Road Directorate
Ministry of Transport - Denmark

Danish Experiences with Speed Management

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Denmark – Key Figures

Denmark is a small country in the northern part of Europe – north of Germany, south of Norway and west of Sweden. The country consists of the peninsula of Jutland and many islands. The capital is Copenhagen. A 20 km tunnel + bridge connects the capital and Sweden. The two biggest islands and the peninsula are connected with bridges.

Inhabitants	5.4 million
Area	43,000 square km
Km of roads	70,000 km
No. of vehicles	2,2 million
Mileage	50 billion vehicle km

Table 1. Key figures.

In Denmark 5.4 million inhabitants live on 43.000 square km (table 1).

The road network is about 70.000 km long and 2,2 million vehicles drive approximately 50 billion kilometres a year. There are at the moment 300 independent road administrations. In two years time there will only be around 100. The road density is 1,25 km per square kilometer.

85% of the population lives in towns and Greater Copenhagen accounts for 1.1 million inhabitants. The average life expectancy is 74.5 years for men and 79.2 for women.

Road Accidents

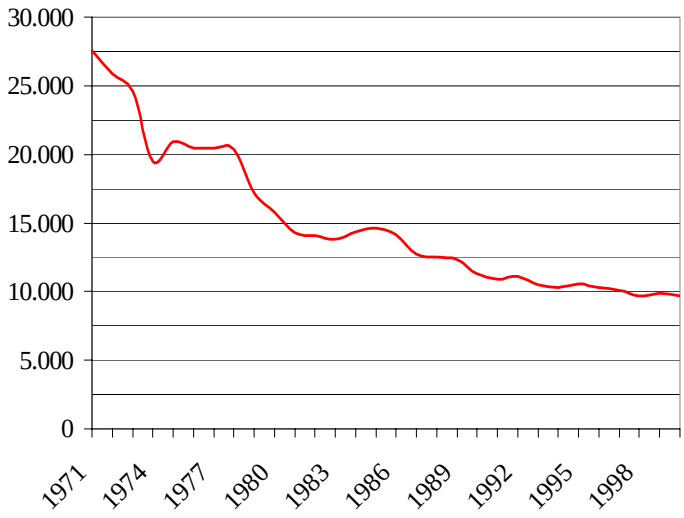

Figure 1. Accidents in Denmark 1971 – 2000, /3/

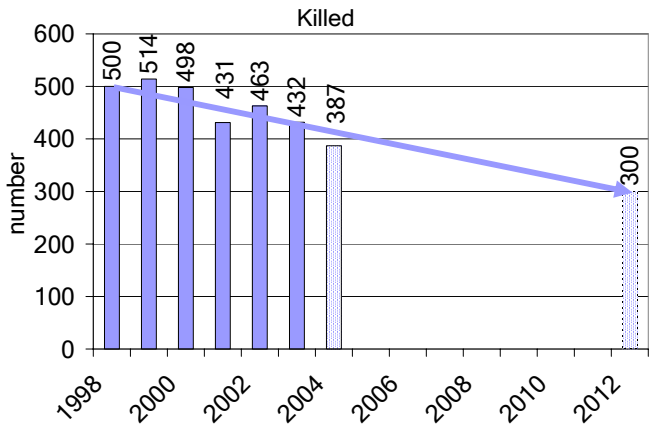

Figure 2. "Each Accident is One too Many" Goals for reduction in number of killed /1/ compared with actual number 1998 – 2004, /3/.

Like in the majority of the western European countries we have seen a great reduction of accidents in Denmark the past 30 years (figure 1). In 1971 the number of road fatalities was almost three times as high as in 2000. During the same period the traffic grew from 22 to 44 billion vehicle km. A great reduction in the frequency of accidents has taken place – road traffic is now more than five times safer than it was 30 years ago /1/!

In 1989 the first National Road Safety Action Plan was made. The ambitious goal was to reduce accidents with at least 40 % from the average of the period 1986 - 1987 to the year 2000, /2/. The result was only 30 %, but that is still considered very satisfying.

The goal of the newest Danish National Road Safety Action Plan from 2001 is to reduce the number of killed and seriously injured by 40% from 1998 to the year 2012, (figure 2 and 3) /3/. This plan is ambitiously entitled "Each Accident is One too Many".

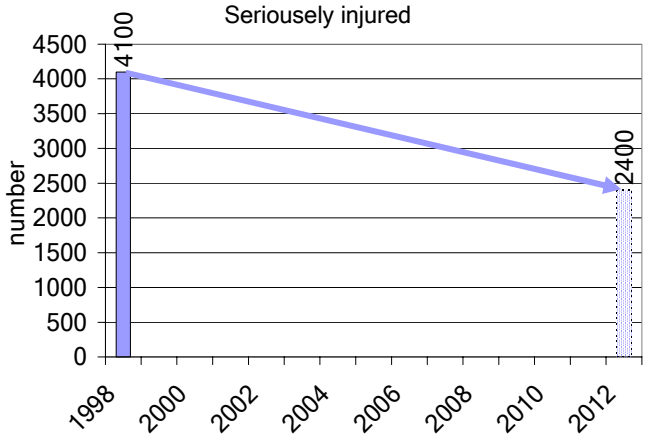

Figure 3. "Each Accident is One too Many" Goals for reduction in number of killed, /1/.

The idea is that fatalities and injuries in traffic should not be accepted neither by the road authorities nor by road users. The Swedish zero vision inspires this idea.

The main areas of action are accidents caused by speeding, accidents caused by intoxicated drivers, accidents with bicyclists and accidents at intersections (figure 3).

Of course overlapping between these areas will occur. For each area a number of 62 actions are suggested. Some of those actions deal with reduction of speeds.

Figure 3. "Each Accident is One too Many" – Main areas of action, /3/.

In 2004 we expect less than 400 killed and 7450 injured. Around 3700 of those are expected to be serious injuries (figure 4). Since 1993 there has been a reduction of 28 % in injury accidents and 18 % in accidents with material damage only. The reduction in injuries was 25 % in the same period and 31 % for killed.

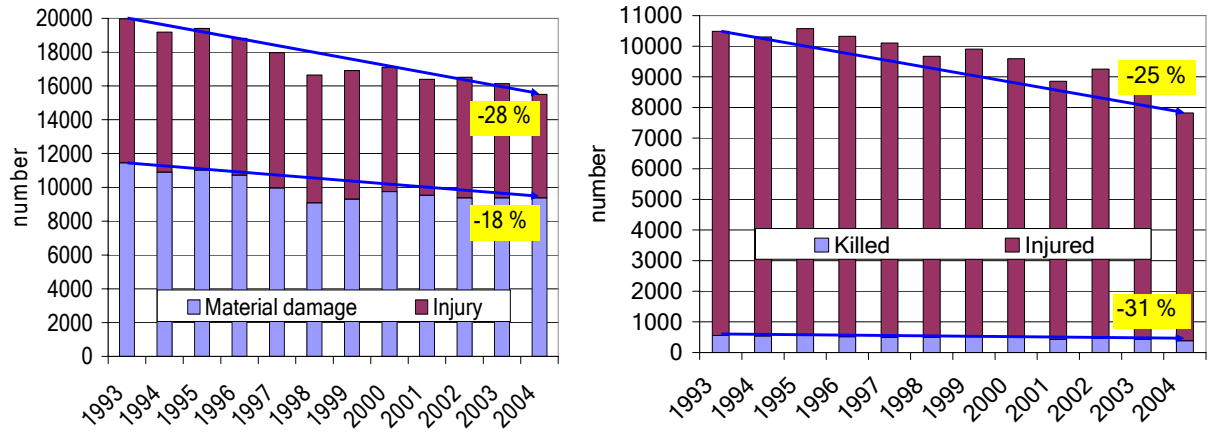

Figure 5. Accidents in Denmark 1993 – 2004, /1/. Figures for 2004 are preliminary.

Speed conditions in Denmark

Figure 6. General Speed limits in Denmark.

The general speed limits in Denmark are:

- 50 km/h in towns
- 80 km/h in urban areas
- 130 km/h on motorways

Local speed limits vary from this: 30, 40, 60, 70 and 80 in urban areas and 50, 60, 70, 90 in rural areas.

The average speed of the cars is considerably higher than allowed. Both in rural and urban areas about half of the car drivers obey the speed limits.

Estimates show that 100 fatal injuries and 1,500 injured could be avoided in Denmark each year if only the average speed was lower than the speed limits. This corresponds to 1/5th of the killed and 1/6th of the injured in Denmark each year.

The introduction of speed limits in Denmark in general and later the reduction of the urban speed limit from 60 km/h to 50 km/h has reduced the number of accidents greatly. But a large number of Danish speed measurements have indicated that drivers still have difficulties respecting speed limits on all types of roads. The average speed of the cars is considerably higher than allowed. Estimates show that 100 fatal injuries and 1,500 injured could be avoided in Denmark each year if the speed was lower than the speed limits. This corresponds to 1/4th of the killed and 1/5th of the injured in Denmark each year.

Why is Speed Management an Important Safety Measure?

Speed is one of the greatest problems related to traffic safety. When a driver steps on the gas pedal he does not feel that he is increasing his risk to get involved in an accident.

Drivers usually think they are able to handle high speed. However, road-safety experts argue that there is a strict connection between speed and traffic accidents. It has been clearly shown by several studies that speeding has a significant effect on road safety. Examples show that even minor changes in speed can lead to quite large reductions in the number of road accidents and injuries.

Most people have an innate instinct of the danger heights involve. Having “fear of heights” is common, whereas the expression “fear of speed” is seldom heard of. Most people quiver if they imagine falling down from the balcony of the third floor. Very few pedestrians or cyclist have this sensation when they move along in ordinary traffic.

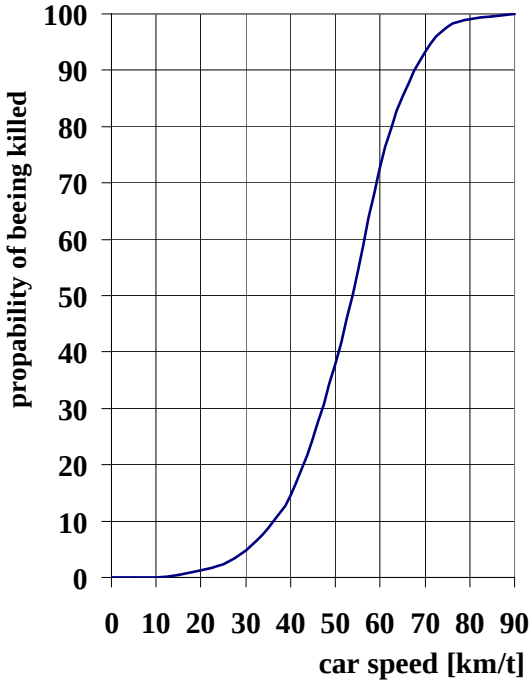

Figure 7. A pedestrians probability of being killed when hit by a car, /4/.

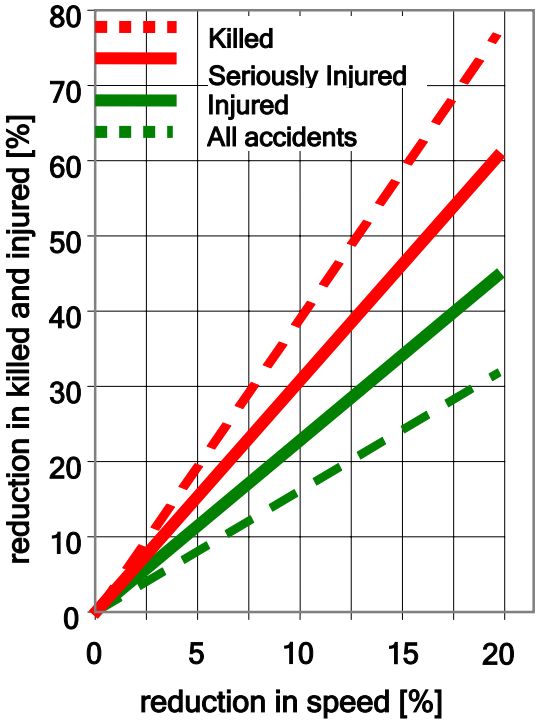

Figure 8. Accidents and speeds, /4/.

However, should an accident occur, the injury would be the same. The speed at which one would hit the pavement upon falling down from the third floor would be app. 50 km/h, which is the speed at which a car might hit someone in the city. Only 6 out of 10 survive such an accident (figure 7). If a pedestrian is hit at a speed of 30 km/h the chance of his or her survival is app. 95%. If on the other hand the speed is 70 km/h the chance of survival is less than 10%, /4/.

Researchers in the Swedish Road and Transport Research Institute ("Väg- och Transportforskningsinstitut", VTI) have shown that a reduction of speed from e.g. 55 km/h to 50 km/h reduces the risk of injuries by 20 – 25%. The same speed reduction reduces the risk of serious injuries by 25 – 30% and the risk of fatalities by 35 – 40% according to VTI (figure 8), /4/.

Studies based on observations on urban roads, indicates that there is a 3 - 6% reduction in the number of accidents for each 1.6 km/h (1 mph) reduction in vehicle speed, /5/, /6/. Not only the number of accidents but especially the severity of the injuries is highly correlated with speed, particularly for vulnerable road users i.e. pedestrians and people on bikes.

Experiences gained throughout Europe points to the fact, that different kinds of speed management have good safety effects. By use of traffic calming solutions, the observed safety effect ranges from 15 - 80%, /7/. Action plans for speed management in residential areas have resulted in improved safety but also action plans implemented on distributor roads or through roads have shown safety effects in the area of 45 - 65%, /8/. Even on rural roads some projects have resulted in a sizeable reduction in speed and number of accidents.

It has been estimated that a reduction of the average speed by 5 km/h on the entire EU road network would decrease the annual number of fatalities in the EU by more than 11,000 and the number of injury accidents by approximately 180,000. The savings are estimated at 30 - 40 billion ECU annually, /7/.

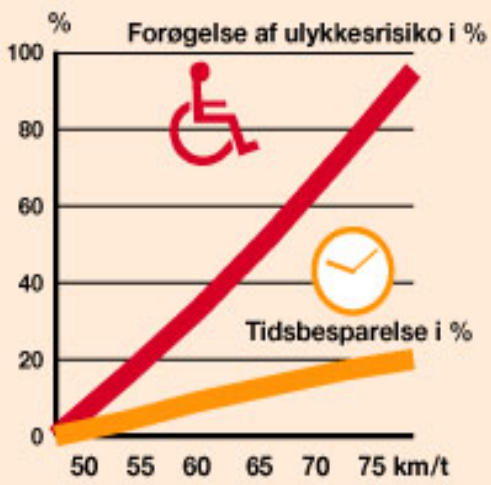

Figure 9. Travel Time Lost Compared with Risk at Different Speeds, /9/.

Travel time is obviously closely related to speed, and it has been claimed that the benefits of speed management programs could not compensate for private and social time losses due to lowered speed levels. However, it has been proven that the extra travel time needed on speed management treated through roads is minimal. Also, the average travel time is not necessarily higher than elsewhere. Figure 9 shows the correlation between speed and savings in travel time and the correlation between speed and increases in accident risk; Driving 75 km/h instead of 50 km/h saves you 20% of the travel time, but the risk is twice as high!

Changes in speed do not only affect safety but also other parameters as perceived risk, barrier effects, traffic noise, energy consumption and pollution.

Speed is also an important factor when talking about quality of life in cities, aesthetics, preservation of historical sites and other environmental aspects.

In other words, when talking about Urban Safety Management, one cannot ignore that a key issue is speed management. Managing the speed on urban roads is of crucial importance in order to create a safe and secure road network, and to ensure a pleasant environment for road users and people in general.

What is Speed Management?

Speed management is basically about regulating the car speed by use of various methods, i.e. legislation, road layout measures/road design, visual effects, regulation, signing and marking, enforcement, campaigns or advanced technology. Speed management is not necessarily about reducing speed, but also to a considerable extent about planning and designing the road layout and the road network in such a way that an appropriate speed is obtained. One of the key elements in speed management planning is the road and speed classification (the preparation of a road hierarchy). Roads in the road network are classified or designated to an appropriate desired speed level, e.g. 30 km/h in residential areas or 60 km/h on major arterial roads. Speed management techniques can therefore be applied to all kinds of urban roads, e.g. residential roads (where the techniques are widely used today), arterial roads, and distributor roads or through roads, /10/. Speed management can also be applied on rural roads e.g. in scarp curves and at intersections.

Techniques of Speed Reduction

But how do we help the driver to drive at an appropriate speed?

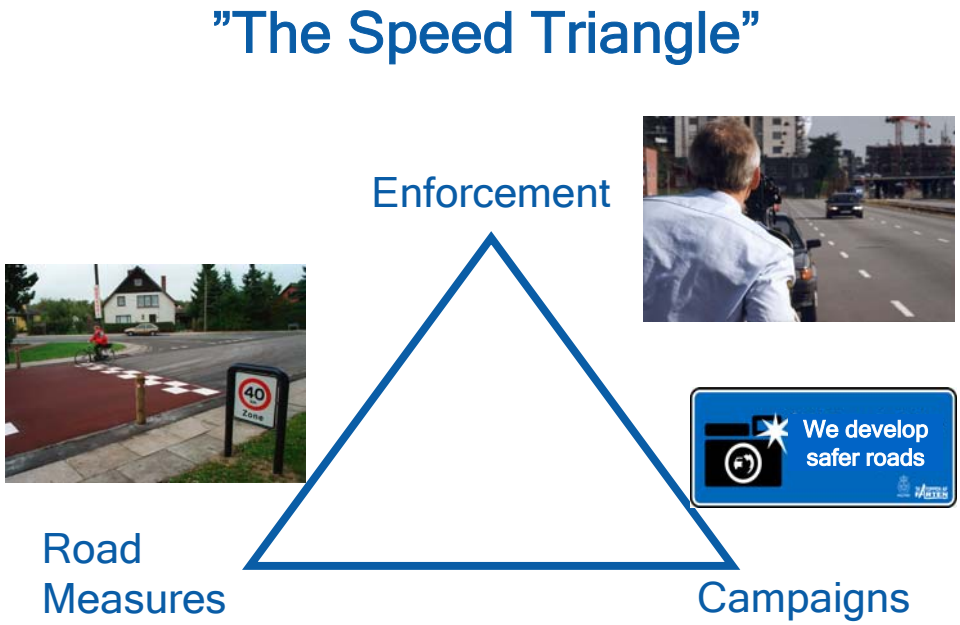

Figure 10. "The Speed Triangle", /12/.

In Denmark we use "the Speed Triangle" to illustrate the different kinds of means of speed reduction:

- Road measures
- Campaigns
- Enforcement.

Studies show that a combination of engineering measures, information and speed enforcement is the most efficient way to solve the problem of speeding cars. In Denmark all three measures have been used extensively for the last decade.

Mobile speed cameras have also proven to play a key part in the overall strategy to reduce car speeds nation-wide.

Traffic Calming and Speed Reducers

Traffic calming is a concept summarized as a number of initiatives to reduce the negative impact of car traffic. The corresponding Danish word (trafiksandering) implies that traffic conditions are made sound - and over the time the word has been used to label many different kinds of measures. The definition of the concept, which has become generally accepted, is:

> *Conversion with the aim to reduce the volume of car traffic and/or to reduce the car speeds - on a particular spot, in one or several streets, or in a complete area.*

Traffic calming has mainly been used in local areas in order to reduce the speed or the traffic flow. This is made possible by using various speed management techniques, /11/.

The varieties of physical techniques used to reduce car speeds are referred to collectively as speed reducers. The choice of which speed reducers to use in a given case depends on the object to be achieved, and more specifically on the road class, desired speed and traffic flow of the road in question.

Some of the most common speed reducers are, /11/:

- Signs
- Pre-warnings
- Gates
- Humps
- Raised areas
- Staggering
- Narrowing
- Roundabouts
- Road Closures

Figure 11. Speed reducers.

A detailed description of speed reducers can be found in the Danish Road Syandards for Urban Areas, /11/.

Speed Enforcement

Manual speed enforcement is used widely in Denmark.

Figure 12. Speed Enforcement, /12/.

Mobile speed cameras have been given a key role in the fight against speeding cars. A pilot project resulted in speed and accident reduction has led to a political decision to implement mobile speed cameras nation-wide, /12/.

Speed cameras are placed on the rear end of a van. This enables the police to move the equipment between several sites during the day.

The police primarily enforce speed limits on roads and streets where many accidents occur. But also streets near schools and other institutions, roads with ongoing roadwork and major roads passing through small villages are subject to speed enforcement. In addition hereto, it is recommended that roads where the local residents have expressed concerns about high speeds will be given high priority.

By making these type of roads a top priority it is expected that the introduction of mobile speed cameras will serve several purposes. Not only will the speed enforcement reduce the average speed and the number of traffic accidents; it will also create a large sense of safety for the local residents who use the road-network on a daily basis. Thereby we hope that the Danish public will come to consider speed enforcement as a community service rather than an inconvenience.

The Danish rules require that photos taken by the speed camera show the licence plate and the face of the driver. A fine including the photo is sent by mail to the owner of the car. According to the traffic code the owner is obliged to disclose the identity of the driver. This rule is made to ensure that it is in fact the speed violator that is fined.

The evaluation of the pilot project is based on speed measurements at 20 chosen sites within the enforcement zones and at 10 sites outside the zones for comparison. The results show a reduction in speeds of 2,4 km/h in average within the zones and no changes outside the zones.

Example:
Environmentally friendly through-roads

Background

During the years 1994 - 1996, the Danish Road Directorate planned and completed the construction of 21 environmentally adapted through-roads in towns on the national road network. The aim was to reduce speed, to increase the road safety and perceived safety, and to improve the road design using different measures.

An early evaluation of the through-roads was conducted in 1996 /13/, shortly after the construction. The report primarily describes the physical changes made and changes in speeds. In a new evaluation report /14/ the road safety effects are calculated and long-term effects on speeds are described.

The 21 environmentally adapted through-roads

Figure 13. Pictures from one of the through-roads in a town called Stenmangle, 10 years after construction.

The measures taken include:

- Gates,
- Roadside reservations,
- Medians,
- Roundabouts,
- Raised areas
- Change in road surface
- Road markings
- Signing
- Lighting
- Road closures
- Rumble strips
- Bicycle tracks and bicycle lanes.

The average length of the through-roads is about 1 km and the average construction cost per kilometer has been less than 1 million Dollars.

Shortly after the implementation, the average speed was reduced about 10 km/h, which is equivalent to a reduction of approximately 16 %. The average reduction however encompasses large variations in each through-road depending on where and which type of traffic measure was used. In addition it is stated, that the travel time for the road users has been increased by up to 15 seconds per kilometers, but at the same time the road users were positive regarding the decrease in speed, /13/.

Figure. 14. Pictures from one of the through-roads in a town called Stenmangle, 10 years after construction.

The long term effects on the speed conditions

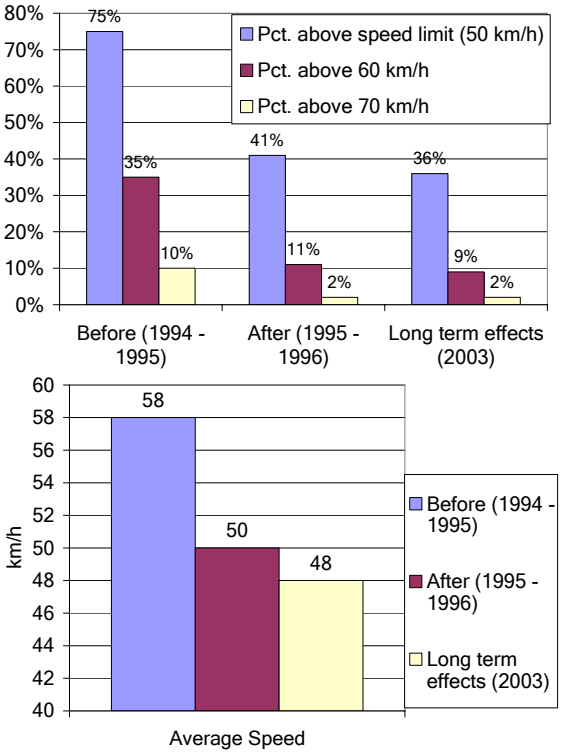

Figure. 15. Effects on speed, /14/.

New speed measurements on the through-roads conducted in 2003 (8 – 10 years after the traffic calming was completed) show that the speed reduction, which was measured shortly after the construction was completed, is un-changed or even lower to date:

- The average speed has dropped from 58 km/h to 48 km/h (figure 15).
- The pct. of vehicles over the speed limit of 50 km/h has dropped from 75 % and to 36 %.
- The pct. of vehicles over 60 km/h has dropped from 35 % and to 9 %.
- The pct. of vehicles over 70 km/h has dropped from 10 % and to 2 %.

It is not possible to establish a relationship between the speed reduction for each individual through-road and the effect on road safety, because the data for each through-road is too small. If the known relation between speed and number of accidents is used to calculate the reduction in personal injury accidents for all 21 through-roads together, the result is a reduction of 30 %, which is consistent with results found in this analysis (se later).

The effects on road safety

The effects on road safety are calculated based on the number of police recorded accidents in five year periods respectively before and after the traffic calming. The results have been corrected for the common trends in number of accidents which has been found by use of a control group of comparable roads. The control group consists of national and country roads in towns with less than 5000 inhabitants.

The trend for number of accidents in the control group, during the period for this analysis, has been positive with a reduction of approximately 25%. The reduction is caused by a general improvement in road safety, but probably also because of traffic calming and the like on some roads in the control group, which have reduced the number of accidents. The extent of conducted traffic calming in the control group is not known, but it means that the calculated effects for the 21 through-roads are conservative. I.e. the actual effects are estimated to be better than the ones calculated in the report.

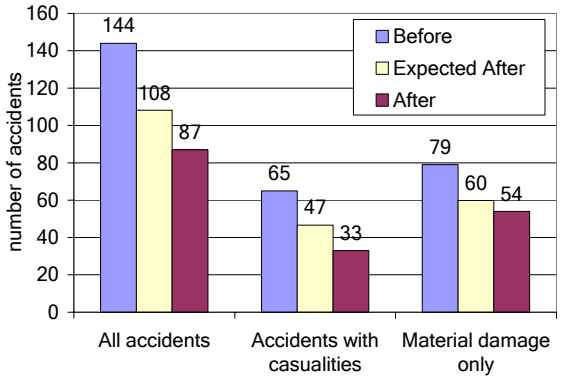

Figure. 16. Reduction in accidetns, /14/.

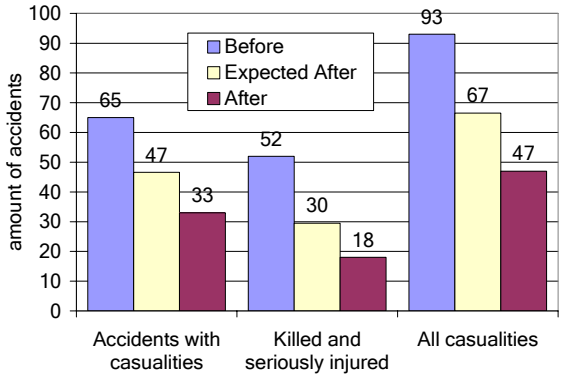

Figure. 17. Reduction in injuries, /14/.

Significant:
Statistically there is a difference - Less than 5 % risk that the difference is because of random variation.
Tendency:
5 – 10 % risk that the difference is because of random variation.
Week tendency:
10 - 15 % risk that the difference is because of random variation.
Not significant:
15 % or more risk that the difference is because of random variation.

Results

Over all the 21 through-roads have over a five year period achieved a reduction of 21 accidents, and of these 12 are personal injury accidents with 12 persons killed or seriously injured and 10 slightly injured compared with the control group.

The number of people injured and the number of personal injury accidents have been cut by half from the before- to the after-period. Held together with the control group the effects for the different accident categories are (figure 16 and 17):

- Number of personal injury accidents has been reduced by 29 % (tendency).
- The total number of accidents has been reduced by 20 % (week tendency).
- Number of accidents with property damage only has been reduced by 10 % (not significant).
- The number of killed has been reduced from 7 to 0 (tendency).
- The number of killed and seriously injured has been reduced by 39 % (tendency).
- The total number of people injured has been reduced by 29 % (significant).

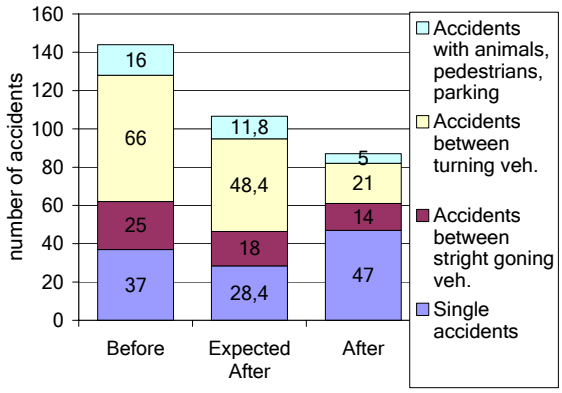

Figure. 18. Accident situations, /14/.

The distribution of accidents in different accident situations has changed in the period after the traffic calming (figure 18):

- The number of accidents between cars driving straight on has been reduced by 22 % (not significant).
- The number of solo accidents has been increased by 65 % (significant).
- The number of accidents with crossing road users has been reduced by 57 % (significant).
- The number of accidents with pedestrians/parked vehicles/animals has been reduced by 57 % (tendency).

The increase in single accidents in the after-period is probably caused by the increased number of obstacles the driver can hit (traffic islands, bollards, signs etc.).

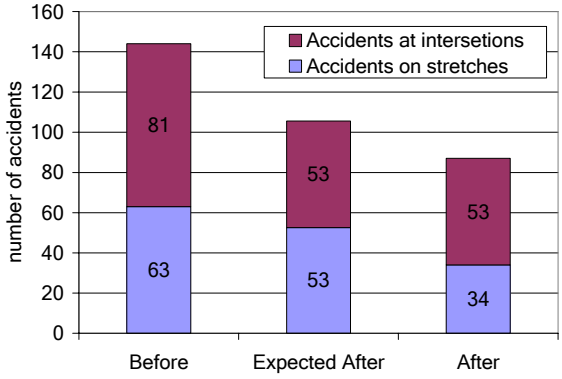

Figure. 19. Intersections contra stretches, /14/.

The number of accidents in intersections has been reduced significant by 35 % (figure 19), while the number of accidents on stretches is unchanged (not significant).

The number of accidents between motor vehicles has been reduced by 21 % (weak tendency), while the number of accidents with vulnerable road users has been reduced only by 5 % (not significant).

The analyses of the effects on road safety furthermore show that:

- The total effect for the 21 through-roads is consistent to effects found on previous implemented similar projects.
- It is the combination of different traffic calming measures that gives positive effects on the road safety. The result shows no clear relations between the effect and specific traffic calming measures.
- Overall the first year benefit of the 21 through-roads in relation to road safety is 4 %.

It should be noted that the road safety effects as well as the first year benefit varies considerable for each through-road.

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