# MOPED AND MOFA ACCIDENTS IN THE NETHERLANDS FROM 1999-2001: ACCIDENT AND INJURY CAUSATION.

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## ABSTRACT

In this paper accidents with mopeds and mofas in the Netherlands are analysed. The moped and mofa accidents were collected from 1999-2001 in the police regions Rotterdam-Rijnmond and The Hague in the Netherlands. This took part in the framework of a European Motorcycle in-depth study (MAIDS), funded by ACEM (the representing body of European motorcycle manufacturers) and the EU. For MAIDS, five European countries collected in total 1000 motorcycle and moped/mofa accidents, as well as a control group of another 1000 motorcycles and mopeds/mofas.
For this study a total of 113 moped and 21 mofa accidents (all Dutch), of which the rider was injured, were analysed. Standard statistical analysis techniques including regression techniques were used to find the over and under represented factors in technical aspects and human factors with respect to the control group. Also specific items like motor power enhancement, no drivers license requirements, young un-experienced riders and the specific status of mopeds in traffic may lead to more accidents than necessary.
Accident and injury causation and differences in occurrences are outlined. Important factors in moped and mofa accidents are discussed in detail.
Recommendations are given for primary and secondary safety enhancements.

## INTRODUCTION

Moped and mofa riders are a vulnerable group of road users, which internationally get little attention, while the number of mopeds is increasing in the ever more dense city traffic. Mopeds are powered two-wheelers with a maximum speed limit of 40 km/h in rural areas and 30 km/h in urban areas. Mofas are powered two-wheelers with a maximum speed limit of 25 km/h. Moped riders are obligated to wear a helmet but for mofa riders a helmet is not required. Several interesting topics related to moped and mofa accidents can be investigated. In accident causation, specific aspects as motor power enhancement, risk taking behaviour of the in general young riders and often illegal driving speeds, may provide interesting results. In injury causation the injury reducing effect of helmets and clothing can be investigated.

In this paper the data collection method, analysis methods, analysis results, discussion and conclusions are presented.

## METHOD

### Data collection

Data collection took place in the framework of a European Motorcycle in-depth study (MAIDS). MAIDS is an in-depth accident collection project funded by ACEM (the representing body of European motorcycle manufacturers) and uses an international harmonised methodology for motorised two-wheeler accident analysis, that was developed by an OECD technical working group [1]. For MAIDS, five European countries collected in total 1000 motorcycle and moped/mofa accidents with an injured rider, as well as a control group of another 1000 motorcycles and mopeds/mofas. For this paper 113 moped and 21 mofa accidents with an injured rider were analysed. The control group consists of 104 mopeds and 47 mofas. All these accidents were collected in the Netherlands from September 1999 – October 2001 in the police regions Rotterdam-Rijnmond and The Hague in the Netherlands.
The police informed the Dutch Accident Research Team (DART) of every motorcycle and moped accident in which the rider was injured. Every $n^{th}$ accident was investigated, where $n$ was kept constant for 24 hours. The accident scene was visited within 24 hours after the accident occurred. Environmental, technical and human factors were investigated and injury data was collected from the hospital and the victim interviewed after the victim's permission.

### Statistical Methods

For the data analysis SPSS [2] was used. Frequency counts, together with cross tabulations gave interesting high frequencies and over and under representations. When a Chi – square test detected a significant difference, the adjusted residuals (ar) were inspected for under and over representation. The adjusted residuals are a measure for the difference between the observed and expected count. Values well above 2 or below –2 identify cells that depart markedly from the model of independence, (may be interpreted as *z*-scores, and identify significant deviations). Regression

techniques – General Linear Model (GLM) and Logistic Regression (LR) – were used to investigate in what way the confounding factors influenced (injury) causation and accident configurations.
In a number of cases box-plots are shown. In figure 1 an explanation is given for the used symbols.

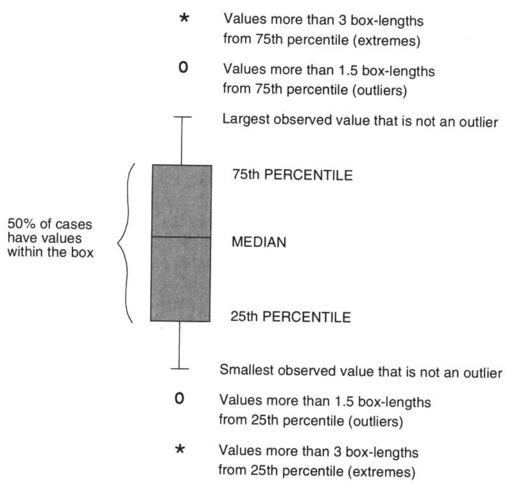



**figure 1 Box-plot explanation (source: [2]).**

## RESULTS

In this paragraph results are presented for accident configurations, accident causation, rider influences and injury causation. In total 134 accidents are selected of which 113 moped accidents and 21 mofa accidents.
In the rest of the paper the mopeds and mofas are abbreviated to MC and the opposing party, the other vehicle to OV.
Firstly accident configurations are discussed.

### Accident configurations

It can be seen in figure 2 that the configurations are quite various. No differences in accident configurations between mopeds and mofas were

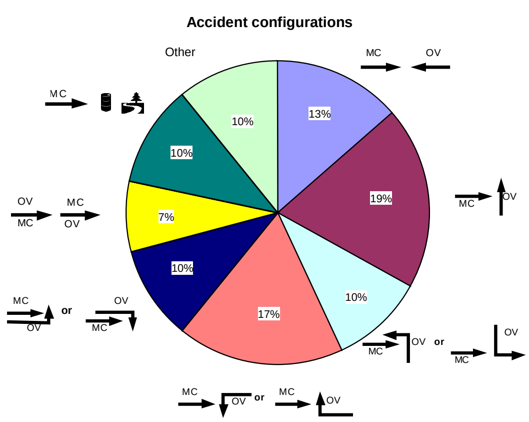
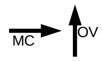
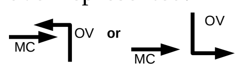



**figure 2 Accident configurations in moped / mofa accidents. MC = moped or mofa, OV = other vehicle.**

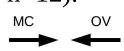
observed. In 19% of the cases the *paths of the MC and the OV are perpendicular and both vehicles are going straight ahead*. In 17% of the cases the *OV and MC are coming from opposing directions, and the OV turns in front of the MC. Head-on collisions* are observed in 13% of the cases. The category *other* (10%) is a summary of a number of the in total 20 categories.
Looking at the involved other vehicle types, it is found that in certain accident configurations certain vehicle types are over represented.



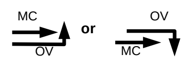

On the *intersections, with both paths perpendicular*, the only two trams in the database are involved; passenger cars are the most frequent impact partner (72%), but not significantly over represented.




In the configuration *OV turning left in front of MC, MC perpendicular to OV path*, passenger cars are over represented (ar=2.6, n=12).




In *head-on* collisions other mopeds and mofas (90%) are strongly over represented (ar=7.4, n=9); almost all these accidents occurred on a bicycle/moped-path open for both directions. In two cases the MC was travelling the wrong way and in 6 cases (33% of all head-on collisions, ar=5.3) the MC was negotiating a (small) bend.




In the category *MC overtaking OV while OV turning right*, passenger cars are the most frequent impact partner (82%), but not significantly over represented (ar=1.6, n=9).
Three trucks were found as a collision partner in this study. In two cases the MC came from the same direction and passed the truck while the truck turned left in one case and right in the other case. In the third case the truck came from the opposing direction and turned in front of the MC. The number of truck accidents is too small to base any conclusions on, however one would not expect them to be (statistically) in the category where the MC passes the truck from behind, based on pure chance.

### Accident causation

The cause(s) of the accident were determined by the accident investigators and are per definition subjective. One of three levels of certainty could be specified for a determined cause - very certain (95%), reasonably certain (80%-95%), possible influence (less than 80% certain). In this paper only the most certain cause and the determined primary cause were taken into account, to discuss only the most important factors. If other less certain factors were of real influence, they are most likely found in over representation of objective measures (e.g. *was a view obstruction present*, instead of *was a view*

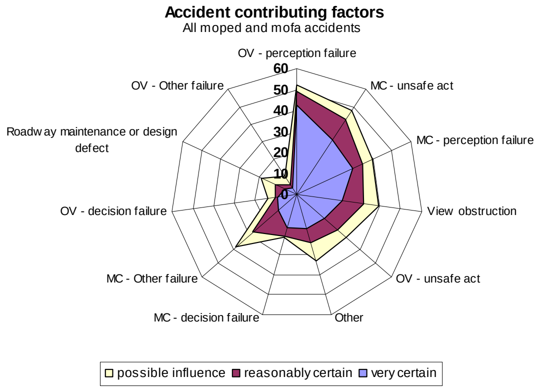



**figure 3 Accident contributing factors in moped /mofa accidents. It is shown in which percentage of the cases a certain cause was determined and with what certainty. More than one cause per accident could be given, which means that the total is higher than 100%.**

*obstruction a cause*). No difference is made between the primary accident cause and most important contributing factors as coded in the OECD-methodology, but both are considered to be equally important. This is a valid choice, because the selection of the primary accident cause is in practice frequently very arbitrary. In figure 3 it is shown what causes are determined when also taking into account the less certain causes. It can be seen that relatively more frequent an MC-other failure, roadway maintenance or design defects and view obstructions are included as less certain causes.

For the remainder of this paragraph, the accident types were divided in single-accidents (16) and in accidents in which a moving OV was involved (118). In the latter scenario the OV driver also could have had influence on the cause of the accident, while in the first selection only the MC and environment could have had influence.

In figure 4, the difference between these two selections is shown. It can be seen that for single accidents, very different causes are coded than for accidents with OV involvement (the higher percentages and peaks are due to the absence of OV involvement). Especially interesting is the category *MC – other failure*, which includes alcohol use. Alcohol use was coded in five cases (31%) of the single accident cases and *pre-occupation* (using mobile phone, looking around, etc.) in 19%. Alcohol use for the MC driver was not found in accidents with OV involvement. Temporary traffic obstructions (4 cases), adverse weather (2), and animal involvement (2) induce the high frequency of the category other.

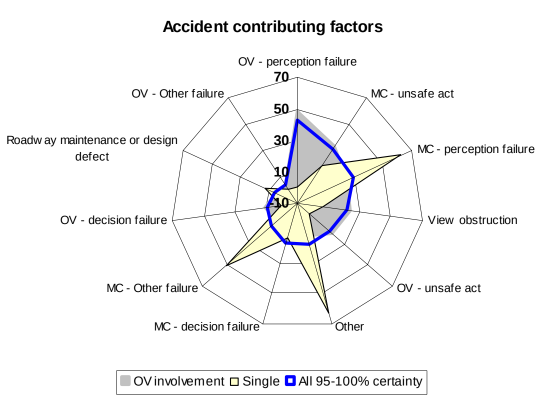



**figure 4 Differences in accident contributing factors between single accidents and accidents with a moving OV.**

In accidents with OV involvement (similar to the 95 – 100% certainty), it may also be observed that an OV – perception failure (48%) is most frequently coded, followed by an MC – unsafe act (33%), MC – perception failure (29%) and view obstruction (22%). For these four categories it was looked at the other contributing factors in these accidents. This is shown in figure 5.

**<u>OV – perception failure</u>** (figure 5a) – The most frequently coded failure is an OV – perception failure (the other vehicle overlooked the MC). In 28% (16 cases) an OV – perception failure was coded as the only certain (95% certainty) cause. In the remaining 41 cases, this failure is most frequently also combined with an unsafe act of this OV (32%). A view obstruction and an MC – unsafe act (24%) are second most frequent, where MC – unsafe acts are less pronounced than in the overall accident contributing factors. The OV – unsafe act is relatively over represented.

Compared to accidents in which the *OV – perception failure* was not coded as a certain cause the following factors were over represented (more present than expected by pure chance):

- *background had negative effect on MC conspicuity* (ar* =2.5, n=14)
- *OV – traffic scanning error* (ar=5.8, n=51)
- The traffic control is more frequently violated (ar=2.1, n=14), compared to accidents where an OV – perception failure was not a cause. When a traffic control was present (51 cases), it was most frequently a traffic light (39%). However, yield signs are over represented (ar=2.3, n=9) compared to other causes.

Under represented are (less present than expected):

- *MC – major unsafe act* (ar=-4.1, n=8),
- *MC – traffic scanning error* (ar=-4.1, n=11)
- *MC – view obstructions* (ar=-3.4, n=18),
- *MC – faulty traffic strategy* (ar=-3.5,n=8),
- *MC – unusual speed* (ar=-2.0, n=6),
- *MC – position in traffic* (ar=-2.6,n=3),
- *OV – stationary view obstructions* (ar =-3.4, n=11).
- The traffic controls on the path of the MC are never violated (ar=-4.1), but are equally frequent present in cases where the OV – perception failure was not present.

* see statistical methods

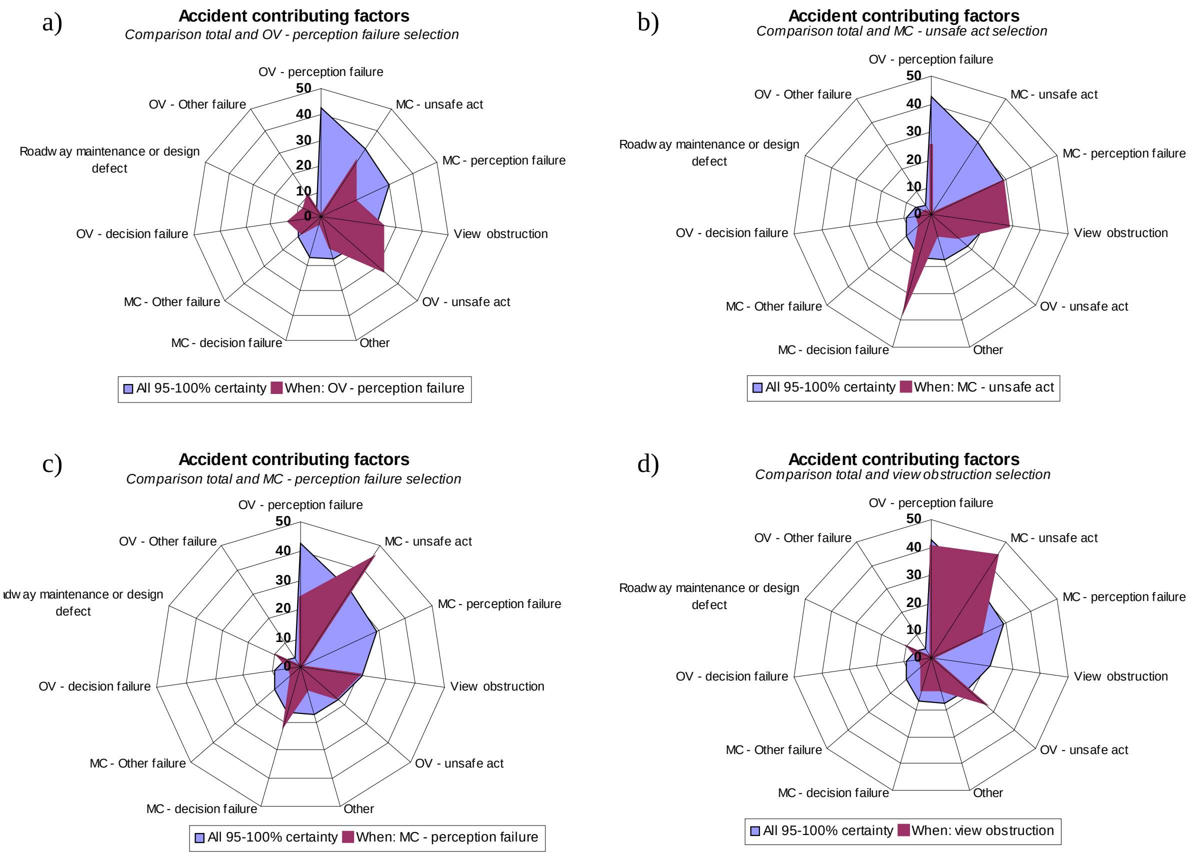



**figure 5 Remaining accident contributing factors. Shown are the accident contributing factors which remain when a) OV – perception failure, b) MC – unsafe act, c) MC – perception failure, and d) view obstruction are selected as main accident contributing factor.**

OV –speed compared to other traffic was not a significant factor.

**MC – unsafe act** (figure 5b) – The second most frequently coded cause is the MC – unsafe act, which most frequently may be interpreted as the MC driving too fast for the situation or making a manoeuvre that is unsuitable for the situation or illegal. An MC – unsafe act was never coded as only certain cause. In figure 6 it may be observed that the travelling speed of the MC is frequently higher than in accidents without an MC – unsafe act. This difference in travelling speed is however not significant in many cases.

Looking at figure 5b, it can be seen that an MC – decision failure (33%) and a view obstruction (28%) are most frequently also coded as a cause of the accident and that these causes are over represented with respect to the general distribution. An MC – perception failure is coded in 28% of the cases and an OV – perception failure in 26% of the cases.

Significantly over represented in accidents where an *MC – unsafe act* was a cause compared to accidents where an *MC – unsafe act* was not a cause are:

- *MC – unusual speed compared to other traffic* (ar=5.7, n=18)
- *MC – traffic scan* (ar=3.8, n=24),
- *MC – traffic strategy* (ar=3.3, n=19),
- *MC – attention failure* (ar=3.2, n=6)
- *MC – traffic knowledge* (ar=2.6, n=8).
- Accidents with an MC – unsafe act occurred more frequently on a location with a traffic control (traffic light) present (ar=2.1, n=11).
- In the cases where a traffic light was present

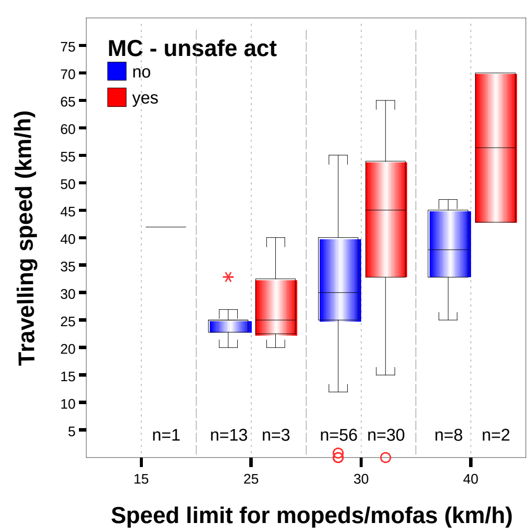



**figure 6 Posted speed limit vs. reconstructed travelling speed in accidents with an *MC - unsafe act* coded vs. accidents without.**

(45), it was violated more frequently (ar=3.1, n=12), than in accidents without an unsafe act as cause.

- View obstructions (stationary or mobile) were also significantly more present.

In the 39 cases in which a major unsafe act was coded for the MC driver (32% of all accidents with OV involvement), this was considered to be a certain accident causing factor in 74% (29) of these cases. In case of a moderate or minor unsafe act, this was only in 31% coded as a certain cause.

During the gathering of the accidents it was found that riders, who were legally guilty of causing the accidents were less reluctant to co-operate. It might therefore be the case that MC – unsafe acts are under represented.

**MC – perception failure** (figure 5c) – Not significantly less coded than the previous cause, the MC – perception failure is coded in 29% of the cases. The MC driver overlooked or did not notice the OV. In four cases this was coded as only certain cause of the accident. In the remaining 25 cases an MC – unsafe act is very pronounced as contributing factor (44% of the cases). This relation was also found, looking at the MC – unsafe act as main cause.

**View obstruction** (figure 5d) – Fourth most frequent, coded in 22% of the cases, is a view obstruction. In three cases it was coded as the only certain accident causing factor. In the remaining 25 cases, perception and unsafe acts play an important role. An MC – unsafe act is coded in 44% of the cases and an OV – unsafe act in 24%. An OV – perception failure was coded in 40% and an MC – perception failure in 20% of the cases.

## Rider influences

Within the MAIDS study a control group of MC riders was obtained by interviewing riders at petrol stations. These petrol stations were selected randomly in the accident collection area and were visited at random days and hours, to obtain a general population of MC riders. 104 moped and 47 mofa riders were interviewed in this control group. In this paragraph differences between the riders of the accident population and the riders of the control group are outlined. General variables like age, length and weight, experience do not differ and are very similarly distributed. When comparing the previous traffic violation convictions (see figure 7) it was found that the group with two or more previous violation convictions in the accident cases (26%) is approximately the same as the control group (24%). However, in the selection were the MC committed an unsafe act in the accident causation (see previous paragraphs), the percentage of previous violations is significantly higher (42%) and also over represented with respect to the control group (ar=2.4, n=13).

When looking at the previous accidents in the last five years, approximately the same trend is observed (see also figure 7). In the accident selection 20% had two or more previous accidents and this is over represented with respect to the control group (ar=2.5, n=21). In the selection where an MC – unsafe act was coded as cause, this is even more the case: 26% (ar=2.2, n=8). In the control group only 12% had more than two accidents.

Looking at the control group, the number of previous accidents and previous violations are highly correlated ($p<0.01$). Based on the number of previous accidents, a good prediction can be made of the number of previous violations. The other way around is less certain, but it may be said that the probability to be involved in an accident is significantly higher with more than two previous traffic violation convictions on record ($p<0.05$). The factors age, experience and the number of kilometres driven per year (GLM was used) were taken into account and did not have a significant influence, but did reduce the overall significance of the model ($p<0.1$).

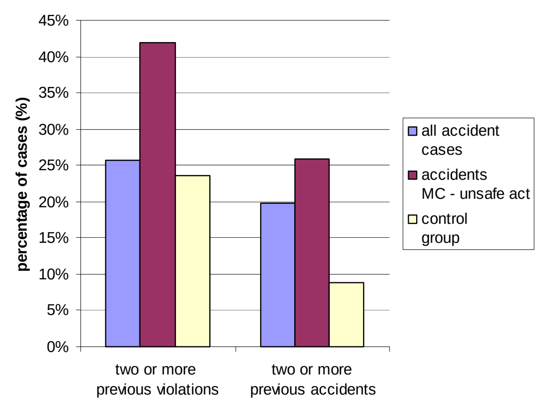



**figure 7 Comparison of previous violations and accidents with the control group.**

Alcohol is consumed in both the accident and control population in about 5% of the cases, but in the accident cases the alcohol consumers are more frequently *significantly impaired* (57%; ar=3.5, n=4). Drugs use is more frequent in the control population, in 8.6% of the cases (ar=2.6, n=13).

There is no significant difference between the accident population and the control group with respect to modifications made to the MC. In both cases approximately 40% of the MC has after market equipment or tuned parts which can make the MC faster (engine, driveline, intake filter, carburettor, exhaust system, cylinder, ignition system or transmission ratio).

**Collision avoidance** – In 52 (39%) accident cases a collision avoidance attempt was made. In the remaining 61% of the cases, no avoidance action was taken. The most frequent collision avoidance actions attempted by the MC rider were braking (83%) or (in combination with) swerving (40%). In most of the cases the taken action was found to be appropriate by the investigators. However, the execution of the action was often poor (40% of the cases) and most frequently reaction failures (9 cases) and loss of controls (5). In the majority of the cases the investigators found that there was inadequate time available to complete the avoidance action (64%).

**Injury data**

After the victim agreed to participate in the study, injury data was obtained from the hospital or rider, and coded as Abbreviated Injury Scores (AIS). In Table 1 it can be seen that in the majority of cases the maximum sustained injuries for a victim are of MAIS $2^-$. In 8 accidents the obtained injuries were fatal and in 8 accidents to severe trauma with long hospitalisation (more than two weeks) and 50% of the hospitalised victims remained in the hospital for more than 4 days.
MAIS$3^+$ injuries were mainly injuries to the lower extremities (33%) and injuries to the head (28%).

**Table 1.**
**Distribution of sustained maximum AIS for the MC rider**

Maximum AIS

| MAIS level | N | % | Valid % | Cumulative % |
|---|---|---|---|---|
| 1 | 45 | 33.6 | 34.1 | 34.1 |
| 2 | 47 | 35.1 | 35.6 | 69.7 |
| 3 | 29 | 21.6 | 22.0 | 91.7 |
| 4 | 6 | 4.5 | 4.5 | 96.2 |
| 5 | 4 | 3.0 | 3.0 | 99.2 |
| 6 | 1 | .7 | .8 | 100.0 |
| Total | 132 | 98.5 | 100.0 | |
| Missing | 2 | 1.5 | | |
| Total | 134 | 100.0 | | |

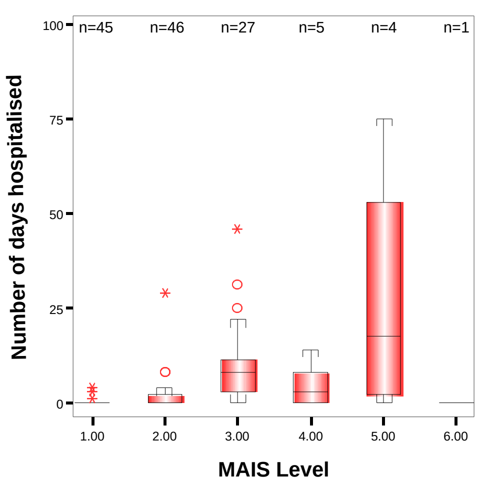



**Figure 8 MAIS level vs. hospitalisation time in days.**

Injuries to the head are cerebrum contusions (6), hematoma (3), unconsiousness (2), epidural or extradural (2), neurological deficit (2) and skeletal fractures (6). Injuries to the upper (9) and lower (23) extremities are all fractures. Thorax injuries are lung, liver and spleen contusions (3), lacerations (6) and multiple rib fractures (1).
Figure 8 shows the hospitalisation time in days vs. the maximum sustained injury level. It can be seen that from AIS $3^+$ the number of days hospitalised vary greatly.
In the following paragraphs the injury causation is further outlined. Firstly the relationship injury type – cause is outlined, and secondly the relationship injury level – collision speed.

**Injury type vs. injury cause** – Table 2 shows that MC rider injuries are mainly due to contact with the environment (The 47% is made up of 25% asphalt and 14% concrete pavement and 8% other). Nine injuries were caused by indirect contact (an injury caused by contact at another body location) and for 20 injuries the cause was unknown. Indirect injuries are mainly due to impact with the environment (3) and OV – side (3). In case of injury causation due to the environment, the moped or mofa in 9 cases (4%) also (possibly) caused the injury (two injury causes).

**Table 2.**
**Injury causation**

| Contact location | N | % | Valid % | Cumulative % |
|---|---|---|---|---|
| Environment | 236 | 44.9 | 46.6 | 46.6 |
| MC | 67 | 12.7 | 13.2 | 59.9 |
| OV - Front | 63 | 12.0 | 12.5 | 72.3 |
| OV - Rear | 14 | 2.7 | 2.8 | 75.1 |
| OV - Side | 109 | 20.7 | 21.5 | 96.6 |
| OV - Top | 4 | .8 | .8 | 97.4 |
| OV - Undercarriage | 4 | .8 | .8 | 98.2 |
| Indirect injury | 9 | 1.7 | 1.8 | 100.0 |
| Total | 506 | 96.2 | 100.0 | |
| Unknown | 20 | 3.8 | | |
| Total | 526 | 100.0 | | |

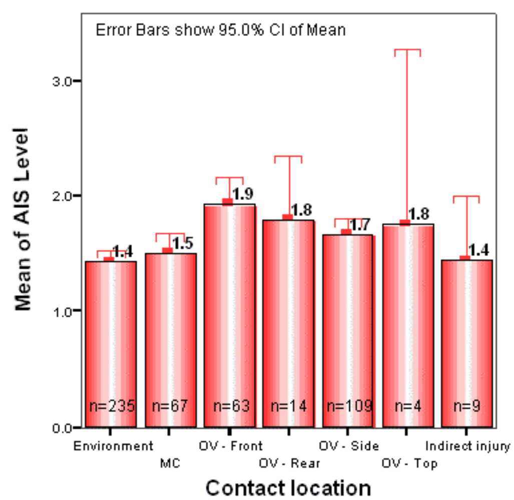



**figure 9 Mean AIS level vs. contact location. OV – undercarriage is not shown, because this was one case with MAIS 5.**

Injuries caused by the environment generally have a lower AIS score, and a significantly lower score than injuries caused by the *OV – front* (see figure 9). In injuries caused by the front of the OV (63 injuries), in a number of cases also contact was made with the MC (10%) or environment (8%). Contact with the *OV – side* is combined with environmental contact (11%) and MC contact (8%). In the rest of the *OV – side* selection, this was the only contact location.

**Injury level vs. collision speed** – The impact speed of the MC was reconstructed according to international guidelines. The mean reconstructed impact speed of mopeds (32 km/h, SD=13 km/h) is - as was to be expected - significantly higher than the mean impact speed of mofas (23 km/h, SD=11km/h). The sustained injury levels do not differ significantly between moped and mofa riders.

The impact speed of the MC is used and does not include the speed of the other vehicle. Because the MC rider is very frequently launched and does not hit a vehicle, the rider continues in the direction of travel with approximately the same speed. In the cases where the rider hits the side of the other vehicle, 50% of the impacts are perpendicular and the speed of the OV is again of little or no influence. In the cases where the impact is not perpendicular, the median impact speed of the OV is only 13 km/h. In the previous paragraph it was shown that most injuries are caused by the environment (asphalt or concrete). It therefore seems a valid assumption to use the MC – impact speed, not including OV – impact speed. This being the case, single and OV – involved accidents may be analysed together. In future publications other collision speed measures will be investigated.

In figure 10 the maximum AIS level of the MC

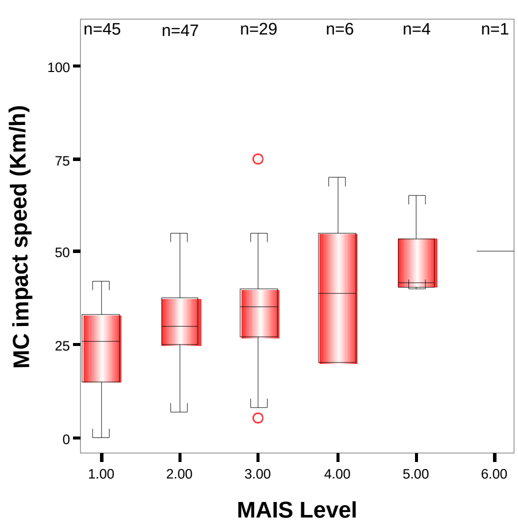



**figure 10 MC impact speed vs. MAIS level, in moped / mofa accidents. Shown are means, standard deviations, outliers and the number of cases.**

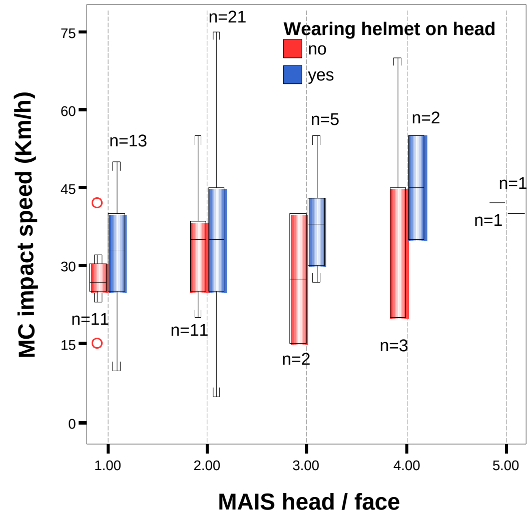



**figure 11 Maximum AIS to the head and face vs. MC – impact speed for helmet wearing.**

rider vs. the reconstructed MC impact speed is shown. A significant correlation between MAIS level and MC – impact speed ($p<0.01$) was found. A higher impact speed leads to more severe injuries.

Looking at the maximum AIS injury sustained at the head and face, it can be seen in figure 11 that the impact speeds for helmet wearers is generally higher than for non-helmet wearers, while looking at the same AIS level. This means that wearing a helmet decreases the injury to the head. The observed difference is not found to be significant, which is very likely due to the low number of $AIS3^+$ injuries, where the difference seems to be increasing. It may also be observed that $AIS3^+$ injuries to the head are also sustained at relatively low speeds when no helmet is worn, while for helmet wearers the impact speeds have to be higher to sustain severe injuries.

For the type of clothing (light, heavy or special) no differences could be found in injury levels. Analysis of the total data set of EU accidents might lead to more insights in this area.

## DISCUSSION

In this discussion, several interesting topics are treated further. Two main causes – OV-perception failure and MC-unsafe acts – and injury causation are discussed in more detail.

### OV – perception failure

An interesting observation is that an OV – perception failure is the most frequently coded certain accident cause, where an OV – unsafe act (32%) is also frequently present, while MC – unsafe acts are less frequently coded (24%) in this selection. Therefore the actions of the other vehicle are most frequently accident causing. In this selection the OV driver was over represented in traffic scanning errors, while the MC was riding on a right-of-way road, and generally less speeding compared to accidents with another causation. It is interesting to note that *view obstructions* were significantly less coded than for other causes, but that the visual background had more frequently a *negative effect* on the MC conspicuity (ar=2.5, n=14).

**MC – unsafe act**

The causes *MC – unsafe act*, *MC – perception failure*, and *view obstruction* are frequently coded together. The speed, traffic scan and traffic strategy of the MC rider are unfit for the situation, certainly when also view obstructions are present (over represented compared to other causes).
Two or more previous traffic violations and two or more previous accidents are significantly more present in accidents where an MC – unsafe act occurred. It is therefore reasonable to suggest letting previous convictions count (after the 2$^{nd}$ violation) when a new violation is committed and to increase for example fines in this case. Taking away license points, from the moped/mofa certificate might be another option. As illegal driving of mopeds, without a certificate already occurs frequently, this last option might not work very well.
Even though no difference was found between the accident population and the control group with respect to the tuning of the MC, MC riders - who committed an unsafe act - seemed to be driving faster (and over the limit) more frequently than those that did not commit an unsafe act.

**Injury causation**

Most injuries are caused by the environment (road), which is also one of the least dangerous. A significant correlation is found between MC impact speed and the maximum sustained injuries. When looking at injuries on the head, wearing a helmet seems to reduce the probability on a severe injury. When no helmet is worn, also more severe injuries occur at lower speeds (25 - 30 km/h). The relationship is not found to be significant. With this information no recommendation can be given about helmet wearing for mofa riders, as their travelling speed should be below 25 km/h. Analysis of the whole European data set might give more insights in this matter. For the type of clothing no effects could be detected.

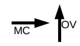
**CONCLUSIONS**

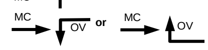
**General**

- 134 Dutch moped / mofa accidents and a control group of 151 riders were analysed as part of 1000 cases in the MAIDS project.

**Configurations**

The most frequent accident configurations are:

- 

- 

: passenger cars over represented.
- 

: other mopeds /mofas over represented, MC frequently negotiating a bend

**Causation**

- The most frequent causes are
  1. OV – perception failure (48%)
  2. MC – unsafe act (33%)
  3. MC – perception failure (29%)
  4. View obstructions (22%)

- Most accidents seem to be very frequently caused by the actions of solely one of the involved parties, either by a perception failure or an unsafe act.

**Rider influences**

- Previous violations and accidents are more present in the accident population than in the control group, especially in the cases where the MC committed an unsafe act (see figure 7).
- When having two or more previous violations on record the probability for the MC rider to get an accident increases. The possible compensating effects of experience, age and driving frequency are taken into account.
- In the accident population, alcohol users were frequently more drunk (significantly impaired) than in the control group, but the number of alcohol users do not differ significantly. Alcohol use was found only in single accidents in this study.

**Injuries**

- Almost 70% of the injuries are MAIS 1 or 2.
- MAIS 3$^{+}$ injuries are mainly injuries to:
  - lower extremities (33%)
  - head (28%)
- Injuries caused by the environment are one of the least severe and significantly lower than injuries caused by the OV – front.

- A significant relationship exists between the maximum sustained injury and the MC – impact speed.
- Safety helmets seem to reduce the maximum sustained head injury. The effect is however not significant.
- An effect of the type of (protective) clothing at these speeds was not found.

**Recommendations**

- Analysis of the whole MAIDS database may give more insights in 'not yet' significant effects and national differences. The effect of helmets might be more pronounced. Also an effect of helmets at lower speeds might be found.

- Better theoretical or practical education of MC riders to make them aware of their behaviour and the consequences is recommended. Because of frequently found poor execution of evasive manoeuvres, it might also be recommended to give moped riders a practical exam before allowing them to ride a moped or mofa.

- Increase fines when multiple violations are on record, because more than two previous violations on record increase the probability to be in an accident.

- Because the negative effect of the background on MC – conspicuity was over represented in accidents with OV perception failures, it might be recommended that MC – riders increase their conspicuity (e.g. wear brighter clothing). In the development of future sensor systems in cars, also attention should be given to this group of vulnerable road users.

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## REFERENCES

**[1] OECD, 1999, *Motorcycles: Common international methodology for in-depth accident investigations,*** http://www.oecd.org/EN/document/0,, EN-document-51-1-no-21-12122-51, 00.html#title0

**[2] SPSS Inc., 1999, *SPSS applications guide,* Chicago, IL, U.S.A.**