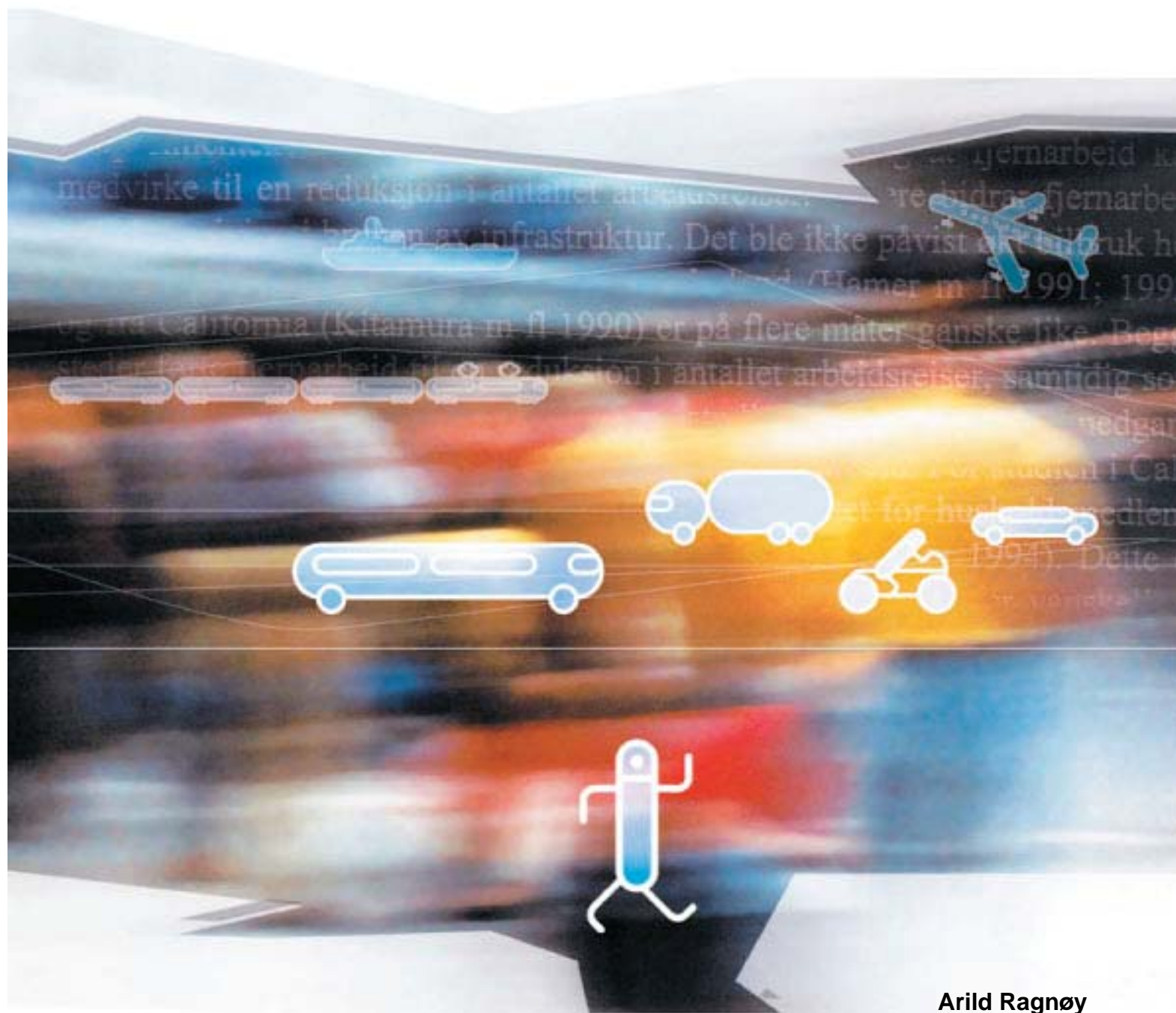


Speed limit changes. Effects on speed and accidents



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Arild Ragnøy

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Summary:

In the autumn of 2001, speed limits were lowered from 90 km/h to 80 km/h and from 80 km/h to 70 km/h on hazardous road sections in Norway. These road sections had been identified as having a high number of fatal or serious injury accidents per kilometre of road. This report presents an evaluation of the effects of these changes in speed limits on speed and accidents.

It is concluded that lowering the speed limit from 80 km/h to 70 km/h has successfully reduced both speed (-2,1 km/h to -4,1 km/h), the number of injury accidents (-14%) and the number of injured road users (-23% to -35%).

The effects of lowering the speed limit from 90 km/h to 80 km/h are less clear. A reduction in speed has been found (-1,6 km/h to -2,8 km/h). Overall, no reduction in the number of accidents or injured road users has been found.

Tittel: Endring av fartsgrenser. Effekt på kjørefart og ulykker

Forfatter(e) Arild Ragnøy

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Sammendrag:

Høsten 2001 besluttet Statens vegvesen, Vegdirektoratet å senke fartsgrensene på 1134 km riks- og europaveger i Norge. 741 km ble skiltet ned fra 80 km/t til 70 km/t og 393 km ble skiltet ned fra 90 km/t til 80 km/t. Strekningene ble valgt ut etter fastsatte kriterier basert på høy skadegradstetthet. Denne rapporten dokumenterer effektene på kjørefart, ulykker og skader av å endre fartsgrensene. Endringene er påvist ved hjelp av før- og etter analyse med referansestreknings. Det er korrigert for regresjonseffekter. Nedskiltingen fra 80 km/t til 70 km/t har gitt en klar, entydig og signifikant reduksjon av både kjørefarten og ulykker og skader. Kjørefarten er endret med mellom -2,1 km/t og -4,1 km/t, samtidig som ulykkestallene er redusert med ca 14%. Antallet drepte og hardt skadde reduseres med mellom 23% og 35%.

Resultatene for nedskiltingen fra 90 km/t til 80 km/t er uklare. Kjørefarten er endret med mellom -1,6 km/t og -2,8 km/t, men antallet ulykker er ikke blitt redusert.

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Preface

The Norwegian Public Roads Administration (NPRA) is well acquainted with the connection between driving speed and accidents and injuries. The driving speed can be affected by the speed limit. Lowering the speed limit reduces the driving speed and thus the number of accidents and their severity.

In the fall of 2001, NPRA decided to reduce the speed limit on 1134 kms of the national and European road network in Norway. The speed limit was lowered from 80 km/h to 70 km/h along 741 km of road and from 90 km/h to 80 km/h on 393 kms. This report documents the effects of the speed limit reductions on driving speeds and on injuries and accidents.

Our contactpersen at the NPRA, was senior engineer Richard Muskaug. Per Ola Roald and Arild Engbretsen, both with the NPRA, have contributed by providing the necessary speed and accident data.

TØI researcher Peter Christensen has helped perform the data analysis and Trude C. Rømming with word processing. TØI department head, Marika Kolbenstvedt, was in charge of the quality assurance of the report.

Researcher Arild Ragnøy was project manager and author of the report.

This report is also written in Norwegian. Thorbjørn Brudeseth (NPRA) has contributed in the translation.

Thanks are due to NPRA section head, Finn H. Amundsen and TØI chief research officer, Rune Elvik, who both offered valuable advice and comments throughout the study.

Oslo, August 2005
Institute of Transport Economics

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Head of Department

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Summary:

Speed limit changes. Effects on speed and accidents

Introduction

In the autumn of 2001, speed limits were lowered from 80 km/h to 70 km/h and from 90 km/h to 80 km/h on hazardous road sections in Norway. These road sections had been identified as having a high expected injury severity density (based on accident costs pr km), i.e. a high number of fatal or serious injury accidents per kilometre of road. In this report we evaluate how these changes in speed limits have affected speed and accidents.

Procedures for identifying roads

Formal procedures were developed to identify road sections where speed limits were to be lowered. These procedures were based on injury severity density, which is a measure of the frequency of accidents leading to fatal or serious injuries.

Additional criteria were developed for roads with a current speed limit of 90 km/h, relating to highway alignment, ADT, road width and roadside development. The criteria were intended to identify those road sections in Norway that had the worst safety problems, as targets for lowered speed limits.

The speed limit were lowered on 294 road sections

Speed limits were lowered on 294 road sections with a total length of 1,134 km. 247 road sections (total length 741 kms) had the speed limit lowered from 80 km/h to 70 km/h. 47 road sections (total length 393 kms) had the speed limit lowered from 90 km/h to 80 km/h.

Before-and-after study

Effects were evaluated by means of a before-and-after study employing the Empirical Bayes design. The normal number of accidents or injured road users on the treated roads was estimated by means of a multivariate accident prediction model. The normal number of accidents or injured road users was then combined with the recorded number of accidents or injured road users on each road section in order to estimate the long-term expected number of accidents or injured road

users. The difference between the recorded number of accidents or injured road users and the long-term expected number of accidents or injured road users shows the expected regression-to-the-mean effect. All estimates of effect have controlled for regression-to-the-mean.

In addition, the study controlled for long-term trends in accident occurrence by applying two comparison groups. These groups were defined as follows:

1. Comparison group 1 consisted of roads that retained the original speed limit of 80 km/h (alternatively 90 km/h)
2. Comparison group 2 consisted of all public roads in Norway (minus those that had the speed limit lowered).

Comparison group 1 is matched to the treated group with respect to speed limit. Changes in the number of accidents or the severity of injuries from the before-period to the after-period in this comparison group will reflect trends that are specific to roads that have a speed limit of either 80 km/h or 90 km/h. Comparison group 2 is much larger than comparison group 1, but will adequately reflect trends that apply to all public roads, and not trends for a specific type of road that depart from the overall pattern.

Neither of the two comparison groups is considered fully satisfactory. Hence, effects have been estimated by means of both groups.

Data on changes in speed

Data on changes in speed have been taken from permanent traffic monitoring stations operated by the Public Roads Administration. There are more than 200 of these stations in Norway, and data from 29 of them have been used. A computer algorithm was developed in order to ensure that only data of acceptable quality was used in the study. Errors in speed data occur at a higher rate than is currently believed.

Comparison road sections for the speed study were found in the same county and with ADT levels similar to the treated roads. The speed limits were unchanged on the comparison roads.

Table S1 shows the number of vehicles included in the speed data. As can be seen from Table S1, valid speed data were obtained from several million vehicles.

Table S1: Number of vehicles at treated locations and comparison locations for which valid speed data have been obtained

Group	Number of vehicles	
	Before	After
Treated roads	19,691,569	20,358,041
Comparison roads	8,674,886	9,008,759
Total	28,366,455	29,366,800

Source: TØI report 729/2004

Effect on speed

Changes in mean speed are shown in Table S2. As can be seen, mean speed was reduced in all groups. The reductions were somewhat larger in the two treated groups (80 km/h to 70 km/h and 90 km/h to 80 km/h) than in the two comparison groups. This indicates that lowering the speed limit had a net effect on speed.

Table S2: Mean speed before and after changes in speed limits

Group	Mean speed (km/h)	
	Before	After
Treated roads 80 km/h to 70 km/h	75.3	71.2
Comparison roads retaining 80 km/h	76.4	74.4
Treated roads 90 km/h to 80 km/h	85.1	82.2
Comparison roads retaining 90 km/h	84.6	83.4

Source: TØI report 729/2004

The net reduction in mean speed attributable to the lowering of the speed limit can be estimated to between 4.1 km/h and minimum 2.1 km/h on roads that had a speed limit of 80 km/h before treatment. The corresponding net reduction in mean speed on 90 km/h roads can be estimated to between 2.8 and 1.6 km/h.

Accident data

The accident data for the treated road sections are presented in Table S3. The before-period included all years from 1993 to 2000, i.e. 8 years. The after-period started at slightly different dates in late 2001 and included the years 2002 and 2003. The mean duration of the after-period was about 2 years and one month.

In total, about 3,700 injury accidents served as the basis for the evaluation. As can be seen from Table S3, the data for some of the categories during the after-period was quite sparse, leading to uncertain estimates of effect.

Table S3: Accident data for treated road sections

Group	Item of data	Before	After
80 km/h to 70 km/h	Total days covered	589,496	148,403
	Injury accidents	2307	455
	Fatalities	211	30
	Critically injured road users	133	4
	Seriously injured road users	404	66
	Slightly injured road users	2949	680
90 km/h to 80 km/h	Total days covered	99,280	27,230
	Injury accidents	718	257
	Fatalities	108	32
	Critically injured road users	43	10
	Seriously injured road users	188	64
	Slightly injured road users	954	373

Source: TØI report 729/2004

The number of accidents or injured road users in the comparison groups were substantially higher than in the treated groups. This applied both to comparison group 1 and comparison group 2.

Effects on accidents and injured road users

Table S4 summarises estimated effects on accidents and injured road users of the changes in speed limits. Effects are stated as percentage changes in the number of accidents or injured road users.

On roads where the speed limit was lowered from 80 km/h to 70 km/h, there has been a reduction of both accidents and the number of injured road users. The size of the reduction attributed to the change in speed limit, labelled net change and shown in two columns to the right in Table S4, differs slightly depending on whether comparison group 1 or comparison group 2 is used to account for long-term trends. By and large, however, the two sets of estimates are quite close. The largest reduction is found for fatalities and critical injuries. This makes sense in view of previous studies of the effects of lowering speed limits.

On roads where the speed limit was lowered from 90 km/h to 80 km/h, the findings are more difficult to interpret. There has apparently been an increase in both the number of accidents, the number of fatalities and the number of seriously or slightly injured road users. When regression-to-the-mean and long-term trends are controlled for by means of comparison group 1, a net increase remains for accidents, seriously injured road users and slightly injured road users. There is a net reduction of the number of fatalities and critically injured road users. If comparison group 2 is used, there is a net increase at all levels of injury severity.

Table S4: Effects on accidents and injured road users of changes in speed limits.
Percentage changes

	Percentage change by source of change in the number of accidents or injured road users					
	Gross change	Regression-to-the-mean	Long-term trend, comparison group 1	Long-term trend, comparison group 2	Net effect based on comparison group 1	Net effect based on comparison group 2
Roads where speed limit was lowered from 80 to 70 km/h						
Accidents	-21	-7	0	-2	-16	-14
Fatalities	-43	-24	27	-1	-42	-25
Critically injured	-88	-35	-16	-21	-78	-77
Seriously injured	-35	-10	-5	-17	-23	-12
Slightly injured	-8	-2	5	0	-10	-6
Roads where speed limit was lowered from 90 to 80 km/h						
Accidents	31	-5	-8	-2	50	41
Fatalities	9	-15	64	-1	-22	29
Critically injured	-15	-5	26	-21	-29	13
Seriously injured	25	-15	8	-17	36	78
Slightly injured	43	-2	-11	0	64	45

Source: TØI report 729/2004

The findings for roads where speed limits were lowered from 90 km/h to 80 km/h do not make much sense, and are strongly influenced by the choice of comparison group. Neither of the two comparison groups used can be considered ideal. Reasons for the dramatic increase in the number of fatalities in comparison group 1 (64%) are not known. If real, this increase is a sign of a drastic deterioration of road safety on roads that retained the 90 km/h speed limit. A similar tendency, but less pronounced, is seen on roads that retained the speed limit of 80 km/h (27% increase).

Conclusions

It is concluded that lowering the speed limit from 80 km/h to 70 km/h on hazardous road sections in Norway has successfully reduced both speed, the number of injury accidents and the number of injured road users. The reduction is largest for fatalities and critical injuries. The effects are statistically significant at the 5% level.

The effects of lowering the speed limit from 90 km/h to 80 km/h are less clear. A reduction in speed has been found, but it was smaller than the reduction associated with lowering the speed limit from 80 km/h to 70 km/h. Overall, no reduction in the number of accidents or injured road users has been found. No effects are significant.

Sammendrag:

Endring av fartsgrenser. Effekt på kjørefart og ulykker

Innledning

Ut fra kunnskap om sammenhengen mellom kjørefart og ulykker og skader besluttet Statens Vegvesen, Vegdirektoratet, høsten 2001 å senke fartsgrensen fra 90 km/t til 80 km/t og fra 80 km/t til 70 km/t på enkelte strekninger på riks- og europavegnettet. Strekningene som ble skiltet ned, ble valgt ut etter fastsatte kriterier basert hovedsakelig på skadegradstetthet (forventet – og registrert skadegradstetthet).

Denne rapporten dokumenterer effekten av de endrede fartsgrensene på kjørefarten og på ulykkene og skadene.

Nedskilting etter faste kriterier

Kriteriene for å senke fartsgrensen er basert på en kombinasjon av krav til størrelsen av forventet- og registrert skadegradstetthet. For endring fra 80 km/t til 70 km/t og alternativt for endring fra 90 km/t til 80 km/t gjelder at :

*”Alle veger med 80 km/t (**alternativt 90 km/t**) fartsgrense som har en forventet skadegradstetthet i sikkerhetsklasse 4 eller 5 (dvs FSGT over 1,65) og som samtidig har en registrert skadegradstetthet i sikkerhetsklasse 3, 4 eller 5 (dvs RSGT over 1,30) skal skiltes ned fra 80 km/t til 70 km/t (**alternativt fra 90 km/t til 80 km/t**). I tillegg skal alle veger med fartsgrense 80 km/t (**alternativt 90 km/t**) med registrert skadegradstetthet i sikkerhetsklasse 5 (dvs RSGT over 3,05) skiltes ned til 70 km/t (**alternativt 80 km/t**), uavhengig av hva den forventede skadegradstetthetene er.”*

For nedskilting fra 90 km/t til 80 km/t ble det også stilt kvalitetskrav til kurvatur, sikt, Ådt, vegbredde, aktiviteter langs vegen. Strekingen kunne dessuten ikke være i tunnel.

294 nedskiltede strekninger

Totalt er det registrert at 294 strekninger med en samlet lengde på 1134 km på riks- og europavegnettet er skiltet ned. 247 strekninger (741 km) er skiltet ned fra 80 km/t til 70 km/t og 47 strekninger (393 km) er skiltet ned fra 90 km/t til 80 km/t.

Før- og etteranalyse med referansestrekning korrigert for regresjonseffekter

Utgangspunktet for prosjektet er nedskilting av strekninger hvor skade- og ulykkestallet er høyere enn hva som er normalt for sammenliknbare strekninger. På de nedskiltede vegstrekningene, eksperimentstrekningene, forventes det at fartsgrenseendringen har effekt på både kjørefarten og på antall skader og ulykker. Ved å sammenlikne en periode før fartsgrenseendringen med en periode etter at endringen har skjedd, kan vi beregne en direkte effekt, også kalt **bruttoeffekten**, av tiltaket på eksperimentstrekningene.

Siden vi på forhånd vet at antallet ulykker og skader er høyt på de strekningene vi skilte ned, er det grunn til å hevde at bruttoendringene vil være tilfeldig høye grunnet statistiske tilfeldigheter. Tilleggseffekten, som beregnes fordi skade- og ulykkestallene er tilfeldig høye i førperioden, kalles **regresjonseffekten**. Vi har benyttet statistiske metoder (empirisk Bayes metode) for å korrigere skade- og ulykkesdata fra førsituasjonen for slike effekter. Regresjonseffekten er beregnet som den prosentuelle forskjellen mellom den forventede og den registrerte skade- og ulykkestallene. Forventede skade- og ulykkestall er beregnet ved en sammenveining av normale og registrerte skade- og ulykkestall slik dette er gjort ved beregning av skadegradstetthet. (Ragnøy, Christensen, Elvik 2002).

Vi har ikke grunn til å anta at fartsdataene i førsituasjonen er tilfeldig høye på samme måte som for skader og ulykker. Dette innebærer at fartsdataene fra førsituasjonen ikke er korrigert for regresjonseffekter.

For å håndtere eventuelle endringer i kjørefart eller i skade- og ulykkestall som ikke har sammenheng med fartsgrenseendringen, men som kan skyldes andre ting (som vær, føre, lys og mørke, eller andre endringer i tiden), har vi benyttet **referansestrekninger**. Referansestrekningene er strekninger som er mest mulig lik eksperimentstrekningene med hensyn til trafikkmengde og type ; samme antall kjørefelt, samme antall kryss pr km, vegstatus osv. På referansestrekningene er fartsgrensen ikke endret.

Den beregnede effekten, hvor endringene på eksperimentstrekningene er korrigert for eventuelle endringer på referansestrekningene (og for skader og ulykker også regresjonseffekter), kalles **nettoeffekten** av tiltaket.

Generelt har det i dette tilfelle være svært vanskelig å velge gode referansestrekninger. Særlig gjelder det analysen av effekten på skader og ulykker.

Store datamengder fra fartsmålingene

Statens Vegvesen foretar automatiske , kontinuerlige fartsmålinger på over 200 punkter på riks- og europavegnettet. Slike målepunkter finnes på 16 av strekningene hvor fartsgrensen ble endret fra 80 km/t til 70 km/t, og på 7 av strekningene hvor fartsgrensen er endret fra 90 km/t til 80 km/t.

Beklageligvis har det ikke vært mulig å finne referansepunkter som tilfredstiller de ideelle kravene nevnt over. Det har vært nødvendig å bruke punkter med samme fartsgrense som i eksperimentpunktet i før-perioden, som ligger på andre veger, men i samme fylke som eksperimentpunktet. Med denne tillempling av

kravene er det funnet referansepunkter til alle eksperimentstrekningene hvor fartsgrensen er endret fra 80 km/t til 70 km/t, og på 2 av eksperimentpunktene hvor grensen er endret fra 90 km/t til 80 km/t.

For å sammenstille data fra før- og etterperioden på eksperiment- og referansestrekningen, er det utviklet et spesielt EDB program. Programmet sjekker gjennomsnittlig timefart time for time fra fartsgrenseendringen og fram til 30/6 2002. Timer hvor kjørefarten er lavere enn 60 km/t benyttes ikke, samtidig som data fra bevegelige helligdager fjernes.

Etter kvalitetssikring gjenstår et datamateriale fra 29 punkter. 13 eksperimentpunkter med referansepunkter og 3 eksperimentpunkter uten referansepunkt.

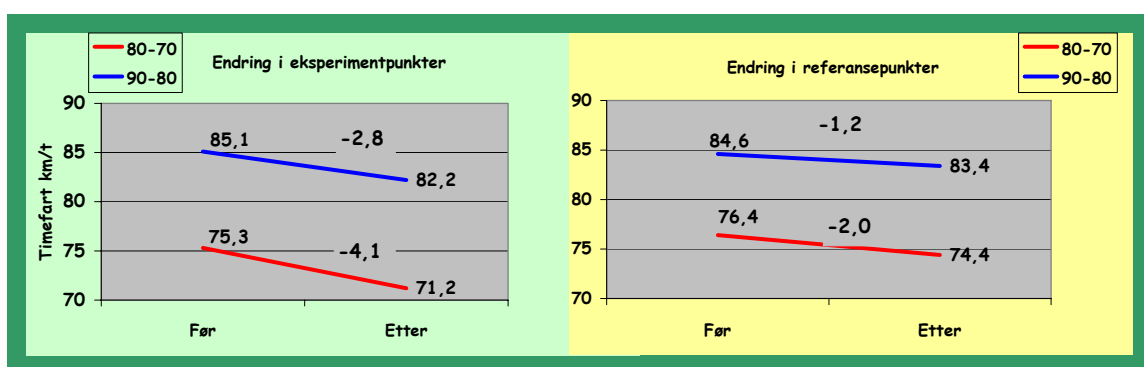
Tabell S1: Datamateriale etter kvalitetssikring. Antall kjøretøyer målt før og etter endring av fartsgrensen i samtlige eksperiment- og referansepunkter.

	Antall kjøretøyer	
	FØR	ETTER
Eksperiment	19691569	20358041
Referanse	8674886	9008759
Sum	28366455	29366800

Kilde: TØI rapport 729/2004

Fartsgrenseendringen har endret kjørefarten med 2-4 km/t

Ved å endre fartsgrensen fra 80 km/t til 70 km/t reduseres kjørefarten med 4,1 km/t, fra 75,3 km/t i førsituasjonen til 71,2 km/t etter fartsgrenseendringen. Resultatet er basert på målinger i 11 punkter fordelt i 8 fylker og omfatter ca 25 millioner kjøretøyer.



Kilde: TØI rapport 729/2004

Figur S1: Resultater av å endre fartsgrensen fra 80 km/t til 70 km/t og fra 90 km/t til 80 km/t. Kjørefart målt i km/t i eksperiment- og referansepunkt i situasjon før og etter endring av fartsgrensen.

I referansepunktene har også kjørefarten endret seg fra før- til etterperioden. I gjennomsnitt for alle punktene har farten endret seg med $-2,0$ km/t. Spredningen er redusert med $0,3$ km/t.

Ved å endre fartsgrensen fra 90 km/t til 80 km/t ble kjørefarten endret med $-2,8$ km/t, fra til $85,1$ km/t i førsituasjonen til $82,2$ km/t i ettersituasjonen. Resultatet er basert på målinger i 5 punkter i like mange fylker. I de to tilhørende referansepunktene har også kjørefarten endret seg med i gjennomsnitt $-1,2$ km/t. Spredningen endret seg ikke i disse punktene.

Den målte effekten av fartsgrenseendringen fra 80 km/t til 70 km/t i eksperimentpunktene var $-4,1$ km/t. I de tilsvarende referansepunktene var endringene $-2,0$ km/t. Dette er som nevnt ikke perfekte referansepunkter, men representerer likevel et stort antall punkter på 80 km/t vegnettet hvor ingen kjente faktorer skal påvirke kjørefarten. Vi kan derfor ikke utelukke at det er forhold vi ikke har kontroll over, som også har påvirket kjørefarten i våre eksperimentpunkter. **Ut fra denne usikkerheten konkluderer vi med at fartsendringen som skyldes fartsgrenseendring fra 80 km/t til 70 km/t er mellom $-4,1$ km/t og $-2,1$ km/t. Spredningen endres ikke.**

Ved endring av fartsgrensen fra 90 km/t til 80 km/t gjelder samme resonnement og problem knyttet til bruken av referansepunktene. **Fartsendringen som skyldes fartsgrenseendring fra 90 km/t til 80 km/t ligger mellom $-2,8$ km/t og $-1,6$ km/t. Spredningen endres ikke .**

Ulykkesanalysen omfatter over 3700 ulykker på eksperimentstrekingene.

Av de totalt 294 strekningene hvor fartsgrensen ble endret, inngår 237 i materialet som ligger til grunn for evalueringen av effektene på skader og ulykker. Strekninger i alle fylker inngår, med unntak av strekningene i Oslo, Rogaland, Hordaland, Nordland, Troms og Finnmark. Bakgrunnen for dette frafallet har vært generelle problemer knyttet til skade- og ulykkesdata fra disse fylkene i 2002 og 2003 (etterperioden).

Tabell S2 viser en oversikt over datamaterialet som inngår i ulykkesanalysen.

Tabell S2: Strekninger som inngår i skade- og ulykkesevalueringen. Antall strekninger og samlet lengde i hver fartsgrenseendring. Før - og etterperiodens lengde (antall dager samlet) og antall ulykker og skader i de to periodene. Antall personer drept (DR), meget alvorlig skadd (MAS), alvorlig skadd (AS) og lett skadd (LS).

Nedskilting	Antall strekn	Lengde km	FØR periode				ETTER periode							
			Dager antall	UL antall	Skadde /drepte antall personer				Dager antall	UL antall	Skadde /drepte antall personer			
					DR	MAS	AS	LS			DR	MAS	AS	LS
80 km/t til 70 km/t	203	631,270	589496	2307	211	133	404	2949	148403	455	30	4	66	680
90 km/t til 80 km/t	34	271,049	99280	718	108	43	188	954	27230	257	32	10	64	373

Kilde: TØI rapport 729/2004

Totalt inngår 3025 (2307+718) ulykker i førperioden og 712 (455+257) i etterperioden. Antall personer drept (DR) og hardt skadd (HS= MAS+AS) utgjør 748 i førperioden og 100 i etterperioden på strekningene som er nedskiltet fra 80 km/t til 70 km/t. Tilsvarende utgjorde 339 og 106 personer på strekningene med fartsgrenseendring fra 90 km/t til 80 km/t

Førperioden var fra 1/1 1993 til 31/12 2000 d v s 8 år. Som etterperiode ble valgt perioden fra ca en uke etter nedskilting og til 31/12 2003.

To sett referansestrekninger

Siden eksperimentstrekningen er valgt slik de er, som strekninger med høye skade- og ulykkestall, vil det være vanskelig, eller nærmest umulig, å finne perfekte referansestrekninger i Norge. Fartsgrensen er endret på alle strekninger hvor den forventede skadegraden er over en viss verdi.

For å kunne foreta en viss sammenlikning med hva som skjer på det øvrige vegnettet hvor fartsgrensen ikke ble endret i den aktuelle perioden, har vi dannet to referansevegnett:

Referanse I, består av de strekningene på riks- og europavegnettet i hvert fartsgrenseintervall hvor fartsgrensen ikke ble endret i etterperioden. For nedskiltingen fra 80 km/t til 70 km/t utgjør referansevegnett I den delen av riks- og europavegnettet hvor fartsgrensen har vært uendret 80 km/t i perioden fra 1993 til og med 2003. Dette vegnettet har en lengde på 11771 km. For nedskiltingen fra 90 km/t til 80 km/t utgjør referansevegnett I det vegnettet som har hatt fartsgrense 90 km/t i hele perioden 1993 til 2003, unntatt motorveg A. Vegnettet er 399 km langt.

Referanse II består av hele vegnettet i Norge uansett fartsgrense og vegtype, fratrukket de strekningene som er nedskiltet fra 90 km/t til 80 km/t eller 80 km/t til 70 km/t (eller der hvor fartsgrensen er økt til 100 km/t).

Resultater skader og ulykker

Tabell S3 viser de samlede resultatene ev fartsgrenseendringene.

Bruttoresultatene i tabell S3 viser at antall registrerte drepte (DR) reduseres med 43,2% for alle strekningene samlet når fartsgrensen endres fra 80 km/t til 70 km/t. Antallet meget alvorlig skadd (MAS) reduseres med 88,0%, alvorlig skadd (AS) med 34,7% og lett skadd (LS) med 7,9%. Drepte og hardt skadde (DR+HS) samlet reduseres med 46,6%. Antallet ulykker reduseres med 21,2%, fra 0,46 ulykker pr km og år i førperioden til 0,36 ulykker pr km og år i etterperioden. Resultatene er signifikante på 5% nivå.

Tilsvarende bruttoresultater for fartsgrenseendring fra 90 km/t til 80 km/t viser en ulykkes**økning** på 31,1 %. Også antall drept (DR = 8,5 %), antall alvorlig skadd (AS = 24,7%) og lett skadd (LS =43,2 %) viser en økning i de registrerte antallene. Antall drepte og hardt skadde (DR+HS) øker samlet med 14,5%. Resultatene er ikke signifikante på 5% nivå.

Tabell S3: Beregnede effekter ved endring av fartsgrenser fra 80 km/t til 70 km/t (øvre del av tabellen) og 90 km/t til 80 km/t (nedre del).
 Bruttoeffekter, regresjonseffekter, bruttoeffekter korrigert for regresjonseffekter, effekter på referansestrekning I og II og nettoeffekter. Alle effekter i %.

Nedskilting fra 80 km/t - 70 km/t							
	Nedskilte strekninger			Referansestrekninger		Nettoeffekter	
	Brutto	Endringer i % Regresjon	Brutto uten regresjon	Referanse I	Referanse II	Endringer i % Basert på referanse I	Endringer i % Basert på referanse II
Ulykker	-21,2	-6,7	-15,5	0,0	-1,8	-15,5	-13,9
DR	-43,2	-23,6	-25,6	27,3	-0,9	-41,6	-25,0
MAS	-88,0	-34,9	-81,5	-15,9	-20,8	-78,0	-76,7
AS	-34,7	-10,3	-27,2	-4,9	-17,2	-23,4	-12,1
LS	-7,9	-2,1	-5,8	4,7	0,5	-10,1	-6,3
Nedskilting fra 90 km/t - 80 km/t							
Ulykker	31,1	-5,0	38,0	-7,8	-1,8	49,8	40,6
DR	8,5	-15,4	28,2	63,9	-0,9	-21,8	29,4
MAS	-14,8	-5,2	-10,1	25,7	-20,8	-28,5	13,4
AS	24,7	-15,3	47,1	7,9	-17,2	36,3	77,6
LS	43,2	-1,7	45,6	-11,5	0,5	64,4	44,9

Kilde: TØI rapport 729/2004

Av den øvre delen av tabell S3 fremgår at regresjonseffekten for personskadeulykker er beregnet til -6,7% når fartsgrensen ble endret fra 80 km/t til 70 km/t. I praksis betyr dette at 6,7% av de registrerte ulykkene i førsituasjonen skyldes tilfeldig variasjon. For skadde og drepte varierer regresjonseffekten med mellom -2,1% for lette skader og -34,9% for meget alvorlige skader.

Den nedre delen av tabellen gir regresjonseffektene for veger hvor fartsgrensen er endret fra 90 km/t til 80 km/t.

Tabellen viser også de beregnede endringene fra før- til etterperioden på de to referansevegnettene. Endringene i antall ulykker, antall meget alvorlig skadde personer og lett skadde personer er ikke vesentlig forskjellige på de to referansevegnettene hvor fartsgrensen er endret fra 80 km/t til 70 km/t. Endringen i antallet drept er derimot relativt forskjellig på de to vegnettene, henholdsvis en økning på 27,3% ved referanse I og en reduksjon på -0,9% ved referanse II. Dette er en til dels betydelig forskjell. Det er referanse I som oppviser en økning i antall drepte, mens referanse II ikke gjøre det. Referanse I er imidlertid det vegnettet som har fartsgrense 80 km/t og således er best til å beskrive hva som skjer på dette vegnettet. Referanse II gjelder alle veger og har således en tendens til å viske ut særegenheter knyttet direkte til spesielle deler av et vegnett. Dersom det har vært en økning i antall drepte på 80 km/t vegnettet i perioden 1993 til 2003 som ikke har vist seg like mye på andre deler av vegnettet bør, det legges mest vekt på referanse I.

For fartsgrenseendring fra 90 km/t til 80 km/t viser referanse I, tabell S3, en økning i antall drepte på 63,9%. Antallet meget alvorlig skadde og alvorlig skadde oppviser også en økning. Dette er relativt dramatiske tall og kan indikere at dette vegnettet har vært utsatt for en betydelig vekst i skadegraden i de senere år, selv om det totale ulykestallet ikke har økt. Det kan være flere mulige forklaringer på dette, men relativt høy kjørefart uten midtrekkverk kombinert med sterk

trafikkvekst kan være noen stikkord. Tallene bak referanse I er imidlertid relativt små. Selv om referanse II er betydelig større og mer robust, kan det likevel være viktige signaler i referansevegnett I om hva som skjer på vegnettet med fartsgrense 90 km/t (hovedsakelig motorveg B).

Uansett hvilket referansevegnett som velges er de beregnede nettoeffektene negative på vegnettet hvor fartsgrensen endres fra 80 km/t til 70 km/t. Reduksjonen av fartsgrensen har dermed entydig medført reduksjon både av antall ulykker og av antall drepte og skadde. Ulykkestallet er redusert med henholdsvis -15,5% og -13,9%. Også for antall meget alvorlig skadd og lett skadd er de to beregningene rimelig i overensstemmelse. For antall drepte viser beregningene av nettoeffektene samme fortegn, men tallverdien er noe forskjellig, henholdsvis -41,6% (referanse I) og -25,0% (referanse II). For drepte og hardt skadde samlet (DR+HS) er nettoeffekten ved å endre fartsgrensen fra 80 km/t til 70 km/t, basert på referansevegnett I, beregnet til -35,1%. Basert på referansevegnett II er tilsvarende nettoeffekt beregnet til -23,4%.

De beregnede nettoeffektene viser en økning i antall ulykker på vegnettet hvor fartsgrensen er endret fra 90 km/t til 80 km/t. Henholdsvis +49,8% og +40,63% avhengig av hvilket referansevegnett som brukes. Nettoeffekten beregnet for alvorlig skadde og lett skadde er også høy og positiv uansett hvilket referansevegnett som legges til grunn.

Dersom referansevegnett I benyttes beregnes en nettoeffekt på -21,8% for antall drept og -28,5% for antall meget alvorlig skadd. Med referansevegnett II beregnes de tilsvarende nettoeffektene til 29,4% og 13,4%.

Både for fartsgrenseendring fra 80 km/t til 70 km/t og for 90 km/t til 80 km/t ser det ut til at antallet drept på referansevegnett I har økt mer enn på referansevegnett II. Hvis økningen skyldes spesielle forhold på dette vegnettet er dette argumenter for å benytte resultatene fra referansevegnett I.

Konklusjon

Reduksjon av fartsgrensen **fra 80 km/t til 70 km/t** har gitt en klar og entydig reduksjon av både kjørefarten og skader og ulykker fra en periode før til etter reduksjonen av fartsgrensene. Resultatene viser at kjørefarten ble endret med mellom -2,1 km/t og -4,1 km/t. Spredningen ble ikke endret.

Samtidig reduseres ulykkestallene med mellom 13,9% og 15,5%. Antallet drepte og hardt skadde reduseres med mellom 23,4% og 35,1%

Nedskiltingen fra **90 km/t til 80 km/t** har medført at kjørefarten fra før til etter nedskilting er endret med mellom -1,6 km/t og -2,8 km/t. Utviklingen av ulykkestallet er vanskelig å tolke. Totalt antall ulykker ser ut til å ha økt på dette vegnettet. Resultatene for antall drepte og hardt skadde avhenger imidlertid av hvilket referansevegnett som velges. Brukes referansevegnett I har antall drepte og hardt skadde vært ganske uendret (+2,8%). Dersom referansevegnett II (hele vegnettet) benyttes, så har antallet drepte og hardt skadde økt med over 50%. Dette er høye, og usikre tall og det er uansett grunn til å se nærmere på utviklingen av skade- og ulykkestallene på veger med fartsgrense 90 km/t.

1 Background

1.1 Introduction

The National Transport Plan 2002-2011 is based on vision zero as an idealized basis for traffic safety in Norway (Ministry of Transport and Communications, Report to the Storting no. 46, 1999-2000). Vision zero states that the long range goal is to develop a transportation system where no one is killed or permanently injured because of accidents.

As part of the vision zero effort, the Norwegian Public Roads Administration has developed a new measure for estimating how hazardous a given road section is, called the injury severity density (Ragnøy, Christensen and Elvik 2002). Estimation of the injury severity by 1 km segments for the entire Norwegian trunk road network, made it possible to identify the most hazardous road sections in terms of injury severity density.

The relation between driving speed and accidents is well known and documented in such guidebooks as the Traffic Safety Handbook. To reduce the number and severity of the accidents on the most hazardous sections, the Directorate of Public Roads decided to reduce the posted speed limits from 90 km/h to 80 km/h and from 80 km/h to 70 km/h on some of these sections. Special criteria were established for reducing the speed limit on a section.

The Institute of Transport Economics was commissioned by the Directorate of Public Roads to evaluate the effect of reducing the speed limit from 90 km/h to 80 km/h and from 80 km/h to 70 km/h for the sections selected. The effect should be measured both with respect to driving speeds (changes in driving speed in km/h) and with respect to accidents, fatalities and injuries (changes in the number of accidents, fatalities and injured).

Since the sections with speed limit reduction initially had a higher than normal rate of accidents, there is reason to underscore that this is not a classical experiment were it is possible to directly determine a general effect on the number of injuries from a 10 km/h speed limit reduction. In such case, random road sections with the same speed limit should have been selected, split into two separate groups and then the speed limit should be reduced for one of the groups and while the speed limit should remain the same on the other.

1.2 The report structure

The report deals with the effect of changing the speed limits on driving speeds and on the number of accidents, fatalities and injured.

Chapters 4 and 5 present results separately for the two effects, speeds in Chapter 4 and accidents and injuries in Chapter 5.

Chapter 6 contains a summary and an overall evaluation of the results.

Chapter 2 describes to begin with the speed reduction criteria prepared by the Directorate of Public Roads and contains an overview of sections with reduced posted speed limits in the various counties.

Chapter 3 reviews the method selected for the evaluation and describes what this means specifically for the parts that concern driving speeds, accidents and injuries.

2 Sections studied

2.1 Speed limit reduction criteria

The criteria for selecting roads for speed limits reductions, are based on a combination of requirements for recorded injury severity density (RISD) and expected injury severity density (AISD). The expected injury severity density is estimated by weighing together normal injury severity densities and recorded injury severity densities as described by Ragnøy, Christensen and Elvik, 2002.

The criterion for reducing the speed limit from 80 km/h to 70 km/h is:

”All roads with an 80 km/h posted speed limit and an expected injury severity density in safety class 4 or 5 (i.e. EISD above 1.65) and at the same time a recorded injury severity density in safety class 3, 4 or 5 (i.e. RISD above 1.30) shall have their speed limits lowered from 80 km/h to 70 km/h. In addition, all roads with an 80 km/h posted speed limit with a recorded injury severity density in safety class 5 (i.e. RISD above 3.05) shall have their speed limits lowered to 70 km/h regardless of the size of the expected injury severity density.”

Similarly, the criterion for lowering posted speed limits from 90 km/h to 80 km/h is:

”All roads with a 90 km/h posted speed limit and an expected injury severity density in safety class 4 or 5 (i.e. EISD above 1.65) and at the same time a recorded injury severity density in safety class 3, 4 or 5 (i.e. RISD above 1.30) shall have their speed limits lowered from 90 km/h to 80 km/h. In addition, all roads with a 90 km/h posted speed limit and a recorded injury severity density in safety class 5 (i.e. RISD above 3.05) shall have their speed limits lowered to 80 km/h regardless of the size of the expected injury severity density.”

It is worth while to underscore that the requirements associated with the reduction of the two speed limits (90 km/h to 80 km/h and 80 km/h to 70 km/h) are identical in respect of expected and recorded injury severity density.

Before lowering speed limits from 90 km/h to 80 km/h, quality requirements were established with respect to:

- Curvature
- Visibility
- Tunnels
- AADT
- Road width
- Activities along the road

This implies in other words that the criteria for lowering the speed limits from 90 km/h to 80 km/h and from 80 km/h to 70 km/h are different. This can be of significance for later interpretation of the results.

2.2 Road sections with lowered speed limits

The regions have themselves used the previously mentioned criteria to select the sections where speed limits were lowered. All regions have participated and lowered posted speed limits either from 90 km/h to 80 km/h and/or from 80 km/h to 70 km/h.

Table 1 gives an overview by county of the number of road sections where speed limits were lowered from 90 km/h to 80 km/h and from 80 km/h to 70 km/h as well as the overall length of the road sections with lowered speed limits.

Table 1: Overview by county of sections on the National and European road network with speed limits lowered from 90 km/h to 80 km/h and from 80 km/h to 70 km/h in the fall of 2001. Number of sections in each county and overall length by county. For each speed limit and overall.

County N O	Name	80 km/h - 70 km/h		90 km/h - 80 km/h		TOTAL	
		No. of sections	Length km	No. of sections	Length km	No. of sections	Length km
1	Østfold	6	20,980	1	17,100	7	38,080
2	Akershus	7	57,469	2	37,319	9	94,788
3	Oslo	0		0		0	
4	Hedmark	13	31,867	2	27,750	15	59,617
5	Oppland	18	56,195	9	53,199	27	109,394
6	Buskerud	16	63,297	2	15,923	18	79,220
7	Vestfold	13	31,927	0		13	31,927
8	Telemark	18	68,285	2	43,581	20	111,866
9	Aust-Agder	11	54,689	3	7,486	14	62,175
10	Vest-Agder	10	41,900	1	10,745	11	52,645
11	Rogaland	17	34,375	1	9,051	18	43,426
12	Hordaland	18	56,081	0		18	56,081
14	Sogn & Fjordane	10	21,036	0		10	21,036
15	Møre & Romsdal	17	47,362	1	6,570	18	53,932
16	Sør-Trøndelag	49	105,661	5	29,954	54	135,615
17	Nord-Trøndelag	15	30,602	6	21,422	21	52,024
18	Nordland	2	4,235	0		2	4,235
19	Troms	1	2,269	2	6,945	3	9,214
20	Finnmark	6	13,143	10	106,015	16	119,158
Total		247	741,373	47	393,060	294	1134,433

Source: TØI report 784/2005

Speed limits were lowered on altogether 294 sections on the National and European road network with a total length of 1134 km .

On 247 road sections (741 km) were speed limits lowered from 80 km/h to 70 km/h and on 47 sections from 90 km/h to 80 km/h. All counties with the exception of Oslo reported speed limit reductions.

The table includes the road sections with lowered speed limits reported by the regions to this project. It cannot be precluded that there are sections with lowered speed limits beyond what is shown in Table 1, but these are not part of this study.

3. Method

3.1 Before-and-after study

The basis for the project is speed limit reduction of road sections where injury and accident rates are higher than what is normally found on comparable roads. Comparable roads are here meant to be roads with same traffic volume, same number of lanes, same number of intersections per km and identical classification in terms of transport function.

To improve safety along these roads, the Directorate decided to reduce posted speed limits by 10 km/h, from 90 km/h to 80 km/h and from 80 km/h to 70 km/h, and it is expected that this has an effect both on driving speeds and accidents. These roads are called the treated roads.

It was desired to identify changes both in driving speeds and accident rates on the treated roads by comparing time periods before and after speed limits were lowered. The time periods used are somewhat different for driving speeds and for injuries and accidents. This will be seen in Chapter 4 (speeds) and Chapter 5 (injuries and accidents).

By comparing a period before speed limit changes with a period after the change occurred, the direct effect of the measure can be estimated. This direct effect is called the *gross effect* of the measures undertaken on the treated sections.

3.2 Regression-to-the-mean

Since it is known beforehand that the number of accidents and injuries on the sections with lowered speed limits is large, there is reason to claim that the changes observed in the after-period will be arbitrarily high because of statistical randomness. This represents a risk of overestimating the effect on accidents and injuries by the speed limit change itself. Any additional effect estimated in the before-and-after study due to the randomly high injury and accident rates in the before-period is called the *regression-to-the-mean*. Such effects could for example be measured by undertaking a before-and-after study of blackspots based on "do-nothing" measures.

One method of correcting such effects is the empirical Bayes method. The method is based on taking a weighted average of normal and recorded number of injuries and accidents to estimate expected numbers. The averaging is done separately for each injury severity level and for accidents. The normal number of injuries and accidents are here meant to reflect those that are normal for similar sections. This means sections with the same traffic volume, speed limit, number of lanes, number of intersections per km and identical classification in terms of transport function. The normal number of accidents and the normal number of injuries and fatalities on the treated sections are estimated using the equations developed to estimate injury severity density, (Ragnøy, Christensen and Elvik, 2002).

Averaging normal and recorded numbers is done with the method presented in the report mentioned.

The difference between the expected and the recorded number of injuries and accidents is considered to be the regression-to-the-mean. This method has been used to correct the number of injuries and accidents in the before-period for regression-to-the-mean. These are termed gross effects corrected for regression-to-the-mean.

There is no reason to expect that the speed in the before-period is unusually high in the same manner as injury and accident rates. This means that the speed data from the before-situation should not be corrected for any regression-to-the-mean.

3.3 Comparison sections

To handle any changes in driving speeds or injury and accident rates not related to speed limit changes, but which could have been caused by other factors (such as weather, driving conditions, light and darkness or other changes with time), so-called comparison sections have been used for comparison with the treated sections.

Comparison sections are sections as similar as possible to the treated sections with regard to traffic volumes and type, number of lanes, number of intersections per km, road status etc. The comparison sections have not had their speed limits changed neither in the before-period nor in the after-period.

Any driving speed and injury and accident rate changes observed on the comparison sections are also assumed to have occurred on the treated sections. By recording speed, injury and accident data in the before and after-periods both on the comparison and treated sections, the effect of the speed limit reduction on driving speeds and on injury and accident rates can be estimated. The estimated effect on the treated sections, adjusted for any changes on the comparison sections, is called the *net effect* of the measure. It is this effect that is due to the measure itself. This approach has been used both for estimating the effect on driving speeds and on injuries and accident.

In this case, it was generally very difficult to select appropriate comparison sections. This was particularly the case when analyzing the effects on injuries and accidents. This is because the selection of sections where speed limits are reduced is based on criteria intended to ensure that these sections are those with a particularly large number of injuries and accidents. There are thus no other road sections in Norway with as many injuries and accidents as on the sections with lowered speed limits.

4. Effect on driving speeds

In the following it has been decided to present results from the two parts of the project separately and then close the report with a common chapter with discussions and conclusions. This main chapter concerns effects of the speed limit changes on driving speeds, while Chapter 5 deals with the effects of speed limit changes on the number of injuries and accidents.

4.1 Study approach

Different drivers will select different driving speeds even under entirely similar conditions. This is linked to such factors as age, driving experience, type of trip etc.

Such differences between drivers are evened out in speed measurements and studies by utilizing average values over a given period of time, typically one hour. The measurement unit will then be average hourly speed. To take care of the speed differences within each hour, the standard deviation is estimated .

The hourly averages show large variations possibly caused by external factors such as light conditions, day of the week, time of year, time of day, police enforcement (visible police) and ATC, speed limits, type of road (tourist route, speed section) or other conditions.

This part of the study intends to measure the effect on driving speeds of changes in the speed limit, **and only the speed limit**. Ideally, this means that it must be ensured that all other conditions are kept constant during a period before and after the speed limit changes are being implemented.

To eliminate, or at least reduce the possibility that driving speed (measured as hourly average) changes are being caused by other factors than those for which it is desired to measure the effect, it is therefore important that the driving speed is measured and compared for concurrent time periods before and after the measure is implemented. Concurrent periods are here meant to be same day of the week, time of day or time of year. For example, first Monday in September in the before-period is compared to the first Monday in September of the after-period. This was done using an especially prepared computer program.

The program uses the date of the speed limit change as a basis. On the fifth day after the change, the after-period starts with hour no. one (from midnight until 1 AM). 8736 hours (or 52 weeks) earlier is the corresponding time in the before-period. If any hourly data is missing, that hour is rejected and the program proceeds to the next hour. If data is found both for the before and after-periods, the data for that hour is stored. The program checks hour by hour from the time of the speed limit change until June 30th, 2002, which is the last date with speed measurements.

Comparison sites are also being used as an additional check to ensure that measured speed variations are not due to other factors than speed limit changes.

The especially developed computer program also reviews the comparison site data and approves an hourly measurement provided before and after data from a

corresponding hour are found both for the treatment sites and the comparison sites.

The program also eliminates all suspiciously low hourly speeds. When an hourly average is lower than 60 km/h, this value is rejected. This is done because it is assumed that during this hour measuring equipment has been malfunctioning or that other conditions (road work, accidents, congestion or other hindrances) slow down traffic to an extent where the speed limit has no influence on driving speeds.

Moreover, the program eliminates all hourly speeds with a standard deviation greater than normal ($>20\text{km/h}$). This is done because experience shows that when the standard deviation between driving speeds within one hour is that large, either the measuring equipment is faulty or traffic operation on the road is irregular.

Last, but not least, the program eliminates measurements taken on any movable holiday. When a "typical" Monday in the before-period is compared with Easter Monday in the after-period, any speed changes from the before-period to the after-period cannot be claimed to only having been caused by speed limit changes.

4.2 Data from 16 treated roads

The Public Roads Administration automatically collects continuous driving speed data from more than 200 sites on the National and European road networks. Sites where data collection is continuous are called level 1 sites. To identify driving speed changes due to speed limit changes using the method previously described, driving speed observations must be taken during long concurrent periods (minimum of 10-15 weeks) for both the before and after-period to produce high quality data for the treatment sites and comparison sites.

In practice this means that continuous measurements (from level 1 sites) must be taken on the section where the speed limit changes (the treatment site). This requirement is basically fulfilled on 16 of the sections where the speed limit is changed from 80 km/h to 70 km/h. Correspondingly, level 1 sites are found on seven of the sections where the speed limit is changed from 90 km/h to 80 km/h.

The chosen method and the especially developed computer program represent by itself a form of quality assurance of the data material. This is so because hours with questionably low driving speeds and questionably high standard deviation are removed. In addition it has been necessary, however, to quality assure the choice itself of the measurement sites and their suitability as speed measurement sites. This has been done in collaboration with persons familiar with the region. This resulted in an additional reduction in the number of treatment sites.

Unfortunately, it has not been possible to find comparison sites that satisfy the ideal requirements previously mentioned. It has been necessary to use sites located on other roads with the same speed limit as the treatment site in the before-period, but in the same county as the treatment site. The weather conditions at these sites will be fairly similar to weather conditions as the treatment sites.

Table 2: Overview by county of sections covered by the speed evaluation. Sections with lowered speed limits, length in km, the time of speed limit reduction, potential measuring sites on sections with speed limit reduction and corresponding comparison sites. The upper part of the table concerns 80 km/h to 70 km/h and the lower part 90 km/h to 80 km/h.

County	Sections with lowered speed limits								Measuring sites				Comparison sites							
	NO	Name	Road Location (from-to)	Length Km	Date signed	From Hp	To Km	Hp	Km	Name	Road	No	Hp	Km	Name	Road	No	Hp	Km	Pair no
80 km/h-70 km/h																				
2	Akershus	RV 2		1,797	5/11 01	4	3,693	4	5,490	UVESUND BRU	RV	2	4	3,800	KRINGEN	RV	22	4	7,800	16
4	Hedmark	RV 3	Ånestad - Terningen skanse	8,270	22/10 01	3	0,625	3	8,895	EBRU	RV	3	3	3,495	MJØSBRUA	EV	6	5	14,200	7
6	Buskerud	RV 35	Langerud - Knivedalen S	4,900	9/1 02	4	5,035	4	9,930	KVERK	RV	35	4	7,371	FLAA	RV	7	7	8,400	6
8	Telemark	EV 18	Bamble kirke - Dørdal	13,000	18/10 01	6	5,193	8	0,174	STOKKEBAKKEN	EV	18	7	1,800	SELJORD	EV	134	10	5,090	8
9	Aust-Agder	EV 18		6,851	24/10 01	17	2,638	17	9,489	OMRE	EV	18	17	7,416	NY VINTERKJ	EV	18	3	2,371	9
12	Hordaland	EV 39	Steinestøvegen - Nordhordland	5,275	1/10 01	21	6,136	22	1,675	KLAUVANESET	EV	39	22	1,000	DJUPEVIK	EV	16	9	5,000	14
12		RV 556	Bønes - Fjøsangerbukta	2,750	16/10 01	3	0,250	3	3,000	BØNES	RV	556	3	2,600	DJUPEVIK	EV	16	9	5,000	15
15	Møre&Romsdal	EV 39	Ekset - Hovden - Ørsta	4,850	15/10 01	6	3,190	6	8,040	V HOVDEN	EV	39	6	5,847	VAAGE	EV	136	5	0,080	1
15		EV 136	Nørvevika - Ålesund	3,700	5/10 01	8	5,640	8	9,720	VOLDSDALEN	EV	136	8	9,140	VAAGE	EV	136	5	0,080	4
19	Troms	EV 8	Troms fisk - Nova krysset	2,300	12/7 01	6	19,500	6	21,769	HUNGEREN	EV	8	6	20,800	NORDKJOSBC	EV	6	12	24,660	3
20	Finnm	RV 93	Bossekop - Salkobekken	2,500	10/12 01	1	0,422	1	2,547	ETTER X FV 14	RV	93	1	1,250	TOMASELV	EV	75	4	15,079	12
90 km/h-80 km/h																				
1	Østfold	EV 6	Svingenskogen-Kalnes	24,390	10/10 01	1	4,580	5	0,730	SANDESUND SØR	EV	6	3	11,40						19
2	Akershus	EV 6	Nordgående retning	32,456	7/11 01	12	1,270	15	2,866	HOVINMOEN ULLE	EV	6	12	4,120	ØRBEKK	EV	6	15	3,850	18
2			Sørgående			15	2,866	12	1,270	EIDSVOLL TUNELI	EV	6	14	1,025						
4	Hedmark	EV 6	Akershus gr.- Kolomoen	23,4	25/10 01	1	0	2	9,5	ESPA KRO	EV	6	1	7,38	VERVEN	EV	6	4	12,495	10
5	Oppland	EV 6	Lillehammer bru N - Rustberg	21,129	22/10 01	6	0,92	10	3,515	ØYER GR. SYD	EV	6	8	4,579						20
20	Finnmark	EV 6	Skiippagurra - Varangerbotn	11,735	3/10 01	23	4,489	23	16,224	SEIDAFJELLET	EV	6	23	9,4						23

Source: TØI report 784/2005

After quality assurance, partly by the computer program and partly by the elimination of unsuitable sites, data from 29 sites remains.

This is shown in Table 2. The upper part of the table shows sites where the speed limit is changed from 80 km/h to 70 km/h, while the lower part concerns 90 km/h to 80 km/h. The table shows that the data material for the evaluation of speed limit changes from 80 km/h to 70 km/h includes eleven data pairs each consisting of treatment and comparison sites (a total of 22 measurement sites).

Correspondingly, the table shows that the data for the 90 km/h to 80 km/h sections consists of two data pairs with both treatment and comparison sites, as well as three treatment sites for which it had not been possible to find suitable comparison sites (a total of seven measurement sites).

In total, at the 16 treatment and 13 comparison sites speed measurements were carried out for more than 97710 hours with more than 57 million vehicles passing. Table 3 shows distributions of the number of vehicles in the before and after-periods at the treatment and comparison sites.

Table 3: Data material used after quality assurance. Number of speed measurements before and after speed limit changes at treatment and comparison sites and in total.

	Treated		Comparison		Total	
	Before	After	Before	After	Before	After
80 km/h -70 km/h	12528963	12821282	5816427	6053589	18345390	18874871
90 km/h -80 km/h	7162606	7536759	2858459	2955170	10021065	10491929
Total	19691569	20358041	8674886	9008759	28366455	29366800

Source: TØI report 784/2005

Table 3 shows that quality assured speed measurements were taken of a total of 28366455 vehicles in the before-situation and 29366800 in the after-situation as well as how these were distributed among treatment and comparison sites.

The number of speed measurements, of course, varied from site to site, but there are never less than 6000 vehicles in any given period (either before or after) at any of the sites selected. The largest value is over three million vehicles passing at any one site in any given period.

With such a large amount of data for both in the before and after-periods, even very small changes (0.2 km/h) in mean speed will be statistically significant. There will, however, always be differences between the before and after-periods that are not possible to fully control for. This means that there can easily be statistical differences between the before and after-periods without this being caused by the speed limit changes. An attempt has been made to control for this using comparison sites. But also between comparison sites and treatment sites, there could be differences that cannot be controlled for that can affect the results in various ways.

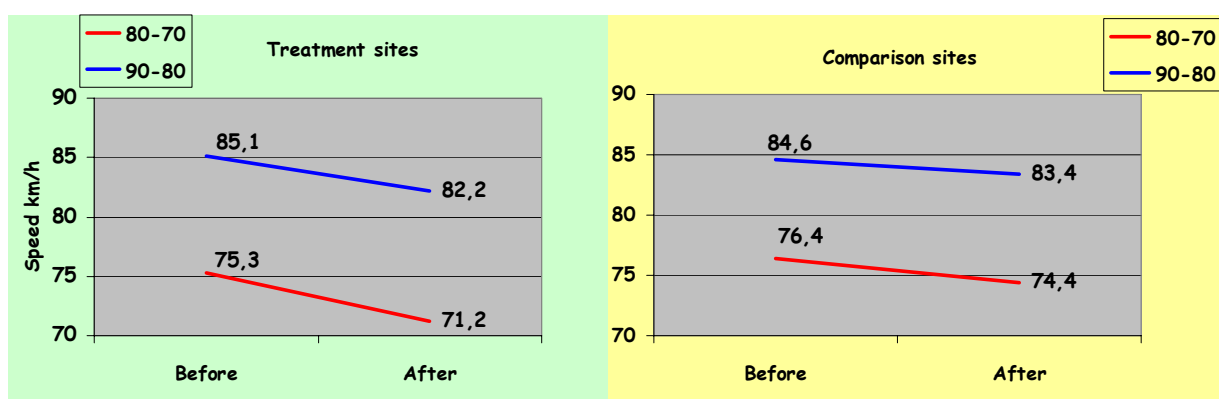
With such a large amount of data, even the minor influence of such external factors could cause significant differences between the before and after-periods. Not all significant differences should necessarily be interpreted as an effect of the

speed limit change. Therefore, small changes (<0.5 km/h) are not interpreted as effects of speed limit changes. The larger the change, the more likely it is that the effect will be due to the speed limit change.

4.3 Results (driving speeds)

Figure 1 shows the overall results from 80 km/h to 70 km/h and 90 km/h to 80 km/h speed limit changes. Changes at the treatment sites are shown in the left part of the figure.

The upper curve in the left part of the figure shows results of the 90 km/h to 80 km/h speed limit changes. The lower curve pertains to the 80 km/h to 70 km/h change. The right hand part of the figure shows the results at the comparison sites (90 km/h to 80 km/h is given by the upper curve in the figure).



Source: TØI report 784/2005

Figure 1: Results of speed limit changes from 80 km/h to 70 km/h and from 90 km/h to 80 km/h. Driving speeds measured in km/h at treatment and comparison sites during the period before and after speed limit changes.

By changing the speed limit from 80 km/h to 70 km/h, driving speeds were reduced by 4.1 km/h. The 75.3 km/h speed in the before-situation was changed to 71.2 km/h in the after-situation.

The result is based on measurements at eleven sites in eight counties. This is displayed in Table 4.

More than 12.5 million vehicles were observed at the eleven treatment sites during each of the periods before and after speed limit changes. Traffic at the comparison sites is about half that found at the treatment sites.

The measured speed change varied from site to site between -2.2 km/h and -7.0 km/h. The standard deviation of speeds at the same sites changes between -0.2 km/h and -0.9 km/h. The average speed declines at all sites and the standard deviation is reduced (smaller speed differences between drivers). Nearly 50% of the drivers exceed the new speed limit (70 km/h).

Table 4: Pair-wise overview of treatment and comparison sites. Number of hours recorded, number of vehicles observed, driving speeds before and after speed limit change (km/h). Gross and net speed change (km/h) with speed limit change from 80 km/h to 70 km/h.

Pair no	Number of hours recorded	Treatment								Comparison								Net effect	
		BEFORE			AFTER			CHANGE		BEFORE			AFTER			CHANGE		Speed km/h	St dev km/h
		Cars no	Speed km/h	St dev km/h	Cars no	Speed km/h	St dev km/h	Speed km/h	St dev km/h	Cars no	Speed km/h	St dev km/h	Cars no	Speed km/h	St dev km/h	Speed km/h	St dev km/h	Speed km/h	St dev km/h
1	6813	902980	69,2	8,4	916166	66,2	7,6	-3,1	-0,9	171689	78,2	12,6	184015	77,3	12,6	-0,9	0,0	-2,1	-0,9
3	13585	2093744	73,3	9,2	2210564	68,7	8,4	-4,6	-0,9	786311	72,9	9,4	800006	72,1	9,2	-0,8	-0,2	-3,7	-0,7
4	7936	3320199	76,5	6,8	3298705	71,9	6,5	-4,7	-0,2	199276	78,4	12,5	212165	76,9	12,5	-1,5	0,0	-3,2	-0,3
6	3174	543133	76,9	7,9	570403	74,6	7,4	-2,2	-0,5	215858	74,2	7,7	226915	74,3	7,7	0,1	0,0	-2,3	-0,5
7	8032	1667124	75,1	6,8	1729701	71,2	6,6	-3,8	-0,3	1553571	82,9	7,2	1617398	82,0	7,1	-0,9	-0,1	-2,9	-0,1
8	1236	171395	75,4	6,6	185997	71,9	6,3	-3,5	-0,3	68527	81,1	11,5	73332	80,2	11,3	-1,0	-0,2	-2,5	0,0
9	6948	1102220	75,3	6,5	1100249	73,1	6,1	-2,2	-0,4	742131	81,3	7,5	784529	78,9	7,5	-2,4	-0,1	0,1	-0,3
12	1469	82119	71,6	9,8	83240	67,7	9,6	-3,9	-0,2	63443	74,0	9,3	62010	73,3	9,8	-0,8	0,4	-3,1	-0,6
14	3715	638258	77,9	6,1	663567	70,9	5,8	-7,0	-0,3	178644	81,6	6,6	190197	79,1	6,3	-2,6	-0,2	-4,5	-0,1
15	3507	946299	73,2	6,1	952346	68,4	5,4	-4,7	-0,7	168544	81,7	6,6	179365	79,0	6,3	-2,7	-0,3	-2,0	-0,5
16	7988	1061492	80,9	8,8	1110344	77,7	8,5	-3,2	-0,3	1668433	68,4	8,1	1723657	64,4	7,5	-4,0	-0,6	0,8	0,3
All	64403	12528963	75,3	7,4	12821282	71,2	7,0	-4,1	-0,4	5816427	76,4	8,2	6053589	74,4	7,9	-2,0	-0,3	-2,1	-0,2

Source: TØI report 784/2005

At the comparison sites, driving speeds have also changed from the before to the after-period. On average for all eleven sites, the speed changed by -2.0 km/h. The standard deviation is reduced by 0.3 km/h.

Since the treatment sites did not have specific comparison sites (comparison sites specifically matched to each treatment site), it is difficult to estimate the exact net effect of the speed limit change, site pair by site pair. The net effect is defined as the change at the treatment site adjusted for changes at the comparison site.

The measured speed limit change effect from 80 km/h to 70 km/h at all treatment sites is -4.1 km/h. At the corresponding comparison sites the changes were -2.0 km/h. As mentioned, these are not perfect comparison sites, but do still represent a large number of sites on the 80 km/h road network where no known factors should have affected the driving speed. Still, the driving speed changed by -2.0 km/h from the before to the after-period. Conditions that could not be controlled for could therefore conceivably also have had an effect on driving speeds at the treatment sites. This uncertainty shall be handled by concluding that the speed change caused by speed limit change from 80 km/h to 70 km/h is between -4.1 km/h and -2.1 km/h. The standard deviation does not change.

Table 5 shows a similar overview of the results from sections where the speed limit was changed from 90 km/h to 80 km/h.

Where the speed limit was changed from 90 km/h to 80 km/h, the driving speed change was measured to be -2.8 km/h. The mean speed in the before-situation is measured to be 85.1 km/h against 82.2 km/h in the after-situation.

The result is based on measurements at five sites in just as many counties. More than seven million vehicles are observed during the before and after-period at the treatment sites. That total traffic at the comparison sites is substantially lower can be explained by the fact that only two of the five treatment sites had comparison sites. The estimated effect varies from -0.8 km/h to -4.1 km/h between the five sites. The site with the modest speed change of -0.8 km/h is particularly secluded with high driving speeds both in the before and after-periods. The overall standard deviation for all sites changed by -0.4 km/h.

The same reasoning and problem related to the use of comparison sites were in evidence with the 90 km/h to 80 km/h speed limit change. The average speed change at the treatment sites is estimated to -2.8 km/h. At the comparison sites the change is -1.2 km/h. Comparison sites are found for only two of the five sites.

When these results are interpreted analogously with the 80 km/h to 70 km/h change, it means that the speed change caused by the speed limit change from 90 km/h to 80 km/h is between -2.8 km/h and -1.6 km/h.

Table 5: Pair-wise overview of treatment and comparison sites. Number of observation hours, number of vehicles recorded, driving speeds before and after speed limit change (km/h). Net and gross speed change (km/h) by the 90 km/h to 80 km/h speed change.

Pair no	Number of hours recorded	Treatment									Comparison									Net effect	
		BEFORE			AFTER			CHANGE			BEFORE			AFTER			CHANGE			Speed km/h	St dev km/h
		Cars no	Speed km/h	St dev km/h	Cars no	Speed km/h	St dev km/h	Speed km/h	St dev km/h		Cars no	Speed km/h	St dev km/h	Cars no	Speed km/h	St dev km/h	Speed km/h	St dev km/h			
10	8008	1570136	86,7	10,1	1639523	83,5	9,6	-3,2	-0,5		2122110	86,8	7,0	2190575	85,7	7,1	-1,1	0,1	-2,1	-0,6	
18	4179	1365872	90,6	7,8	1403068	88,0	7,9	-2,6	0,1		736349	78,4	6,1	764595	76,6	5,8	-1,8	-0,3	-0,9	0,4	
19	7085	2822900	81,3	8,1	3043425	79,2	7,6	-2,0	-0,5								0,0	0,0	-2,0	-0,5	
20	9477	1315225	85,1	7,6	1359552	80,9	7,3	-4,1	-0,3								0,0	0,0	-4,1	-0,3	
23	4558	88473	91,5	10,5	91191	90,7	10,6	-0,8	0,2								0,0	0,0	-0,8	0,2	
All	33307	7162606	85,1	8,4	7536759	82,2	8,1	-2,8	-0,4		2858459	84,6	6,8	2955170	83,4	6,7	-1,2	0,0	-1,6	-0,3	

Source: TØI report 784/2005

5. Effect on injuries and accidents

This chapter deals with the effect of the speed limit changes on the number of injuries and accidents.

5.1 Study approach (injuries and accidents)

Changes in the number of fatalities and injuries as well as the number of accidents are the result variables in the accident evaluation. The following notations were used:

Fatalities(FA)

Very seriously injured (VSI)

Seriously injured (SI)

Lightly injured (LI)

Severely injured ($SEI=VSI+SI$)

Accidents (ACC)

The changes will be demonstrated by comparing the period before speed limit reduction with the period after. The changes are given in percent relative to the before-situation. A negative percentage indicates a reduction.

Changes on the comparison sections shall be estimated and designated in the same manner as changes on the treated sections. The changes are also given in percent of the before-situation level. Any changes estimated on the comparison sections are also changes to be expected to occur on the treated sections. The changes on the treated sections shall therefore be adjusted for changes measured on the comparison sections. This is being done by the estimation of so-called odds ratios.

This approach is identical to adjusting the treatment section material from the before-situation with the estimated changes on the comparison sections from the before to the after-situation.

Accident and injury numbers will also be adjusted for regression-to-the-mean. The regression-to-the-mean are given in percent of the recorded numbers..

5.2 Available data (injuries and accidents)

5.2.1 Sections with a reduced speed limit, treated sections.

Of the total of 294 road sections with lowered speed limit, 237 sections are included in the material used as a basis for evaluating the effects on injuries and accidents. These constitute the treated sections where the speed limit was changed either from 90 km/h to 80 km/h or from 80 km/h to 70 km/h. Sections from all counties are included with the exception of the sections in Oslo, Rogaland, Hordaland, Nordland, Troms and Finnmark. The reason for this omission has been general problems related to injury and accident data from these counties in 2002 and 2003 (the after-period). The injury and accident evaluation comprises:

- 203 sections in 13 counties with a total length of 631.270 km where the speed limit was changed from 80 km/h to 70 km/h.
- 34 sections in 11 counties with a total length of 271.049 km where the speed limit was changed from 90 km/h to 80 km/.

Descriptions of the sections included are found in Tables 6 and 7.

In addition to showing the number of sections included in the evaluation for each of the two speed limit changes, the tables show the before and after-period durations (from date to date and number of days) as well as injury and accident numbers during the two periods.

A total of 3025 (2307+718) accidents are included in the before-period and 712 (455+257) in the after-period. On the sections with speed limits lowered from 80 km/h to 70 km/h, there were 748 fatalities and severe injuries in the before-period and 100 in the after-period. Corresponding figures for the sections with a speed limit change from 90 km/h to 80 km/h were 339 and 106 respectively.

The times of the speed limit reductions are also given in the tables. To obtain a before-period of entire years (simplicity in comparison section accident data) the 1.1.1993 to 31.12.2000 period was chosen. This covers eight years or 2922 days. The chosen after-period ranges from one week after speed limit reduction until 31.12.2003. This represents 2.1 years or 650-800 days.

The number of sections with a speed limit reduction from 80 km/h to 70 km/h is much larger than the number with speed limit reduction from 90 km/h to 80 km/h. This is the case both overall and by county and means that results from the 80 km/h to 70 km/h group can be meaningful at the county level. For comparison, the results from the other group, 90 km/h to 80 km/h, are also presented at the county level, but the numbers are too small to be meaningful.

Table 6: Overview by county of the injury and accident evaluation sections with speed limit changes from 80 km/h to 70 km/h. Number of sections in each county by length (km), time of speed limit change, duration (in days) of before and after-periods and number of accidents and injuries during the two periods. Number of fatalities (FA), very seriously injured (VSI), seriously injured (SI) and lightly injured (LI).

Speed limit change 80km/h - 70 km/h				BEFORE period				AFTER period												
County	No of sections	Length of km	Date of Change	Fromdate	Todate	NO of days	Accident number	Injured/killed No of persons				NO of days	Accident number	Injured/killed No of persons						
No	Name	sec						FA	VIS	SI	LI			FA	VIS	SI	LI			
1	Østfold	6	20,980	mars/okt 02	01.01.93	31.12.00	17532	160	13	4	19	213	mars/okt02	31.12.03	4014	29	3	0	4	45
2	Akershus	7	57,469	okt/nov 01	01.01.93	31.12.00	20454	220	15	12	46	290	okt/nov 02	31.12.03	4773	46	5	2	7	47
3	Oslo				01.01.93	31.12.00							31.12.03							
4	Hedmark	13	31,867	okt/nov 01	01.01.93	31.12.00	37986	111	8	10	23	142	07.11.01	31.12.03	10179	25	4	1	8	54
5	Oppland	18	56,195	22.10.01	01.01.93	31.12.00	52596	188	20	7	40	236	07.11.01	31.12.03	14094	26	0	0	3	40
6	Buskerud	16	63,297	okt01/jan02	01.01.93	31.12.00	46752	215	29	11	38	294	okt01/jan02	31.12.03	11679	43	4	0	4	62
7	Vestfold	13	31,927	02.10.01	01.01.93	31.12.00	37986	110	8	7	9	147	10.10.01	31.12.03	10166	25	2	1	4	28
8	Telemark	18	68,285	okt/des 01	01.01.93	31.12.00	52596	245	10	9	37	332	okt/des01	31.12.03	13833	63	0	0	8	106
9	Aust-Agder	11	54,689	24.10.01	01.01.93	31.12.00	32142	288	19	25	38	348	07.11.01	31.12.03	8613	48	1	0	7	72
10	Vest-Agder	10	41,900	11.10.01	01.01.93	31.12.00	25550	127	20	3	22	171	15.10.01	31.12.03	8060	33	8	0	5	45
11	Rogaland																			
12	Hordaland																			
14	Sogn & Fjordane	10	21,036	okt/nov01	01.01.93	31.12.00	29220	65	8	5	12	70	05.11.01	31.12.03	7860	13	0	0	1	16
15	Møre & Romsdal	17	47,362	okt 01	01.01.93	31.12.00	49674	172	16	15	43	189	07.11.01	31.12.03	13311	35	0	0	3	59
16	Sør-Trøndelag	49	105,661	jan/feb 02	01.01.93	31.12.00	143178	302	29	23	57	404	jan/ feb02	31.12.03	34741	55	3	0	12	87
17	Nord-Trøndelag	15	30,602	nov/des 01	01.01.93	31.12.00	43830	104	16	2	20	113	nov/des 01	feb03	7080	14	0	0	0	19
18	Nordland																			
19	Troms																			
20	Finnmark																			
Total 80-70		203	631,270				589496	2307	211	133	404	2949			148403	455	30	4	66	680

Source: TØI report 784/2005

Table 7: Overview by county of the injury and accident evaluation sections with speed limit changes from 90 km/h to 80 km/h. Number of sections in each county by length (km), time of speed limit change, duration (in days) of before and after-periods and number of accidents and injuries during the two periods. Number of fatalities (FA), very seriously injured (VSI), seriously injured (SI) and lightly injured (LI).

Speed limit change 90km/h - 80 km/h				BEFORE period			Accident number	Injured/killed No of persons				AFTER period			Accident number	Injured/killed No of persons			
County No Name	No of km sec	Length of km	Date of Change	Fromdate	To date	NO of days		FA	VIS	SI	LI	Fromdate	To date	NO of days		FA	VIS	SI	LI
1 Østfold	1	17,100	10.10.2001	01.01.93	31.12.00	2920	60	13	8	15	83	15.10.01	31.12.03	807	25	4	0	3	43
2 Akershus	2	37,319	07.11.2001	01.01.93	31.12.00	5840	111	21	4	37	150	14.11.01	31.12.03	1552	43	6	2	14	63
3 Oslo				01.01.93	31.12.00														
4 Hedmark	2	27,750	25.10.2001	01.01.93	31.12.00	5840	93	9	9	21	133	31.10.01	31.12.03	1584	27	2	4	13	35
5 Oppland	9	53,199	okt / nov 2001	01.01.93	31.12.00	26280	116	20	2	34	167	okt/nov 01	31.12.03	7114	20	7	1	6	36
6 Buskerud	2	15,923	08.10.2001	01.01.93	31.12.00	5840	65	5	3	7	62	15.10.01	31.12.03	1614	10	1	1	4	19
7 Vestfold																			
8 Telemark	2	43,581	16/17.10.2001	01.01.93	31.12.00	5840	128	24	9	36	160	22.10.01	31.12.03	1600	38	2	2	12	39
9 Aust-Agder	3	7,486	10.10.2001	01.01.93	31.12.00	8760	13	2	3	3	13	17.10.01	31.12.03	2415	4	1	0	1	8
10 Vest-Agder	1	10,745	11.10.2001	01.01.93	31.12.00	2920	32	6	1	5	47	17.10.01	31.12.03	805	24	0	0	1	30
11 Rogaland																			
12 Hordaland																			
14 Sogn & Fjordane																			
15 Møre & Romsdal	1	6,570	11.10.2001	01.01.93	31.12.00	2920	14	3	0	0	23	17.10.01	31.12.03	805	4	1	0	1	11
16 Sør-Trøndelag	5	29,954	okt 2001	01.01.93	31.12.00	14600	63	4	4	26	87	12.10.01	31.12.03	4050	52	7	0	8	76
17 Nord-Trøndelag	6	21,422	okt 2001	01.01.93	31.12.00	17520	23	1	0	4	29		31.12.03	4884	10	1	0	1	13
18 Nordland																			
19 Troms																			
20 Finnmark																			
Total 90-80	34	271,049				99280	718	108	43	188	954			27230	257	32	10	64	373

Source: TØI report 784/2005

5.2.2 Comparison sections

Comparison sections are being compared with treated sections in before-and- after studies such as these. Speed limits are not changed on the comparison sections. Since the treated sections are selected in the manner that they are, as sections with a large number of injuries and accidents, it will be difficult, or nearly impossible, to find perfect comparison sections in Norway. The speed limit is changed on all sections where the expected injury severity exceeds a certain level.

To still being able to undertake some comparison of what is happening on the remaining road network where the speed limit has not been changed, two possible comparison networks were established:

Comparison I consists of those sections on the National and European road network where the speed limit had not been changed. Comparison network I associated with the 80 km/h to 70 km/h speed limit reduction consists of that part of the National and European road network that retained its 80 km/h speed limit from 1993 until and including 2003. This road network has a total length of 11771 km. Correspondingly, for the 90 km/h to 80 km/h speed limit reduction, comparison network I consists of the road network where the speed limit has been 90 km/h throughout the entire 1993 to 2003 period. The road network classified as motorway A was excluded. The road network is 399 km long.

Before and after-periods are the same for both comparison networks and the same as for the treated sections.

Comparison II consists of the entire road network in Norway regardless of speed limit and road type, minus the section with speed limit reductions from 80 km/h to 70 km/h or from 90 km/h to 80 km/h (or where speed limits were raised to 100 km/h).

5.3 Results (injuries and accidents)

The following presents accident, injury and fatality results from the speed limit changes. It was decided to present the results in the following order:.

Gross effects

Regression-to-the-mean

Changes on the comparison sections

Summary and estimation of net effects

The results of the 80 km/h to 70 km/h section speed limit change are presented first under each of these points.

5.3.1 Gross effects

By gross effects are meant the changes that can directly be seen as the difference between the before and after-period in the recorded number of accidents or injuries.

Length in km of the speed limit reduction sections is identical in the before and after-periods. Duration, in terms of length of time period, is on the other hand different for the two periods. This must be taken into account. The durations are given in Table 6 and Table 7.

The percent change is estimated as the difference between number in the before-period and the number in the after-period adjusted for differences in the duration relative to the number in the before-situation.

The estimated changes from 80 km/h to 70 km/h shown in Table 8 are by county and overall. The table also shows the number of accidents and the number of injured and killed per km and year in the before-period. The road network with speed limit reduction consists of 203 sections in 13 counties with a total length of 631.270 km.

Table 8: Overview by county of gross changes (%) in number of injuries and accidents with 80 km/h to 70 km/h speed limit reduction. Number of accidents and injured/killed per km and year in the before-period.

Speed limit change 80 km/h - 70 km/h			Before period				Change in %							
County	No of sec	Length km	Accidents pr km and year	Injured/killed persons no per km and year				Accidents	Injured/killed persons					
No	Name			FA	VIS	SI	LI		FA	VIS	SI	LI		
1	Østfold	6	20,980	0,953	0,077	0,024	0,113	1,268	-20,8	0,8	-100,0	-8,0	-7,7	
2	Akershus	7	57,469	0,478	0,033	0,026	0,100	0,630	-10,4	42,8	-28,6	-34,8	-30,5	
3	Oslo													
4	Hedmark	13	31,867	0,435	0,031	0,039	0,090	0,557	-16,0	86,6	-62,7	29,8	41,9	
5	Oppland	18	56,195	0,418	0,044	0,016	0,089	0,525	-48,4	-100,0	-100,0	-72,0	-36,7	
6	Buskerud	16	63,297	0,424	0,057	0,022	0,075	0,580	-19,9	-44,8	-100,0	-57,9	-15,6	
7	Vestfold	13	31,927	0,430	0,031	0,027	0,035	0,575	-15,1	-6,6	-46,6	66,1	-28,8	
8	Telemark	18	68,285	0,448	0,018	0,016	0,068	0,607	-2,2	-100,0	-100,0	-17,8	21,4	
9	Aust-Agder	11	54,689	0,658	0,043	0,057	0,087	0,795	-37,8	-80,4	-100,0	-31,3	-22,8	
10	Vest-Agder	10	41,900	0,433	0,068	0,010	0,075	0,583	-17,6	26,8	-100,0	-28,0	-16,6	
11	Rogaland													
12	Hordaland													
14	Sogn & Fjordane	10	21,036	0,386	0,048	0,030	0,071	0,416	-25,6	-100,0	-100,0	-69,0	-15,0	
15	Møre & Romsdal	17	47,362	0,454	0,042	0,040	0,113	0,498	-24,1	-100,0	-100,0	-74,0	16,5	
16	Sør-Trøndelag	49	105,661	0,357	0,034	0,027	0,067	0,478	-24,9	-57,4	-100,0	-13,2	-11,2	
17	Nord-Trøndelag	15	30,602	0,425	0,065	0,008	0,082	0,461	-16,7	-100,0	-100,0	-100,0	4,1	
18	Nordland													
19	Troms													
20	Finnmark													
Total 80-70			203	631,270	0,460	0,042	0,027	0,081	0,588	-21,2	-43,2	-88,0	-34,7	-7,9

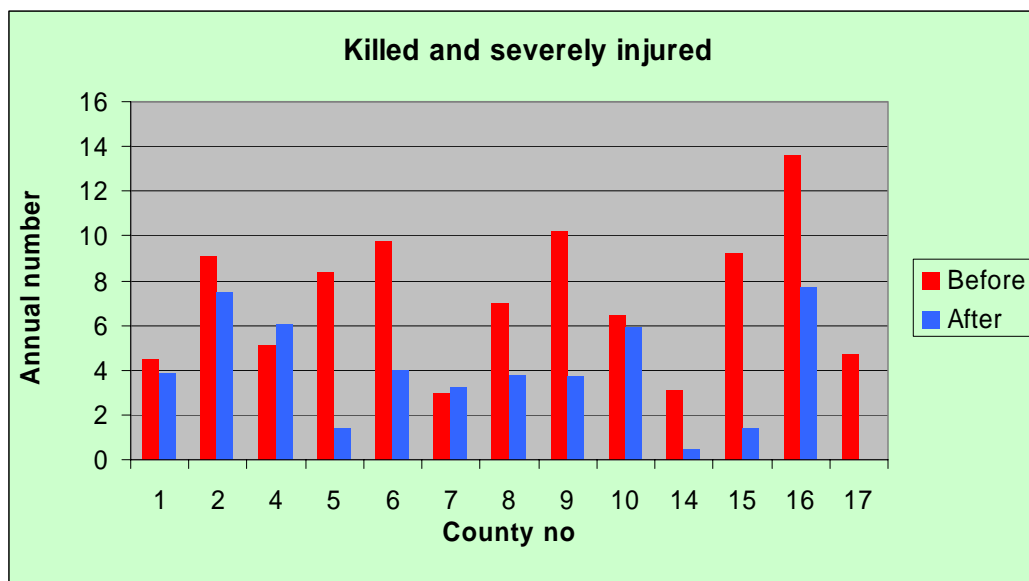
Source: TØI report 784/2005

Table 8 shows that the recorded number of fatalities (FA) is reduced by 43.2% for all sections combined when the speed limit is changed from 80 km/h to 70 km/h. The number of seriously injured (VSI) is reduced by 88.0%, seriously injured (SI) by 34.7% and lightly injured (LI) by 7.9%. Killed and severely injured (FA+SEI) together are reduced by 46.6%. The combined number of accidents in all counties is reduced by 21.2%, from 0.46 accidents per km and year in the before-period to

0.36 accidents per km and year in the after-period. The overall results for all counties combined are significant at the 5% level.

The number of accidents were reduced in all counties. The change varies between -2.2% and -48.4%.

The change in the number of fatalities and severe injuries also varied substantially between the counties. Figure 2 shows the annual number recorded killed and severely injured by county (county number) in the before and after-situation with a speed limit reduction from 80 km/h to 70 km/h by county (county number).



Source: TØI report 784/2005

Figure 2: Recorded annual number killed and severely injured on the treatment road network before and after speed limit change from 80 km/h to 70 km/h.

All counties, with the exception of two, experienced a reduction in the number of fatalities and people severely injured from the before-period to the after-period. The numbers for the two exceptions are too small to be statistically reliable. Overall for all counties, the number killed and severely injured is reduced from 94.0 persons per year in the before situation to 49.9 per year in the after-situation (as mentioned, a reduction of 46.6%).

Table 9: Overview by county of gross changes (%) in the number of injuries and accidents with 90 km/h to 80 km/h speed limit reduction. Number of accidents and injured/killed per km and year in the before-period.

Speed limit change 90 km/h - 80 km/h			Before period				Change in %					
County	No of	Length	Acciden	Injured/killed persons			Acciden	Injured/killed persons				
No Name	sec	km	pr km and year	no per km and year	FA	VIS	SI	LI	FA	VIS	SI	LI
1 Østfold	1	17,100	0,439	0,095	0,058	0,110	0,607	50,8	11,3	-100,0	-27,6	87,5
2 Akershus	2	37,319	0,372	0,070	0,013	0,124	0,502	45,8	7,5	88,1	42,4	58,0
3 Oslo												
4 Hedmark	2	27,750	0,419	0,041	0,041	0,095	0,599	7,0	-18,1	63,9	128,2	-3,0
5 Oppland	9	53,199	0,273	0,047	0,005	0,080	0,392	-36,3	29,3	84,7	-34,8	-20,4
6 Buskerud	2	15,923	0,510	0,039	0,024	0,055	0,487	-44,3	-27,6	20,6	106,8	10,9
7 Vestfold												
8 Telemark	2	43,581	0,367	0,069	0,026	0,103	0,459	8,4	-69,6	-18,9	21,7	-11,0
9 Aust-Agder	3	7,486	0,217	0,033	0,050	0,050	0,217	11,6	81,4	-100,0	20,9	123,2
10 Vest-Agder	1	10,745	0,372	0,070	0,012	0,058	0,547	172,0	-100,0	-100,0	-27,5	131,5
11 Rogaland												
12 Hordaland												
14 Sogn & Fjordane												
15 Møre & Romsdal	1	6,570	0,266	0,057	0,000	0,000	0,438	3,6	20,9	0,0	0,0	73,5
16 Sør-Trøndelag	5	29,954	0,263	0,017	0,017	0,108	0,363	197,6	530,9	-100,0	10,9	214,9
17 Nord-Trøndelag	6	21,422	0,134	0,006	0,000	0,023	0,169	56,0	258,7	0,0	-10,3	60,8
18 Nordland												
19 Troms												
20 Finnmark												
Total 90 -80	34	271,049	0,331	0,050	0,020	0,087	0,440	31,1	8,5	-14,8	24,7	43,2

Source: TØI report 784/2005

Table 9 shows corresponding results for the road network having the speed limit changed from 90 km/h to 80 km/h. The eleven county, 34 road section speed limit reduction network makes up a total of 271 km. Results by county are thus based on relatively limited data which hardly are individually meaningful.

Table 9 shows a total gross accident **increase** of 31.1%. The recorded number of fatalities (FA=8.5%), of seriously injured (AS=24.7%) and of lightly injured (LS=43.2%) also show an increase. The number of fatalities and severely injured (FA+SEI) increased by 14.5%. None of the increases are significant at the 5% level.

5.3.2 Regression-to-the-mean

The regression-to-the-mean are estimated as a percentage difference between expected and recorded injury and accident numbers relative to recorded numbers. The upper part of Table 10 shows the estimated overall regression-to-the-mean for the sections.

The upper part of Table 10 reveals that the regression-to-the-mean for injury accidents is estimated to -6.7% when the speed limit is changed from 80 km/h to 70 km/h. This means in practice that 6.7% of the recorded accidents in the before-situation (154.4 accidents) are caused by random variations and that the "correct" accident number is 2151.6 and not 2307.

For injured and killed the regression-to-the-mean varies between -2.1% for light injuries and -34.9% for very serious injuries.

Table 10: Estimated regression-to-the-mean for sections where the speed limit is changed from 80 km/h to 70 km/h (upper part) and 90 km/h to 80 km/h(lower part). Recorded and expected injury and accident numbers in the before-situation.

	Number	Number	The mean %
80 km/h - 70 km/h			
Accidents	2307	2151,6	-6,7
FA	211	161,2	-23,6
VIS	133	86,6	-34,9
SI	404	362,2	-10,3
LI	2949	2886	-2,1
90 km/h - 80 km/h			
Accidents	337	320,0	-5,0
FA	56	47,4	-15,4
VIS	16	15,2	-5,2
SI	91	77,1	-15,3
LI	449	441,6	-1,7

Source: TØI report 784/2005

This pattern is not unexpected for two reasons. Firstly, the largest regression-to-the-mean is typically found with the lowest numbers, i.e. number killed and number seriously injured. This is to be expected because pure random variations play a relatively larger role the lower the number. Secondly, serious accidents are overrepresented on the sections in question. Therefore, all else being equal, a greater regression-to-the-mean should be expected with serious injuries than with lighter injuries. The latter are in many cases underrepresented and the regression-to-the-mean here is also close to zero.

The overall regression-to-the-mean for killed and severely injured (80 km/h to 70 km/h) is estimated to 18.5%.

When the estimated accident regression-to-the-mean is used to correct the previously estimated gross accident reduction effect for an 80 km/h to 70 km/h speed limit change (-21.2%, see Table 8), the results in Table 10 implies that the adjusted gross effect (gross effect without regression-to-the-mean) can be estimated to -15.5%.

Correspondingly, the gross effects can be estimated for fatalities (-25.6%), very seriously injured (-81.5%), seriously injured (-27.2%) and lightly injured (-5.8%). For fatalities and severely injured, the overall gross effect adjusted for regression-to-the-mean can be estimated to -34.5%.

The lower part of Table 10 shows the estimated overall regression-to-the-mean for the sections where the speed limit was changed from 90 km/h to 80 km/h. Here, the estimated regression-to-the-mean are generally lower than the 80 km/h to 70 km/h values. However, all have the same sign and are smallest where the absolute numbers are largest.

For accidents, the regression-to-the-mean for the 90 km/h to 80 km/h change is estimated to -5.0%. The largest regression-to-the-mean is for fatalities, where the regression-to-the-mean is estimated to -15.4%

Since the regression-to-the-mean is negative and some gross effects on the 90 km/h to 80 km/h network are positive with larger values, this indicates that the gross effects adjusted for regression-to-the-mean will be positive and numerically larger than without this adjustment. For fatalities, this adjusted gross effect can be estimated to 28.2%. The total for killed and severely injured, the gross effect of speed limit change from 90 km/h to 80 km/h adjusted for regression-to-the-mean is estimated to 33.2%

5.3.3 Comparison sections

The choice of injury and accident prone sections for speed limit reduction made it difficult to find suitable comparison sections in this part of the project. Two possible comparison networks were defined (see section 5.2.2). The road network called **comparison I** (the remaining National and European network in the relevant counties with unchanged speed limit) is really two different networks for the two speed limit changes. **Comparison II**, the entire road network in Norway minus the parts where the speed limit was changed, is identical for the two groups.

Table 11 shows the estimated changes for the two comparison networks from the before to the after-period for the 80 km/h to 70 km/h change.

Table 11: Percent change in the number of injuries and accidents on comparison network I and II for sections with a speed limit reduction from 80 km/h to 70 km/h. Total number of accidents and injuries per month in the before and after-period.

Comparison I	80 km/h - 70 km/h				Change %
	Before Number	No per month	After Number	No per month	
Accidents	9188	95,71	2298	95,75	0,0
FA	534	5,56	170	7,08	27,3
VIS	276	2,88	58	2,42	-15,9
SI	1578	16,44	375	15,63	-4,9
LI	11822	123,15	3095	128,96	4,7
Comparison II					
Accidents	66575	693,49	17222	680,71	-1,8
FA	2213	23,05	578	22,85	-0,9
VIS	1140	11,88	238	9,41	-20,8
SI	8789	91,55	1919	75,85	-17,2
LI	80214	835,56	21241	839,57	0,5

Source : TØI report 729/2004

Table 11 shows that comparison II comprises a considerably larger amount of data than comparison I. While comparison I encompasses 9188 accidents in the before-situation and 2298 in the after-situation, for comparison II the number of accidents is 66575 in the before-situation and 17222 in the after-situation. Comparison II should therefore be considered to be a more robust comparison

than comparison I. The comparison I material represents 11771 km of road and includes the far busiest roads in Norway.

The table also shows the estimated changes from the before to the after-period on the two comparison networks. Changes in number of accidents, number of persons very seriously and lightly injured are not significantly different on the two networks. But the change in fatalities, on the other hand, is relatively different on the two networks, with a 27.3% increase on comparison I and a -0.9% reduction on comparison II.

This represents a fairly substantial difference. Comparison I shows an increase in fatalities, while comparison II does not. Comparison I, however, is the network with an 80 km/h speed limit and thus best suited to describe what is happening on this road network. Comparison II includes all roads and is therefore not suited to take into account any distinctive characteristics of special parts of the road network. Since there has been a substantial increase in fatalities on the 80 km/h network in the 1993 to 2003 period that has not appeared to the same extent on the other parts of the network, more weight should be given to comparison I.

Similarly, Table 12 shows the two comparison networks for the 90 km/h to 80 km/h speed limit change. (Comparison II is of course identical for the two speed limits).

Table 12: Percentage change in the number of injuries and accidents on comparison network I and II for 90 km/h-80 km/h speed limit reduction sections. Number of accidents and injuries in total and per month in the before and after-period.

Comparison I	90 km/h - 80 km/h				Change %
	Before Number	No per month	After Number	No per month	
Accidents	638	6,65	147	6,13	-7,8
FA	83	0,86	34	1,42	63,9
VIS	35	0,36	11	0,46	25,7
SI	126	1,31	34	1,42	7,9
LI	908	9,46	201	8,38	-11,5
Comparison II					
Accidents	66575	693,49	17222	680,71	-1,8
FA	2213	23,05	578	22,85	-0,9
VIS	1140	11,88	238	9,41	-20,8
SI	8789	91,55	1919	75,85	-17,2
LI	80214	835,56	21241	839,57	0,5

Source: TØI report 784/2005

Here as well, changes from the before to the after-period are smaller in absolute value for comparison II than for I. The difference in absolute numbers for the two road networks is, however, striking. On the road network with a stable 90 km/h speed limit (not motorway A), Table 12 shows a 63.9% increase in fatalities for

comparison I. The numbers of very seriously injured and seriously injured also show an increase. These are relatively dramatic figures and can indicate that this road network has experienced a significant increase in injury severity in recent years even though the number of accidents has not increased. There are many possible explanations for this, but relatively high driving speeds and no median barrier combined with strong traffic growth represent some keywords. The numbers behind comparison I are, however, rather small. While the evaluation is based on 271 km road with reduced speed limit, comparison I consists of 399 km. Still, even if comparison II is significantly larger and more robust, comparison network I can be an important indicator of what is happening on the 90 km/h speed limit network (motorway B and "the remainder" (not motorway A)) in the counties in question. This should be investigated more closely.

5.3.4 Summary and estimation of net effects

Table 13 shows a summary of previously estimated effects as well as an estimation of net effects. The upper part of the table concerns the 80 km/h to 70 km/h speed limit reduction and the lower part pertains to 90 km/h to 80 km/h.

Net effects refer to estimated percentage change from the before to the after-period adjusted for regression-to-the-mean and for the development on the comparison sections.

Table 13 shows gross effects, gross effects adjusted for regression-to-the-mean, changes on the two comparison networks and the estimated net changes depending on the speed limit changes.

Table 13: Summary of estimated effects of speed limit changes from 80 km/h to 70 km/h (upper part of table) and 90 km/h to 80 km/h (lower part) as well as estimation of net effects. Gross effects, regression-to-the-mean, effects on comparison sections I and II. All effects in %.

Speed limit change 80 km/h - 70 km/h							
	Sections with lowered speed Changes %			Comparison section Changes %		Net effect Changes % Based on	
	Gross	Regression to the mean	Gross without regression	Comp I	Comp II	Comp I	Comp II
Accidents	-21,2	-6,7	-15,5	0,0	-1,8	-15,5	-13,9
FA	-43,2	-23,6	-25,6	27,3	-0,9	-41,6	-25,0
VIS	-88,0	-34,9	-81,5	-15,9	-20,8	-78,0	-76,7
SI	-34,7	-10,3	-27,2	-4,9	-17,2	-23,4	-12,1
LI	-7,9	-2,1	-5,8	4,7	0,5	-10,1	-6,3
Speed limit change 90 km/h - 80 km/h							
Accidents	31,1	-5,0	38,0	-7,8	-1,8	49,8	40,6
FA	8,5	-15,4	28,2	63,9	-0,9	-21,8	29,4
VIS	-14,8	-5,2	-10,1	25,7	-20,8	-28,5	13,4
SI	24,7	-15,3	47,1	7,9	-17,2	36,3	77,6
LI	43,2	-1,7	45,6	-11,5	0,5	64,4	44,9

Source: TØI report 784/2005

Regardless of which comparison network is chosen, the estimated net effects, both for accidents and for each severity, were negative on the 80 km/h to 70 km/h network. Thus, the speed limit reduction has resulted in a clear reduction both in the number of accidents and the numbers killed and injured. The number of accidents are reduced by 15.5% and 13.9% respectively. Also for the number of very seriously injured and lightly injured, the two estimates are in reasonable agreement, with reductions of about 77% (VSI) and about 8% (LI).

Estimates of the net effect on fatalities give the same sign, but are numerically different, -41.6% and -24.9% for comparison I and II respectively. The differences arise due to differences in estimated changes in the numbers killed on the two comparison sections (27.3% and -0.89%). These differences have been discussed previously. The net effect for fatalities and severely injured (FA+SEI) from a 80 km/h to 70 km/h speed limit change, based on comparison network I, is estimated to -35.1%. Based on comparison network II, the corresponding net effect is estimated to -23.4%. The results are significant at the 5% level.

Both the estimated gross effects and the net effects show an increase in the number of accidents on the road network where the speed limit is changed from 90 km/h to 80 km/h. Adjusted for regression-to-the-mean, the gross estimate shows an increase of 38.0%. Since both comparison networks have had a reduction in the number of accidents, this means that the net effect will be relatively large, 49.8% and 40.6% respectively. The net effects estimated for seriously injured and lightly injured are also large and positive regardless of which comparison network is used as a basis. The net effect is in the order of 35% to 75%. The gross effects are also positive and large for these severities. The reductions are not large enough for the estimated effects to be significant at the 5% level..

The estimated net effects for these severities vary significantly depending on the differences in results for changes in the number killed (FA) and very seriously injured (VSI) on these comparison networks,. When comparison network I is used (National and European roads with unchanged speed limit of 90 km/h and no type A motorway), the net effects are estimated to -21.8% for fatalities and -28.5% for severe injuries. The corresponding net effects for comparison network II are 29.4% and 13.4% respectively.

Both for the 80 km/h to 70 km/h and the 90 km/h to 80 km/h speed limit change, it appears that the number of fatalities is significantly larger on comparison network I than on comparison network II. This can be an indication that road networks with 80 km/h and 90 km/h speed limits can have had a greater increase in fatalities than the remaining network. In that case, this is an argument for using the results from comparison network I.

6. Discussion and conclusions

6.1 Speed limit change from 80 km/h to 70 km/h

The **80 km/h to 70 km/h** speed limit reduction has given a clear and unambiguous reduction in both driving speeds, injuries and accidents from a period before to a period after speed limits were reduced (gross effects). The results show a driving speed reduction of 4.1 km/h from 75.3 km/h to 71.2 km/h. The number of accidents was at the same time reduced by 21.2%. Fatalities and severe injuries were reduced by 46.6%.

The quality of the comparison sections for speed evaluation is discussed and commented in section 4.3. The comparison sections are not found to be ideal, but are still given some weight. As an assessment and a conclusion, the net change from the 80 km/h to 70 km/h speed limit change is estimated to be between -4.1 km/h and -2.1 km/h. The standard deviation was not changed.

Since sections to be given lowered speed limits were selected by considering the number of accidents and injuries, evaluating the effect on accidents and injuries requires that the number of injuries and accidents in the before-situation be adjusted for regression-to-the-mean. The estimated regression-to-the-mean of the 80 km/h to 70 km/h speed limit change for injuries and accidents seem reasonable. For fatalities and severe injuries, the overall regression-to-the-mean is -18.5% . Adjusted for this regression-to-the-mean, the overall gross effect of the 80 km/h to 70 km/h speed limit change for fatalities and severe injuries is estimated to -34.5% .

The two comparison networks necessary to estimate the net effects for injuries and accidents give different results from before the speed limit change was implemented until after. The difference between the two networks is, however, not very large even though some attention to the difference in the estimated change in the number of fatalities is justified. For comparison I, the number of fatalities increased by $+27.3\%$, while the figure for comparison II is -0.9% . On the network with an unchanged 80 km/h speed limit, the number of fatalities increased by 27.3%, while on the entire network, regardless of speed limit, no change took place.

Arguments for selecting comparison I is based on the fact that this network is more similar to the speed limit reduced sections (80 km/h to 70 km/h) than comparison II. Comparison II is considerably larger and thus numerically more robust than comparison I. It can be claimed, however, that comparison I, which consists of nearly 12000 km road, should be adequate to be used as a comparison and that it is this comparison that best takes care of the distinctiveness of the 80 km/h speed limit network.

Based on comparison network I, the net effect on accidents of the 80 km/h to 70 km/h speed limit change (also adjusted for regression-to-the-mean) is estimated to -15.5% . For fatalities and severe injuries the net effect is -35.1% .

6.2 Speed limit change from 90 km/h to 80 km/h

The speed limit reduction from 90 km/h to 80 km/h has resulted in a driving speed reduction of 2.8 km/h (gross effect). The speed evaluation comparison sections, similarly to the 80 km/h to 70 km/h speed limit change, have certain weaknesses. Moreover, comparison sections were not found in all counties. For only two of the five treated sections was there a comparison section. For the comparison sections, a speed reduction of 1.2 km/h was estimated. The total driving speed reduction for the 90 km/h to 80 km/h speed limit reduction is estimated (net effect) at between – 2.8 km/h and –1.6 km/h. The standard deviation was not changed.

The effect on the number of accidents and injuries from the 90 km/h to 80 km/h speed limit reduction can at best be considered as unresolved and difficult to interpret. The recorded change from before to after speed limit reduction (gross effects) shows an increase both in accidents and injuries. The number of accidents increased by 31.1% and fatalities and severe injuries increased by 14.5%. The number of very serious injury (VSI) was reduced by 14.8%.

The estimated regression-to-the-mean for this speed limit change, similarly to the 80 km/h to 70 km/h, seems reasonable.

The changes in number of accidents on the comparison networks were –7.9% and –1.9% respectively. The increase in the number of recorded accidents (gross effect), the negative regression-to-the-mean and the reduction in the number of accidents on both comparison networks, suggest that the number of accidents has increased on the sections where the speed limit was reduced from 90 km/h to 80 km/h. The net effect is estimated to be between 40% and 50% depending on which comparison network is selected.

The effect of the 90 km/h to 80 km/h speed limit reduction on the various injury severities is significantly different for the two comparison networks. The number of fatalities increases by 63.9% on comparison network I, while the number is nearly unchanged on comparison network II. There is also a relatively large difference for the other injury levels.

Arguments for selecting comparison network I rather than II are the same with this speed limit change as with the 80 km/h to 70 km/h change. While comparison I is meant to attend to the distinctiveness of the road network with a 90 km/h speed limit, comparison II is more robust and much larger. When discussing comparison network I for 80 km/h to 70 km/h, comparison I was chosen because this road network after all represented a certain length relative to the experiment. Here (90 km/h to 80 km/h), this argument cannot be used because comparison network I represents only 399 km of road, while the treatment section makes up 271 km. Selecting comparison network II means that a 90 km/h to 80 km/h speed limit change will entail an increase for all severities (net effects). Compared with the 80 km/h to 70 km/h change, the 90 km/h to 80 km/h change is considered a relatively small experiment that should not be given too great a weight and where the choice of comparison network has been very difficult. It is, however, worth underscoring that both comparison networks I (both speed limits, both 90 km/h and 80 km/h) shows a relatively significant increase in the number of fatalities estimated to 27.3% for 80 km/h and 63.9% for 90 km/h. These are high figures that need to be reviewed for a verification and a more detailed explanation.

7. References

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