Road Safety in Sweden and the Effect of Speed on Safety

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Abstract

Sweden has one of the best traffic safety situation in the developed countries. One reason behind this is the cooperation between the Nordic countries and their Road Administrations. The traffic safety situation in a country can be described in different ways which is demonstrated in the article,

Beside the effect of traffic on the number of fatalities and injured in traffic the speed situation is an important factor. In the article the power model to explain the effect of speed on safety is presented.

1 **Introduction**

The country of Sweden

Sweden is situated in the north of Europe. The number of inhabitants is about 9 millions and the area is about 450 000 square kilometres. Greece is less than one third of Sweden and has more inhabitants. Sweden is thereby not density populated but the population is dense in the region of Stockholm and Göteborg, the biggest cities. During the winter period the climate varies a lot between the north and the south part of Sweden. It is very cold and snowy in the north and in the south the temperature is below zero just during a couple of days or weeks in the winter period. Sweden is a member of the European Union but not monetary.

Surrounding countries – the Nordic countries

Sweden is one to the Nordic countries together with, Finland, Norway, Island and Denmark. Earlier the traffic safety research many times was coordinated between the Nordic countries and the experiences were shared between these countries. This situation is now being made on a European base. Norway and Island, however, are not members of EU but Norway has a research agreement.

Figure 1. Denmark, Finland, Norway and Sweden.

Traffic Safety and cooperation between the Nordic countries

As most people in the Nordic countries understand each other, as their native language is almost the same, it has been natural to work together and take part in traffic safety solutions in the other Nordic countries. This work has been supported by the Road Authorities in the different countries. At the same time it has been some kind of competition between the countries concerning traffic safety. Different traffic safety measures have been tested and compared. A lot of this work is for example presented in "The handbook of traffic safety measures", now in English.

Traffic safety policy

The Nordic cooperation has many times resulted in measures more or less taken at the same time in several countries. The differences between the countries have however resulted in different actions, measures and legislation. One example is the speed limits on motorways which are 100 km/h in Norway, 110 km/h in Sweden, 120 km/h in Finland and 130 km/h in Denmark. Outside urban area Sweden has odd limits, Finland has even limits and Norway has every tenth from 60 to 100 km/h.

2 Traffic safety measurements

Traffic safety targets and EU

Traffic safety targets concerning the number of fatalities in traffic in the future have been presented at different occasions in all countries. Finland was among the first countries to present a traffic safety target in 1970. How the targets are coordinated with the EU-target of 2010 compared to the year of 2000 is difficult to present. The development of fatalities is presented in Figure 2 for 1995 to 2004.

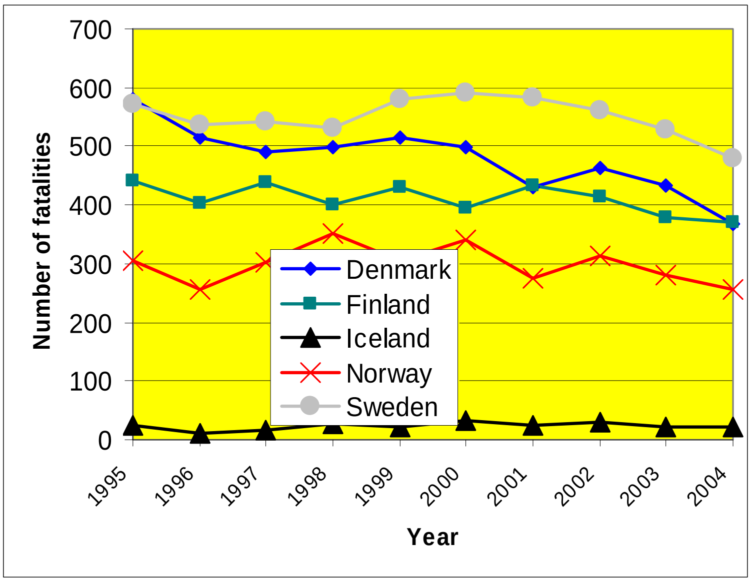

Figure 2. Fatalities in the Nordic countries 1995-2004

2004 was a good traffic safety year for almost all countries. The values for the different countries and the years 1995- 2004 is presented in Table 1. Even if the reduction of the number of fatalities seems very small in the different countries the total reduction in all countries is 22 % or on average 2 % per year. At the same time the increase of traffic is af the same magnitude as the fatality decrease. Most of the reduction has occurred in Denmark and not in Sweden

Table 1. The fatalities in the Nordic countries 1995-2004

Year	Denmark	Finland	Iceland	Norway	Sweden	Sum
1995	581	441	24	305	572	1923
1996	514	404	10	255	537	1720
1997	489	438	15	303	541	1786
1998	499	400	27	352	531	1809
1999	514	431	21	304	580	1850
2000	498	396	32	341	591	1858
2001	431	433	24	275	583	1746
2002	463	415	29	312	560	1779
2003	432	379	23	280	529	1643
2004	369	370	23	259	480	1501
Change	-36 %	-16 %	-4 %	-16 %	-16 %	-22 %

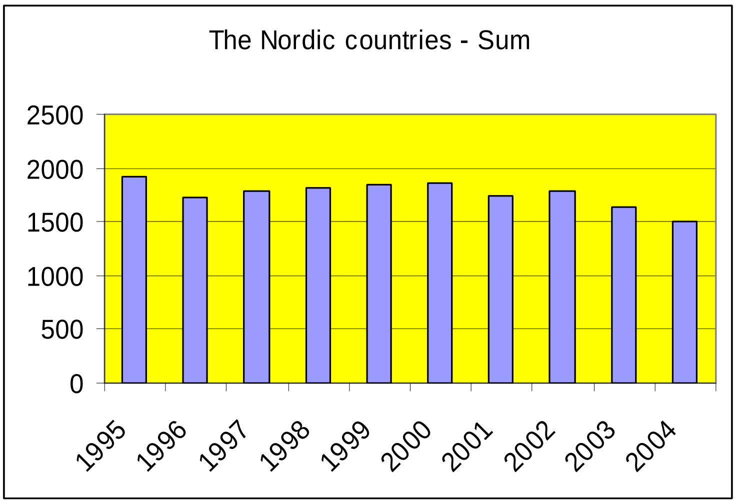

Figure 3. The sum of fatalities in the Nordic countries 1995-2004

Different ways to present the traffic safety

In relation to population

Normally the number of inhabitants in a country is known. Then it is easy to calculate the number of fatalities per 100.000 inhabitants. This measure can be compared between countries and different activities inside a country.

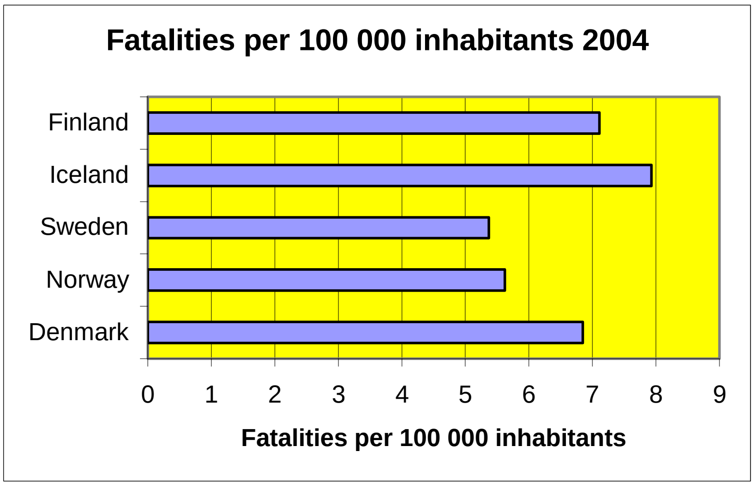

Figure 4. Fatalities in traffic per 100 000 inhabitants in the Nordic countries 2004

In relation to vehicle kilometres

There normally is an estimate of the total road traffic in different countries. These estimates however vary in accuracy between countries. They normally are based on different methods to count traffic or asking a sample of vehicle owners – vehicle travel surveys. But other methods are also used. The fatalities per million kilometres can be divided in the fatality risk of the driver and the fatality risk of other road user groups.

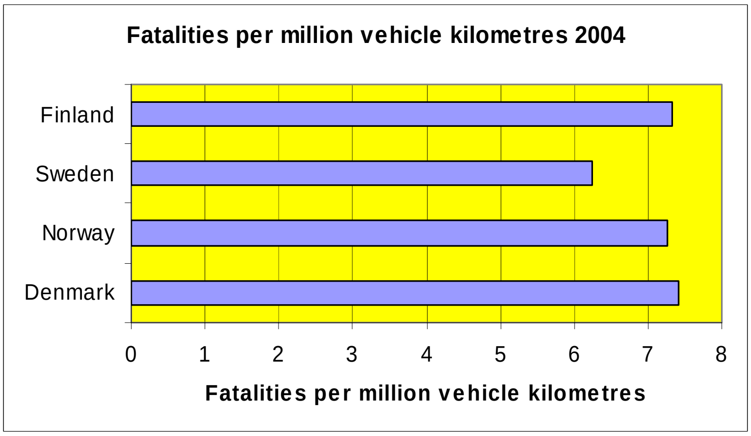

Figure 5. Fatalities per million vehicle kilometres in the Nordic countries 2004

In relation to person kilometres

Estimates also exist of the person kilometres for different road user groups on a national level through travel surveys. This way is of course the best way to describe the difference of risk between different road user groups, but it is very costly to have accurate information for different road user groups.

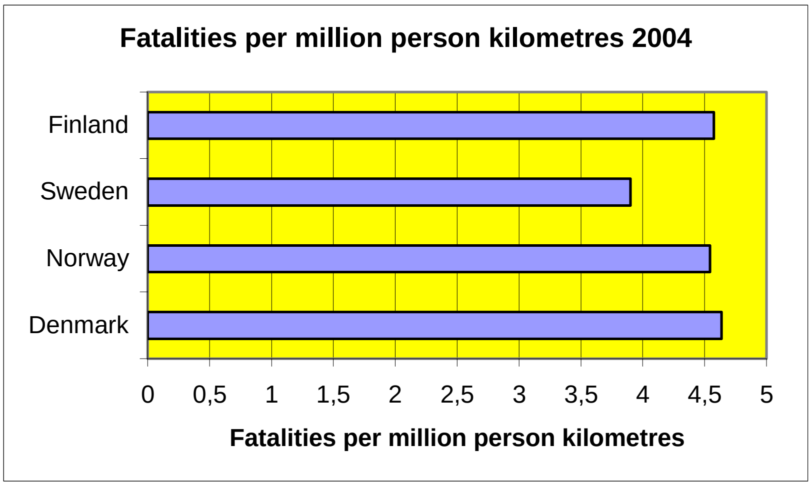

Figure 6. Fatalities per million person kilometres in the Nordic countries 2004

Injury risk in relation to speed limit, urban/rural and accident type etc.

The above calculations can be done for roads with the same speed limit and a traffic flow of some magnitude for example "motorway of the speed limit 110 km/h and traffic flow between 30 000 to 40 000 vehicles a day". You need some traffic counts. In this case the number of fatalities is complemented by injured persons or injury accidents. In the table below killed or injured persons are used to estimate the injury risk – the probability for passenger car occupants to be injured in traffic.

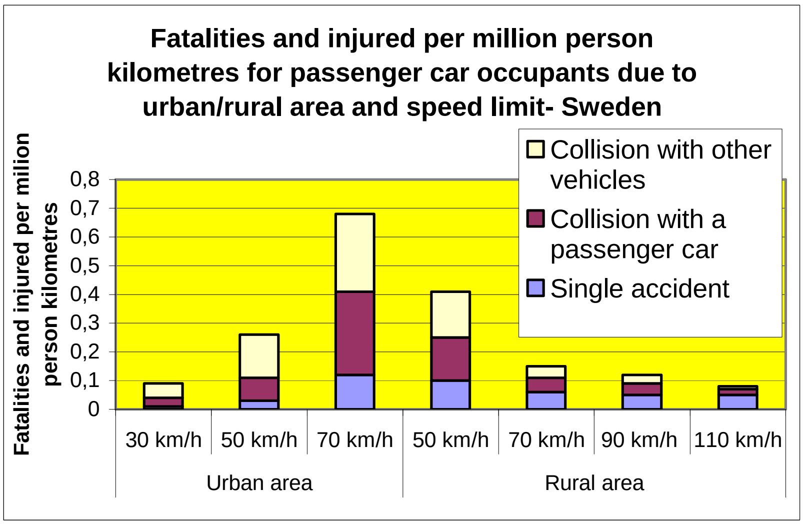

Figure 7. Injured per million person kilometres for passenger cars, speed limit, accident type and urban/rural area.

The collision matrix

The collision matrix is a fingerprint of the traffic safety situation in a country. It can be used even for smaller areas. See table 2.

Table 2. Collision matrix of fatalities in traffic in Sweden 2004

Sweden									
2004	In single	In collision with							Total
Killed as	accidents	Passernger car	Lorry	Bus	Motor cycle	Moped/ cycle	Animal	Other	
Car occupant	129	66	63	8			10	8	284
Lorry occupant	6	1	3				2	2	14
Bus occupant	3		1						4
Motorcyclist	21	26	3	1	3		1	1	56
Mopedist	5	8	3					2	18
Cyclist	6	16	3	1				1	27
Pedestrian		49	12	2	1	1		2	67
Other	8						1	1	10
Total	178	166	88	12	4	1	14	17	480

The collision matrix shows who is killed and the traffic elements involved. The collision matrix is also important for all injured. By dividing the two matrices the injury severity can be calculated. Countries like the Netherlands and Great Britain can easily or have produced the collision matrices in their traffic safety statistics.

3 Speed

Speed development and speed information

After the amount of traffic speed is the most important factor behind the fatalities and injured in traffic. The philosophy to accept the increase in road traffic and speeds make it very costly to at the same time decrease the number of killed and injured in traffic. To decrease the car use is very difficult but there are not only safety which put demands on that. You have the climate problem and the economic problem with fuels and taxes. Speed is regulated with different speed limits in all countries except on some motorways in Germany. The situation has change from the situation where the speed limit was not accepted in urban areas but accepted in rural areas to be more accepted in urban areas, even if humps and dumps are needed, to be more neglected in rural areas as for example on motorways. Some groups in some countries are asking for higher speed limits on motorways and 160 km/h seems to be the speed limit of today on motorways in a few countries. In Sweden an increase from 110 km/h to 120 km/ is tested on a motorway.

Investigations of speed changes and traffic safety

Sweden has a long history of speed limits. Sweden changed in 1967 from left to right hand side traffic. In order not to have traffic safety problem the speed limit were very low after the change, 40 in urban areas and 60 km/h in rural areas. After some months the speed limit was differentiated in rural areas 70, 90, 110 km/h and 130 on motorways. 130 km/h on motorways disappeared after some years (the motorway length was very small in 1970). A couple of times the system was replaced with 90 km/h but new attempts with less road length of 110 km/h were introduced. For a researcher it was a fantastic playground. The results of all these changes resulted in the power model which afterwards was calibrated to the result from other countries.

The power model

The power model predict the change in traffic safety if the average speed is change from $\mathbf{v_0}$ to $\mathbf{v_1}$ independent if it is an increase in speed or an decrease in speed. The model can handle accidents or injured. In order to estimate the change in injury consequences both fatal accidents and fatalities ought to be investigated. The model is simple and is described below.

Change in traffic safety situation if mean (median) speed is changed from v_0 to v_1	
Accidents (y)	Injured (z)
Fatal accident	Fatalities
$y_1 = \left(\frac{v_1}{v_0}\right)^4 y_0$	$z_1 = \left(\frac{v_1}{v_0}\right)^4 y_0 + \left(\frac{v_1}{v_0}\right)^8 (z_0 - y_0)$
Fatal accidents and serious injury accidents	Fatalities and severely injured
$y_1 = \left(\frac{v_1}{v_0}\right)^3 y_0$	$z_1 = \left(\frac{v_1}{v_0}\right)^3 y_0 + \left(\frac{v_1}{v_0}\right)^6 (z_0 - y_0)$
All injury accidents	All injured (incl. fatalities)
$y_1 = \left(\frac{v_1}{v_0}\right)^2 y_0$	$z_1 = \left(\frac{v_1}{v_0}\right)^2 y_0 + \left(\frac{v_1}{v_0}\right)^4 (z_0 - y_0)$

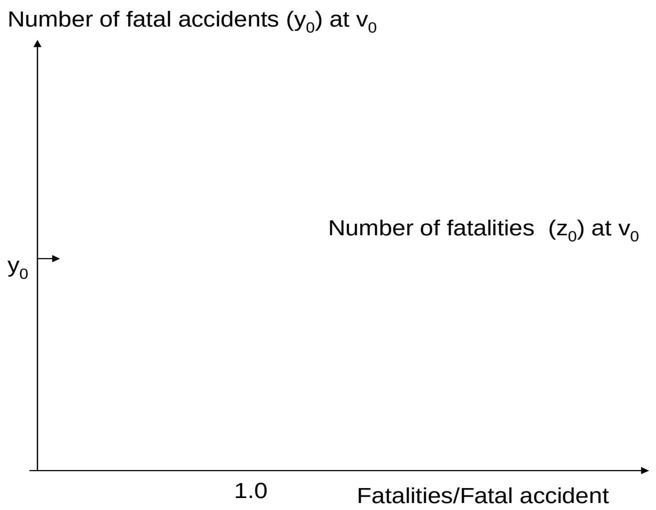

Figure A: The number of accidents is $\mathbf{y_0}$ and the number of fatalities is $\mathbf{z_0}$ at the speed $\mathbf{v_0}$

In Figure A just the value of the number of fatal accidents is shown.

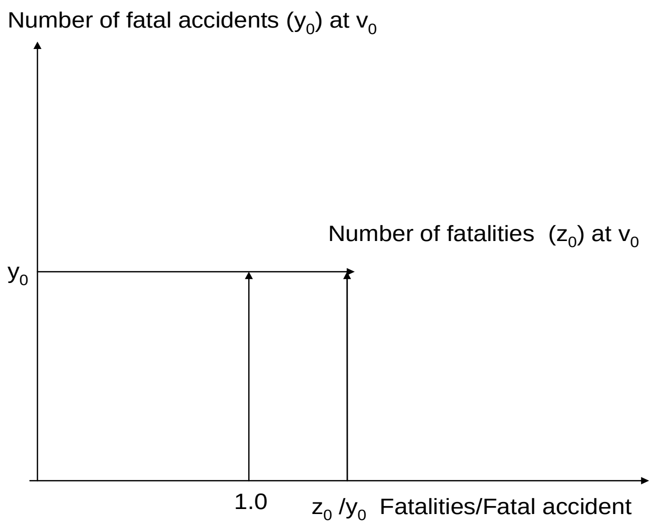

Figure B: The area is z_0 as $y_{0*}z_0/y_0 = z_0$, $z_0/y_0>1$ on average more than one killed in fatal accidents.

In Figure B the number of fatal accidents is presented as an area. As each fatal accident have at least one fatality (1.0) the number of fatalities /fatal accident is more than 1.0 (z_0/y_0).

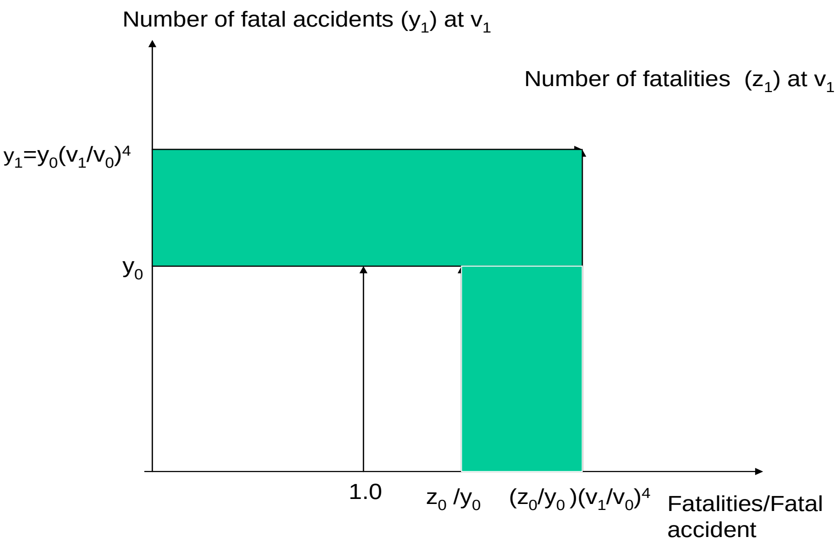

Figure C: v_0 to v_1. y_0 and z_0/y_0 is then both multiplied with $(v_1/v_0)^4$

In Figure C the speed increased from v0m to v1 and the area is growing both concerning the fatal accidents and the number of fatalities/fatal accident- the severity of the accidents.

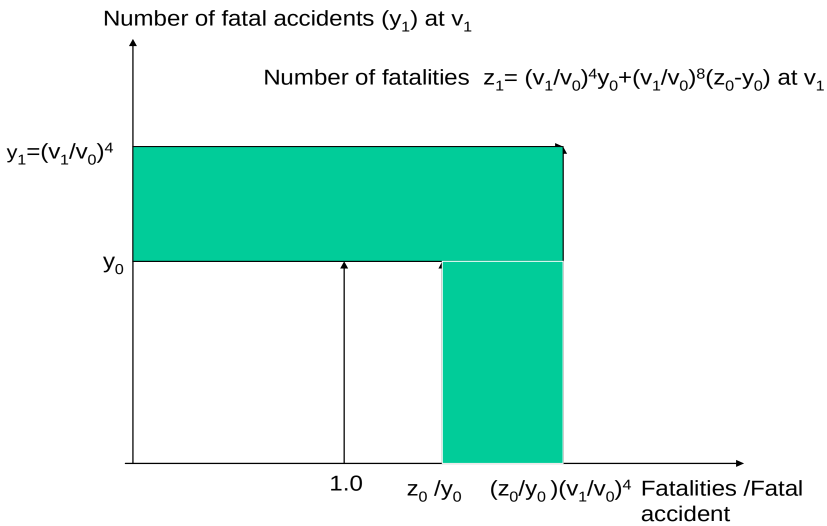

Figure D: y_1 at speed v_1 is $y_{0*}(v_1/v_0)^4$ and z_1 is $y_1 + (z_0- y_0)(v_1/v_0)^8$

Figure D presents the number of fatalities when speed has increased from v_0 to v_1

Use of the power model

The power model estimates the speed effect everything else unchanged. The model can be used to predict the safety effect of speed limit changes, both increases and decreases. In some sense most traffic safety measures means some speed changes. Therefore it is important to have relevant speed measurements.

Future

Positive and negative traffic safety factors

A lot of traffic safety measures are taken but often we forget that at the same time measures or decisions are taken which has a negative effect on safety and it is very important to investigate even the effect of the negative factors.

How to deal with increasing traffic, increasing speeds and heavier vehicles for example?

Increasing road standard is one solution but very few societies can afford to spend too much tax money on that in relation to other important needs as education, the health sector and care of old people.

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