Single Accidents among Pedestrians and Cyclists in Sweden


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Abstract

Single accidents among pedestrians and cyclists, especially on days with slippery road conditions, have been considered an important problem in medical care. The aim of this project was therefor to elucidate possible differences in injury risks for pedestrians and cyclists depending on the type of surface, the quality of the surface and slippery road conditions in the winter. Injury registration, road surface studies and exposure measurements were then required. Three hospitals with existing injury records were chosen and consequently also the urban areas where these hospitals are situated. The studies were carried out during the whole of 1994. Hospital registration comprised a description of injuries, accident sites and long-term consequences. Approximately 450 injured pedestrians and cyclists per 100,000 inhabitants respectively, were injured during the year of registration. That is approximately twice as many injured as injured in motor vehicle accidents. The pedestrian flow is not influenced by season and precipitation but of cold weather and winter road condition. The cyclist flow is influenced a lot of season, precipitation and winter road condition. Pedestrians have six to eight times higher injury risks on icy or snow-covered roads than in the summer, while there is only a slight increase in cyclists' injury rates. Pedestrian slipping and falling accidents are above all a problem among elderly people, while the reverse applies to cyclists, where mostly children and young people are injured.

Key Words Pedestrian, Cyclist, Single Accident, Road Surface Condition
Background

Single accidents among pedestrians and cyclists, especially on days with slippery road conditions, have been considered an important problem in medical care. High proportions of injuries, above all among pedestrians, burden the medical services. Normally, this is not defined as a traffic safety problem since no (motor) vehicle is involved. In principle, this also applies to cyclists’ falling accidents. On the other hand, it is a transport safety problem and as such, relating to injuries in traffic environments, considerably greater than for other road users together.

Test design

The aim of the project was to elucidate possible differences in injury risks for pedestrians and cyclists depending on the type of surface, the quality of the surface and slippery conditions in the winter. Injury registration, road surface studies and exposure measurements for pedestrians and cyclists were then required. Three hospitals with existing injury records in different climate zones in Sweden were chosen and consequently also the urban areas where these hospitals are situated.

Figure 1 A map of Sweden showing climate areas and test cities.
Information on the type of pavements in pedestrian and cycle areas was obtained by the municipalities. Depending on the type of pavement, slightly fewer than 50 areas were studied in detail in each urban area to describe the quality of the surface and record the occurrence of pedestrians and cyclists during the bare ground period. Observation areas were then chosen among the areas studied in detail and amounted to slightly more than ten in each urban area. One of the aims of the observation areas was to carry out a continuous registration of road conditions and record the occurrence of pedestrians and cyclists during the winter period.

**Studies of the road surface and road conditions**

This paper deals more with winter road conditions and not so much with bare ground conditions as the investigation itself. The areas studied in detail were divided according to function, type of pavement and quality. During the winter of 1993/94, weather conditions were generally normal. The distribution of winter road conditions in regard to time shows that pedestrian and cycle areas in Gothenburg were bare during half the winter and streets approximately 80% of the winter. In Umeå, pedestrian and cycle areas had 25% bare ground, while heated pedestrian areas had 85% bare ground. Prior to the accident study, each day was classified into days with mainly bare ground, mixed road conditions and mainly ice and snow for the pedestrian and cycle areas in each urban area. The differences were minor between pedestrian and cycle areas in all three urban areas.

**Friction**

No specific differences between the different types of pavements were observed in slippery conditions. Friction levels were, however, significantly lower on bare ground with sand than on unsanded bare ground.

**Flow calculations**

There is no significant difference in pedestrian flows between bare ground in the winter and mixed road conditions, but only 75% of the bare ground flow exists in icy and snowy conditions. The difference is greater for cyclists. In mixed road conditions only fully 60% and on icy or snow-covered roads scarcely half as many use a cycle compared with bare ground conditions in the winter. When the temperature is below 0°C the pedestrian flow decreases by 10-15% for each decrease with 5°C. It is mainly children and elderly people that stand for the decrease. The greatest decrease for cyclists is because of the season winter itself. The winter flow is about half the summer flow. The pedestrian flow is not depending so much on precipitation, but the cyclist flow is. At slight precipitation the flow decreases by 40% and at heavier precipitation by 60%. It is the same for rain and snow.
Injury registration

Traffic injury registration started in December 1993 and continued until the end of 1994. The following methods were used in collecting data:

- hospital registration of injured persons and accidents
- follow-up of long-term consequences of injuries
- inventory of accident sites.

Table 1 presents the collected basic material on injured pedestrians and cyclists.

Table 1  Number of injured pedestrians and cyclists registered at three hospitals during 1994, number of follow-ups on a long-term basis and number of examined accident sites.

<table>
<thead>
<tr>
<th>Material</th>
<th>Gothenburg number</th>
<th>Lidköping number</th>
<th>Umeå number</th>
<th>Total number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hospital registration</td>
<td>525</td>
<td>91</td>
<td>450</td>
<td>1 066</td>
</tr>
<tr>
<td>Pedestrians</td>
<td>215</td>
<td>42</td>
<td>231</td>
<td>488</td>
</tr>
<tr>
<td>Cyclists</td>
<td>310</td>
<td>49</td>
<td>219</td>
<td>578</td>
</tr>
<tr>
<td>&quot;Long-term&quot; consequences</td>
<td>58</td>
<td>18</td>
<td>59</td>
<td>135</td>
</tr>
<tr>
<td>Pedestrians</td>
<td>36</td>
<td>8</td>
<td>31</td>
<td>75</td>
</tr>
<tr>
<td>Cyclists</td>
<td>22</td>
<td>10</td>
<td>28</td>
<td>60</td>
</tr>
<tr>
<td>Examination of accident sites</td>
<td>152</td>
<td>69</td>
<td>183</td>
<td>404</td>
</tr>
<tr>
<td>Pedestrians</td>
<td>61</td>
<td>33</td>
<td>90</td>
<td>184</td>
</tr>
<tr>
<td>Cyclists</td>
<td>91</td>
<td>36</td>
<td>93</td>
<td>220</td>
</tr>
</tbody>
</table>

Injured persons

A total of approximately 450 pedestrians and cyclists per 100,000 inhabitants and year are injured. The injured pedestrians are mostly elderly women, while the injured cyclists are most often young boys. Pedestrian injuries are on an average more serious than cyclist injuries, 30 % and 20 % respectively being hospitalised. The long-term effects of accidents are quite serious among pedestrians; a year after the accident 35 % still have pain and motion problems and between 5-7 % of the injured need social service. Pedestrians' falling accidents are more expensive for society than single accidents among cyclists. It should be observed that this is not particularly caused by the fact that many elderly people are injured in pedestrian accidents, but also because the cost of sick-listing is twice as high among pedestrians compared with cyclists.

Accident sites

Only 30 % of the accidents occur in areas classified by municipalities as central city areas, while consequently 70 % occur in the peripheral parts of the urban areas.
The role of the road surface

The injured persons consider the condition of the road surface to be of significance for the accident, 78% among pedestrians and 42% among cyclists. Among those who considered the road surface to have contributed to the accident, the majority have commented on the problem of slippery conditions.

Injuries - type and quality of pavements

When pedestrian accidents have occurred on high standard pavements, it is surprisingly more common that the injured consider the surface to be involved than when the accident occurred on low standard pavements. A conceivable explanation is that pedestrians have adapted their walking speed or attention, for example, to the low standard. A comparison between injury rates for asphalt surfaces and slabs, calculated in different ways, shows that the two types of pavements seem just as safe in regard to the safety aspect.

A comparison between the stated accident causes, in addition to calculations of the injury rates for different levels of the standard, indicates that behavioural adaptation to varying surface standards is considerably lower for cyclists than for pedestrians. For cyclists, a high standard causes fewer accidents. Attempts to calculate the injury rate for the different surfaces show that the difference in risk levels between different pavements seems small also to cyclists.

Injuries - road conditions

The classification of days based on observations of road conditions implies that during days with bare ground there may also be icy and snow-covered roads. During the days classified as mainly bare ground, more than half of the pedestrian injuries occurred on icy and snow-covered roads and concerning cyclists approximately one third occurred on ice or snow.
Concerning all urban areas, the injury rate for pedestrians on mainly bare ground in winter is twice as high as in the summer. Days with mixed road conditions were slightly more than six times more dangerous, while ice and snow were scarcely eight times more dangerous than summer conditions. All differences are statistically guaranteed except the difference between mixed road conditions and icy and snow-covered roads.

The old pedestrians have a much higher injury risk than the adults. The greatest difference is in the summer when the elderly people have seven times higher injury risk. In the winter the risk is 4-5 times higher. All differences between adults and elderly people are statistically guaranteed.

**Figure 2** Injury rates for pedestrians. A confidence interval of 95% with respect to the uncertainty of the number of injured is indicated by arrows. Adults: 16-65 years old.
Concerning the three urban areas, the injury rate for cyclists on bare ground in the winter is approximately half as high as in the summer. Other winter road conditions are slightly more dangerous than summer road conditions. This is mainly because of the many cycle accidents involving children in Gothenburg in the summer. It may also be the case that the category of cyclists in the winter differs from that in the summer. Elderly cyclists' injury risk is almost twice as high as that of adults, except on icy and snow-covered roads, where it is considerably higher. No differences are statistically guaranteed, except the difference between adults and elderly on icy and snow-covered roads.

Figure 3  Injury rates for cyclists. A confidence interval of 95 % with respect to the uncertainty of the number of injured is indicated by arrows. Adults: 16-65 years old.
Recommendations to the road authority

The recommendations to road authorities are based on injury risks among pedestrians and cyclists in single accidents. No other considerations have been applied. These injuries are worth taking seriously. Compared with those injured in collisions they are

- just as many,
- just as serious measured in number of hospitalised (= seriously injured),
- almost as serious measured as average medical care cost,

and are to a great extent to be referred to the road authority's responsibility (especially regarding pedestrian accidents).

Pedestrian accidents are above all caused by slippery winter road conditions. Elderly people are also affected by falling accidents on bare ground, while such accidents are very rare for other age categories. Furthermore, pedestrian accidents also show several signs of behavioural adaptation. This means that an improved standard of the pedestrian surfaces does not always reduce the number of accidents. A reduction in the number of accidents can only be expected if the standard is even and of high quality. The correspondence between accident number and surface quality for cyclists is simpler: a high standard leads to fewer accidents.

Based on these comprehensive results, the following recommendations can be given to road authorities:

- First, concentrate on improved winter road maintenance for pedestrians and secondly, an improved surface standard in bare ground conditions.
- The winter road maintenance should be of high and uniform standard.
- Provide more heated surfaces for pedestrians.
- Better winter road maintenance (stated in order of priority) should be provided for:
  - elderly pedestrians
  - adult pedestrians
  - elderly cyclists
  - adult cyclists
- Sand/gravel should be swept up as soon as possible after winter - above all on hills in cycle areas!
  - Summer road maintenance should be guided by efforts towards a uniform standard for pedestrians and a high average standard for cyclists.
- Concentrate on summer maintenance, above all in areas frequented by elderly pedestrians.
- Do not focus maintenance on hard slabs and central city areas. Most accidents occur on asphalt surfaces, in peripheral parts of the urban areas.

Behavioural adaptation may also be more frequent than discussed above. In Sweden, the quality of pedestrian and cycle areas is very high in the international perspective. One reason is winter conditions which demand even surfaces for efficient snow and ice removal. As a result, pedestrians’ and cyclists’ expectations on the quality of surfaces may be too high and minor defects may cause serious problems compared with conditions where pedestrians and cyclists expect general defects.
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