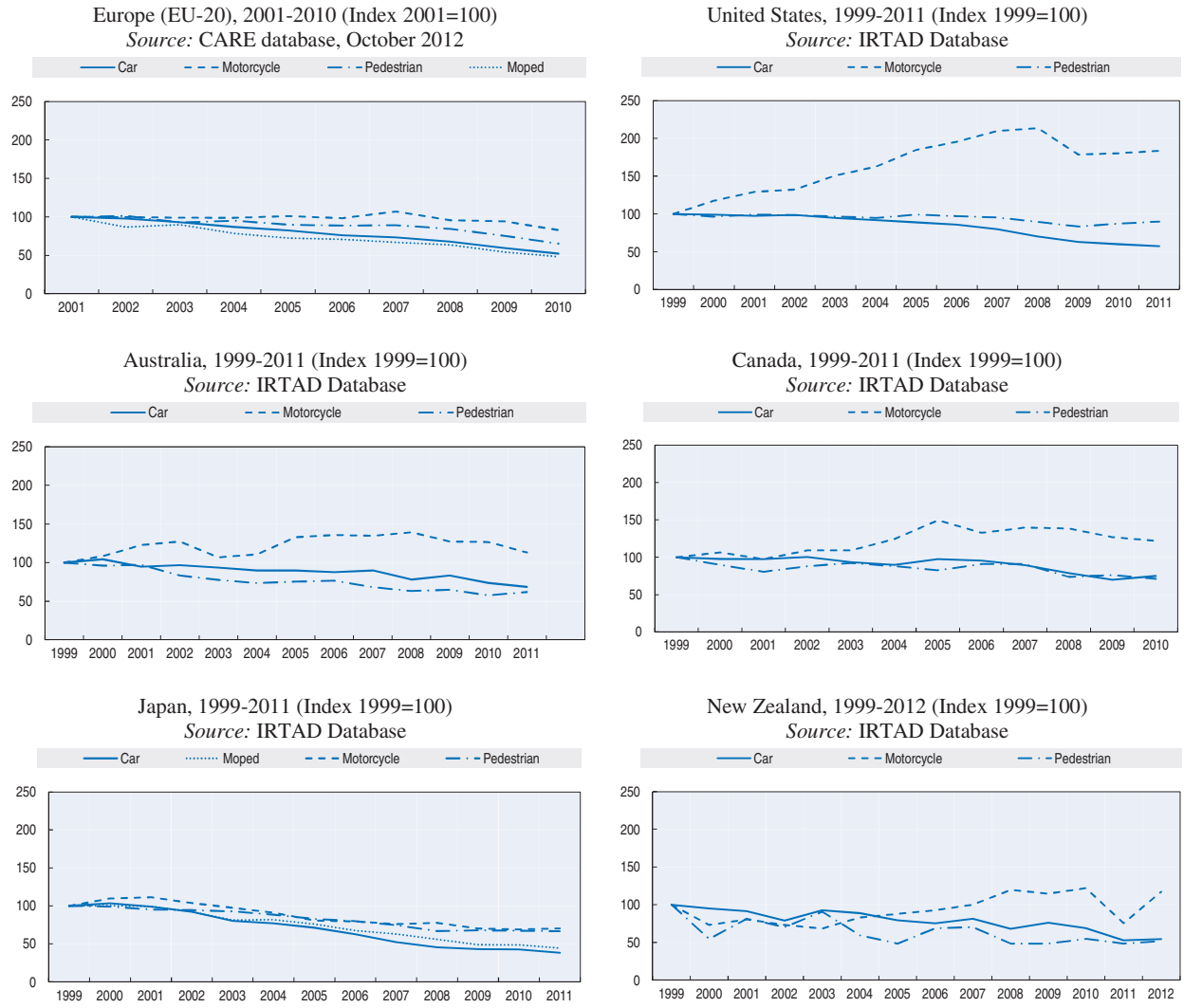
In order to better understand PTW road crashes, it is necessary to analyse crash data for motorcycles and mopeds separately in the context of their exposure. As seen in Chapter 2, mopeds are becoming less popular in many countries, while the number of motorcycles and scooters (125cm3 and more) is increasing very quickly. We will see in Chapter 9 that the situation is however quite different in low- or middle-income countries.

Motorcycle and moped fatalities, together referred to as powered two-wheelers (PTWs), accounted for 16.5% of the total number of road crash fatalities in 2010 in the 29 OECD countries for which data are available, but only 8 % of the fleet.

Figure 3.4 shows the increasing trend for motorcycle user fatalities compared to trends for other modes of transport, such as mopeds, passenger cars and pedestrians, in 14 European countries,[2] in the United States, in Australia, in Canada, in Japan and in New Zealand. The increase is sharper in Europe, the United States, Australia and Canada, and less pronounced – yet still visible – in Japan and New Zealand.

In the United States, there were increasing trends in motorcyclist fatalities and injuries from 2000 to 2009. The vast majority of PTW fatalities (97.2%) involved motorcycles above 50 cc. Moped fatalities, and to some extent estimated injuries, increased disproportionately in 2008 and 2009, perhaps due to increased moped activity in response to increased fuel prices and severe economic conditions during this period (NHTSA, 2012).

Figure 3.4. **Index of motorcycle and moped fatalities compared with pedestrians and car passengers**



PTW-Rider crash characteristics by gender

In most countries, the proportions of males and females among the riders killed follow the proportions of males and females in the motorcyclist population. As PTWs become more popular among

females, one can also observe an increasing trend in the percentage of females killed and injured in PTW crashes.

Results of epidemiologic studies do not reach consistent conclusions. Some studies have reported a higher crash risk for men than for women (Lardelli-Claret et al., 2005; Lin et al., 2003b) while one study found the opposite (Chang et al., 2007). Two studies, where the design adjusted for distance travelled, did not observe any valid statistical relationship between gender and crash risk (Harrison et al., 2005; Mullin et al., 2000).

Given the heterogeneity of the male and female populations among the riders, it is difficult to draw firm conclusions on their respective level of risk. As a matter of fact, several factors may explain risk variation between men and women: type of travel, risk taking, natural fragility, choice of vehicle, travel purposes, etc.

Effect of rider age on crash characteristics

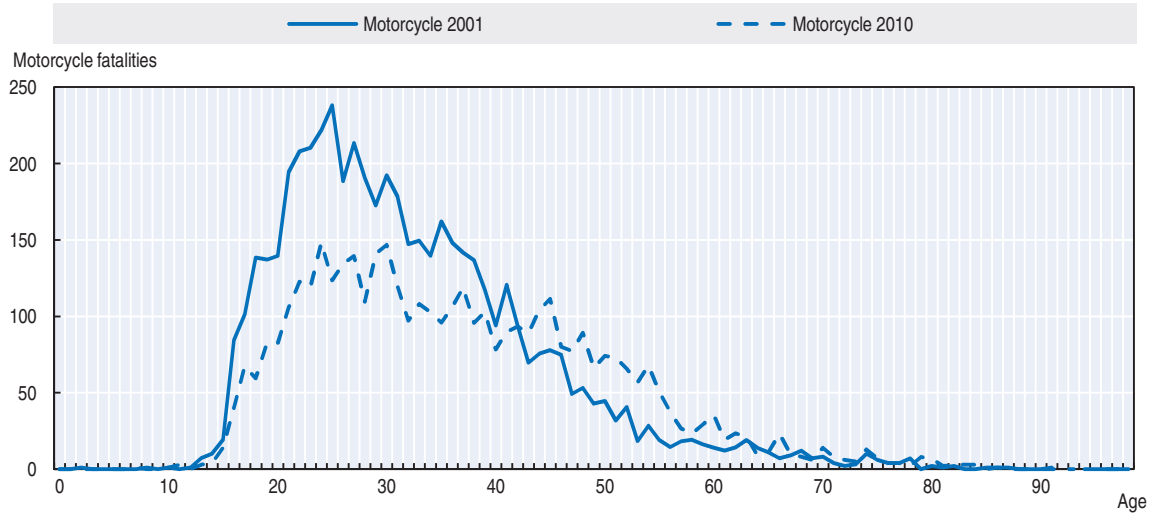
In most countries, the number of fatalities among the 40-60 year old riders increased significantly during the last decade. There has been a shift in fatalities from the youngest age groups to middle-aged riders. This is linked to the increasing popularity of PTWs among this age group.

In Europe, 30% of motorcyclists killed are less than 25 years old. However, the average age of motorcyclists killed has increased, from 30 years in 1995 to 38 in 2007. The number of rider fatalities decreased between 2001 and 2010 only for those under the age of 40 (Figure 3.5). During the decade, the number of fatalities among the 40-60 year old riders doubled.

The same patterns are observed in the United States, Canada and Australia. Data from the United States (NHTSA, 2012) shows a 78% increase in fatality of motorcyclists (including 3-wheelers) in the 40+ age group over a ten-year period.

Figure 3.5. **Motorcycles rider fatalities by age in 2001 and 2010**

Both EU-20



Date of query: October 2012

Source: CARE Database / EC

Most epidemiological studies show a higher crash risk for the youngest age groups (Chang et al. 2006; Evans 2004; Harrison et al., 2005; Lardelli-Claret et al., 2005; Lin et al., 2003; Mullin et al., 2000; Reeder, 1995 and Yannis et al., 2005).

Monthly, weekday, and hourly periodic characteristics

PTW rider crashes, injuries and fatalities are strongly correlated with periodic factors such as seasons, months, day of week, and time of day. These periodicities reflect both environmental and socio-cultural factors.

PTW crashes reflect the motorcycling activity associated with season and weather. In most countries, there are relatively few fatalities in the winter, and relatively many in the summer, reflecting the seasonal pattern of use of mopeds and motorcycles. The impact of season is however less marked for mopeds.

As with other crashes, the number of PTW crashes increases during the weekend. While there are many crashes every day of the week, these numbers increase on weekends. However, in an Australian study, Blackman and Haworth (2013) found that this trend occurred for motorcycle crashes, but not moped and scooter crashes, presumably reflecting the greater use of mopeds and scooters for commuting.

Road type

In most OECD countries, the majority of PTW fatalities occur outside urban areas, and particularly on the non-motorway rural roads. The existence of medians, separating opposite traffic flows, the quality of the road surface and the absence of sharp bends explain the lower fatality rate on motorways. However, in several Southern European countries (Greece, Italy, Portugal, Slovenia and Romania), more than 50% of PTW fatalities occur inside urban areas, most probably due to increased PTW mobility inside urban areas compared to the other countries.

Almost one third of all PTW rider fatalities occur at a junction, whereas for car occupant fatalities, only 14% occur at junctions. Nearly 50% of the total number of PTW rider fatalities recorded at a junction occurred at crossroads.

Impact of engine displacement and type of vehicle

Engine displacement, expressed in cubic centimetres (cm^3), is an indicator of the power of a vehicle.[3] Several epidemiological studies focused on the relation between engine displacement and crash occurrence and severity. Some studies suggest that users of PTW with higher displacement have a higher risk of crash (Nairn et al., 1993) and a higher risk of being seriously injured (Pang et al., 2000; Quddus et al., 2002). Other studies have not found any association (Chang et al., 2006; Langley et al., 2000; Zambon et al., 2006).

According to the MAIDS project (which analysed both fatal and non-fatal crashes), there was no significant difference between the crash data and the exposure data except for the over 1001 cm^3 category, which was found to be under-represented (i.e. had less risk) (see Table 3.3) (ACEM, 2006).

Table 3.3. **Distribution of crashes in the MAIDS project by engine displacement**

Engine displacement (cm^3)	Crash data		Exposure data	
	Frequency	Percent	Frequency	Percent
Up to 50	394	42.7	367	39.8
51 to 125	89	9.7	86	9.3
126 to 250	37	4.0	32	3.5
251 to 500	56	6.1	50	5.4
501 to 750	206	22.4	193	20.9
751 to 1000	80	8.7	107	11.6
1001 or more	58	6.3	88	9.5
Unknown	1	0.1	0	0.0
Total	**921**	**100.0**	**923**	**100.0**

Source: MAIDS (ACEM, 2006).

A recent study in Greece showed the highest severity is observed for motorcyclists aged less than 21 years riding mopeds (Yannis et al., 2005). This result may be attributed to more risk-taking behaviour and inexperience of young drivers, together with the poor driving performance of mopeds in demanding conditions.

In the United States, a study (Teoh, 2010) found large variations in driver death rates (per 10 000 registered vehicles) when examined by motorcycle type, and the biggest risk was found for the super sport category (see Table 3.4). However, its results cannot be generalised, as the study was undertaken in the United States, where the motorcycle fleet composition may not be representative of those of other countries, and neither the distance travelled nor the age or experience of the rider were taken into account.

Table 3.4. **Motorcycle driver deaths per 10 000 registered vehicles by motorcycle type**

2000-2008, United States

Motorcycle type	Drivers Deaths (2000 -2008)	Relative risk compared to cruiser/ standard motorcycle
Cruiser / Standard	5.1	1.0
Touring	6.0	1.17
Sport Touring	4.3	0.85
Sport / unclad sport	11.6	2.28
Supersport	22.3	4.36

Source: Teoh (2010).

Studies of the influence of engine displacement on safety should take into account that riders of high displacement PTWs ride further every year than those riding small PTWs (Broughton, 1988; Carre et al., 1994; ONISR 2005; Yannis et al., 2007). One study estimated that riders of PTWs with an engine capacity of greater than 500 cm^3 on average travel four times as far as those driving PTWs of 50 cm^3 (Broughton 1988). The choice to replace a low displacement PTW with a more powerful bike is often due to the desire to travel more (Broughton 1988; Yannis et al., 2007). Therefore, statistically, riders of the most powerful motorcycles may be over-represented but, in terms of km-ridden, their fatality rate may not be significantly higher.

To summarise, power may not constitute by itself a direct cause of crashes; but it can be associated with purchase motivation by different age groups of riders and their usage of their PTWs.

Serious injuries among motorcyclists

The challenge of serious injuries

As seen earlier in this chapter, most of the information above is based on fatal crash data, because they are easily available in most countries. However, understanding the nature and extent of serious injuries among motorcyclists is essential in the perspective of a Safe System approach. It is also very important from an economic and health perspective, given the high costs associated with the most severe injuries.

Compared to other road users, motorcyclists sustain much more severe injuries and the risk of sustaining a major handicap is higher than the risk of dying. As an example, in France in 2006, motorcyclists represented 24% of fatalities and 30% of injured road users with a long-term handicap (Amoros et al., 2008; ONISR 2007). In 2004, there were as many motorcyclists severely injured as car occupants. In 2012, in Great Britain, motorcyclists were 35 times more likely to be killed in a road crash than a car occupant and 50 times more likely to be seriously injured (Department for Transport, 2013).

Motorcyclists are more likely, not only to be killed, but also very seriously injured in a road crash than other motorised road users. As the large majority of motorcyclists is younger than other motorised road users, this translates into many years lost or with reduced capacities.

Characteristics of motorcyclist injuries

Motorcyclist injuries most commonly occur to the extremities – lower limbs in particular – and then head injuries. Spinal injuries are less frequent, but can have severe long-term consequences. Spine, head and limb injuries are the main causes of long-term handicap (Moskal et al., 2008).

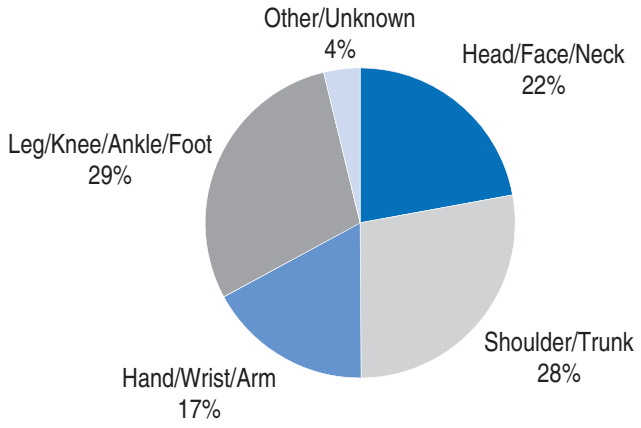
The percentage of severe head injuries remains high, despite the use of helmets. Head and trunk injuries are the main causes of death (Dischinger et al., 2006).

In France, in 1996-2004, 24% of head injuries, 44% of spine injuries and 38% of leg injuries leading to severe handicap were sustained by motorcyclists (Amoros et al., 2008).

Figure 3.6 presents the distribution of injuries among motorcyclists in the United States in 2009. It shows that half of all injuries were to the head/face/neck or shoulder/trunk regions, while almost three in ten were to the leg/knee/ankle/foot region.

Figure 3.6. **Distribution of injuries among injured motorcyclists**

United States, 2009

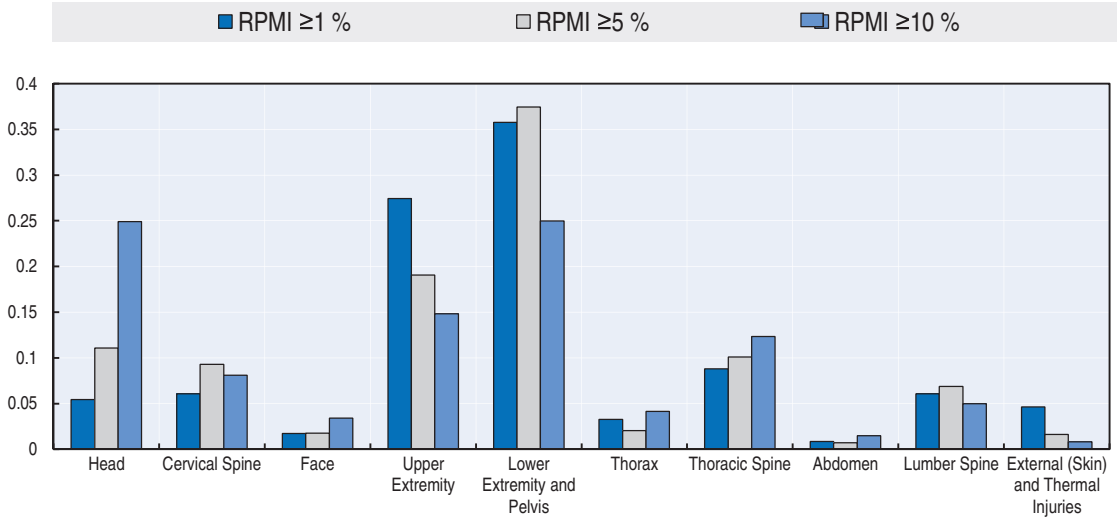


Source: NHTSA.

Figure 3.7 illustrates some Swedish findings and how the severity of motorcyclist injuries compares across parts of the body. For the broadest spectrum of injury, where the risk of permanent medical impairment is 1% or greater, lower extremity and pelvis, and upper extremity injuries predominate, together accounting for more than 60% of injuries. Head and lower extremity and pelvis each comprise a quarter of the most severe injuries, where the risk of permanent medical impairment is 10% or greater. Thoracic spine injuries are also more strongly represented among the most severe injuries.

The very severe injuries with long term impairment suffered by motorcyclists translate into very high social and medical costs. Reducing not only the number of deaths but also the number of serious injuries among motorcyclists is a top priority in the context of a Safe System.

Figure 3.7. **Motorcycle injury distribution and risk of permanent medical impairment**



* RPMI: Risk of Permanent Medical Impairment.

Source: Swedish Transport Administration.

Crash scenarios

Table 3.5 summarises the various types of crashes which are detailed in the sections below. The exact prevalence varies greatly among the different countries, depending in particular on the characteristics of their road network and traffic. Sometimes loss-of control crashes are classified in the police reports as multi-vehicle crashes, although the crash with the other vehicle is only the result of the loss of control. On the other hand, a single vehicle crash may originate from a problem of interaction with another road user.

Table 3.5. **Types of crashes involving PTWs**

Single vehicle crashes (20 to 45% of fatal crashes)	Loss of control Other
Multi vehicle crashes (30-50% of fatal crashes)	At junction Not At junction with vehicle in the same direction Not at junction with vehicle in the opposite direction Other
Crash with a pedestrian (less than 10 % of fatal crashes)	

Single vehicle crashes

Single-vehicle crashes are estimated to comprise between 20% and 45% of PTW crashes, depending on the jurisdiction. The Department for Transport reports 24% of motorcycle fatalities and 28% of casualties are attributable to single vehicle crashes in Great Britain (Department for Transport, 2013). In France (ONISR, 2010) in 2009, 36% of motorcycle fatalities and 34% of moped fatalities were due to single-vehicle crashes, these crashes comprising 19% of motorcycle injury crashes and 18% of moped injury crashes. Results from the 2BESAFE project suggest that single-vehicle crashes make up 25% of all PTW crashes in Italy, 38% in Greece and 44% in Finland and Sweden (2BESAFE, 2010). In 2011, 46% of motorcyclists killed in the United States were involved in single-vehicle crashes (NHTSA, 2013). Single-vehicle crashes are often underreported in official statistics, particularly those of relatively low severity. Thus, official statistics may underestimate the true number of single-vehicle PTW crashes and over-estimate their severity compared to multi-vehicle crashes.

Loss of control

A loss-of-control crash is considered as such – for research purposes – when only one vehicle is at the origin of the crash situation, independently of the number of vehicles finally hit. A difficulty with police reports in some countries is that they are based on the number of vehicles hit, while the concept of "loss of control" is sometimes absent from police reports.

Loss of control is due mainly to the following causes:

- poor road design in curves (lack of visibility, changes in the curve radius, etc.) and/or an excessive speed (exceeding speed limits or inappropriate speed);
- lack of riding technique and competence in analysing the situation of the rider;
- the influence of alcohol;
- poor control of the trajectory (e.g. over-braking);
- mechanical problems;
- bad road conditions.

Other "single vehicle" crashes

This second category of single-vehicle crashes does not, strictly speaking, refer to a loss of control initiating the problem but a sudden encounter with an unexpected obstacle (which is not a road user) on the carriageway. In practice, these situations only account for a small proportion of PTW crashes. The following configurations can be distinguished:

- PTW is confronted by an animal suddenly crossing the carriageway.
- PTW hits an obstacle on the carriageway (stone fallen down from a hill, or any object fallen from a truck, etc.).
- Other.

Multi-vehicle crashes (excl. pedestrians)

At junction

Crashes at junctions cover a large proportion of crashes involving a PTW and another vehicle (principally a passenger car). According to the MAIDS project (ACEM, 2006), 50% of PTW crashes occur at junctions; however, this proportion varies largely between countries or settings. The SafetyNet project (SafetyNet, 2009)) identified four typical scenarios:

- Turning left (or right)[4] by the other vehicle, with the PTW arriving in the opposite direction;
- Turning left or Turning right or U-turn by the other vehicle, with the PTW in the same direction;
- Other vehicle crossing the path of the PTW, which has the right of way;
- PTW crossing the path of the other vehicle which has the right of way.

Not at junction with vehicles in the same way and same direction

Typical crash scenarios include:

- Other vehicle changing lane or overtaking,
- PTW changing lane or overtaking,
- Rear-end collision (by a PTW / by the other vehicle).

Not at junction with vehicles on the same road at opposite direction

Typical crash scenarios:

- PTW is overtaking or has crossed the centreline onto the opposite carriageway;
- Other vehicle is overtaking or has crossed the centreline onto the opposite carriageway.

Other types of multi-vehicle crashes

Typical crash scenarios include:

- Aberrant manoeuvre by the PTW (wheelies, going the wrong way along a street, going the wrong way in a roundabout, sudden acceleration, etc.
- Aberrant manoeuvre by the other vehicle (U-turn, door opening, etc.).

Crashes with pedestrians

Crashes between PTWs and pedestrians represent a growing issue as part of overall pedestrian crashes (Martin et al., 2011), notably due to the increasing proportions of PTWs in cities (Kopp, 2011). Paulozzi (2005) showed that the risk of PTW drivers fatally injuring a pedestrian was twice that than for automobile drivers. A recent study (Clabaux et al., 2014) shows that two-wheeler drivers run a risk of hitting and injuring a pedestrian in towns that is nearly three times higher than for four-wheeled vehicle drivers, notably linked with filtering manoeuvres.

Conclusions

Crash characteristics and scenarios

On average, in OECD countries, PTWs riders and passengers comprise 17% of all road fatalities, while only representing 8% of the fleet. PTWs are clearly overrepresented in road traffic casualties. Depending on the country, they are between 9 and 30 times more at risk in traffic than a car occupant. This is largely due to their greater vulnerability and lack of protection in the event of collision. When involved in a crash, PTW riders are exposed to a significantly higher risk of severe injuries, entailing long-term disabilities.

The safety situation of motorcyclists has deteriorated in the past decade compared with the significant progress for other road users. PTW trends are not following the overall decrease in fatalities in the OECD countries; this may be explained by the large increase in PTW numbers and respective mobility, as PTWs have been steadily gaining in popularity in recent years. PTW is the only mode of transport for which the number of fatalities has increased over the last decade – significantly in some countries – which stresses the importance of taking immediate appropriate countermeasures.

Many countries face similar patterns. In Europe, the number of motorcyclists killed in the 40-60 year age group has doubled in 10 years. 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.

A significant proportion of crashes are single-vehicles crashes occurring on rural roads. Almost one third of all PTW fatalities occur at junctions – a proportion notably higher than for other road users. This stresses the importance of taking specific measures to improve junction safety for PTWs.

Most of the data presented in this chapter and in other research publications are based on fatality data because these data are easily available and usually reliable. It is, however, essential to gain more information on serious injuries, because they represent a major challenge in improving road safety and, perhaps more for motorcyclists, measures and equipment can help to reduce the severity of serious injuries.

Figures dealing with non-fatal crashes generally tend to be more or less underestimated, notably due to under-reporting to police and subsequent under-reporting in police crash databases. However, some countries now have experience in linking police and health database in order to have a more complete picture of the consequences of crashes.

Notes

1. In Sweden, the STRADA (Swedish Traffic Accident Data Acquisition) information system gathers crash information from the police (when, how and where the crash took place) which is linked with information from health care on the nature of the injuries.

2. These include: Belgium, Denmark, Greece, Spain, France, Ireland, Italy, Luxembourg, Netherlands, Austria, Portugal, Finland, Sweden and United Kingdom

3. Power-to-weight ratio more directly indicates acceleration and top speed performance capacity. Weight can vary markedly for the same power

4. Turning left in countries where one drives on the right; Turning right in countries where one drives on the left.

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