Abstract
It is generally acknowledged that the number and severity of road accidents increase with increasing driving speeds. Several studies based mainly on studies of the effects of changes in speed limits on rural roads show that as the mean speed increases by 1 km/h, the number of injury accidents increases by approximately 3 percent. Studies of the effects of the speed of a single vehicle on its accident risk are less numerous and not particularly well known. In recent years, however, several such new studies have been published. In this paper the results of these studies are applied to the speeds on Finnish rural main roads to calculate how speeding offences in different speed categories contribute to road accidents. It is concluded that a large number of minor speeding offences (e.g. less than 10 to 20 km/h over the limit) cause as much or more accidents than a smaller number of greater offences.

1 Introduction

Several studies have concluded that accident frequency increases with mean speed of traffic (Elvik & Vaa 2004, Ranta & Kallberg 1996). The results are usually compatible with the Swedish model, according to which the number of injury accidents increases in relation to the second power of the mean speed, and fatal accidents in relation to the fourth power (Nilsson 2004).

Although the effect of mean speed on accidents is widely known and acknowledged, studies on the impacts of the speed of a single vehicle on its accident risk are rare and not particularly well known. In the following, research results concerning this effect are presented and applied to the speeds on Finnish rural main roads to determine the relative contribution of speeding offences in different speed categories to accidents.

2 Driving speeds on Finnish rural main roads

The Finnish Road Administration has about 200 permanent automatic speed-measuring stations all over the main road network, covering about 13,000 kilometres of roads. We studied the speeds on two types of two-lane single-carriageway roads: roads which have a 80 km/h seasonal speed limit in winter and roads with a permanent 100 km/h speed limit in summer. The former represent roads where speeding is most common and the latter roads where speeding is relatively rare.

The speed distributions on this road are presented in Fig 1. The mean speed was 83.4 km/h on 80 km/h roads in winter and 96.1 km/h on 100 km/h roads in summer.
Proportions of vehicles exceeding the speed limit were as follows:

<table>
<thead>
<tr>
<th>Over speed limit (km/h)</th>
<th>80 km/h roads in winter</th>
<th>100 km/h roads in summer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-10</td>
<td>48%</td>
<td>28%</td>
</tr>
<tr>
<td>11-20</td>
<td>16%</td>
<td>8.3%</td>
</tr>
<tr>
<td>21-30</td>
<td>3.3%</td>
<td>1.7%</td>
</tr>
<tr>
<td>&gt; 30</td>
<td>0.8%</td>
<td>0.5%</td>
</tr>
</tbody>
</table>

In a large majority of all speeding offences the speed was no more than 10 km/h over the speed limit (Figure 2).

3 Impact of single vehicle speed on accident risk

The first studies of the effects of the speed of a single vehicle on its accident risk were carried out in the 1960s. They concluded that the relationship was U-shaped such that the deviation from mean speed in either direction increases risk (Solomon 1964, Cirillo 1968, Research Triangle Institute 1970). Later studies confirm that driving faster than the mean speed increases risk. They did not, however, find that slowing down below the speed limit would increase the accident risk. The reason for this deviation from earlier results may lie in differences in the study design (earlier studies included in the accident data also vehicles that were slowing down before turning), traffic volumes and variations in speed (in the 1960s there
were no speed limits on rural roads). According to Fildes the accident risk of a single vehicle increased in proportion to its speed (Figure 3).

![Figure 3. Accident involvement rate by variation from average traffic speed (Federal Highway Administration 1998).](image)

In recent studies the relationship between speed and accident risk is described as a power function. Three different functions describing accident risk ($R$) are used here:

Maycock et al. (1998), all self-reported accidents: 

$$R = 0,265 \cdot \left( \frac{v}{v_M} \right)^{13,1}$$  \hspace{1cm} (1)

Quimby et al. (1999), all self-reported accidents: 

$$R = 0,215 \cdot \left( \frac{v}{v_M} \right)^{7,75}$$  \hspace{1cm} (2)

Kloeden et al. (2001), injury accidents: 

$$R = e^{(0,07039 \cdot D + 0,0008617 \cdot D^2)}$$  \hspace{1cm} (3)

where $v_M$ is the mean speed of traffic, $v$ is the speed of the individual vehicle and $D$ is the difference between individual speed and the mean speed of traffic. The effect of speed on accident risk varies considerably between these models (Figure 4).
4 Contribution of different speeding categories to all speeding accidents

First, the relative accident risks for vehicles exceeding the speed limit were calculated for 5 km/h speed ranges (1 to 5 km/h, 6 to 10 km/h etc. over the limit) as the weighted average of the values given by formulae 1 to 3 (for each formula separately) at 1 km/h speed intervals. The proportions of vehicles travelling at different speeds were used as weights. The relative risk for speed category 81 to 85 km/h for 80 km/h roads, for example, is the weighted average of the risk for speeds 81, 82, 83, 84 and 85 km/h. The relative risks for different speeding categories are presented in Figure 5 for both road classes and the three risk functions. As expected, the shapes of the risk functions resemble those presented in Figure 4.

The relative contribution of different speeding categories to all speeding accidents was then calculated by multiplying the relative risk from Figure 5 by the respective proportion of vehicles from Figure 2, and by dividing the products by the sum of all products, for each risk for-
mula 1 to 3 separately. The resulting figures are percentages representing the contribution of each speeding category to all speeding accidents, for each of the three risk formulae 1 to 3 separately, as presented in Figure 6.

Figure 6 shows that minor speeding offences (not more than 10 to 20 km/h over the speed limit) represent a substantial proportion of all speeding accidents, even though speeds exceeding the speed limit by 40 km/h or more are also important. It is also evident that all three risk formulae are generally consistent in showing the importance of minor speeding offences. Only the calculations based on the formula by Kloeden et al. on 100 km/h roads in summer emphasize the impact of major offences. It is worth noting, however, that the functions were based on data where the number of accident vehicles driving faster than 40 km/h over the speed limit was relatively small, and it is questionable whether the formula predicts correctly the accident risk attributed to such high speeds.

The results of Figure 6 are summarised in Table 1, which shows that vehicles driving 1 to 10 km/h over the speed limit contribute to 23 to 47 percent of all speeding accidents on 80 km/h roads in winter and 15 to 47 percent of all speeding accidents on 100 km/h roads in summer. The respective proportions of speeds 1 to 20 km/h over the limit are 49 to 77 percent on 80 km/h roads in winter and 25 to 77 percent on 100 km/h roads in summer.

Table 1. Contribution to all speeding accidents of various speeding categories on Finnish two-lane single-carriageway main roads. The figures show the minimal and maximal effects according to the three risk functions.
5 Discussion

The results presented above should be assessed critically for a number of reasons. Most of these reasons concern the three risk models. Firstly, there are considerable differences between the three models, which indicate that the relationship between the speed of an individual vehicle and its accident risk needs to be studied further. Secondly, it may well be that the models were applied to higher speeds than they are valid for. The data on which the models were based probably included a relatively small number of vehicles driving faster than 40 km/h over the speed limit. Therefore risk functions may not predict correctly the effects of very high speeds. Thirdly, it could be argued that the relationships between speed and accident risk described by the three models do not necessarily reflect correctly the causal relationship between speed and accident. For example, the fast-driving cars and their drivers may be different from slower cars and their drivers, which may explain at least part of the relationship. Fourthly, vehicle speed in the three risk models was defined in reference to the mean speed of traffic without any reference to absolute speed. It is possible that the shape of the risk function is actually different for different speed ranges, and for roads with 80 and 100 km/h speed limits, for example.

The effect of speed on accident severity was not taken into account in the calculations, which has probably led to underestimation of the effect of higher speed compared to minor speeding offences. It seems likely, however, that the bias caused by this deficiency is small compared to the rather large variation between the models. Therefore it should not be a major concern here.

Speeding is a major road safety problem all over Europe (ETSC 1995). The role of minor speeding offences, however, may be generally underestimated. An individual driver does not necessarily always sense that driving e.g. 15 km/h over the speed limit would cause any particular increase in his accident risk. However, when we look at a large number of drivers as a group, even a minor increase in average speed inevitably leads to an increase in the number of accidents and the severity of their outcomes, assuming that everything else remains unchanged (Nilsson 2004).

In spite of the shortcomings of the method used, this study clearly indicates that the effects of minor speeding offences on road accidents should not be overlooked. If vehicles travelling up to 10 to 20 km/h above the speed limit contribute to one half of all speeding accidents, this could give reason to reconsider the potential of enhanced speed enforcement as an effective road safety measure.

It is concluded that a large number of minor speeding offences is as big or even bigger a road safety problem than a small number of major speeding offences.

6 References


