NOTAT

Til Transport-, Bygnings- og Boligministeriet

Vedr. Forskningsprojekt om aldersgrænsen for erhvervelse af kørekort til stor knallert og lille motorcykel.

Fra Mette Møller, Kira H. Janstrup, Luca Furlanetto
DTU Management Engineering

December 2018

Mopeds - Risk of serious injury or death

Delnotat III

Danmarks Tekniske Universitet
Department of Management Engineering
DTU Management Engineering

Diplomvej
Bygning 372
2800 Kgs. Lyngby

Tlf. 45 25 65 37
Fax 45 93 34 35

mette@dtu.dk
www.man.dtu.dk

Table of Contents

1 Objective

The current report presents an analysis of the risk of serious injury or death in Denmark regarding moped 30 and moped 45. The analysis regards the period 2007 - 2017.

2 Methodology

The risk of serious injury or death has been calculated as a ratio between the number of accidents, in which at least one moped was involved, and the exposure, which refers to the total mileage driven.

The accident observations have been obtained through Vejman, a road management system operated by Vejdirektoratets (Danish Road Directorate). The exposure is based on data from the Transportvaneundersøgelsen (The Danish National Travel Survey).

2.1 Exposure

The exposure, or the total kilometres driven, is based on data from the Transportvaneundersøgelsen (TU), The Danish National Travel Survey. It consists of an interview survey, which serves to document the travel behaviour of the Danish population. Among other things, it indicates the trip length made in one day by a moped user. Based on this data, the total km driven between 2007-2017 in each of the six macro areas has been calculated (further details in later sections).

2.2 Accidents

The accident observations state the location, age of the driver, and the type of injury sustained in the accident. This was used to create the following two categories:

- *Total risk of serious accident:* includes accidents that have caused death or serious injury to any of the persons involved.

- *Own risk of serious accident*: includes accidents that have caused death or serious injury to the moped driver.

Notice that an accident involving two mopeds has been counted twice: first, two are the number of mopeds involved; second, if the accident have caused a serious injury to one of the drivers and not to the other, the accident can be counted or not in own category depending on the point of view.

The two types of risk of accident have been calculated as follows:

$$Own\ risk\ of\ accident = \frac{Number\ of\ severe\ or\ fatal\ accidents\ for\ mopeds\ driver}{Exposure}$$

Intuitively, this calculation represents how dangerous driving a moped is for the moped driver.

$$Total\ risk\ of\ accident = \frac{Number\ of\ mopeds\ related\ severe\ or\ fatal\ accidents}{Exposure}$$

This calculation represents how dangerous driving a moped is not only for the driver him/herself but for all road users. Given that only severe and fatal accident are considered, the risk of accident can be interpreted as risk of serious injury or death.

2.3 Spatial subdivision of the country

Since it is assumed that geographical and social contexts may influence the risk, it was decided to divide the country into macro areas sharing the same characteristics. The data from The Danish National Travel Survey also indicates the municipality crossed by each journey. This information can be aggregated into groups of municipalities but cannot be explored further (for example, NTM zones are not available). The spatial subdivision of the country has been based on municipality as well. First, the territory is distinguished between urban and rural areas based on population city size. The municipalities of the nine largest cities have been identified as urban area, while the rest of the country has been identified as rural area. However, it has been noticed that some of municipalities nearly only contain highly populated areas, while other municipalities also contain less populated areas. Two different categories were therefore created:

- The three largest cities which nearly only contain highly populated areas: Copenhagen, Odense, and Aarhus
- Larger cities which also contain less populated areas: Esbjerg, Kolding, Vejle, Horsens, Randers, and Aalborg

Given that Copenhagen contains many different municipalities, an aggregation of these must be considered in the category. Instead of selecting an arbitrary aggregation of the municipalities, the NUTS (Nomenclature of Territorial Units for Statistics) area, named by Byen København, which well contains the entire urban area of the capital, was chosen. The idea of considering all the remaining areas as one unique rural macro area has been rejected due to a previous analysis (not included here for the sake of simplicity), which pointed out a higher number of km driven in Jutland in comparison with Zealand. For this reason, and in order to capture the possible social differences, the following categories have been created:

- Countryside North Zealand and Bornholm
- Countryside South and West Zealand
- Countryside North and West Jutland
- Countryside Funen, South and East Jutland

Notice that the exact borders between the last four categories are based on the NUTS areas. It follows a map representing all the six created macro areas.

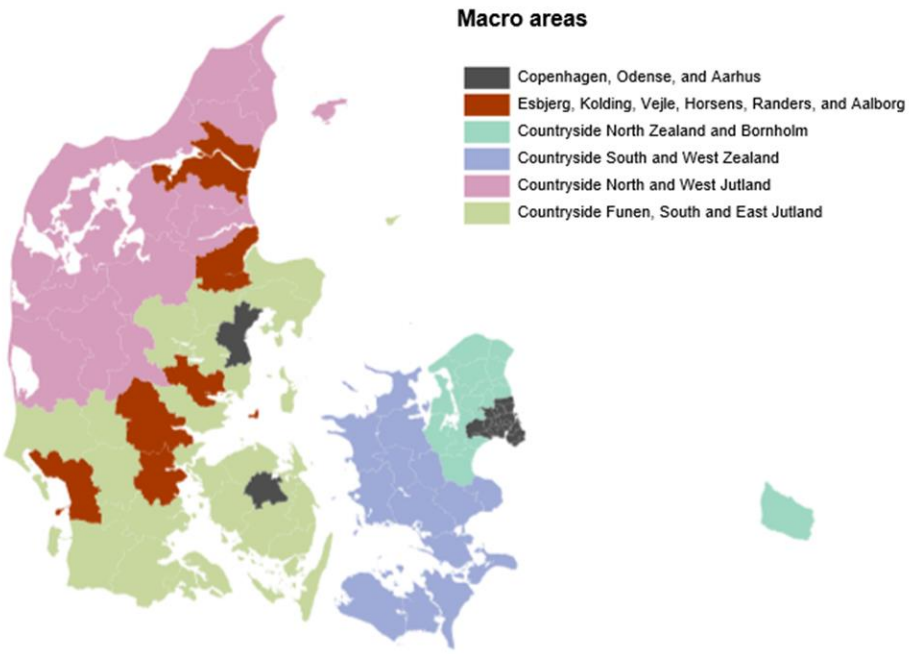

Figure 1 Overview of the six macro areas used in the analysis

2.4 Type of mopeds

Two types of mopeds are considered in the current analysis: Mopeds 30 and Mopeds 45. The maximum speed of a Moped 30 is 30 km/h and the minimum age of the users is 15 years old. The maximum speed of a Moped 45 is 45 km/h and the minimum age of the users is 18 years old. However, mopeds that have been adjusted (illegally) in order to drive faster are widespread.

We calculate the risk of serious injury or death with respect to the type of moped and the age of the user in order to create the following categories:

- Moped 30 and 45
- Moped 30
- Moped 30 young users (15-17 years old)
- Moped 45

Due to an insufficient number of observations, we decided to exclude the category Mopeds 45 young users from the statistical analysis.

3 Underreporting

According to Janstrup et al (2016)[1] a relevant proportion of severe accidents, *i.e.* accidents that have caused serious injury, are not reported to the police. This is particularly relevant for the current analysis, given that the considered accident data is provided by the police. Intuitively, we should multiply the number of severe accidents by the under-reporting rate in order to obtain a better approximation of the reality. Table 1 shows the *Police catch rate* by means of transport. It is important to be aware that the numbers are based on data from Funen 2003-2007. The numbers may have changed.

Table 1: Underreporting rates

Transport Mode	Police Catch Rate (%)
Pedestrian	*56*
Bicycle	*14*
Moped	*45,6*
Motorcycle	*17,6*
Car	*68,2*
Bus	*13*
Other	*77,6*

4 Results

The results are divided into categories based on moped type and user age. The risk of severe injury or death per million km driven and the 95% Confidence Interval is shown each time for both the *Own risk of serious accident* and the *Total risk of serious accident*. The results are shown both in charts and in tables. The tables show the results numerically, while the charts aim to visualize the risk of seriour injury or death. Notice that the tables show three parameters: *Num. acc.* Which is the yearly average number of accidents, *Rate* which is the risk of serious injury or death, and *C.I.* which the confidence interval.

[1] Janstrup, K.H., Kaplan, S., Hels, T., Lauritsen, J., Prato, C. (2016). Understanding traffic crash under-reporting: Linking police and medical records to individual and crash characteristics, Traffic Injury Prevention, 17, 6, 580-584.

4.1 Moped 30 and Moped 45

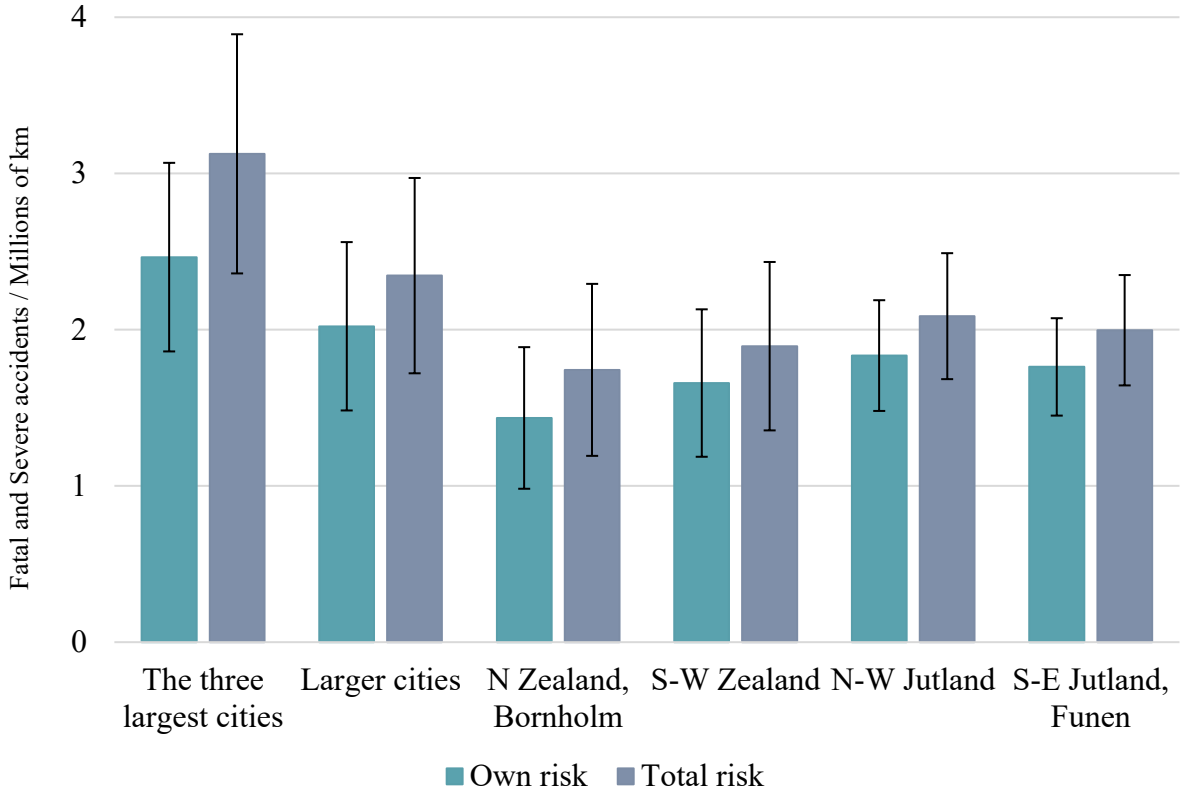

Figure 2: Risk of serious injury or death, mopeds 30 and 45.

Table 2: Risk of serious injury or death, mopeds 30 and 45

Geography	Exposure	Own risk of serious accident			Total risk of serious accident		
	(Million Km)	Num. acc.	Rate	C.I.	Num. acc.	Rate	C.I.
The three largest cities	27,8	68	2,5	[1,9 - 3,1]	87	3,1	[2,4 - 3,9]
Larger cities	26,1	53	2,0	[1,5 - 2,6]	61	2,3	[1,7 - 3]
N Zealand, Bornholm	19,2	28	1,4	[1 - 1,9]	33	1,7	[1,2 - 2,3]
S-W Zealand	26,2	43	1,7	[1,2 - 2,1]	50	1,9	[1,4 - 2,4]
N-W Jutland	36,8	67	1,8	[1,5 - 2,2]	77	2,1	[1,7 - 2,5]
S-E Jutland, Funen	48,4	85	1,8	[1,5 - 2,1]	97	2,0	[1,6 - 2,3]

Figure 2 and Table 2 show the combined risk of serious injury or death for moped 30 and moped 45. What can be noticed from table 2 is that the general risk of serious injury or death is slightly higher in the big cities compared with the countryside. In the following section, we present a comparative analysis about the risk of serious injury or death focused on urban and rural area.

Reasonably, the *total risk* is higher than the *own risk* because each accident in the own category is also in the total one but not the opposite. The difference therefore represents the accidents that have caused serious injury or death, not to the moped driver, but to the other subject involved, which is likely a pedestrian or a cyclist. This explains why the own and the total risk is higher for *The three largest cities* than for the other areas. Cities are characterized by having a higher number of pedestrians and cyclists compared to the countryside.

4.2 Comparison between urban and rural areas

The previous section identified a difference between cities and countryside. In order to clarify this two new categories were created and are compared urban area and rural area. The *Urban area* includes: *The three largest cities* and *Larger cities*; while the category *Rural area* includes the remaining four macro areas.

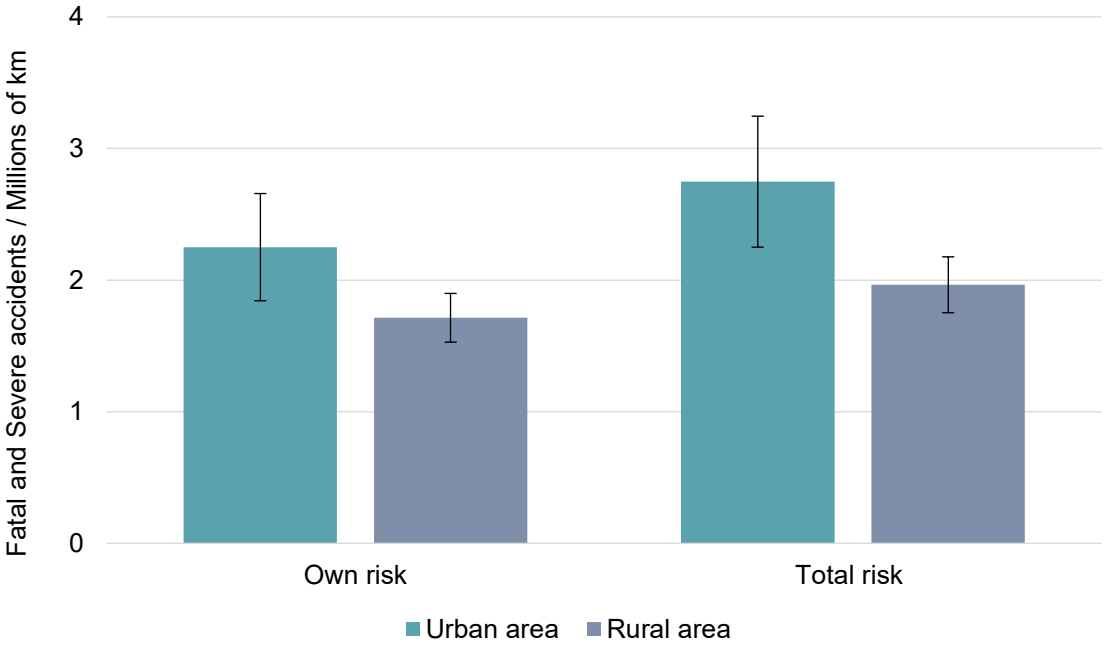

Figure 3: A comparison between urban and rural areas with regard to own risk and total risk.

Table 3: A comparison between urban and rural area

Geography	Exposure	Own risk of serious accident			Total risk of serious accident		
	(Million Km)	Num. acc.	Rate	C.I.	Num. acc.	Rate	C.I.
Urban area	53,9	121	2,3	[1,8 - 2,7]	148	2,7	[2,3 - 3,2]
Rural area	130,6	224	1,7	[1,5 - 1,9]	256	2,0	[1,8 - 2,2]

Figure 3 and Table 3 compare the own risk and total risk in rural and urban areas. Results indicate that the risk of serious injury or death is higher in urban areas than in rural areas for own as well as total risk.

A possible explanation could be that mopeds are less common in urban areas. Indeed the km driven per person in urban area are 0,4, while it is 13 in rural areas. Therefore, it is reasonable to think that other road users in the countryside (such as car driver, truck drivers *etc.*) are more aware of the mopeds, while mopeds might be less expected in the cities. Other explanations include that moped riders are easily overlooked and their speed may be underestimated by other road users.

4.3 Moped 30

In this section we focus on the risk of serious injury or death for moped 30 only.

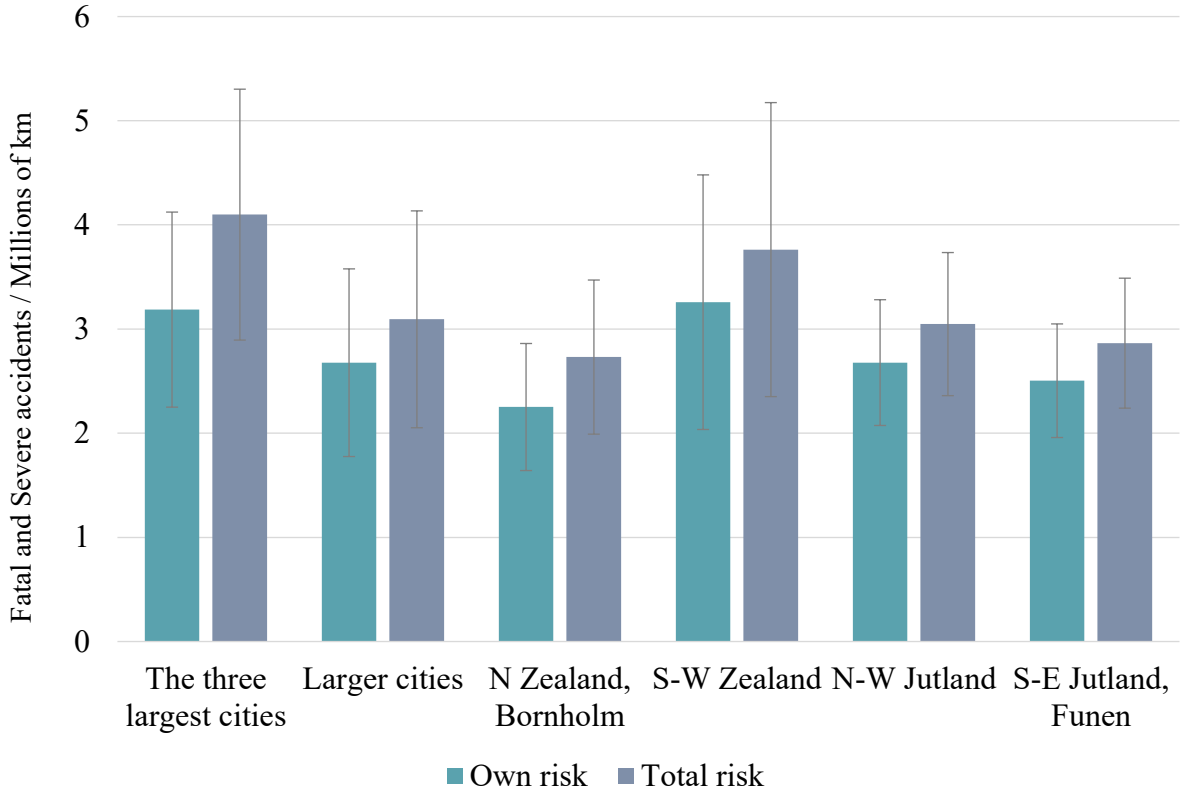

Figure 4: Risk of serious injury or death for moped 30.

Table 4: Risk of serious injury or death moped 30

Geography / macro areas	Exposure	Own risk of serious accident			Total risk of serious accident		
	(Million Km)	Num. acc.	Rate	C.I.	Num. acc.	Rate	C.I.
The three largest cities	18,1	58	3,2	[2,3 - 4,1]	74	4,1	[2,9 - 5,3]
Larger cities	17,5	47	2,7	[1,8 - 3,6]	54	3,1	[2,1 - 4,1]
N Zealand, Bornholm	10,6	24	2,3	[1,6 - 2,9]	29	2,7	[2 - 3,5]
S-W Zealand	11,5	38	3,3	[2 - 4,5]	43	3,8	[2,4 - 5,2]
N-W Jutland	22,9	61	2,7	[2,1 - 3,3]	70	3,0	[2,4 - 3,7]
S-E Jutland, Funen	29,5	74	2,5	[2 - 3]	85	2,9	[2,2 - 3,5]

Figure 4 and Table 4 show that *The three largest cities* together with *S-W Zealand* have the highest risk of serious injury or death while, *N-Zealand* has the lowest. The reason for the difference between urban and rural areas might be as mentioned in the previous subsection.

4.4 Moped 30 young users

We now look specifically on the risk of serious injury or death for young (15-17 years old) moped users (Figure 4 and Table 4). The highest risk is identified in the three largest cities. Given that the analyzed population is smaller than before, the confidence interval is bigger.

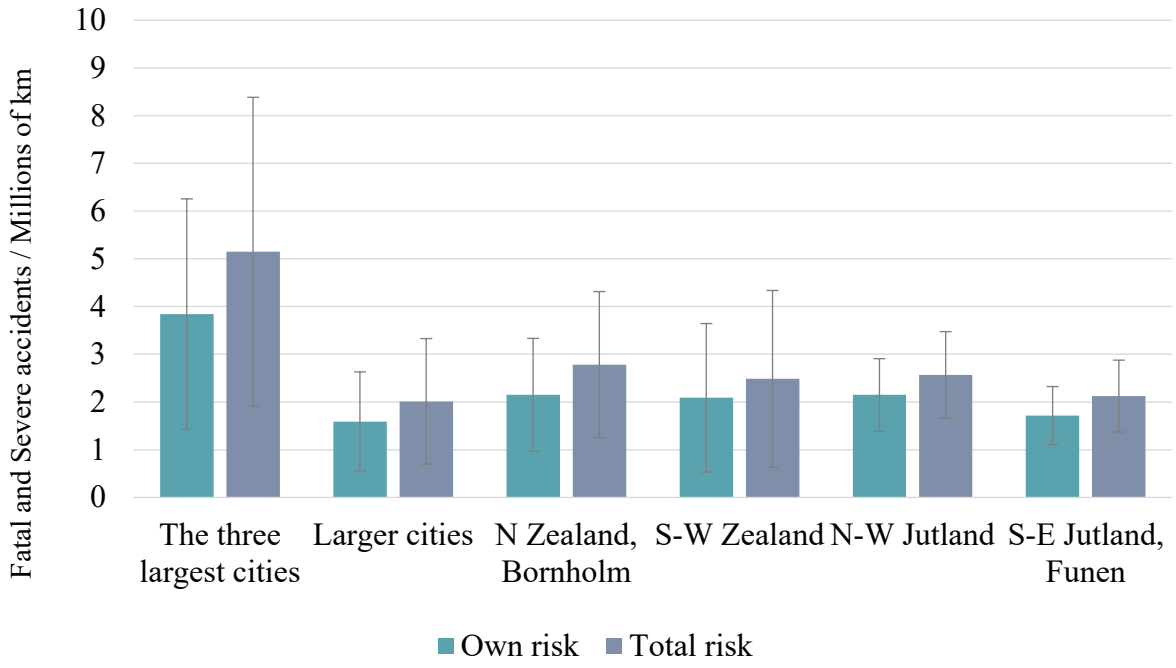

Figure 4: Risk of serious injury or death for moped 30 young users (15-17 years old).

Table 5: Risk of serious injury or death mopeds 30 young users (15-17) years old

Geography / macro areas	Exposure	Own risk of serious accident			Total risk of serious accident		
	(Million Km)	Num. acc.	Rate	C.I.	Num. acc.	Rate	C.I.
The three largest cities	3,4	13	3,8	[1,4 - 6,3]	18	5,1	[1,9 - 8,4]
Larger cities	8,2	13	1,6	[0,6 - 2,6]	16	2,0	[0,7 - 3,3]
N-Zealand, Bornholm	3,6	8	2,2	[1 - 3,3]	10	2,8	[1,3 - 4,3]
S-W Zealand	5,3	11	2,1	[0,5 - 3,6]	13	2,5	[0,6 - 4,3]
N-W Jutland	8,5	18	2,1	[1,4 - 2,9]	22	2,6	[1,7 - 3,5]
S-E Jutland, Funen	12,5	21	1,7	[1,1 - 2,3]	26	2,1	[1,4 - 2,9]

Based on the results of the analysis, it can be stated that the risk for young moped drivers is not higher than for other ages. There is a higher risk of serious injury or death in *The three largest cities* and a lower risk in the remaining categories. However, due to the large confidence interval iit is not possible to draw any conclusion on the small difference.

4.5 Moped 45

We now look at the risk of serious injury or death for moped 45 (Figure 6 and Table 6).

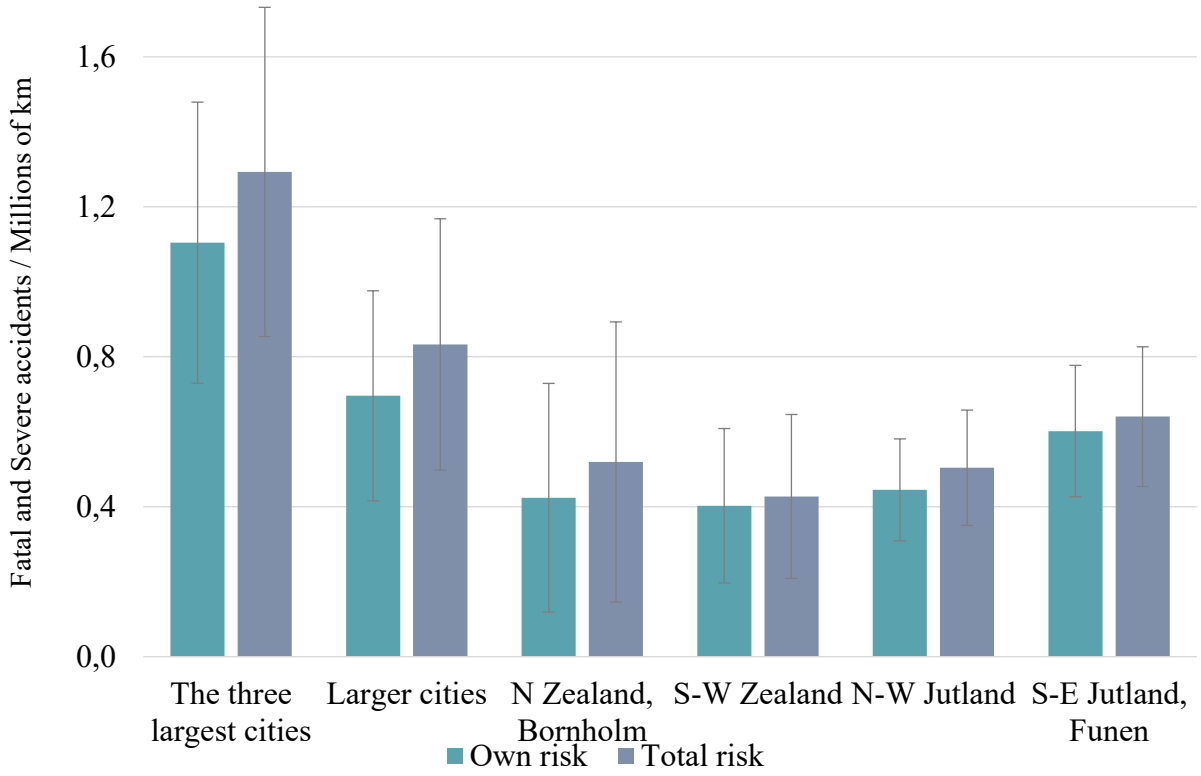

Figure 5: Risk of serious injury or death, moped 45

Table 6: Risk of serious injury or death, moped 45

Geography	Exposure	Own risk of serious accident			Total risk of serious accident		
	(Million Km)	Num. acc.	Rate	C.I.	Num. acc.	Rate	C.I.
The three largest cities	9,6	11	1,1	[0,7 - 1,5]	12	1,3	[0,9 - 1,7]
Larger cities	8,6	6	0,7	[0,4 - 1]	7	0,8	[0,5 - 1,2]
N Zealand, Bornholm	8,6	4	0,4	[0,1 - 0,7]	4	0,5	[0,1 - 0,9]
S-W Zealand	14,7	6	0,4	[0,2 - 0,6]	6	0,4	[0,2 - 0,6]
N-W Jutland	13,9	6	0,4	[0,3 - 0,6]	7	0,5	[0,4 - 0,7]
S-E Jutland, Funen	18,9	11	0,6	[0,4 - 0,8]	12	0,6	[0,5 - 0,8]

As for moped 30, the risk of serious injury or death is slightly higher in urban areas compared with the countryside for both types of risks of accident. In addition, it can be seen that the risk of serious injury or death for moped 45 is lower than the risk for moped 30. Due to this, the following presents a comparison of the two.

4.6 Comparison between moped 30 and moped 45 – Own risk

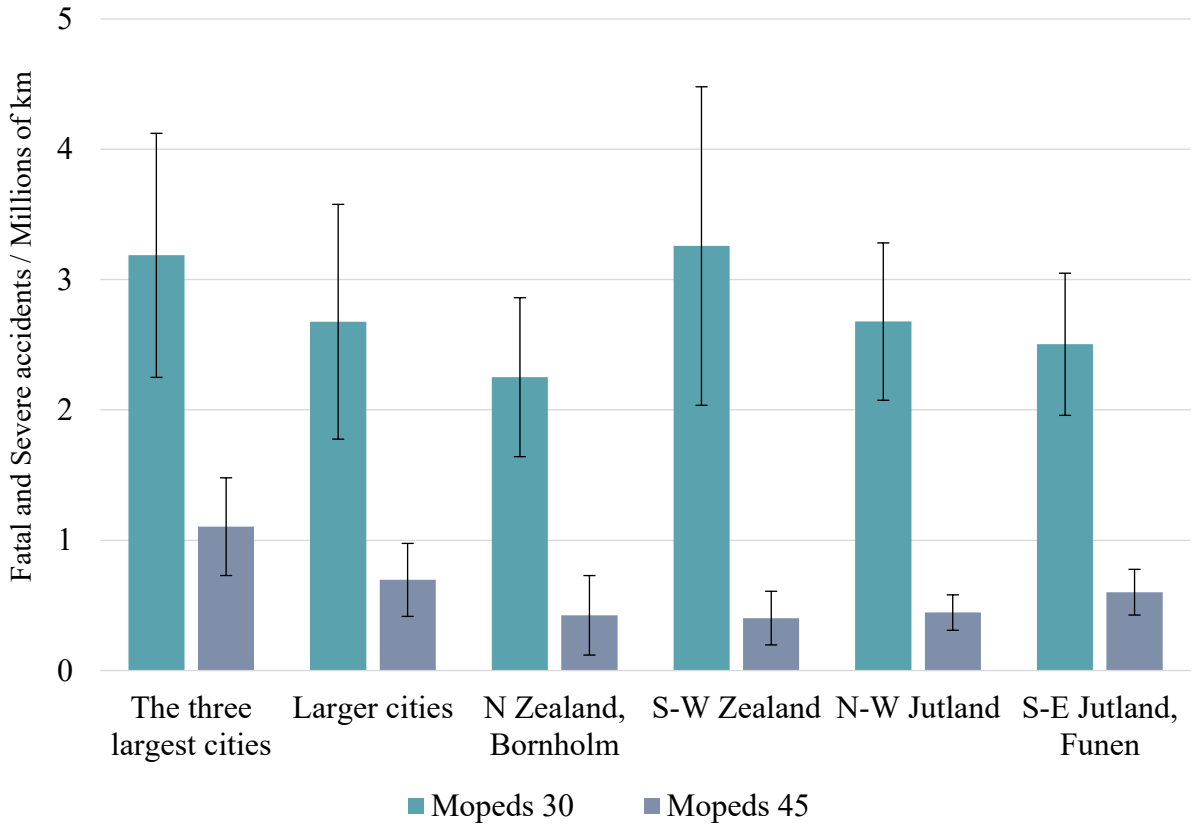

Figure 7: Comparison of the own risk of serious injury or death between moped 30 and moped 45.

Table 7: Comparison of the own risk of serious injury or death between moped 30 and moped 45

Geography	Mopeds 30			Mopeds 45		
	Num. acc.	Rate	C.I.	Num. acc.	Rate	C.I.
The three largest cities	58	3,2	[2,3 - 4,1]	11	1,1	[0,7 - 1,5]
Larger cities	47	2,7	[1,8 - 3,6]	6	0,7	[0,4 - 1]
N Zealand, Bornholm	24	2,3	[1,6 - 2,9]	4	0,4	[0,1 - 0,7]
S-W Zealand	38	3,3	[2 - 4,5]	6	0,4	[0,2 - 0,6]
N-W Jutland	61	2,7	[2,1 - 3,3]	6	0,4	[0,3 - 0,6]
S-E Jutland, Funen	74	2,5	[2 - 3]	11	0,6	[0,4 - 0,8]

Figure 7 and Table 7 highlights the higher risk of serious injury or death for moped 30 compared with moped 45, and given that the maximum speed of moped 30 is lower than moped 45, the result is somewhat surprising.

4.7 Comparison between moped 30 and moped 45 – Total risk

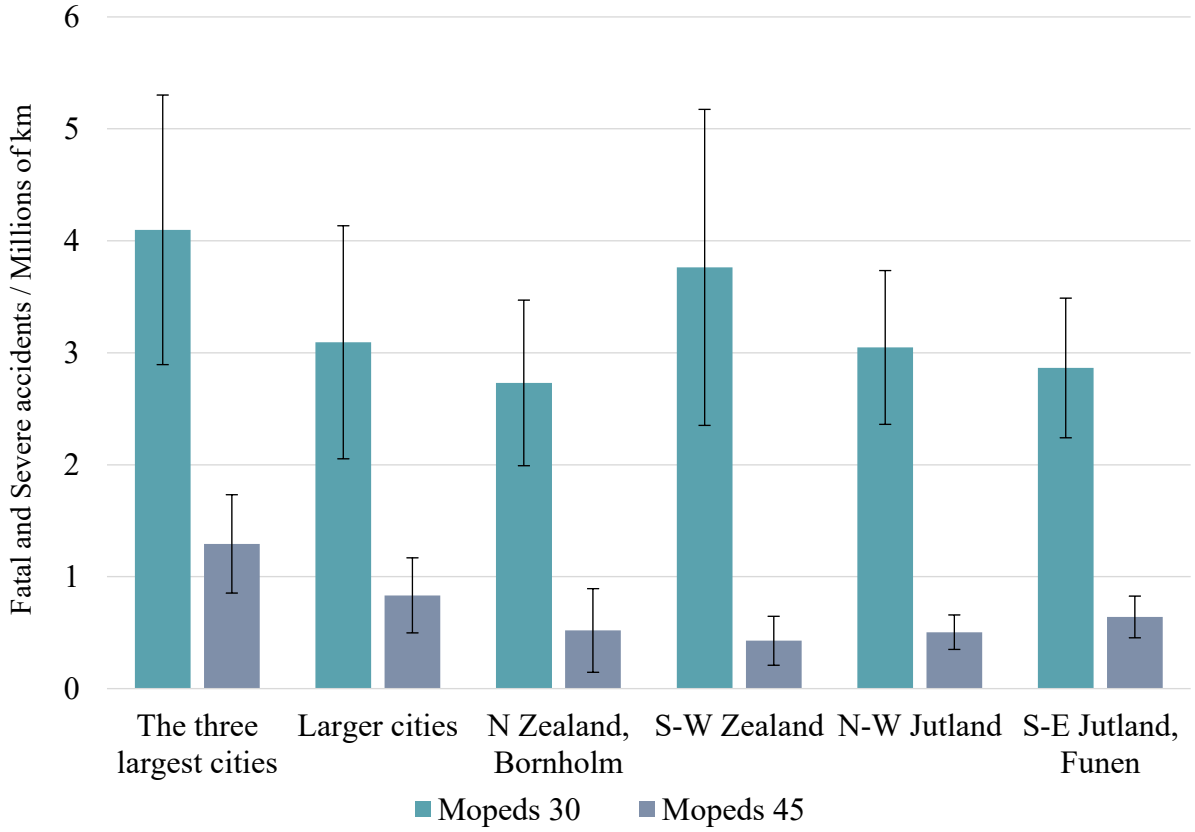

Figure 7: Comparison of the total risk of serious injury or death between moped 30 and moped 45.

Table 8: Comparison of the total risk of serious injury or death between moped 30 and moped 45.

Geography	Mopeds 30			Mopeds 45		
	Num. acc.	Rate	C.I.	Num. acc.	Rate	C.I.
The three largest cities	74	4,1	[2,9 - 5,3]	12	1,3	[0,9 - 1,7]
Larger cities	54	3,1	[2,1 - 4,1]	7	0,8	[0,5 - 1,2]
N Zealand, Bornholm	29	2,7	[2 - 3,5]	4	0,5	[0,1 - 0,9]
S-W Zealand	43	3,8	[2,4 - 5,2]	6	0,4	[0,2 - 0,6]
N-W Jutland	70	3,0	[2,4 - 3,7]	7	0,5	[0,4 - 0,7]
S-E Jutland, Funen	85	2,9	[2,2 - 3,5]	12	0,6	[0,5 - 0,8]

Once again, the risk of serious injury or death is higher for moped 30 than for moped 45.

4.8 Risk of serious accident for young cyclist

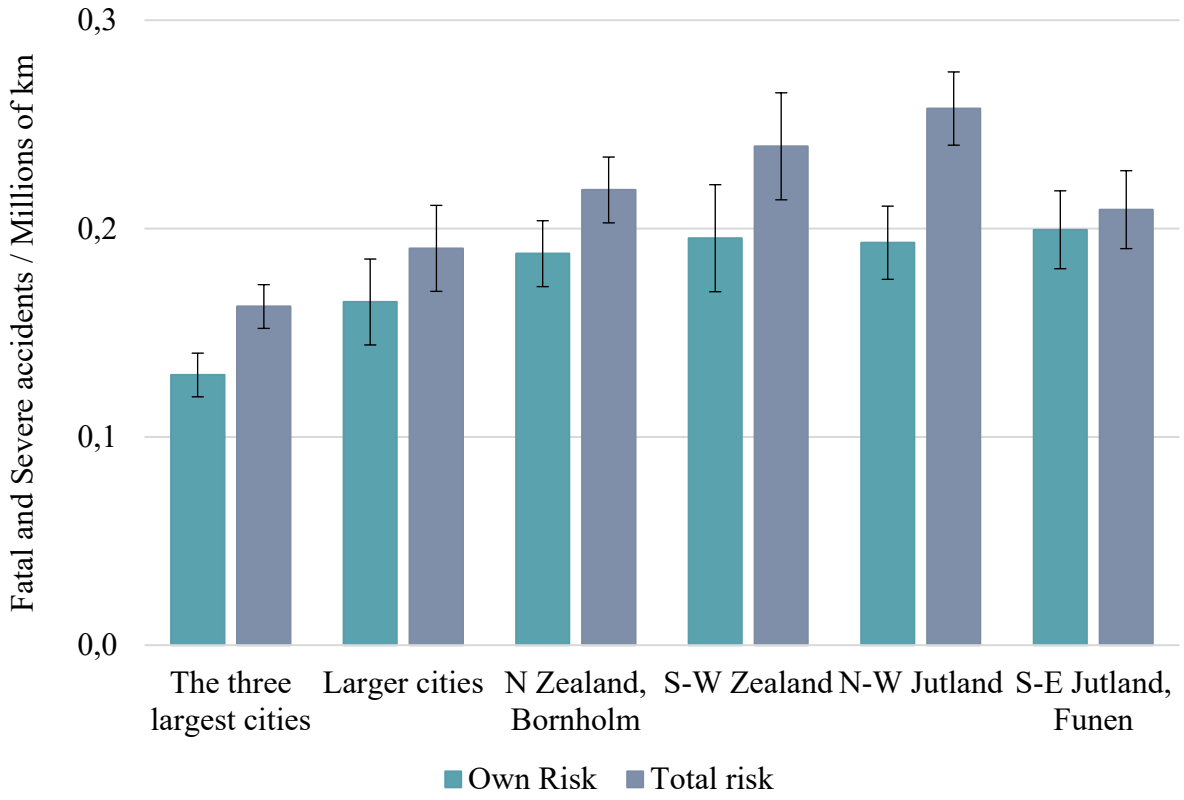

Figure 8: Risk of serious injury or death for young cyclists.

Table 9: Risk of serious injury or death for young cyclists.

Geography	Exposure	Own risk of serious accident			Total risk of serious accident		
	(Million Km)	Num. acc.	Rate	C.I.	Num. acc.	Rate	C.I.
The three largest cities	52,6	7	0,13	[0,12 - 0,14]	9	0,16	[0,15 - 0,17]
Larger cities	17,7	3	0,16	[0,15 - 0,18]	3	0,19	[0,17 - 0,21]
N Zealand, Bornholm	20,8	4	0,19	[0,17 - 0,2]	5	0,22	[0,2 - 0,23]
S-W Zealand	14,4	3	0,20	[0,17 - 0,22]	3	0,24	[0,21 - 0,27]
N-W Jutland	19,8	4	0,19	[0,18 - 0,21]	5	0,26	[0,24 - 0,28]
S-E Jutland, Funen	28,3	6	0,20	[0,18 - 0,22]	6	0,21	[0,19 - 0,23]

The risk of serious accident for bicycles appears different from mopeds given that the risk is lower for cyclists in the city compared with the rural areas. It is also worth noting that the risk of serious injury or death for young cyclists on average is ten times smaller than for drivers of moped 30. With regard to cyclists, it is important to remember that the level of underreporting is very high for cyclist accidents.

5 Conclusion

Based on data from the Danish National travel Survey and the police registered road traffic accidents the risk of serious injury or death has been calculated for moped 30, moped 45, moped 30 and 45 combined, and bicycle.

With regard to moped 30 and 45 results show that the risk of serious injury or death is higher in urban areas than in rural areas. Results also indicate that the risk of young moped riders is not higher than the risk of the general population.

Further, results show that the risk related to moped 45 is lower than the risk related to moped 30.

Unlike the risk identified in relation to mopeds, the risk of serious injury or death for young cyclists is smaller in urban areas, and 10 times smaller than the risk of moped 30.