DRIVER ASSESSMENT OF ROAD WEATHER CONDITIONS AND ROAD WEATHER INFORMATION

Niina Sihvola, VTT Technical Research Centre of Finland, Espoo, Finland
niina.sihvola@vtt.fi

ABSTRACT

This study investigated four issues relating to road weather conditions: (1) do the drivers receive forecast information, (2) do the drivers change their travel plans or driving behaviour because of road weather conditions, (3) how do drivers assess different road weather conditions, and (4) how do these assessments relate to weather forecasts? The data was collected via interviews at service stations and on the roadside. The road weather forecast class was poor or hazardous during 61% of the time the interviews were taking place. About 75% of respondents rated the road weather conditions to be poor or hazardous. Overall, 62% of drivers had received or looked for information on weather and road conditions before and/or during the trip, typically from radio or TV. Drivers were more likely to have acquired information on weather and road conditions than other drivers if they were less experienced, they had driven for a longer time before the interview or they were on a trip they did not make frequently. In comparison with the uninformed drivers, those who had looked for or received weather forecast rated the conditions as worse, the road surface more slippery and the accident risk higher. Every fifth respondent indicated that they had changed or considered changing the travel plans for their current trip because of the road weather conditions either before the trip or during the trip. The most frequently mentioned action was allocating more time to the trip. The results indicated that it is important to inform drivers about road weather conditions. The drivers’ estimations on the road surface friction level did not correspond to the information from road weather stations and the drivers had difficulties to assess the road weather conditions.
1. **INTRODUCTION**

Despite effective winter road maintenance, hazardous road conditions cannot be avoided entirely and drivers are faced with poor road conditions. In bad weather they have to estimate the driving conditions and how to change their driving behaviour compared with that in normal weather.

Many studies have shown that the accident risk in adverse weather and road conditions is many times higher than on a bare road surface (Saastamoinen, 1994; Liikennevakuutuskeskus, 1997; Malmivuo and Peltola, 1997; Wallman, 2004). Figure 1 shows the effects of relative duration of adverse road weather conditions on accident rate (Wallman, 2004). For example, in black ice conditions, the shorter the duration the higher the accident rate. Furthermore, Malmivuo (2004) has estimated that the relative risk of different winter conditions is very similar in Finland to that in Sweden. It is therefore justifiable to assume that the results of Wallman (2004) are valid also for Finnish winter conditions.

![Figure 1: Relative accident rate (relative to the rate at dry bare road) as a function of relative duration (proportion of total vehicle mileage in specific road weather condition) for three different ice and snow conditions (Wallman, 2004).](image)

The main errors leading to increased risk in winter are drivers’ poor ability to recognise slipperiness and to adapt their speed to adverse winter conditions (Rämä, 2001). On a slippery road surface only 14% of Finnish drivers estimate the road to be slippery, while more than half consider the friction normal (Heinjoki, 1994). In terms of speed, average speeds on a slippery road surface are roughly 4 km/h lower than in good winter conditions (Saastamoinen,
The reduction is not sufficient to compensate for the reduced friction (Rämä, 2001).

Since 1997, road users in Finland have been given information on forecasted driving conditions on the main roads. The aim of the road weather information service has been to help drivers prepare for difficult driving conditions and delays caused by the weather, specifically on days when conditions are the worst. The forecast is based on current weather and road conditions, maintenance, and weather forecasts. The forecasts are valid for 24 hours and are produced at least four times a day. A sudden and unpredicted change in road conditions elicits an extra forecast. Forecasts are regional based on 19 provinces. They are broadcast on national television and radio channels as part of the normal weather forecast and are available on the Internet.

The road weather information service sets three levels for conditions on roads: normal, poor, and hazardous. Normal road conditions in the southern part of Finland means that the main roads are relatively bare; further north, road surfaces are often covered with packed snow where only the wheel tracks are bare. In the worst case normal road conditions indicate light snowfall that is not expected to continue. Road weather is poor when there is heavy snowfall or snowfall is expected to continue for a long time, visibility is clearly reduced because of the snow, or changing temperatures cause slipperiness. Conditions are hazardous when freezing rain causes slipperiness that cannot be prevented through maintenance, or when the snowfall is so heavy that roads cannot be adequately ploughed.

In 1997–2007, poor road weather conditions were predicted about 27–35% of the time and hazardous conditions 2–5% of the time. Warnings were usually successfully focused on days with a distinctly high accident rate. However, there were also days when the road weather information service forecast poor or hazardous road weather conditions but the number of accidents was low. During the three most detailed study years (2004–2007), poor or hazardous road conditions on accident-prone days were well warned of in advance. (Sihvola et al., 2008.)

The service has been well recognised and accepted since its inception; during the first winter 87% of interviewed drivers knew of it (Nygård and Rämä, 1999), rising to 90% 2 years later (Anttila et al., 2001). Most of the drivers (77%) found the service useful compared with regular weather forecasts, and 77% of drivers indicated that they had used the information almost daily. Interviews showed that getting information on the following day's weather was important and that the service had a considerable effect on driver behaviour (Anttila et al., 2001).

Empirical evidence of quantitative safety impacts of weather-related in-vehicle information systems is rare. In order to assess numerically the possible safety impacts, Aittoniemi (2007) applied the Delphi method. Provided the results of the expert survey prove correct and these systems are installed in every passenger car in Finland, injury accidents due to bad weather and road conditions could be reduced with a weather and road condition warning service by 11–18%. This corresponds to a 3–4% reduction of injury accidents in main roads each year.
Rämä et al. (2009) have estimated that if all drivers had a system that warned them about local slipperiness and reduced visibility, fatalities and injuries would be reduced by 3–4% in Finland.

The aim of the earlier road weather information service evaluations has been to improve the quality of the service and investigate, how well drivers recognise and accept the road weather information. The present study was designed to update the situation and produce new information about effects of the road weather information. During last year e.g. new media has emerged, and in this study we wanted to investigate is it used when looking for road weather information. Also previous information about prevailing road weather versus driver assessments was quite old and needed to be updated.

The study investigated four issues relating to road weather conditions: (1) do the drivers receive forecast information, (2) do the drivers change their travel plans or driving behaviour because of road weather conditions, (3) how do drivers assess different road weather conditions, and (4) how do these assessments relate to weather forecasts?

2. **Method**

The data was collected during the winter of 2007–2008 via interviews at service stations (76%) and on the roadside (24%). The aim was to conduct interviews when the weather was poor or hazardous. The timing of the interviews was based on weather forecasts and actual weather conditions. Drivers were interviewed on 8 days between 9:00 am and 6:00 pm, usually at several sites at the same time. Three service stations and one site for roadside interviews were used. The sites were located in the vicinity of automatic road weather stations and automatic traffic measurement spots.

At service stations all customers stopping for coffee or a cold meal were asked if they were willing to be interviewed. About 80% of them agreed to participate in the survey. Customers who had not driven on the main road in question were excluded.

On the roadside, drivers were randomly picked from the traffic flow and pointed to a bus stop for the survey. Police invisibly measured the speed of the selected drivers by radar before they were asked to stop. Interviews on the roadside were shorter than interviews performed at the service stations.

In the statistical analyses, significant differences between driver groups were determined with chi-square tests. The P-value is given, where statistical testing has been done.
3. RESULTS

3.1. Drivers

The data included 308 drivers of which 180 were interviewed in poor or hazardous road weather conditions.

The proportion of females was 13% of the whole data and 10% of the data for poor or hazardous road weather conditions. Share of young drivers was low in both data. Also the share of drivers, who drive less than 10,000 km per year was low. Compared to whole data, in poor or hazardous road weather conditions there were more drivers, who drive more than 50,000 km per year (Table 1). About one fifth of the respondents were drivers of heavy vehicles.

Table 1. Information about interviewed drivers.

<table>
<thead>
<tr>
<th></th>
<th>Whole data</th>
<th>Poor or hazardous road weather conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Females/males</td>
<td>13%/87%</td>
<td>10%/90%</td>
</tr>
<tr>
<td>Average age</td>
<td>44 years</td>
<td>45 years</td>
</tr>
<tr>
<td>Driver’s age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- less than 26 years</td>
<td>8%</td>
<td>9%</td>
</tr>
<tr>
<td>- 26–35 years</td>
<td>19%</td>
<td>15%</td>
</tr>
<tr>
<td>- 36–45 years</td>
<td>26%</td>
<td>26%</td>
</tr>
<tr>
<td>- 46–55 years</td>
<td>25%</td>
<td>30%</td>
</tr>
<tr>
<td>- 56–65 years</td>
<td>20%</td>
<td>18%</td>
</tr>
<tr>
<td>- over 65 years</td>
<td>2%</td>
<td>2%</td>
</tr>
<tr>
<td>Vehicle kilometrage during the previous year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- less than 5,000 km</td>
<td>2%</td>
<td>1%</td>
</tr>
<tr>
<td>- 5,000–9,999 km</td>
<td>6%</td>
<td>4%</td>
</tr>
<tr>
<td>- 10,000–19,999 km</td>
<td>18%</td>
<td>18%</td>
</tr>
<tr>
<td>- 20,000–50,000 km</td>
<td>41%</td>
<td>37%</td>
</tr>
<tr>
<td>- 50,000 km or more</td>
<td>32%</td>
<td>40%</td>
</tr>
</tbody>
</table>

Overall, 70% of the trips were work related, 10% of the drivers were on a shopping trip and 20% were on a leisure trip. Ninety-five percent of the drivers had been driving more than 20 km before the interview. Over 50% of the drivers drove the same trip at least once a week. Seven percent of the drivers were driving the trip they were on for the first time.

3.2. Receiving road weather information

In total 62% of the drivers had received or looked for information on weather and road conditions before the start of their trip and/or during the trip (Figure 2). The most common sources of information were radio (56%) and TV (47%) (Figure 3). The share of information
received via the Internet was 19%. The drivers also wished to receive information in the future through mobile services in addition to the traditional sources.

Figure 2: Receiving road weather related information.

Figure 3: Sources of road weather information. Note that the respondent could select more than one of the offered options.

The information on road weather conditions corresponded well to the drivers’ own experience: 85% of the drivers answered that the road weather information they had received during the trip or before the trip corresponded very well or well to their own experience. Only 3% of the respondents reported that the information they had received corresponded to their own experience very poorly or poorly. If the driver felt that the road weather information did
not correspond to his or her own experience, the weather was typically assessed to be better than forecast.

There were some differences by driver group. Drivers who were less experienced, had driven for a longer time before the interview or were on a trip they did not make frequently, were more likely than other drivers to have acquired information on weather and road conditions:

- More than 70% of drivers who had driven over 100 km before the interview had acquired weather information, while the proportion among less than 100 km driven drivers was little over 50% (p<0.05).
- Almost 80% of drivers who were making the trip for the first time had acquired information on road weather conditions, while the proportion among drivers, who made the trip almost daily, was 52% (p<0.06).
- Drivers who had driven less than 20,000 km over the past year responded more often than other drivers that they had received road weather information (p<0.05).

### 3.3. Effects of road weather conditions on travel plans

Overall, 21% of the respondents indicated that they had changed or considered changing the travel plans for their current trip because of the road weather conditions either before or during the trip. The most frequently mentioned action was allocating more time to the trip (76% of the responders) (Figure 4). Other frequently answered alternatives were changing or considering changing the departure time (27%), considering cancelling the trip (12%) and changing or considering changing the trip route (12%). Seventy-two percent of the drivers said that their trip was mandatory, i.e. could not have been cancelled or postponed. Based on the respondents’ views, only 8% of the trips could have been made using public transport.

![Figure 4: Made or considered changes reported by drivers who had made or considered making changes to their travel plans for their current trip because of road weather conditions. Note that the respondent could select more than one of the offered options.](image-url)
Elderly drivers (over 64 years) reported more often than others that they had considered or changed the plans of the trip because of the weather: 41% indicated they had changed or considered changing the plans, while among respondents aged 26–64 years the proportion was 21% and among the youngest group 9% (p<0.05).

The purpose of the trip had an effect on whether the trip could have been cancelled or postponed. Drivers on a work-related trip seldom reported that they could have cancelled or postponed it (p<0.01).

Based on interviews it was not possible to get information on drivers who had cancelled their trip because of the weather or used public transport. Comparison of traffic volumes, however, showed that during poor or hazardous road conditions the traffic volume was about 10% less than in normal road conditions. The traffic volume data was based on automatic traffic measurement points near the interview sites.

3.4. Reported effects of road weather information on driving behaviour

In general, information about poor road weather conditions was most often reported to lead to increasing the distance to the preceding vehicle, focusing attention on the road surface, avoiding overtaking, and lowering the travel speed (Figure 5). Drivers estimated that the information that most affected their behaviour was warnings concerning main roads shown on a provincial map, and verbal descriptions of the weather and road conditions. Also individual and focused information, such as that on road maintenance, was appreciated.

![Figure 5: Reported effects of information about poor road weather conditions.](image-url)
3.5. Prevailing road weather during interviews versus driver assessments

The road weather forecast class given by the road weather information service was poor or hazardous during 61% of the time the interviews were taking place. Of the respondents, 17% rated the road weather conditions as hazardous and 57% as poor during the interview. Snowfall was most often cited as a factor affecting the current road weather conditions. Police measurements at the roadside survey location showed that drivers drove 4 km/h slower when the road weather forecast class was poor than when it was normal (p<0.01).

Slipperiness was classified into four categories: (1) non-slippery (i.e. friction more than 0.45), (2) almost non-slippery (friction 0.36–0.45), (3) quite slippery (friction 0.26–0.35), and (4) slippery (friction less than 0.26). Based on information gathered from automatic road weather stations, 55% of the interviews were done at a time when the road was non-slippery, 9% of the time the main road near the interview place was almost non-slippery, 13% of the time the road was quite slippery, and 23% of the time it was slippery. It was snowing during 80% of the interview times; the intensity of the snow was mostly light.

The drivers’ estimations of the road surface skidding level did not correspond to the information from the road weather stations (p<0.05). About half of the drivers rated the road surface as very slippery or slippery and about half as non-slippery or almost non-slippery (Figure 6). The opinions of the drivers did not depend on whether the road surface was slippery or non-slippery according to the road weather station. When the road surface was slippery, 63% of the drivers reported the road to be slippery or quite slippery, 33% almost non-slippery and 4% non-slippery. When the road surface was non-slippery, 60% of the drivers reported the road to be slippery or quite slippery, 29% almost non-slippery and 11% non-slippery. Drivers who had driven for a shorter time before the interview estimated more often than the others that the road was non-slippery (p<0.01).

![Figure 6: Drivers’ estimations of the road surface skidding level compared with the information given by road weather stations.](image-url)
In general, those who had looked for or received information on the current weather and road conditions rated the conditions as worse, the road surface more slippery and the accident risk higher than those who had not received this information. Twenty-one percent of the drivers who had acquired road weather information reported the road weather to be hazardous, while the proportion among drivers who did not have information was 11% (p<0.07). At the roadside survey site where police measured the speeds, drivers who had received information on road weather conditions drove 5 km/h slower than other drivers when the road weather forecast class was poor (p<0.01).

4. DISCUSSION

The present study was designed to produce information contributing to better information on road weather conditions. The main issues included (1) how drivers assess different road weather conditions, (2) how these assessments relate to weather forecasts, (3) whether drivers receive forecast information, and (4) whether informed drivers change their travel plans or driving behaviour.

The main results of the study showed that drivers’ estimations on the road surface friction level did not correspond to the information from road weather stations. The most dangerous situations are those in which an automatic road weather station has indicated that the road is slippery, but the respondent has not detected it and reports no slipperiness. When the road surface was slippery, every third driver estimated that the road was almost non-slippery and some drivers estimated that the road was not slippery at all. The opposite situation is not that alarming, because even if the automatic road weather station has indicated that the road is non-slippery it could have been slippery in some spots, as the weather station only measures small areas of the road. This result highlights the importance of informing drivers about road weather conditions.

Furthermore, the results showed that most of the drivers (62%) had received information on road weather before or during the trip, typically from radio or TV. The share of information received via the Internet (19%) was notably higher than in previous studies. For example, in a study conducted by Kilpeläinen and Summala in 2002, only a couple of percent of drivers had acquired information from the Internet. Specifically, drivers were more likely to have acquired information on weather and road conditions if they were less experienced, had driven for a longer time before the interview or were on a trip they did not make frequently. In comparison with uninformed drivers, those who had looked for or received a weather forecast rated the conditions as worse, the road surface as more slippery and the accident risk as higher. It can also be assumed that people who generally worry about safety both actively use weather information and evaluate conditions as worse.

Compared with earlier studies, the proportion of drivers who had received information on road weather was quite high. In earlier telephone interview studies, 44–65% of the
respondents estimated having seen a road weather forecast on TV at least once a day and 32–45% reported having heard the forecast on the radio that often (Nygård and Rämä, 1999; Anttila et al., 2001). In a study in which answers were collected at service stations, 16% of the drivers said that they had actively acquired traffic-related weather information for the trip in question through some medium, and 15% of the drivers were concluded to have received the information passively through e.g. the evening news, not considering it information acquisition (Kilpeläinen and Summala, 2002). The discrepancy is partially explained by the different nuances of the questions. The telephone interview asked whether the subject had noticed road weather forecasts at least once a day. Compared to the Kilpeläinen’s and Summala’s questionnaire study, the data in this study was gathered by interviews, allowing the interviewer to interact more with the respondent, e.g. explaining that also receiving information counts, not only searching for it actively.

The aim of traffic weather information is naturally not merely for it to be received, but to have an effect on driver behaviour where needed. Every fifth respondent indicated that they had changed or considered changing their travel plans for the current trip because of the road weather conditions, either before or during the trip. The proportion is quite high compared to earlier results. In the Kilpeläinen and Summala study (2002), only 6% of the drivers reported any changes in travel plans before or during the trip. The discrepancy is partially explained by the different nuances of the questions. In this study drivers were asked whether they changed or considered changing the plans of their trip, whereas in the earlier study (Kilpeläinen and Summala, 2002) they were asked whether they had to make changes to the travel plans before or during the trip.

In this study the most often mentioned change or considered change during or before the current trip was allocating more time to the trip, followed by changing or considering changing the departure time, considering cancelling the trip and changing or considering changing the trip route. In general the road weather condition information was most often responded to lead to increasing the following distance, focusing attention to the road surface, avoiding overtaking, and lowering the travel speed. The answers support the earlier findings of Kilpeläinen and Summala (2002), in which the most frequently reported changes were allowing more time for the trip, altering the time of departure and changing the route.

To have an effect on traffic safety, a traffic weather information system should be easily accessible to drivers, used by a considerable proportion of them, appear reliable and, finally, contribute to pre-trip decisions and on-road driving. The problem with common weather forecasts is that they classify a whole region on the basis of the worst conditions within the region, even if the local road weather information is available from road weather stations. Drivers’ perceptions are most likely to concern a specific road. Mobile in-vehicle information technology is now increasingly providing effective means of distributing local real-time road information. This is favoured by the drivers: The study showed that in the future, drivers wish to receive information also through mobile services in addition to the traditional information sources. The automobile industry is also actively developing in-vehicle instruments to
measure relevant safety-related parameters, especially friction. Such information can further be applied e.g. to intelligent speed adaptation systems or local danger warning systems, which have shown to have clear effect on safety.

The main implication of this study is that road weather information is useful and needed and that it also has an effect on safety. The study showed that road weather information can e.g. affect trip decisions and driving speeds. A connection was also seen between received information and the driver’s estimation of current road weather conditions. Drivers who had received information were more likely to estimate the road weather as poor and the accident risk as high.

ACKNOWLEDGEMENTS

Appreciation is extended to the Finnish Road Administration for its support of this study. The author wish to thank Elina Aittoniemi, Mikko Poutanen, Riikka Rajamäki, Jutta Jantunan, Arja Wuolijoki and Erkki Ritari for helping with the data collection, and Pirkko Rämä and Juha Luoma for their helpful suggestions on earlier drafts of this paper.

REFERENCES


