WINTERTIME ROAD CONDITIONS AND ACCIDENT RISKS IN PASSENGER CAR TRAFFIC

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ABSTRACT

This article examines the accidents in passenger car traffic in different wintertime road conditions. The prevalence of different wintertime road conditions and the accident risks are also studied.

The earlier research has stated that the rarer the wintery road conditions are the higher is the risk in these conditions. It is also noted, that even when the road condition is assessed to be slippery, the drivers do not change their behaviour adequately.

The accident risks calculated in this research for wintery road conditions are 4 to 5 times higher than the risks on bare road. These results are in line with previous studies even though these risk ratios are slightly smaller compared to earlier ones.

The climate is changing, and the challenges for the parties responsible for the roads maintenance are growing. The effects of the chances in winter conditions are contradictory as some changes, such as bare roads becoming more common, reduce and some changes, such as the wintery road conditions becoming rarer, increase the risk in passenger car traffic.

KEYWORDS

ROAD CONDITIONS / WINTER / TRAFFIC SAFETY / ACCIDENT RISK / PASSENGER CARS

1. INTRODUCTION

There are many factors affecting road safety and the accident risk in passenger car traffic. The most important are the driver, the road and its environment and the vehicle, but also the underlying factors, such as the legislation, enforcement and education, have an impact on the risk. The question studied here, how the road condition influences the risk, has a strong connection to all of these.

Here the road condition refers to the road surface, which is affected by the weather as well as e.g. the road characteristics and the road maintenance. Temporal and local alternations are important features of the road condition. Finland as a long country, over 1,000 km from south to north, has very varying road conditions in different parts of the country over the year.

The season affects the accident risk. In winter, the friction of the road surface and the area in sight are often inferior to summer. Snow and ice reduce the friction which in turn makes the stopping distances longer and diminishes the steering ability. On the other hand snow banks limit the visual range and may narrow the breadth of the road. [1] A strong connection has been detected between the friction and the accident risk especially when the friction factor is under 0.5 [2].

This paper is based on the research project “Wintertime road conditions and accident risks in passenger car traffic” [3] conducted at Tampere University of Technology in 2008, which reviewed the prevalence of different wintertime road conditions and the accidents in passenger car traffic. The wintertime was defined as the months from December to March, when there are mainly wintery road conditions in Finland. The study’s analyses focused in Finland. The earlier research was mainly dissected from the Nordic countries which have similar conditions to Finland, i.e. Sweden and Norway, see Figure 1.

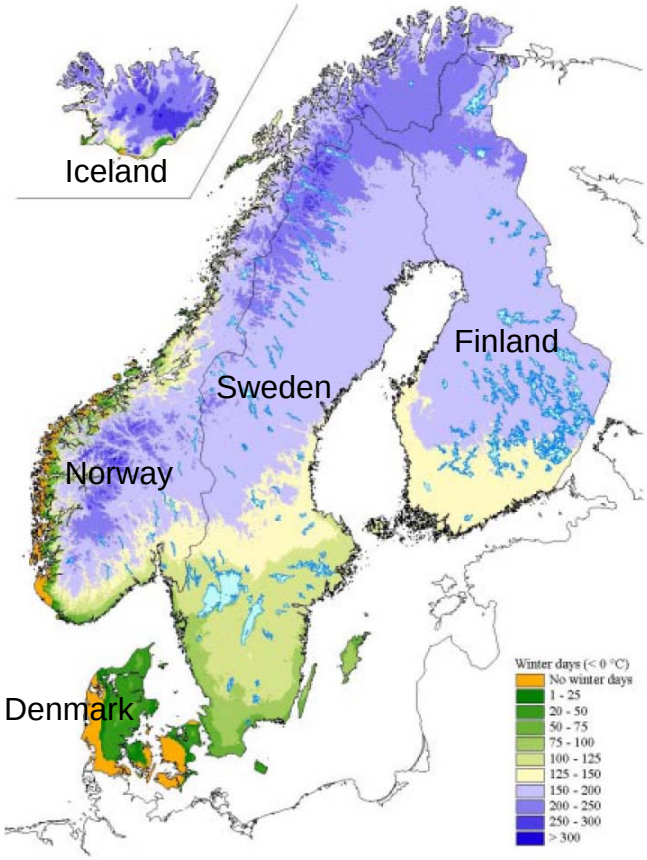

Figure 1 – The average length of winter (mean temperature under 0 °C) in the Nordic countries 1961–1990. [4]

The accidents in passenger cars and the road conditions in wintertime were analysed with statistical data. The accident risk for a specific road condition can be calculated by dividing the accidents in these conditions with the vehicle mileage in corresponding conditions. In the data available there is not similar accuracy for the vehicle mileage in different road conditions as there is considering the road conditions in accidents. The classifications of the road conditions are dissimilar in different sources which makes it difficult to combine them. In addition, the road condition in different sources is based on subjective observations. The available accident statistics are often small-scale and therefore include contingency. The road conditions also vary from winter to winter. Taking the mentioned uncertainties into account, a relationship was defined between wintery road conditions and the accident risk in passenger car traffic.

2. THE EFFECT OF THE ROAD CONDITION ON THE RISK OF PASSENGER CAR TRAFFIC IN EARLIER RESEARCH

Many studies have stated that the accident risk for a specific road condition is the higher, the more uncommon the prevalence of the road condition is [5, 6]. The risk is the highest when the road condition changes unexpectedly [1].

The accident risk in wintery road conditions is generally higher in the early and late winter compared to midwinter, and is mainly higher in the south than in the north [5, 7]. Another general outcome has been that the highest relative risk is in icy or slushy road conditions, see Table 1.

Table 1 – The effect of the road condition on the accident risk in earlier studies [7]

Study (risk ratio)	Year	Result			
Polvinen (icy/bare)	1985	14–20			
	1987	25–35			
Talvi- ja tieliikenne (slippery/antiskid)	The 1990s	Southern Finland	Central Finland	Northern Finland	
		4.2	2.1–3.3	3	
Malmivuo & Peltola	1997	Bare	Snowy	Slushy	Icy
		1	8	12	17
VTI (snowy or icy/bare)	1997	Daylight	Darkness		
		2–20	2–7		
Hvoslef (icy or snowy/bare)	1986	3–6			
Malmivuo & Kärki	1990–2002	Snowy/dry	Slushy/dry	Icy/dry	
		1.7–3.1	8.4–28.8	12.4–28.9	

There are notably more single and meeting accidents in icy or snowy road conditions compared to bare road. The single accidents are although slighter in icy or snowy road conditions than on bare road surface. This is explained for instance by snow being also on the banks and snow softening the collision and hindering from hitting rocks or trees. Instead in the meeting accidents the consequences are more severe in icy and snowy road conditions than on bare roads, which may be due to the fact that many of these accidents happen sideways. In half of the fatal accidents in icy or snowy road conditions the car has skidded and met the other car sideways, and the share on bare road was only 3 per cent respectively. [8]

According to a Swedish study the average speeds of vehicles sank most when the road surface was covered with snow or thick ice compared to dry and bare conditions. Loose snow and slush had also relatively big influence on the average speeds. [9]

However the behaviour of the drivers does not change adequately, even though the road is assessed to be slippery. The drivers also assess the road to be less slippery than it actually is, and the drivers are not aware of the condition of their tyres. [10]

The tyres are the most important factor related to the handling characteristics in accidents caused by passenger cars [11]. Tyres have been one of the causes in nearly 40 per cent of accidents occurring in snow or slush [12]. Tyres that are worn out increase the accident risk especially in extreme road conditions.

3. WINTERTIME ACCIDENTS IN DIFFERENT ROAD CONDITIONS

The statistical analyses were made separately for traffic accidents and fatal accidents in Finland. The data in the analyses were the Finnish Motor Insurers´ Centre's traffic accident statistics [13], statistics gathered from the fatal accidents investigated by the road accident investigation teams [14], and Finnish Road Administration's follow-up data on the quality of wintertime maintenance [15].

The traffic accident statistics [13] included the data from the years 2004, 2005, and 2006, and considered accidents leading to material or personal damage of which claims had been paid under motor liability insurance. Altogether there were 281,867 such accidents in the data. Of these 11,651 were accidents that happened to passenger cars, and in which the road conditions can be seen as a significant factor (reversing accidents and accidents happening elsewhere than on roads were removed from the data) and happened in wintertime i.e. between December and March.

From the studied traffic accidents 80 per cent happened in snowy or icy road conditions. Ten per cent of the accidents took place in dry and bare conditions as well as in dry and wet conditions. Though the road conditions vary in different parts of Finland, most accidents happen on snow or ice in all Finnish regions. The share of accidents taking place in wintery conditions grows when moving from the south towards the east and north, see Figure 2.

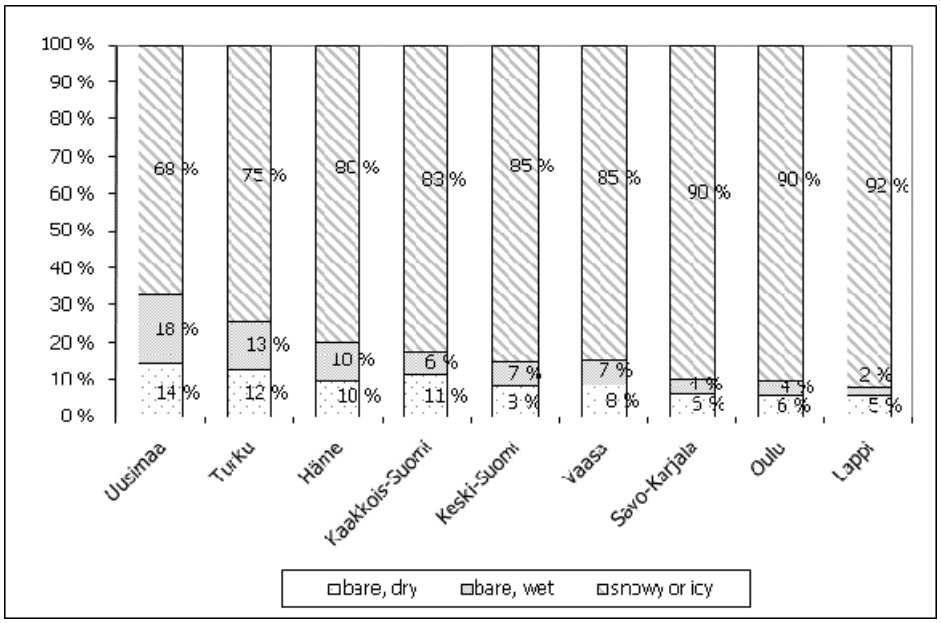

Figure 2 – The share of road conditions in traffic accidents in different road regions in Finland in wintertime (from December to March) years 2004–06. The southernmost area (Uusimaa) is on the left, the northernmost area (Lappi) is on the right.

Single and multiple-vehicle accidents as well as animal accidents leading to death and in which a passenger car was involved were analysed with the help of data collected by the road accident investigation teams in years 1997–2006 [14]. There were 2,009 such accidents between years 1997 and 2006, and of these, 598 took place in the analysed winter months (December, January, February and March).

Of the analysed fatal accidents 34 % happened on bare roads, 11 % on thin ice, 30 % on snow or ice, 13 % on bare ruts and 12 % on loose snow or slush. Fatal accidents take place more often on bare road than traffic accidents. Reasons for this can be e.g. the

softening effect of snow, differences in crash speeds or in accident types. Figure 3 illustrates that the road conditions in fatal accidents varies greatly in different regions in Finland.

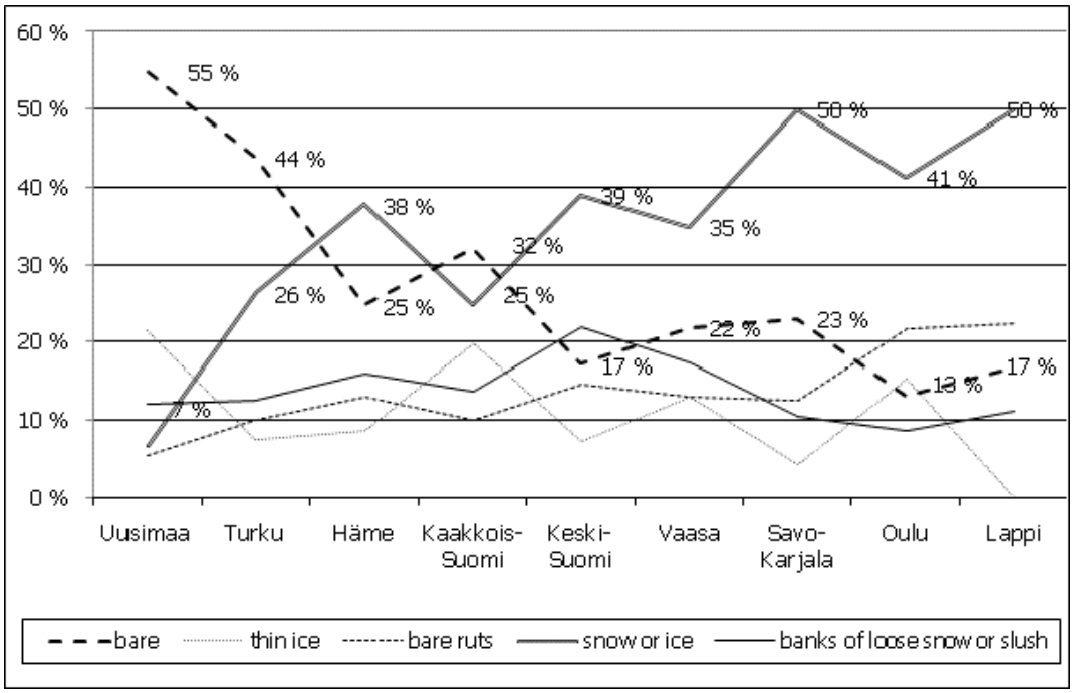

Figure 3 – The share of road conditions in fatal accidents in different road regions in Finland in wintertime (from December to March) years 1997–2006. The numerical values in the figure are the shares of bare road and snow or ice.

Previous Figures 2 and 3 demonstrate the distribution of accidents in different road conditions in Finland. These figures did not yet present or take into account the traffic flow in different road conditions. The accident risk in different road conditions can be assessed by proportioning the number of the accidents to the traffic volume.

4. WINTERTIME ACCIDENT RISKS IN DIFFERENT ROAD CONDITIONS

4.1. The prevalence of road conditions in Finland

Finnish Road Administration's follow-up data on the quality of winter maintenance [15] was considered to be the best suitable data for this research. This data includes information on the road conditions from December to March in different parts of Finland. For this research the data was obtained from winters 2003–2004, 2005–2006 and 2006–2007 including altogether approximately 400,000 road condition measurements. The data was not gathered for the winter 2004–2005.

Figure 4 shows the distribution of road conditions in Finland based on road condition measurements. As can be seen from the figure, the road is mostly bare in the southernmost Finland and the snowy and icy road condition becomes more general towards the north.

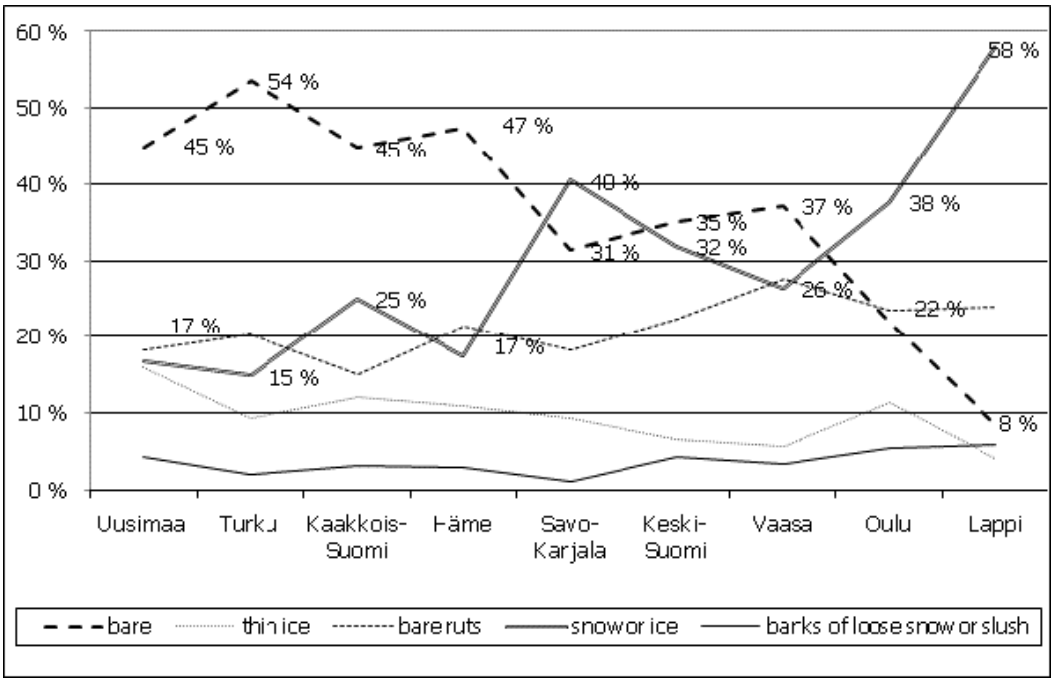

Figure 4 – The road conditions in different road regions in Finland in wintertime (from December to March) 2003–2004, 2005–2006 and 2006–2007. The numerical values in the figure are the shares of bare road and snow or ice.

As can be seen from Table 2, the main roads are mostly bare in wintertime. Banks of loose snow or slush can be regarded as the most demanding road condition. The prevalence of this road condition is 3 to 5 per cent being highest on the lower road network. Snow or ice is also a more common road condition on the lower road network. This is natural considering the winter maintenance standards applied to different road classes.

Table 2 – The road conditions in different road classes in wintertime (from December to March) 2003–2004, 2005–2006 and 2006–2007

Road condition	Main roads (Class I)	Main roads (Class II)	Regional roads	Connecting roads	Whole country
Bare	53 %	33 %	26 %	18 %	37 %
Thin ice	15 %	8 %	6 %	4 %	10 %
Bare ruts	23 %	30 %	22 %	12 %	21 %
Snow or ice	7 %	26 %	42 %	62 %	29 %
Banks of loose snow or slush	3 %	3 %	4 %	5 %	3 %
Total	100 %	100 %	100 %	100 %	100 %

The follow-up data on the quality of winter maintenance does not include traffic volume data in different road conditions. Therefore the analyses are based on the amount of measurements. There are more measurements on the lower road network than their corresponding share is of the traffic volume, which means that more general wintery road condition on this network is emphasized in the data. This influences the calculation of the accident risk so that the actual risk on bare road is lower than what is calculated here and higher in wintery road conditions respectively. For this reason, the calculated accident risk ratio between wintery road conditions and bare road is lower than actually.

Accident risks were calculated for different road conditions both for traffic accidents and fatal accidents. As there is no road condition data available for the winter 2004–2005, the average for years 2004–2006 was used without this data.

4.2. The risk of road accidents

The accident risk for traffic accidents on bare road varied between 0.11 and 0.26 accidents per million vehicle kilometres for different regions, and was on average 0.17 accidents per million vehicle kilometres in the whole of Finland. The accident risk in snowy or icy road conditions varied between 0.45 and 0.87 accidents per million vehicle kilometres, and was on average 0.70 accidents per million vehicle kilometres.

Figure 5 illustrates the relationship between the accident risk in snowy or icy road conditions and the prevalence of the conditions in different Finnish regions. The accident risk is generally smaller in the north than in the south.

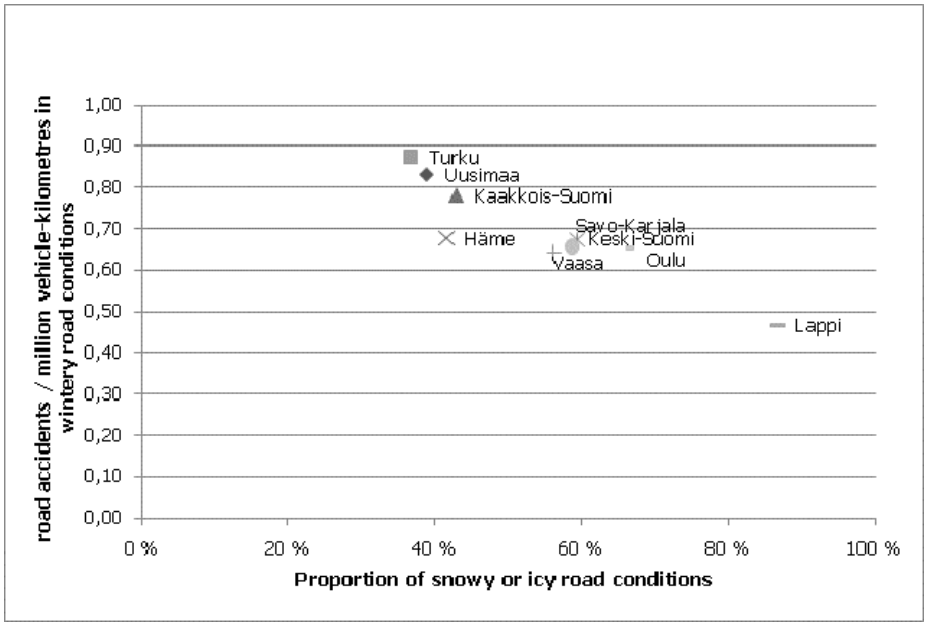

Figure 5 – The traffic accident risk in different road regions and the prevalence of wintery road conditions, based on accidents in wintertime 2004–2006 and the prevalence of road conditions in winters 2003–2004, 2005–2006 and 2006–2007.

For traffic accidents the accident risk in snowy or icy road conditions was 4.1 times higher compared to bare road in the whole of Finland. The risk ratio was smallest in northernmost Finland (Lappi i.e. Lapland), where the risk in snowy or icy road conditions was 1.8 times higher that the risk on bare road.

4.3. The risk of fatal accidents

The data available considering the fatal accidents was from a longer time period (1997–2006) compared to the data of the prevalence of the road conditions (2003–2004, 2005–2006, and 2006–2007). This in addition to the factors of uncertainty mentioned before makes it more useful to analyse the risk rations rather than the absolute risks.

The risk for fatal accident on banks of loose snow or slush was 4.9 times higher compared to bare road. The risks for fatal accidents in different road classes are compared with the risk on bare main road in class I in Table 3. The table indicates that the accident risk is clearly the highest on loose snow or slush in higher road classes. The main roads have a high winter maintenance standard, and the road surface is tried to be kept clean from snow and ice. For this reason there are more bare roads the higher the road class is. As stated in previous studies, also here it can be concluded that the accident risk is higher the rarer a specific road condition occurs.

Table 3 – The risk of fatal accidents in different road classes compared to bare main road, class I (index=1.0).

Road condition	Main roads (Class I)	Main roads (Class II)	Regional roads	Connecting roads	Whole country
Bare	1.0	1.1	1.4	1.5	1.1
Thin ice	1.5	1.5	1.6	1.3	1.5
Bare ruts	0.8	0.4	1.1	0.7	0.8
Snow or ice	3.2	1.0	1.4	0.5	1.2
Banks of loose snow or slush	8.8	5.8	2.8	0.8	4.9

The results are in line with previous ones even though these risk ratios are slightly smaller. This is partly because the deficiencies in the data, for which reason the road condition data and traffic volume data has been connected directly, not stressing the prevalence of wintery conditions in lower road classes. In addition the road prevalence data is from winters that have been warmer than average (especially winter 2006–2007), which increases the prevalence of bare roads in the data. Because of these factors the accident risk on bare roads is lower here, and the calculated risk ratios are likely to be smaller than actually.

5. DISCUSSION OF THE FUTURE

Climate is unquestionably warming [16]. The progression of the climate change affects the prevalence of different road conditions in future. It is worth to remember, that because of climate's natural changes there will still also be cold winters. The farther in future we go, the rarer the cold circumstances become. [17]

For Finland, climate warming may mean that the temperatures now common in southern coast will be in Central Finland by the year 2030. At the same time the winter maintenance procedures now followed in Southern Finland will continuously move to the north [17]. The crossing of the freezing point and thus the need for antiskid treatment would go down in Southern Finland but would grow in Northern Finland. Rainy weathers are expected to increase in the wintertime. The emergence of slippery conditions is often hard to predict, which boosts the need for prediction models for slipperiness. [18]

The Finnish winter maintenance policy was renewed in 2008 and it will be adopted on autumn 2009. The policy is aware of climate warming and that the increase in extraordinary weather conditions is a new challenge for winter maintenance. Compared to the previous policy, the standard for maintenance has been slightly upraised. The antiskid treatment has been made more efficient by for instance improving the anticipation of antiskid treatment on busy roads, removing the former reductions for night-time, and by standardising requirements for friction. Overall, the financing need for winter maintenance in Finland is somewhat increasing because of the climate chance. [17]

The variability of winter road conditions is growing, which increases the need for real-time information for drivers. Different projects have been realised for instance in Finland and Sweden to bring the drivers information considering the road conditions. For example the Swedish SRIS-project aims to bring information of the friction to drivers by combining data gathered from the road weather stations and cars equipped with sensors, and calculating an index for the friction [19].

Warmer winters are becoming more general and therefore there will be more bare roads than earlier. The effect of warmer winters on the accident risk in passenger car traffic is however contradictory. The accident risk is lower on bare roads compared to icy or snowy roads. Yet rarer wintery road conditions increase the accident risk for these conditions. For instance in Sweden the winter maintenance policy has strongly leant on the fact, that there are more accidents on wintery road conditions the rarer these conditions exists, and it is considered to be the best situation when there are often wintery conditions or not at all [6].

There are many challenges connected to analysing the accidents risks in wintery road conditions. Many studies have stated that the absence of data related to road conditions or traffic volume is reducing the data on accidents, which in many cases is already small. Because of the small data the random variation may have a big influence on the results. Besides different winters may have very dissimilar road conditions and comparing several countries with each other has also the challenge of differences in road condition and accident data classifications. In spite of many challenges, the differences in the accident risks for different road conditions are clearly recognisable. In future it is interesting to discuss, how the risks change as the prevalence of different road conditions chances, and what different actors can do to reduce the accident risk.

REFERENCES

[1] Elvik, R. & Vaa, T. (2004). The Handbook of Road Safety Measures. Elsevier.

[2] Wallman, C.-G. & Åström, H. (2001). Friction measurement methods and the correlation between road friction and road safety. A literature review. VTI meddelande 911A.

[3] Salli, R. & Lintusaari, M. & Tiikkaja, H & Pöllänen, M. (2008). Keliolosuhteet ja henkilöautoliikenteen riskit. Tampereen teknillinen yliopisto.

[4] Tveito, O.E. & Førland, E.J. & Alexandersson, H., Drebs, A. & Jónsson T. & Tuomenvirta, H. & Vaarby Laursen, E. (2001). Nordic climate maps. DNMI-Report. 06/01 KLIMA.

[5] Bergström, A. (2003). Tema Vintermodell – Olycksrisker under för-, hög- och senvintern. VTI notat 19-2003.

[6] Sarjamo, S. & Malmivuo, M. (2004). Talviliikenteen turvallisuus Suomessa ja Ruotsissa. Liikenneturvallisuuden pitkän aikavälin tutkimus- ja kehittämisohjelma LINTU, julkaisu 5A/2004.

[7] Malmivuo, M. & Kärki, O.(2002). Ajokeliin liittyvä riski. Tiehallinnon selvityksiä 39/2002. Tiehallinto.

[8] Niska, A. (2006). Tema Vintermodell. Olycksrisker och konsekvenser för olika olyckstyper på is- och snöväglag. VTI Rapport 556.

[9] Wallman, C.-G. & Möller, S. & Blomqvist, G. & Bergström, A. & Gaunt, H. (2005). Tema Vintermodell: Etapp 1. Framkomlighetsmodellen. VTI meddelande 958-2005.

[10] Heinijoki, H. (1994). Kelin kokemisen, rengaskunnon ja rengastyypin vaikutus nopeuskäyttäytymiseen. Tielaitoksen selvityksiä 19/1994. Tielaitos.

[11] Liikenneturva (2008). Auton renkaat. Liikenneturva's web pages in Finnish. http://www.liikenneturva.fi/fi/turvalaitteet/auton_renkaat/index.php. Accessed 27.3.2008.

[12] Autonrenrengasliitto 2007. Henkilö- ja pakettiautojen rengasriskit 2000-luvulla. Autonrengasliitto ry.

[13] VALT (2007). Vakuutusyhtiöiden liikenneturvallisuustoimikunnan liikennevahinkotilasto vuosilta 2004–2006. Statistics from VALT.

[14] VALT (2007). Tutkijalautakuntien tutkimien kuolemaan johtaneiden moottoriajoneuvo-onnettomuuksien tilastoaineisto vuosilta 1997–2006. Statistics from VALT.

[15] Tiehallinto (2007). Talvihoidon laadunseuranta-aineisto talvikuukausilta 2003–2004, 2005–2006 ja 2006–2007. Statistics from Tiehallinto.

[16] IPCC (2007). Climate Change 2007: Synthesis Report. An Assessment of the Intergovernmental Panel on Climate Change. Available at http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf.

[17] Tiehallinto (2009). Ilmastonmuutoksen vaikutus tiestön hoitoon ja ylläpitoon. Tiehallinnon selvityksiä 8/2009. Tiehallinto.

[18] Saarelainen, S. & Makkonen, L. (2007). Ilmastonmuutokseen sopeutuminen tienpidossa. Esiselvitys. Tiehallinnon selvityksiä 4/2007. Tiehallinto.

[19] Kircher, K. & Fors, C. & Berg, Y. (2008). Fokus på halka. Fokusgruppsresultat om attityder kring framtida halkinformationsystem. VTI-notat 8/2008.