

## Summary

# Moped crashes in Norway 2007-2016

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*In 2006-2016 27 fatal crashes with mopeds occurred in Norway. Results from in-depth investigations of these crashes are summarized in the present study. During this period the number of fatal and injury crashes with mopeds as well as crash risk for mopeds has considerably decreased. Contributing factors to the decrease of fatal crashes with mopeds are decreases of rider related risk factors such as unlicensed riding, riding under the influence of alcohol or drugs, unhelmeted riding, being male, and tuning up the engine of mopeds. Fatal crashes with mopeds are for the most part single vehicle or head-on crashes. Crashes at intersections are on average less severe and the most common crash type among injury crashes with mopeds. The triggering party in the majority of collisions with mopeds is a moped rider. The most severely injured party in collisions with mopeds is usually the moped rider. If a counterparty in a crash is killed or injured, this is mostly a pedestrian or cyclist, although most crash partners are cars and trucks. Crash involved moped riders are on average 23.4 years old and the large majority is under 21 years. Fatally injured moped riders are on average older (32.3 years) and riders above 40 years are overrepresented. In about four out of five fatal moped crashes at least one of the following rider related risk factors has been present: Unhelmeted riding or losing the helmet in the crash; riding under the influence of alcohol; unlicensed riding. About every fourth fatal crash involved moped had some technical defect and 59% of all fatal crash involved mopeds had been tuned up. Tuning up mopeds is by many riders regarded as a safety measure. However, the results of the present study do not support this view. Most likely, tuning up mopeds increases crash risk.*

The main aim of the present report was to increase knowledge about moped crashes and to develop suggestions for measures that can be expected to reduce the numbers of killed or seriously injured (KSI) moped riders. The report is based on in-depth investigations of 27 fatal crashes that occurred in Norway in 2007-2016 as well as 3714 injury crashes with mopeds that are registered in official crash statistics. The in-depth investigations of fatal moped crashes were conducted by crash analysis teams of the Norwegian Public Roads Administration.

## Moped crashes and crash risk

### ***Crash numbers and crash risk have considerably decreased for moped riders.***

The annual number of fatal moped crashes has during the years 2007-2016 decreased from five per year to one per year. The annual number of injured moped riders has in the same time decreased by 56% from 544 to 240 per year. The number of registered mopeds has increased by 15% although the number of new mopeds has decreased by 33%.

Injury risk for moped riders is far higher than for car drivers, but lower than for most other road user groups. It is about halved over time during the study period. Injury risk has decreased more over time among moped riders than among other road user groups, except for riders of light motorcycles.

### ***Corresponding to the decrease of fatal crashes, the prevalence of several relevant risk factors has decreased.***

The analyses of fatal and injury crashes show that the occurrence of several relevant risk factors has considerably decreased over time: Unlicensed riding, riding under the influence of alcohol (DUI), unhelmeted riding or riding with a helmet that is too large or not fastened appropriately, riding mopeds with tuned up engines, and male riders. The proportion of fatal moped crashes in which a moped rider has been the triggering party has decreased as well. Moped riders' average age has decreased in fatal crashes and remained about unchanged over time in injury crashes.

***Most fatal crashes were single vehicle and head-on crashes while most injury crashes were intersection or single vehicle crashes.***

As shown in figure S.1 the majority of fatal moped crashes were single vehicle crashes, followed by head-on collisions. Among injury crashes, crashes at intersections are the largest group. Crashes at intersections are on average less serious than other crashes.

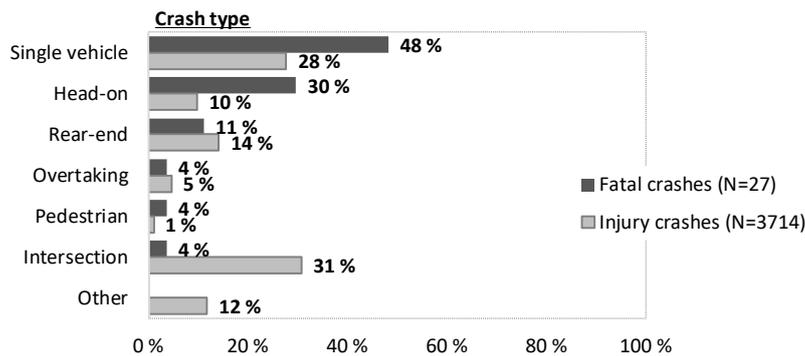


Figure S.1: Types of fatal and injury crashes with moped (2007-2016).

***Collision partner in most collisions with mopeds are passenger cars. However, if a counterparty in a crash is killed or injured, this is mostly a pedestrian or cyclist.***

In the majority of collisions with mopeds the moped rider is the one who sustains most serious injuries. In cases where a collision partner is injured or killed, this is for the most part a pedestrian or cyclist, although the most common collision partners are passenger cars, followed by trucks.

***In most fatal moped crashes the moped rider has been the triggering party.***

In about half of all fatal moped collisions the moped has been the triggering party. In total moped riders contributed to the occurrence of two thirds of all fatal moped crashes (they were either the triggering party or both parties contributed to the crash).

Hardly any of the fatal crash involved moped riders had tried to avoid the crash by braking or steering maneuvers, while a large proportion of crash involved motorcyclists had either braked hard or tried to steer away immediately before the crash. A possible explanation is that moped riders have poorer risk perception than motorcyclists. Other possible explanations are that mopeds are less maneuverable than motorcycles or that mopeds do not as easily leave braking or skidding marks on the road surface than motorcycles.

***Most moped crashes occur under good riding conditions. Nighttime crashes are on average more serious than daytime crashes.***

Most injury crashes with mopeds occur in daylight on dry roads, in the afternoon and during summer. These are conditions which are generally most favorable for moped riding. Among fatal moped crashes, there are larger proportions that occur at night and in darkness. Nighttime crashes are on average more serious than daytime crashes, which may be due to rider related factors such as fatigue, and poor moped conspicuity in the dark.

## Rider and vehicle related contributing factors in fatal moped crashes

In most fatal moped crashes at least one rider or moped related crash or injury factor has been present. Figure S.2 shows an overview of the occurrence of different types of unlawful behaviors: Unlicensed riding, DUI, unhelmeted riding (or wearing a helmet that is not properly fastened and lost in the crash), as well as riding a moped with technical defects or a tuned engine. There is a considerable overlap between most of these factors. The individual factors are described and discussed in more detail below.

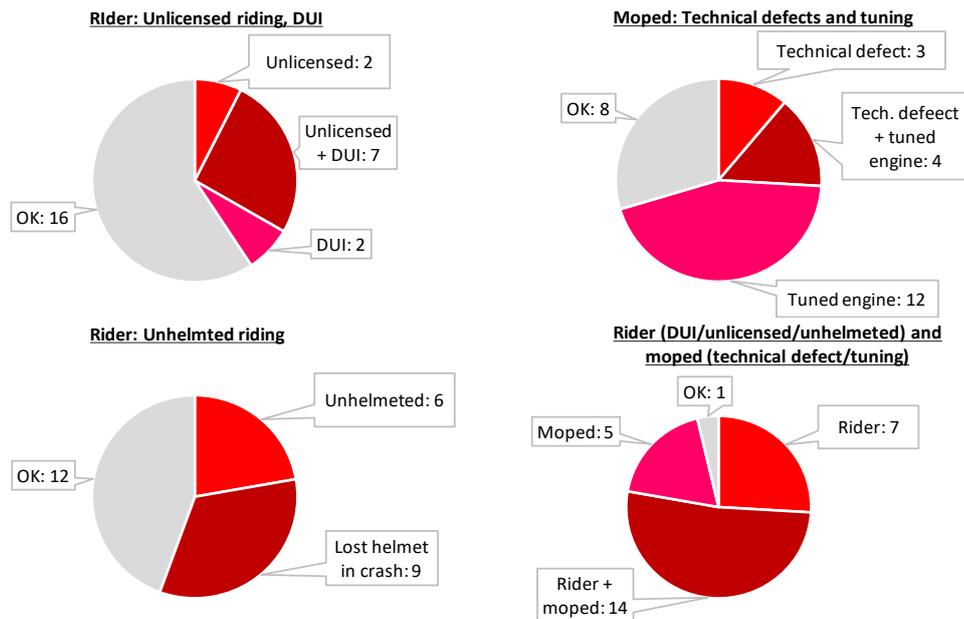


Figure S.2: Rider and moped related contributing factors in fatal moped crashes (2007-2016).

Additionally, over half of all fatal crash involved moped riders were either young (14-20 years) or inexperienced (i.e. had a month or less experience with the moped). Figure S.3 shows the proportions of young and inexperienced riders. It can be seen in the figure that far from all inexperienced riders were young. Compared to injury crash involved moped riders, those in fatal crashes were older. The riders' age and experience are in more detail discussed below.

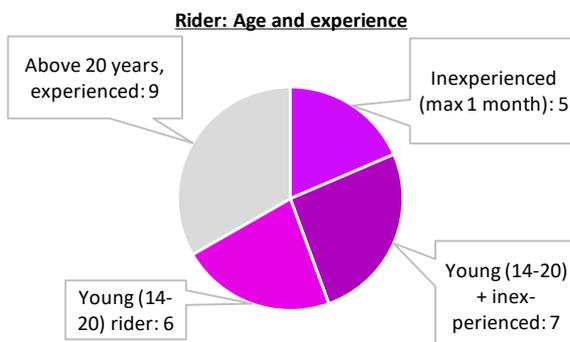


Figure S.3: Age and experience of fatal crash involved moped riders (2007-2016).

Other rider related contributing factors in fatal moped crashes were (in descending order of importance, only factors that have contributed to at least three crashes):

- Inattention/distraction (seven crashes)
- Reckless riding (six crashes)
- Suicide/illness (three crashes).

Results from the present and other studies show that different rider related risk factors are correlated, i.e. when a riders shows one kind of risky behavior, other risk factors are likely to be present as well.

## Moped riders

***Most crash involved moped riders are young (14-20 years). Older riders are overrepresented in fatal crashes.***

As shown in figure S.4 moped riders' average age increases with increasing injury severity. The proportion of riders below 21 years is 71% among all injured and 48% among fatally injured moped riders. The proportion of riders above 40 years is 12% among all injured and 41% among fatally injured moped riders. The large proportions of young riders are partly due to the fact that most moped riders are young. Additionally young riders have on average higher risk.

The results from the present analysis indicate that older riders have higher risk of more serious crashes than younger riders. The same relationship between average age and injury severity was found among light motorcycle riders as for moped riders. However, among riders of heavy motorcycles age and injury severity are about unrelated (figure S.4).

Injured moped riders are on average of about the same age as injured light motorcycle riders, and younger than injured heavy motorcycle riders.

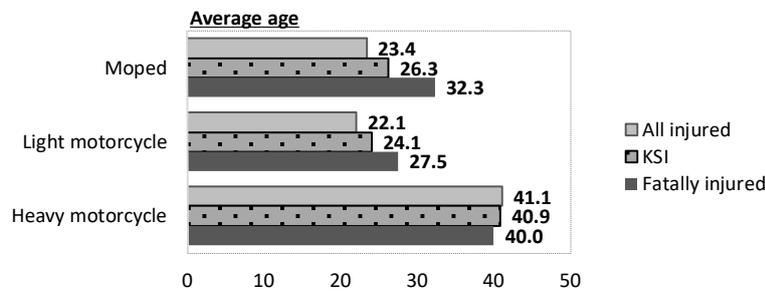


Figure S.4: Crash involved moped and motorcycle riders' average age (2007-2016).

***Most crash involved moped riders are males, especially in fatal crashes.***

The proportion of female moped riders is far higher in injury crashes (37%) than in fatal crashes (4%). Results from the present and other studies show that men on average have higher crash risk than women, are on average involved in more serious crashes, and are more often the triggering party in crashes.

***About one third of fatal crash involved moped riders were unlicensed. Unlicensed riders showed more other risky rider behavior than licensed riders.***

Among fatal crash involved moped riders 36% were unlicensed. Most unlicensed riders had their license revoked. Unlicensed riders were more often than licensed riders under the influence of alcohol, riding unhelmeted or losing their helmet in the crash. Similar correlations between unlicensed riding and other types of illegal or risky behavior were also found in other studies.

***DUI was the most important driver related factor in fatal moped crashes. About one third of fatal crash involved moped riders had been under the influence of alcohol or drugs. However, during the last five years of the study period, none of the fatal crash involved moped riders had been under the influence of alcohol or drugs.***

Most riders who had been under the influence of alcohol or drugs, had been drunk. In almost half (41%) of all fatal crashes in which the moped rider had been the triggering party, the rider had been drunk riding. Drunk riding is known from other studies to increase crash risk considerably, especially for the most serious crashes, and to be related to other risky and unlawful behavior, including non-traffic related criminal offences. The results of the present study indicate that there has been a strong decline of DUI among fatal crash involved moped riders. However, due to the relatively small numbers the result must be regarded as uncertain.

***About half of all fatal crash involved moped riders was inexperienced.***

Among fatal crash involved moped riders 46% had only ridden the moped for one month or less. Thus, inexperienced riders contribute to a considerable proportion of fatal moped crashes. Inexperience was not necessarily related to young age; four of those with little experience were above 40 years. Unlicensed riding occurred more often among inexperienced riders than among more experienced riders. However, inexperienced riders were not more often than others the triggering party in the fatal crashes.

***More than half of all fatally injured moped riders and passengers had either been riding unhelmeted or lost the helmet in the crash.***

Among those moped riders and passengers who were fatally injured, 23% had been unhelmeted and 35% lost the helmet in the crash, either because it was not fastened appropriately and/or because it was too large. All those who had been unhelmeted or lost the helmet had serious or fatal head injuries. Among those who had worn a helmet and did not lose it in the crash, most had head injuries as well, but none of these were serious. In injury crashes, non-use of helmets is related to more serious injuries. Unhelmeted riding was found to be related to other risk factors and to being the triggering party in the crash.

***Excessive speed has only contributed to a small proportion of fatal moped crashes.***

Among the fatal crash involved mopeds only one had been riding above the speed limit and one had excessive speed (not above the speed limit). Thus, speed is far less common as a crash contributing factor in fatal moped crashes than in other fatal crashes.

***In three fatal moped crashes delayed emergency response may have contributed to the fatal outcome.***

Almost half of all fatally injured moped riders died at the scene. However, in three cases the emergency medical service was notified with a delay of several hours or not at all (these riders were found some days after the crash) and these delays are likely to have contributed to the fatal outcome of these crashes.

***Most fatal moped crashes occurred on leisure time trips.***

Most fatal crash involved moped riders had been on leisure time trips and the majority had been well known at the crash scene.

## Mopeds

***About every fourth fatal crash involved moped had a technical defect that had contributed to the crash.***

Among the fatal crash involved mopeds 26% had a technical defect, mostly on the brakes. All technical defects are considered as crash contributing factors.

***Tuning up moped engines has a large degree of social acceptance and is often regarded as a safety measure. Empirical results do not support the hypotheses that tuning up mopeds reduced crash risk.***

Over half (59%) of the fatal crash involved mopeds had tuned up engines. Half of the tuned up mopeds had a speed above 45 km/h, i.e. above the legal maximum speed for mopeds.

Tuning up mopeds is quite common and often regarded as a safety measure by moped riders. The argument is that slow moving vehicles are exposed to increased risk of being rear-ended and may provoke risky overtakings. Results of the present and other studies that reject the hypothesis of tuning as a safety measure are:

- Based on the estimated proportion of tuned up mopeds in general traffic (not crash involved mopeds) and the proportion of tuned up mopeds in fatal crashes, tuning increases fatal crash risk by about 300%.
- Tuning up mopeds allows higher speeds and increasing speed is well known to be related to a strong increase of crash risk and injury severity.
- Only in one of the fatal moped crashes that were investigated in the present study did *low* speed of the moped contribute to the crash. This crash occurred on a road that according to the crash investigation team of the Public Roads Administration should have been closed for low-speed vehicles.
- Tuning up mopeds has been found to be related to other types of risky and unlawful/criminal behavior among youths.

In total, empirical results do not support the hypothesis of tuning up mopeds as a safety measure.

## Road related factors in moped crashes

***Most moped crashes occur on one- and two-lane roads with 50 km/h speed limits. Only few moped crashes occur at higher speed limits or on multi-lane roads.***

Both fatal and injury crashes with mopeds occur for the most part on those roads that are most used by moped riders. Of the fatal moped crashes investigated in the present study, three occurred on multi-lane roads. About half of all fatal moped crashes occurred on rural roads. The remaining fatal moped crashes occurred mostly in residential areas.

***Crashes at intersections are more common among injury crashes with mopeds than among fatal moped crashes.***

About half of all injury crashes with mopeds occurred at intersections, roundabouts or driveways (51%). Among fatal moped crashes, only 14% occurred at intersections etc. Most fatal crashes occurred on straight (67%) or curved (22%) midblock sections. The higher prevalence of non-fatal crashes at intersections is due to the lower speed and thus on average lower injury severity at intersections, compared to midblock sections.

***Road related factors are likely to have contributed to almost half of all fatal moped crashes.***

The proportion of fatal moped crashes where at least one road related factor contributed to the crash, is 41%. The most common road related crash contributing factors were insufficient or switched off road lighting, road surface and misleading road design. However, none of these factors contributed to more than five crashes. In 30% of fatal moped crashes a road related factor has contributed to the fatal outcome (hazardous roadside, trees/poles).

## Potential safety measures

*Measures against rider related risk factors have a theoretical potential of preventing about four out of five fatal moped crashes. Potential measures are, amongst others, enforcement, alcohol ignition interlock and vehicle impoundment.*

If none of the fatal crash involved moped riders had been riding unlicensed, under the influence of alcohol/other drugs, or unhelmeted (or with a too large or unfastened helmet), up to 78% of crashes might have been avoided. Additionally, a large proportion of riders were young and/or inexperienced. Potential measures that may reduce rider related risk factors are:

- **Enforcement:** Increased enforcement, mainly of DUI, unlicensed riding, and unhelmeted riding.
- **Anti-DUI measures:** Alcohol ignition interlock, vehicle impoundment (in addition to increased enforcement).
- **Measures against non-use of helmets:** Enforcement and information, with a special focus on fitting helmets and on the requirement to fasten helmets correctly.
- **Measures against unlicensed riding:** Electronic rider authentication is a potential measure in addition to enforcement. Because of the relationship between unlicensed riding and other risk behavior DUI related measures can also be expected to be effective against unlicensed riding.
- **Measures for increasing driver skills:** Possible measures are increased focus on riding skills in rider education as well as educational measures for inexperienced licensed riders.

*Measures for preventing riding with technically defect mopeds have a theoretical potential of preventing about every fourth fatal moped crash. The potential effects of measures against tuning up mopeds are more uncertain. Possible moped related measures are increased enforcement as well as measures for sales, import and type approval of mopeds.*

If none of the fatal crash involved mopeds had been technically defect, 26% of crashes might have been avoided. If none of the 59% tuned up mopeds had been tuned up, several crashes might have had less serious outcomes. Less than 59% of crashes could probably have been avoided. Potential measures are:

- **Enforcement:** Potential enforcement measures include increased traditional enforcement (by the police or Public Roads Administration), as well as alternative forms of enforcement. For example, the police may visit schools as has been done in trials in Sweden. Increased efforts to confiscate license plates from technically defect mopeds as well as increased road side technical controls are also potentially effective measures.

- ***Specific measures against tuning up mopeds:*** Potential measures against tuning up mopeds are a prohibition against mopeds that easily are tuned up (mopeds that are tuned down for type approval), new rules for import of such mopeds, prohibition against the sales of accessories necessary for tuning up mopeds and sanctions against retailers tuning up mopeds.

***In most fatal moped crashes at least one road related factor was found that may have contributed to the crash or the fatal outcome of the crash. However, the theoretical potential of avoiding crashes is probably smaller.***

In 74% of fatal moped crashes road measures might theoretically have reduced crash risk. These are crashes in which specific road related contributing factors were found, infrastructure measures are suggested by the crash investigation teams of the Public Roads Administration, or the crashes were head-on collisions on undivided roads. Additionally, road related factors have contributed to the fatal outcome of 30% of fatal crashes. However, in most crashes with road related contributing factors, rider and/or moped related contributing factors were present as well and infrastructure measures could probably not have prevented all fatal moped crashes where a road related contributing factor was present.

Potential infrastructure measures are (in decreasing order of the number of crashes in which the measures have a potential effect):

- Median barrier (8 crashes)
- Improving hazardous roadside and removing trees and poles (8 crashes)
- Improving road surfaces (4 crashes)
- Closing multi-lane roads for slow moving vehicles (3 crashes)
- Improving road lighting (3 crashes)
- Not switching off road lighting at night (2 crashes)
- Improved visual guidance (2 crashes)
- Improved marking of road side objects (2 crashes)
- Improved design of bus stops (2 crashes)
- Improved design/signposting of narrow passages (1 crash)
- Improved sight distances at driveways in industrial areas (1 crash)
- Avoid high pavement edge drops (1 crash).