

**Summary:**

# Safety effects of road salting in winter road maintenance

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*Road salt is used in Norway to improve safety by increasing friction on icy roads. Given the adverse environmental effects of using road salt, it is important to know that the assumed safety effects are realised. Many studies both from Northern Europe and North America indicate that road salting reduces the number of accidents, but the reported effects are larger in older studies. The effects are also greater for less serious accidents (material damage) than for accidents with personal injury. The use of road salt should also be informed by important contextual factors. For instance, the increase in accident risk when driving on snow or ice-covered roads is greater in those areas where such driving conditions are encountered less often. Furthermore, road salting leads to better friction and thus increased speed. One is therefore faced with two optimization issues: a) what is the increase in risk on the remaining or surrounding unsalted snow or ice-covered roads when salt has been used on parts of the road network, and b) does the speed increase from road salting increase the number of more serious road accidents? Norwegian studies of the effects of road salting are old and need updating, not least to account for the above optimization issues.*

## Friction, speed and accidents

The association between road friction and accidents is generally well documented in the international research literature – the poorer the friction, the higher the rate of accidents. Dry bare roads have better friction and lower accident rates than wet bare roads, and wet bare roads have better friction and lower accident rates than snow or ice-covered roads.

There is also a well documented tendency of road users adapting their driving behaviour to suit different road conditions. On winter roads with ice or snow, car drivers generally maintain a lower speed than they do on dry bare roads. Studies indicate that speeds are less by between 5 and 15 km/h on snow or ice-covered roads in Norway, and even more in Sweden, where one reason could be the higher speed limits in general, and where speeds on dry bare roads are less restricted by speed limits. Thus the speed differences between driving on dry bare roads and driving on snow or ice-covered roads are greater in Sweden than in Norway.

Accidents on winter roads where speed levels are restricted will on average be less serious than accidents on dry bare roads where speeds are higher. Accordingly, and well documented in the research literature, with snow and ice on the roads there is a much greater increase in the number of less serious accidents (with only material damage) than serious ones (involving fatality or serious injury).

Some studies have found that accidents involving personal injury do not increase with snowfall and winter conditions; some even show that fatal accidents are reduced on winter roads. Other studies find that serious accidents do increase when there is snow or ice on the roads, but that less serious accidents increase even more. In general, the research literature documents a rather clear tendency of snow and icy conditions reducing the severity level of accidents.

## **Road salt and safety**

Given the clear association between winter road conditions, road friction and accident rates, the potential gain in the degree of safety from removing ice and snow from road surfaces is significant. Salting is a very effective deicing measure when applied at temperatures close to 0°C but not during or after a heavy snow fall. According to the international research literature, salting reduces road accidents in winter, with older studies documenting better effects than more recent studies.

There are methodological weaknesses with many of these studies, however, the most typical being salted roads compared with non-salted roads without controlling for other variables that might have a bearing on the number of accidents. Typically, salted roads carry much more traffic than non-salted roads and high traffic volumes will contribute to dissipating ice and snow as well as reducing speed. Thus, some of the effects attributed to road salting can be a result of other differences between salted and non-salted roads.

Many studies do not take into account the degree of severity of an accident when estimating the effect of road salting. This is unfortunate given the association between friction, speed and collision impact. Road salting increases speed, and thus the favorable effect this has on accidents will be that much less when one looks at the effects on the more serious accidents involving fatality and serious injury.

Swedish studies as well as some Norwegian and Finnish studies document that the risk of an accident while driving on snow or ice-covered roads is greater the less frequent these conditions are met. An important consequence is that road salting, which removes ice and snow from large parts of the road network, may lead to an unforeseen increased risk on parts of the road network where ice and snow are not removed. A recent study from Northern Sweden indicates that if winter road maintenance results in traffic distributions of 20-30 per cent on snow or ice, the number of serious accidents may in fact be higher than it would be if larger volumes of the traffic were on snow or ice.

Recent studies document that the effects of road salting on safety vary, and are under some conditions even absent. It is difficult to estimate the safety effect of road salting, because this depends on: how familiar road users are with winter conditions, the severity of the accidents studied and on how the conditions are before salt is applied.

## **Optimization problems in winter road maintenance**

There are two important optimization issues that need to be addressed if good safety effects of winter road maintenance are to be achieved. The first concerns road salt improving road friction and resulting in higher speeds and more severe accidents when they occur. The second concerns the risk of driving on ice or snow increasing when such conditions are rare.

In Norway the goal for road safety is based on Vision Zero, which states that the ultimate vision for road safety is to reduce to zero the number of road accidents involving fatality and very serious injury. Thus the goal is about the most serious accidents. Safety measures that include improving road friction, increase speed and may be counter-productive given such safety goals. If road salting increases speed by 5-10 km/h, the number of serious accidents can be expected to increase and more or less nullify the favorable effect of improved road friction. It is thus important that friction measures are bolstered by speed limits and controls to restrict the increase in speed.

Controlling speed by introducing limits is a very obvious measure by which to restrict speed and avoid road users' speed adaptation. One important reason why road salting has not had the same favorable effects in Northern Sweden as elsewhere might be the fact that, traditionally, speed limits have been higher in Northern Sweden than in other parts of the country. The importance of speed control in achieving the desired effect of road salting has also been documented in some older Nordic studies. In Finland, on roads with no speed limits, a study found no safety effect of road salting, the likely reason being that drivers increased their speed so much that there were no safety effects left. Speed control is vital if road friction measures are to improve safety – and not just increase speed. The second optimization problem concerns the fact that the safety risk with driving on snow or ice-covered roads is greater the less frequently drivers meet such conditions. Given that this is correct, it follows that road salting may increase risk levels on parts of the road network where ice and snow are not removed. As already mentioned, a recent study based on Swedish data indicates that having 20-30% of road traffic on snow or ice is worse than having either more on bare roads (better friction improves safety) or more of the traffic on snow or ice (road users' expectations of winter conditions improve safety). Accordingly, road maintenance practices resulting in such traffic distributions between snow and ice-covered roads and bare roads should be avoided.

## **The need for new studies**

There are a number of challenges when studying the effects that road salting and other forms of winter road maintenance have on safety. A review of the literature reveals a large variation in estimates. Norwegian studies document up to 26% accident reduction when road salt is applied on winter roads, whereas some results from Northern Sweden indicate that, under certain conditions, road salting may increase the number of serious accidents.

The large variation in estimates is one of several reasons why there is a need for new studies into the association between winter road maintenance, road friction,

speed and accidents. There are several factors indicating that earlier results may no longer be valid.

Many studies summing up the associations between winter road maintenance, road friction, speed and accidents reveal that the effects on safety of low road friction and friction control seem reduced over time. Older studies report better safety effects than more recent studies. Based on accident data from the 1990s, Norwegian studies of these associations are all fairly old.

Modern cars are equipped with advanced driver assistance systems, e.g. electronic stability control, anti-lock braking systems, ice warning systems, etc., which probably influence a car driver's adaptation to different road surfaces. Drivers' adaptations are important for how friction control measures work, but there is currently very little knowledge of how drivers adapt to these new advanced driver assistance systems.

Winter road maintenance practices have changed radically during recent years in Norway, with respect to both organization and methods. Winter road maintenance techniques have improved, and specific winter maintenance is put out to sub-contractors. The Norwegian Public Roads Administration (NPRA) has carried out an extensive research programme "SaltSmart" identifying a number of potential improvements in the winter maintenance of roads and has recently published a revised handbook on road maintenance (No. 111).

Changes in the car fleet and in the winter maintenance of roads suggest that there is a need for new studies on road safety effects of winter maintenance in Norway. With Vision Zero as the basis for road safety, it is important to clarify the effects in the most serious accidents. The winter maintenance of roads and serious accidents have not been adequately analysed in Norway..

We suggest conducting aggregate studies based on methods similar to those used previously, i.e. comparing between accident rates on salted and unsalted roads. In addition, it would be interesting to conduct experiments on a smaller scale on roads with various forms of winter maintenance combined with information on weather and road conditions and possibly by varying speed limits in accordance with road conditions. This could be combined with road-side interviews of drivers and a number of variables recorded. It ought also to be possible to conduct experiments in limited geographic areas and to implement advanced winter maintenance practices based on currently available knowledge.