Road accidents in Finland and Sweden
A comparison of associated factors

Harri Peltola, Juha Luoma

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Harri Peltola, Juha Luoma, VTT Ltd

Finnish Transport Safety Agency
Liikenteen turvallisuusvirasto Trafi
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FOREWORD

The study was conducted as part of the research programme *Traffic Safety 2025*. Participants in the programme in 2015 included the Finnish Transport Agency, Finnish Transport Safety Agency, Nokian Tyres Ltd and VTT Technical Research Centre of Finland Ltd. Information about Traffic Safety 2025 is available at http://www.vtt.fi/sites/tl2025/en/english.

The study was designed and the report written by Harri Peltola and Juha Luoma, both from VTT Ltd. Accident data was analysed using the ONHA tool developed in cooperation with Mikko Virkkunen of Simsoft Ltd. Members of the steering group were Ville Autero, Inkeri Parkkari and Mikko Räsänen from the Finnish Transport Safety Agency, and Auli Forsberg and Arja Toola from the Finnish Transport Agency. The linguistic editing was carried out by Adelaide Lönnberg. Finally, we wish to thank the Swedish Transport Agency for providing the Swedish accident data. The primary Swedish contact was Khabat Amin.

Helsinki, 18 January 2016

Mikko Räsänen
Chief Adviser
Finnish Transport Safety Agency Trafi

ALKUSANAT

Tämä Suomen ja Ruotsin tieliikenneonnettomuuksia käsittelevä tutkimus tehtiin VTT:llä Turvallinen liikenne 2025 -tutkimusohjelmassa (http://www.vtt.fi/sites/tl2025/). Ohjelman jäseniä vuonna 2015 olivat Liikennevirasto, Liikenteen turvallisuusvirasto Trafi, Nokian Renkaat Oyj ja Teknologian tutkimuskeskus VTT Oy.

Tutkimuksen ja raportin tekivät Harri Peltola ja Juha Luoma VTT:stä. Onnettomuustietojen analysoinnissa käytettiin ONHA-työkalua, joka on kehitetty yhteistyössä Simsoftin Mikko Virkkusen kanssa. Työn ohjausryhmään kuuluivat Ville Autero, Inkeri Parkkari ja Mikko Räsänen Liikenteen turvallisuusvirasto Trafista sekä Auli Forsberg ja Arja Toola Liikennevirastosta. Raportin kieliasun tarkasti Adelaide Lönnberg. Haluamme kiittää lisäksi Ruotsin kuljetushallitusta (Transportstyrelsen) Ruotsin onnettomuusdatan luovuttamisesta tutkimuksen käyttöön. Yhteyshenkilönä Ruotsissa toimi Khabat Amin.

Helsingissä, 18. tammikuuta 2016

Mikko Räsänen
Johtava asiantuntija
Liikenteen turvallisuusvirasto Trafi

FÖRORD

Den här studien genomfördes som en del av forskningsprogrammet Säker trafik 2025. Medlemmar i forskningsprogrammet år 2015 var Trafikverket, Trafiksäkerhetsverket,

Nokian Renkaat Oyj och Teknologiska forskningscentralen VTT Ab. Information om Säker trafik 2025 finns på http://www.vtt.fi/sites/tl2025/.

Harri Peltola och Juha Luoma, båda från VTT, planerade studien och skrev rapporten. Olycksdatan analyserades med ONHA-verktyget som utvecklats i samarbete med Mikko Virkkunen från Simsoft. Styrningsgruppen bestod av Ville Autero, Inkeri Parkkari och Mikko Räsänen från Trafiksäkerhetsverket och Auli Forsberg och Arja Toola från Trafikverket. Adelaide Lönnberg kontrollerade språket. Vi vill tacka den svenska Transportstyrelsen för utlämningen av den svenska olycksdatan. Khabat Amin var kontaktperson i Sverige.

Helsingfors, den 18 januari 2016

Mikko Räsänen
Ledande sakkunnig
Trafiksäkerhetsverket Trafi

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ABSTRACT

We updated some general road-safety comparisons between Finland and the best performing European countries safety-wise: Sweden, the UK and the Netherlands (SUN countries). The main conclusions were that (1) there is a substantial safety potential for Finland and (2) Sweden is the number one choice among the SUN countries for safety comparison with Finland, to define more specific aspects of the safety potential.

Comparison of the number of fatalities per population between Finland and Sweden showed that for Finland, there is a safety potential of 99 yearly fatalities. Two thirds of the potential is on public highways and one third on other roads, mainly streets. The highest potential for fatality reduction is for cars, related mainly to head-on and single vehicle fatalities.

In contrast to traditional analyses of age and gender of killed car drivers, we examined the age and gender of all car drivers involved in fatal accidents as the driver. As suggested by the population risks, Finland has a safety potential especially for young (<=25 years) and elderly (>70 years) male car drivers.

One of our main conclusions is that advanced use of disaggregated data provides more options than programmes created for analysing e.g. European-wide accident data. Additionally, we suggest improvements to the compared datasets related to recording of suicides and severity of injuries, as well as to the contents and validation of the data. We recommend further comparison studies related to the severity of injuries and different traffic environments.

TIIVISTELMÄ

Tutkimuksen päätavoitteena oli selvittää niitä tekijöitä, jotka ovat vaikuttamassa Suomen Ruotsia huonompaan tieliikenneturvallisuustilanteeseen. Toisena tavoitteena oli päivittää Suomen ja liikenneturvallisuudeltaan Euroopan parhaiden maiden vertailutuloksia [Luoma, J., Peltola, H. ja Salenius, S. (2013). Miksi tieliikenteen turvallisuus Suomessa ei ole parhaiden maiden joukossa? Liikenneviraston tutkimuksia ja selvityksiä 44. Helsinki: Liikennevirasto ja Trafi.] Vertailut tehtiin yhdistelemättömästä onnettomuusaineistosta, joten samalla saatiin kokemuksia alkuperäisaineiston ja eurooppalaisella onnettomuusanalyysityökalulla käytettävän datan käyttömahdollisuuksista. Onnettomuusanalyysit tehtiin VTT:ssä kehitetyllä ONHA-työkalulla.

Ruotsin, Ison-Britannian ja Alankomaiden (SUN-maat, Sweden, UK, Netherlands) liikenneturvallisuustilanne on säilynyt edelleen olennaisesti Suomea parempana. Kun Suomessa kuolleiden määrä miljoonaa asukasta kohti oli vuosina 2009–2013 keskimäärin 50, vastaava tunnusluku oli kaikissa SUN-maissa yli kolmannesta parempi (31–33). Turvallisuusvertailuja varten määrittelimme termin *turvallisuuspotentiaali*. Tarkoitamme sillä sitä, kuinka monta kuolemaa vuosittain tulisi Suomessa vähentää, jotta turvallisuustilanne kulloinkin tarkasteltavalla tunnusluvulla, yleensä asukaslukua kohti laskettuna kuolemien määränä, olisi sama kuin vertailumaissa. SUN-maiden turvallisuustilanne olisi tarkoittanut 111 tieliikennekuoleman vähenemistä vuosittain.

Liikenneyksiköittäin tarkasteltuna turvallisuuspotentiaali olisi ollut suurin henkilöautossa kuolleiden osalta, 85 kuolemaa vuosittain. Kuitenkin suhteellinen kuolemanriski asukaslukua kohti oli Suomessa suurin kuorma- ja pakettiautoissa (3,1-kertainen SUN-maihin verrattuna) ja mopoissa (2,6-kertainen määrä). Henkilöautoissa kuoli Suomessa asukaslukuun nähden 2,2-kertainen määrä SUN-maihin verrattuna.

Onnettomuuksien taustatekijöitä tarkastelimme vertailemalla kuolleiden määrää asukaslukua kohti Suomessa ja Ruotsissa. Tarkastelut perustuivat vuosina 2009–2013 poliisin raportoimien onnettomuuksien ja kuolemien määriin. Suomen turvallisuuspotentiaalista Ruotsiin verrattuna voidaan tehdä mm. seuraavanlaisia päätelmiä:

- Suomen turvallisuuspotentiaali on 99 kuolemaa vuosittain. Siitä kaksi kolmasosaa kertyy maanteiltä (69 %) ja kolmasosa niiden ulkopuolelta (31 %), lähinnä kaduilta.
- Liikenneyksiköittäin merkittävimmät turvallisuuspotentiaalit ovat: henkilöauto (64 kuolemaa vuodessa), jalankulkija (9 kuolemaa), pyöräilijä (9 kuolemaa), kuorma-auto (5 kuolemaa), pakettiauto (5 kuolemaa) ja mopedi 4 kuolemaa.
- Kuolleiden määrä ajoneuvokilometriä kohti on Suomessa keskimäärin 31 % Ruotsia suurempi, mutta sen lisäksi Suomessa ajoneuvokilometrien määrä asukasta kohti on 23 % Ruotsia suurempi.
- Onnettomuusluokista erityisesti kohtaamisonnettomuuksissa kuollaan Suomessa Ruotsia useammin, niiden turvallisuuspotentiaali on 30 liikennekuolemaa vuodessa.
- Liikennekuolemien erityisiä riskiryhmiä Suomessa ovat 15–17 sekä 18–20 -vuotiaat. 15–17 -vuotiaiden turvallisuuspotentiaali on mopedikuolemissa (neljä kuolemaa vuodessa) ja moottoripyöräkuolemissa (kolme kuolemaa vuodessa) sekä 18–20 -vuotiailla henkilöautokuolemissa (12 kuolemaa vuodessa).
- Henkilöauton kuljettajina miehet ovat henkilölukua kohti naisia useammin osallisena kuolemaan johtaneissa onnettomuuksissa sekä Suomessa että Ruotsissa. Suomen turvallisuuspotentiaali on 46 kuolemaa onnettomuuksissa, joissa mieskuljettaja ajoi henkilöautoa ja 6 kuolemaa onnettomuuksissa, joissa naiskuljettaja ajoi henkilöautoa.

- Kuolemaan johtaneiden onnettomuuksien henkilöautoa ajavissa miehissä Suomessa ovat Ruotsiin verrattuna yliedustettuina erityisesti 18–19 -vuotiaat sekä yli 70-vuotiaat.
- Henkilöauton kuljettajina kuolemaan johtaneissa onnettomuuksissa henkilölukua kohti oli naiskuljettajia Suomessa vain hieman useammin kuin Ruotsissa.
- Nopeusrajoitusten aiheuttamaa turvallisuuspotentiaalia ei voitu määrittää täsmällisesti, mutta Suomessa liikennekuolemat ja loukkaantumiset tapahtuvat keskimäärin hieman korkeammilla nopeusrajoituksilla kuin Ruotsissa.
- Kulkutapatutkimuksen tietojen perusteella näyttäisi siltä, että Suomen korkeampien kilometriä kohti laskettujen riskien vuoksi sekä jalankulkijoita että pyöräilijöitä kuolee vuosittain kuusi enemmän kuin Ruotsissa, mutta lisäksi kolme jalankulkijaa ja kolme pyöräilijää kuolee Suomen Ruotsia suurempien kilometrisuoritteiden vuoksi.

Suomen onnettomuusaineistoja tulisi edelleen kehittää erityisesti loukkaantumisen vakavuuteen ja itsemurhien rekisteröintiin liittyen. Turvallisuusvertailuja suositellaan jatkettavan erityisesti loukkaantumisten vakavuuden ja onnettomuuksien liikenneympäristöjen osalta. Vertailut voidaan tehdä monipuolisemmin kuin Euroopan laajuisten aineistojen analyysit, jos käytettävissä on yhdistelemätön onnettomuusaineisto.

SAMMANFATTNING

Vi uppdaterade några jämförelser i trafiksäkerheten mellan Finland och de länder som har högsta trafiksäkerheten: Sverige, Stor-Britannien och Nederländerna (SUN-länderna). De viktigaste slutsatserna var att (i) det finns ett betydande säkerhetspotential i Finland och (ii) för att utreda mer specifika aspekter av säkerhetspotentialet i Finland, lämpar sig Sverige bäst av SUN-länderna för jämförelser i säkerheten mellan länderna.

En jämförelse av antalet dödade per invånare mellan Finland och Sverige visade att säkerhetspotentialet för Finland är 99 dödade per år. Två tredjedelar av potentialet är på allmänna vägar och en tredjedel på icke-allmänna vägar, främst på gator. Det största potentialet för minskad dödlighet är för bilister, huvudsakligen för frontalkollisioner och singelolyckor.

I motsats till traditionella analyser av ålder och kön av de dödade bilförarna, analyserade vi ålder och kön av alla bilförare involverade i dödsolyckor. Resultaten visade att Finland har ett säkerhetspotential speciellt för unga (<= 25 år) och gamla (>70 år) manliga bilförare.

En huvudslutsats är att utökad användning av uppdelad data ger fler alternativ än program som skapats för att analysera t.ex. olycksdata för hela Europa. Dessutom föreslår vi förbättringar till den jämförda datan angående registreringen av självmord och svårighetsgraden på skadorna samt till datans innehåll och validering. Vi rekommenderar fortsatta jämförande studier för skadornas svårighetsgrad och olika trafikmiljöer.

1 Introduction

1.1 Background

A recent study (Luoma, Peltola & Salenius 2013) compared traffic safety and related factors in Finland with those in the best performing countries Sweden, the UK and the Netherlands (the SUN countries). In contrast to traditional country-wise road safety comparisons, the study included other transport modes and modal split. The main results indicated that 77 road fatalities (out of 296) would have been prevented annually in Finland in 2006–2010 if the number of fatalities per capita had been the same as in the best performing countries. A major identified contributing factor was distance travelled in road traffic per person, which was greatest in Finland overall, especially by passenger car. In the last 25 years, road traffic in Finland has increased far more than in the SUN countries. Over the same time period, Finland has not been able to decrease the fatality rate as much as the SUN countries.

Furthermore, if road fatalities per age group in Finland had been as low as in the SUN countries, roughly 70% of prevented fatalities would have been in age groups older than 24 years, although the relative difference was greatest among 15–17 year olds. This result emphasizes the importance of focusing road safety measures on large target groups in addition to identified risk groups. In addition, we found that the main road safety problems in Finland are largely limited to male drivers, and comparison of some intermediate performance factors such seatbelt use and age of cars showed that road-safety performance is lower than in the SUN countries.

Comparisons with similar countries can be used to identify where there is potential for safety improvements. If another county has performed better in similar conditions, that would suggest potential for improvements. This study was initiated to further examine detailed road accident data in Finland and Sweden. Road, traffic and climate conditions in these two countries are relatively similar to those in the Netherlands and the UK. Additionally, access to disaggregated accident data enables a more detailed analysis of accidents than would be possible with tools created for analysing accident data across Europe.

1.2 Aim

The main aim of this study is to identify factors behind Finland having a poorer road traffic accident record compared to Sweden, a country that has very similar road, traffic and climate conditions to Finland. Several differences between the road accidents in these countries have been identified by Luoma et al. (2013), although the approach of their study did not allow for detailed analyses.

Another aim is to study whether there are any benefits to using real disaggregate data compared to data that can only be used through special analysis tools like SAP Businessobjects when using the European Care/CADaS database.

An additional aim is to update some of the general comparisons between Finland and the best performing European countries safety-wise: Sweden, the UK and the Netherlands.

The report has the following structure: Section 2 presents the approach including data, modifications etc., and Section 3 reports on the general safety comparisons between Finland and the best performing countries in Europe. Section 4 provides the results of the detailed accident comparisons between Finland and Sweden. The main findings and conclusions are discussed in Section 5.

2 Approach

We use the term *safety potential* to describe how much safety would improve in Finland if the rate of a selected measure in one or more countries existed in Finland as well. In our analyses we use population risk (number of fatalities per million population) to compare safety as a main measure. The main sources of the identified safety potential—(1) different amount of exposure to accidents (e.g. vehicle kilometres) or (2) difference in risk per exposure—are analysed as far as there is reliable data available.

The starting point for the study was general safety data received from European-wide data sources like Eurostat, the Care/CADaS database, and ETSC PIN and OECD reports (Eurostat 2015, European Commission 2015, ETSC 2015, OECD/ITF 2015).

In-depth analysis of accident-related data between Finland and Sweden was based on the availability of detailed disaggregate data. The data allowed us to perform the analyses combining hierarchically structured data, i.e. data from all the three levels of accidents. For example, one can select accidents in urban areas involving a car driven by a novice driver and analyse whether the killed or injured persons are these drivers, persons in their vehicles or other road users (Figure 1). Analyses were carried out using a net-based computer program created to enable versatile analysis of accident data without endangering personal data privacy.

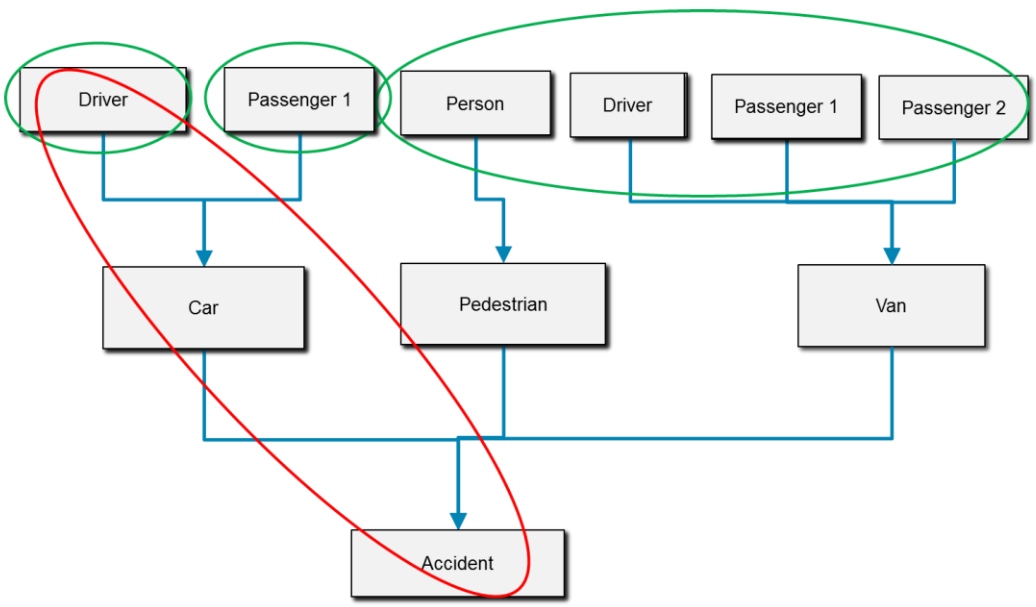


Figure 1. Example of hierarchically structured accident data.

Data from both countries is based on police reports of injury accidents. Finnish data was obtained from the database of the Finnish Transport Agency. The data was prepared by Statistics Finland, an organisation that publishes official Finnish road safety statistics (Statistics Finland 2015). Swedish data was collected from the national road traffic accident information system STRADA (Swedish Traffic Accident Data Acquisition) (Swedish Transport Agency 2015). It was provided by the Swedish Transport Agency as a database dump in MS Access files.

The recommended definition for a person killed in a road traffic accident is: Any person killed immediately or dying within 30 days as a result of an injury accident, excluding suicides (UNECE, ITF and Eurostat 2009). Sweden has excluded suicides as suggested since 2010, but in Finland they are included in the official road accidents statistics. Otherwise both countries record road fatalities according to the recommendation (Statistics Finland 2015, Trafikanalys 2014).

In Finland, the definition of a person injured in a traffic accident is: Any person who was not killed, but sustained as a result of the accident injuries requiring treatment or observation in hospital, at home (sick leave) or surgical treatment, such as stitches. Bruises, scratches and the like not requiring the above treatment are not regarded as injuries (Statistics Finland 2015). For Sweden the definition is simply: Slightly injured person: Persons slightly injured in road traffic crashes reported by the police (OECD/ITF 2015). For seriously injured, there is a list of injuries that are considered serious.

Numbers of accidents and their consequences in 2009–2013 (Table 1) show that the number of fatalities was approximately the same, but compared with Finland the number of injured persons was substantially higher in Sweden. This result suggests that more slight injuries are recorded in Sweden.

Table 1. Number of injury accidents and their consequences by road category[1] in Finland and Sweden in 2009–2013 recorded by the police (Statistics Finland 2015, Swedish Transport Agency 2015).

	Number of accidents by severity				Consequences to involved persons			
	Fatal		Injury(2)		Killed		Injured	
Road category	Finland	Sweden	Finland	Sweden	Finland	Sweden	Finland	Sweden(3)
Public highways	925	1088	14576	50276	1021	1185	20447	76078
Non-highway (other) roads(1)	316	295	13995	31015	328	304	16791	39053
Total	1241	1383	28571	81291	1349	1489	37238	115131

(1) Street, private road, other type or not known
(2) Someone injured but no one killed
(3) Severity of injuries not defined in Finland. In Sweden the share of severely injured of all injured was 14.1% on public highways and 12.2% on other roads.

Numbers of vehicle kilometres used in calculating fatality rates were received from national statistics (Trafikverket 2015, Trafikanalys 2015, Finnish Transport agency 2015).

[1] Road category public highway refers to national and main roads including motorways (in Finland “maantiet” and in Sweden “allmänna vägar”).

Detailed comparisons were based primarily on national definitions, as the police adhere to these in their reports. One exception was accident type; in Finland it is defined by the involved traffic elements and police judgement of the accident. In Sweden the judgement is based on registered involved traffic elements and their movements during the accident. Although the accident types did not match perfectly, the Swedish types could be modified into the Finnish equivalent. The modifications were based largely on the involvement of unprotected road users (Table *2*).

Table 2. Number of non-fatal accidents by accident type in Sweden in 2009–2013 (Swedish Transport Agency 2015).

Accident type in Strada [1]	Accident type, modified for comparison with Finnish accident type coding											
	Single	Turning	Overtaking	Crossing	Head-on	Rear-end	Moped	Cycle	Pedestrian	Animal	Other	Total
Turning		3980						3	8			3991
C/M with MV							2997	7588	3			10588
P with MV								1	6614			6615
P/C/M							264	1951	2696			4911
T1/T2								9	116		204	329
Crossing				7693					2		3	7698
Head-on					3831			2	1		6	3840
Overtaking			905				1				2	908
Single	25150							6	8			25164
Rear-end						13153	1	4	14		7	13179
Animal										1809		1809
Other							1	61	115		3465	3642
Total	25150	3980	905	7693	3831	13153	3264	9625	9577	1809	3687	82674

(1) C=Cycle, M=Moped, MV=Motor vehicle, P=Pedestrian, T1=Train, T2=Tram

It is acknowledged that differences in the reporting systems of the two countries could be responsible for some of the obtained findings. Furthermore, no statistical tests of significance were performed. Consequently, only substantial differences and clear similarities with sufficient frequencies are discussed.

3 Road safety in Finland vs. the best in Europe

3.1 Variation in time and space

At the beginning of the 21st century, Sweden, the UK and the Netherlands were considered to be the best performing counties in Europe in regard to road safety, and were accordingly named the SUN countries (Koornstra, Lynam, Nilsson, Noordzij, Pettersson, Wegman & Wouters 2002). Their first-rate performance was still evident in 2009–2013; had the fatality rate per population in Finland been as low as the average in the SUN countries, 102 fatalities would have been prevented, or 38% of the country's yearly figure of 271 (Figure 2). It should be noted that in the UK, confirmed suicides are excluded from road fatalities and in Sweden they have been excluded since 2010. Thus in Sweden, from 2010 to 2014 a yearly average of 26 fatalities or 8.4% of all fatalities on roads have been removed from the road statistics as suicides (OECD/ITF 2015, Trafikanalys 2014). For the Netherlands, fatalities reported by the police are used in the comparisons, although it has been reported that they do not cover all road fatalities (OECD/ITF 2015).

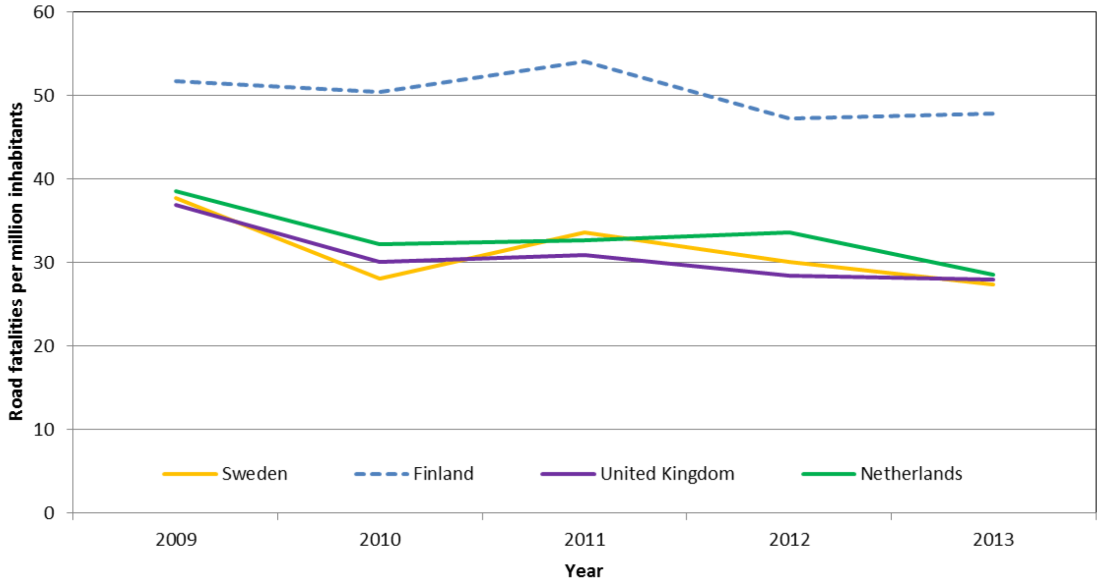


Figure 2. Fatality rate per population in Finland and SUN countries in 2009–2013 (European Commission 2015, Eurostat 2015).

The countries being compared are different in e.g. population density (people living per square km), but also differ within the countries themselves. Population density in Finland and Sweden is very similar as a whole (18 and 23 people per square km respectively). Population densities in the UK and the Netherlands are markedly higher, with 261 and 494 people per square km respectively. The population density affects the number of fatalities per population; as shown in Figures *3–6*, in each country the number of fatalities per population is lowest in NUTS2 areas that have the highest population density. In particular, note that the population density scales in the figures for Finland and Sweden (Figures *3* and *4*) differ from those in the UK and the Netherlands (Figures *5* and *6*).

The average population density in each country correlates with the share of fatalities in urban areas (designated by urban boundary signs). In countries with a low population density (Finland and Sweden), the share of fatalities in urban areas is 24.0% and 26.3% respectively, whereas in countries with a high population density (UK and the Netherlands) it is 35.9% and 39.4% respectively.

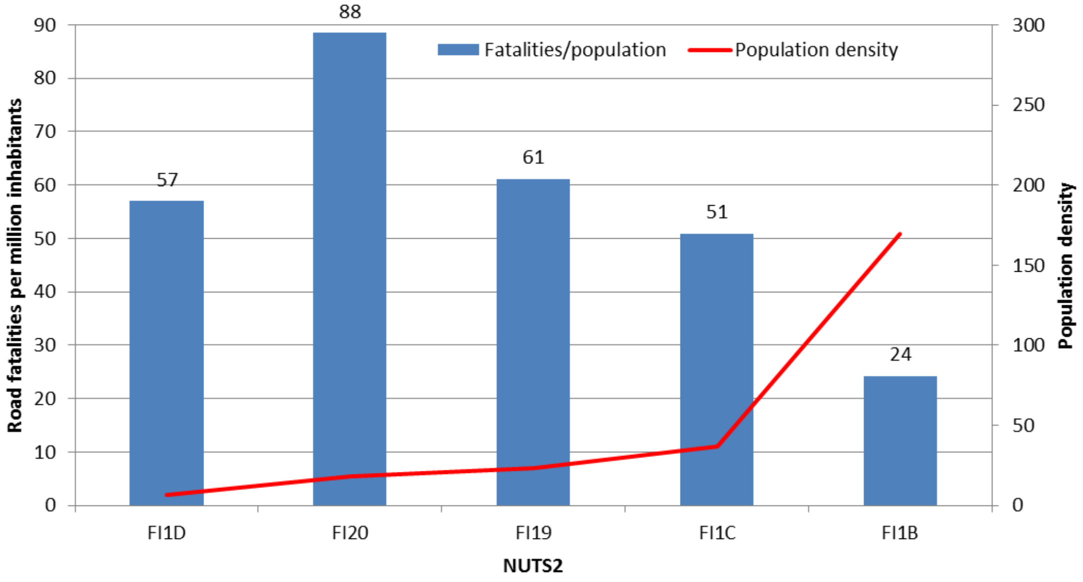


Figure 3. Fatality rate per population in Finland in 2012–2013 and population density by NUTS2 area (European Commission 2015, Eurostat 2015). Only 2-year data used for Finland, as NUTS2 areas have been modified.

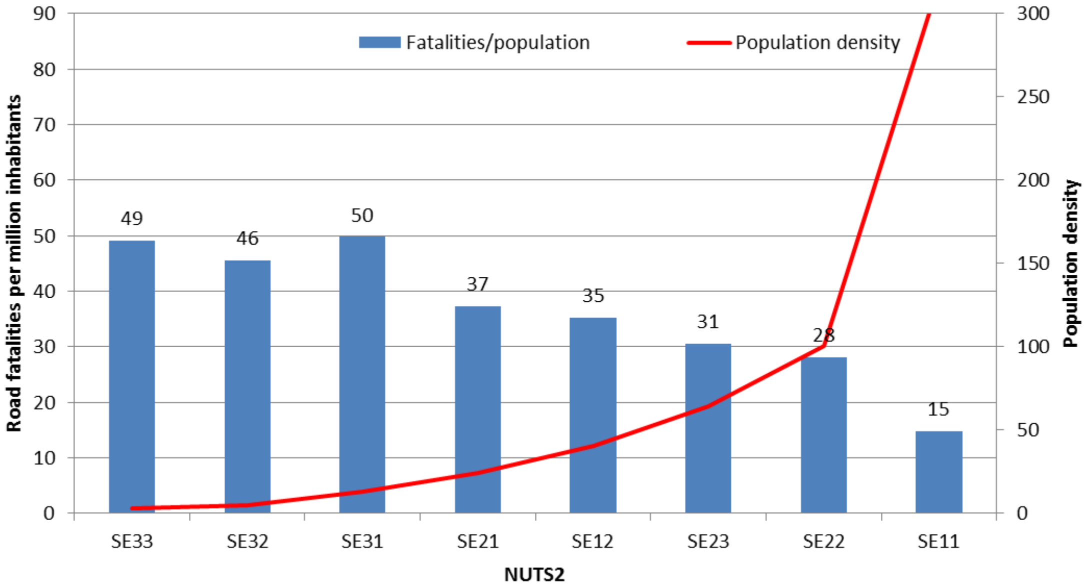


Figure 4. Fatality rate per population in Sweden in 2009–2013 and population density by NUTS2 area (European Commission 2015, Eurostat 2015).

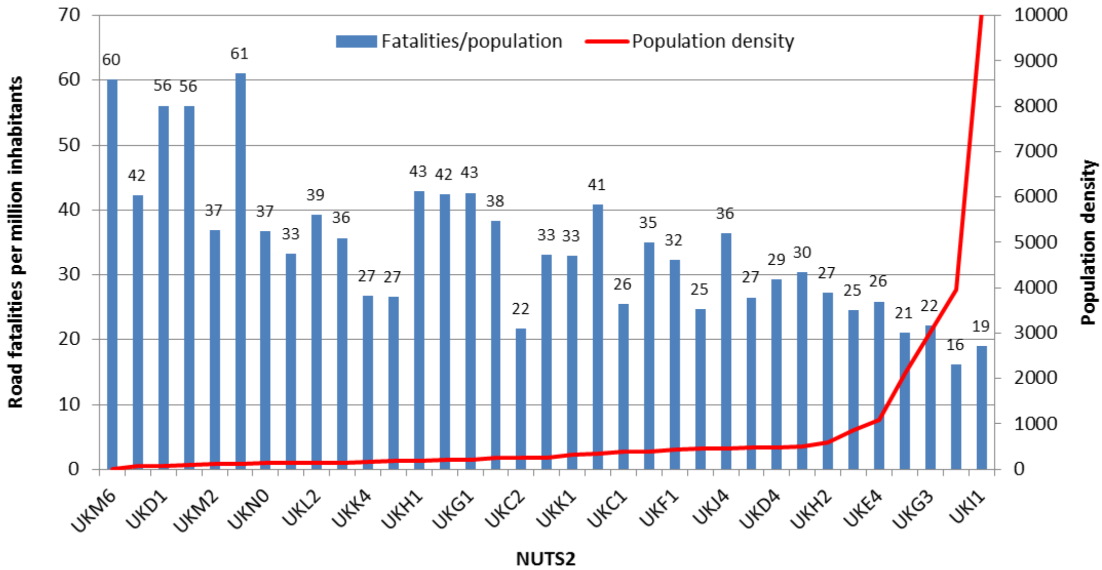


Figure 5. Fatality rate per population in the UK in 2009–2013 and population density by NUTS2 area (European Commission 2015, Eurostat 2015).

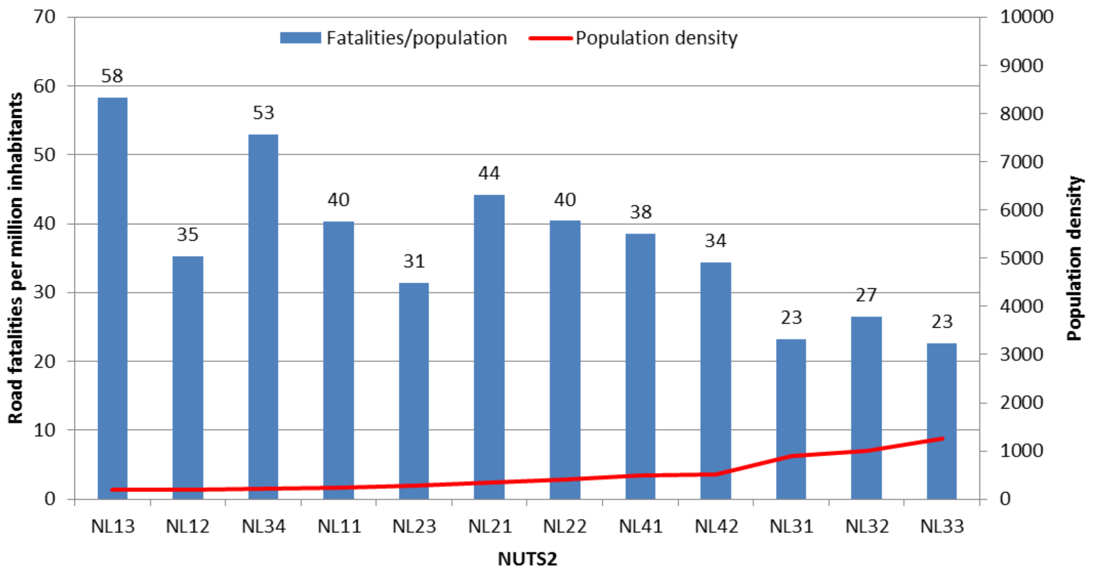


Figure 6. Fatality rate per population in the Netherlands in 2009–2013 and population density by NUTS2 area (European Commission 2015, Eurostat 2015).

Furthermore, the countries in the comparison have different weather and lighting conditions, which may affect the monthly distribution of fatalities. Finland and Sweden have a similar pattern, with a high share of fatalities during the summer months and a low share in winter (Figure *7*), while the variation of fatalities in the Netherlands and UK is much lower.

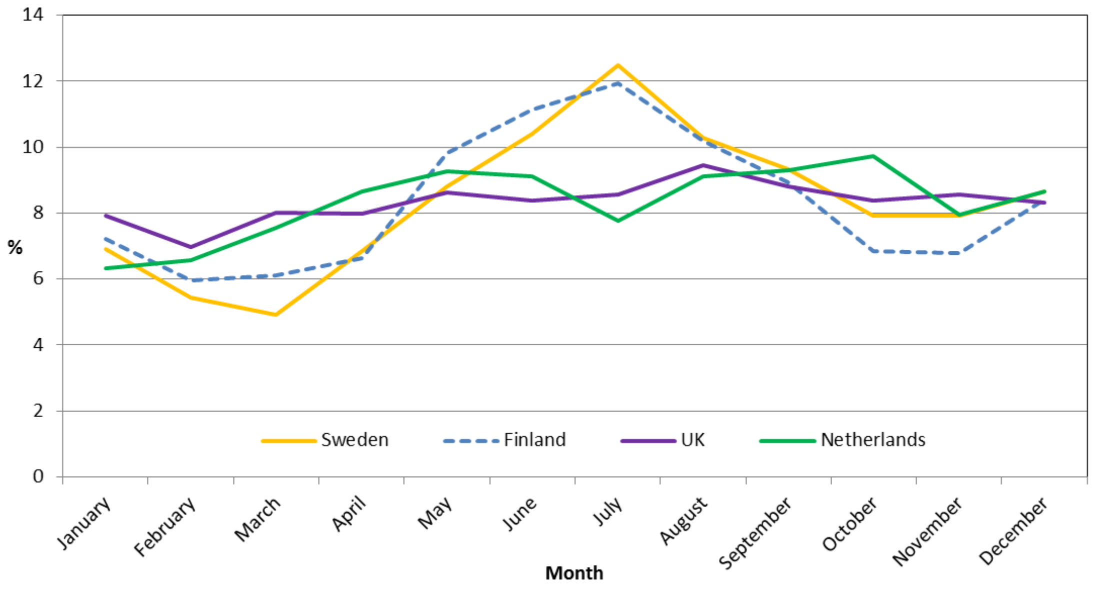


Figure 7. Share of fatalities (%) by month in 2009–2013 (European Commission 2015).

3.2 Involved traffic units

Comparison of killed persons by traffic unit reveals that countries have different shares of fatalities among traffic units—probably caused, at least partly, by differences in exposure to different modes (Table 3). Finland's higher total fatality numbers are mostly caused by killed persons in passenger cars.

Had the fatality rate per population for cars been as low in Finland as the SUN average, 85 fatalities in cars (53.5% of all car fatalities) would have been prevented annually. Figures for cars were higher than the SUN average also for Sweden; in this case the prevented fatalities in cars would have been 34 (21.0% of all car fatalities). In the UK, the highest share of fatalities among the comparison countries is pedestrian fatalities, and in the Netherlands bicyclists.

Table 3. Number of fatalities per population by traffic unit in Finland and SUN countries in 2009–2013 (European Commission 2015, Eurostat 2015).

	Fatalities per population(1)					Reduction if (3)
Traffic unit	Finland	Sweden	UK	Netherlands	SUN(2)	SUN average
Passenger car	30.8	18.1	15.0	13.9	14.3	-85
Bus	0.2	0.2	0.2	0.0	0.2	0
Goods vehicle	3.3	1.4	1.0	1.3	1.1	-11
Moped	1.6	0.9	0.2	2.5	0.6	-5
Motorcycle	4.6	4.5	6.3	3.3	5.2	3
Pedal cycle	4.0	2.3	1.8	8.2	2.9	-6
Pedestrian	6.5	4.9	7.4	3.8	6.1	-2
Other vehicle	1.5	0.8	0.4	1.6	0.6	-4
Total	52.5	33.0	32.3	34.6	30.9	-111

(1) Road fatalities per million inhabitants
(2) Average for the SUN countries (Sweden, UK, Netherlands)
(3) Yearly reduction of fatalities if No. of fatalities per population same as SUN average

In 2012 the number of vehicle kilometres by person was the highest in Finland (10 040 km/person), followed by Sweden (8 140 km/person), the UK (7 990 km/person) and the Netherlands (7 630 km/person) (OECD/ITF 2015). If the vehicle accident rate per kilometre remained the same and the numbers of vehicle kilometres in Finland were cut down to the SUN average, Finnish vehicle accidents would be reduced by 20.9% (38 fatalities less in vehicles).

3.3 Involved persons

In every age category, the number of fatalities per population is greater in Finland than in any of the SUN countries (Table *4*). The greatest relative difference between Finland and the SUN countries is in the number of fatalities in the age category 15–17 years: the number killed per population in Finland is more than double that in any SUN country. The number of lives saved if Finland had the SUN fatality rate would be greatest in the two oldest age groups: the safety potential is highest for these two groups, but the population in these groups is also the most extensive.

Table 4. Number of fatalities per population by age in Finland and SUN countries in 2009–2013 (European Commission 2015, Eurostat 2015).

	Fatalities per population(1)				
Age	Finland	Sweden	UK	Netherlands	SUN(2)
0-14	8	5	5	6	5
15-17	78	32	35	31	34
18-20	116	59	74	65	71
21-24	84	53	56	63	57
25-64	49	32	33	29	32
65-	79	50	43	72	49
Total	53	33	32	35	33

(1) Road fatalities per million inhabitants
(2) Average for the SUN countries (Sweden, UK, Netherlands)

The share of females of the entire number of persons killed in traffic is close to one out of four in Finland, Sweden and the UK (25.8%, 24.8% and 25.4%). In the Netherlands this proportion is a bit higher at 27.5%.

4 Road safety comparison between Finland and Sweden

Based on the comparisons in Section 3, road traffic conditions are in many ways pretty similar between Finland and Sweden compared to those in the UK and the Netherlands. A road safety comparison between Finland and Sweden begins with an overview of road accidents and their consequences as well as risks (Section 4.1). Next, a comparison of major differences is conducted to find the potential for safety improvements (Section 4.2.1), followed by a more detailed accident comparison done separately for traffic units of special interest: fatalities in cars and goods vehicles (Section 4.2.2), killed bicyclists and pedestrians (Section 4.2.3), and fatalities on mopeds and motorcycles (Section 4.2.4).

4.1 Overview of road safety

4.1.1 Accidents and consequences

The number of fatal accidents in 2009–2013 and their share by road type is compared in Figure *8*. The average yearly number of fatal accidents was 248 in Finland and 277 in Sweden. Even the distribution between public highways and other roads is of the same order; around three out of four fatalities have occurred on public highways. The type of road in the STRADA data is unknown for 3,9% of fatal accidents based purely on police reports (Swedish Transport Agency 2015); in Finland this information is completed during the reporting process. In the following we compare accidents on public highways and other roads; unknown road categories are considered to be other roads.

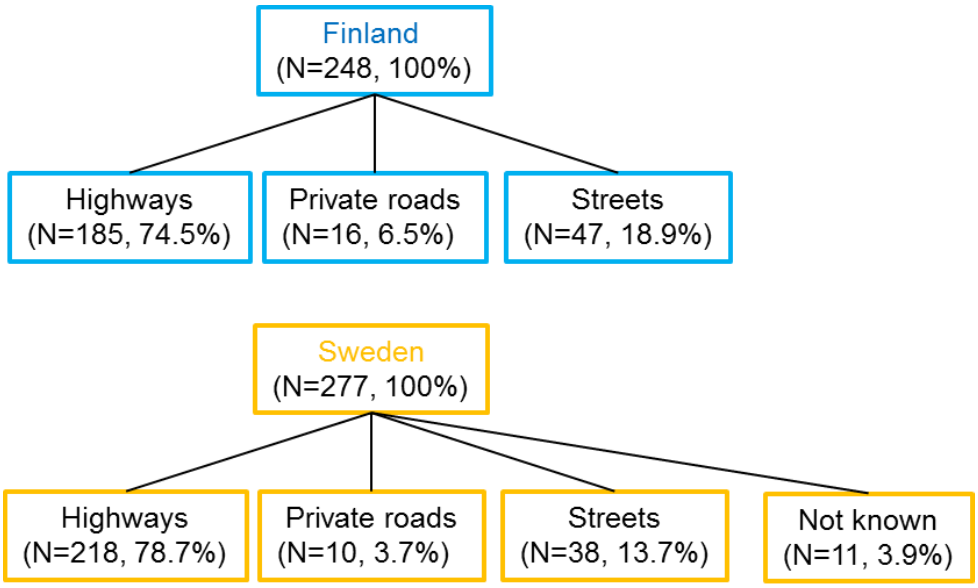


Figure 8. Average yearly number and share (%) of fatal accidents by road type in Finland and Sweden in 2009–2013 (Statistics Finland 2015, Swedish Transport Agency 2015).

The shares of fatalities by traffic unit type on public highways and other roads (street, private road, other road or unknown road category) are presented in Figures *9* and *10*. These results suggest that:

- In both countries around three out of four fatalities have occurred on public highways (see figure legends). The total number of fatalities on public highways is slightly higher in Sweden than in Finland (although Swedish fatalities on unknown roads were considered to come from other roads).
- On public highways, fatalities in passenger cars are dominant: around two out of three fatalities occur in cars. By contrast, on other roads pedestrians and cyclist fatalities are relatively much more common.
- The share of fatalities in cars is higher in Finland than in Sweden on both public highways and other roads.

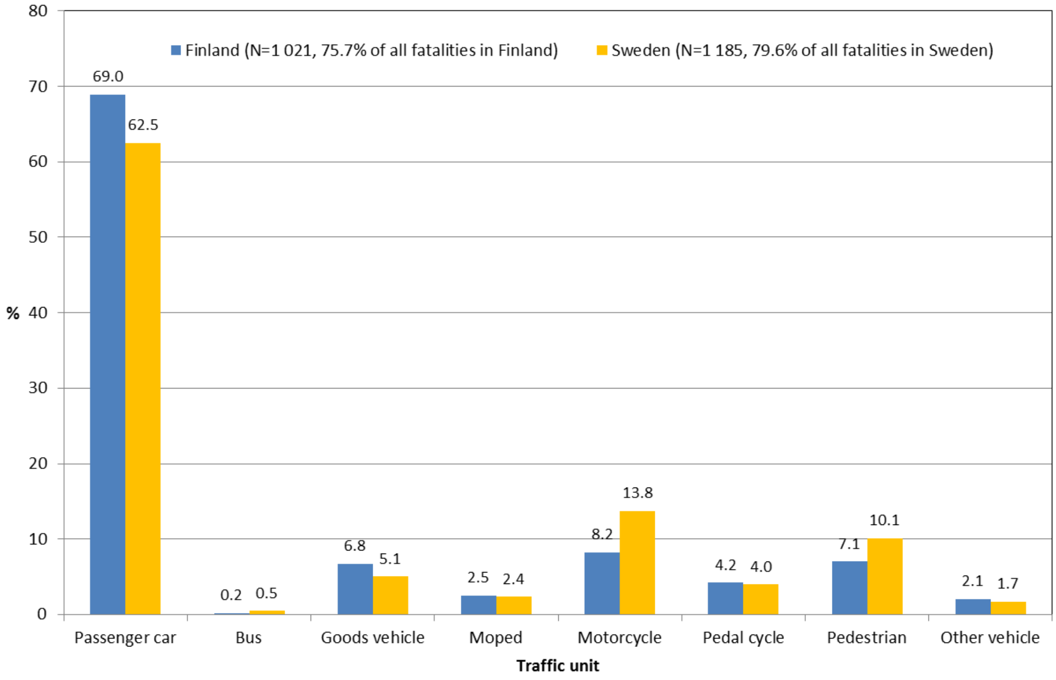


Figure 9. Share of fatalities (%) by traffic unit on public highways in Finland and Sweden in 2009–2013 (Statistics Finland 2015, Swedish Transport Agency 2015).

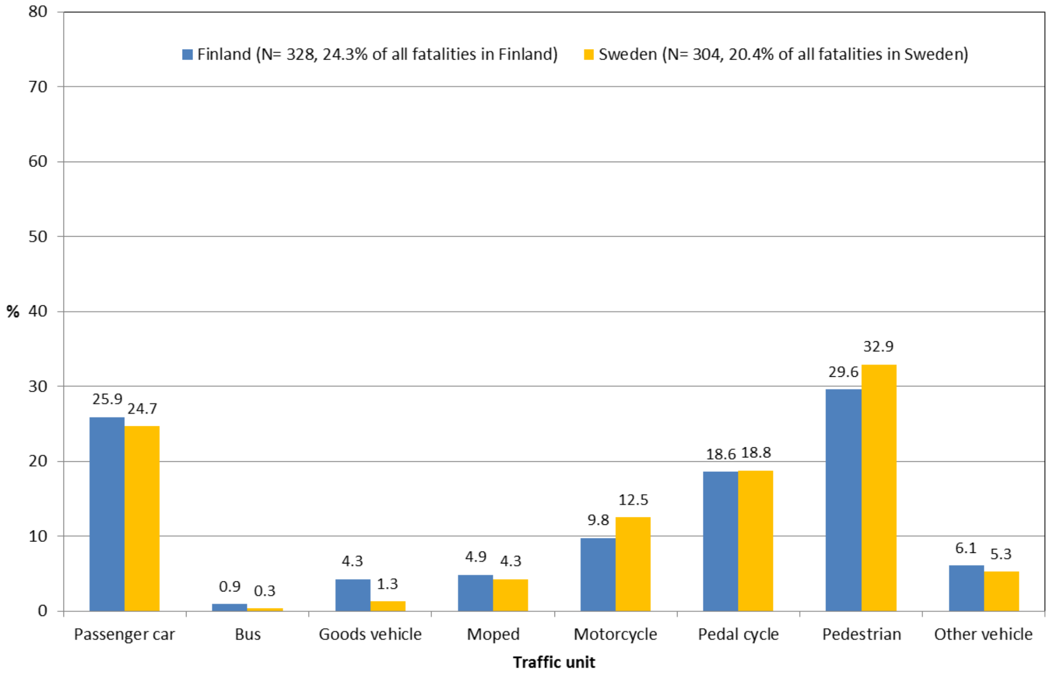


Figure 10. Share of fatalities (%) by traffic unit on non-highway roads in Finland and Sweden in 2009–2013 (Statistics Finland 2015, Swedish Transport Agency 2015).

As noted above, definitions of injuries in traffic accidents are not as precise as fatalities. In addition, injury accidents are under-reported, especially for minor injuries and injuries incurred by bicyclists. To have relatively comparable data, injuries reported by the police are used for comparison, although police forces are limited in the accurate estimation of injuries (OECD/ITF 2015, Trafikanalys 2014). (STRADA includes information on injury severities defined by hospitals, but this kind of data for Finland is not available for the years of the comparison.)

The share of injury accidents by road type is compared in Figure *11* for Sweden and Finland. Even though the number of fatal accidents in the comparison countries is of similar magnitude, the number of injury accidents in Sweden is 2.8 times higher than in Finland. The share of injury accidents occurring on public highways is clearly higher is Sweden; in addition, some of the 9% of injury accidents that occurred on unknown road types might have happened on public highways. There were no clear differences in the share of injured persons across road types between accidents resulting in serious and slight injuries in Sweden.

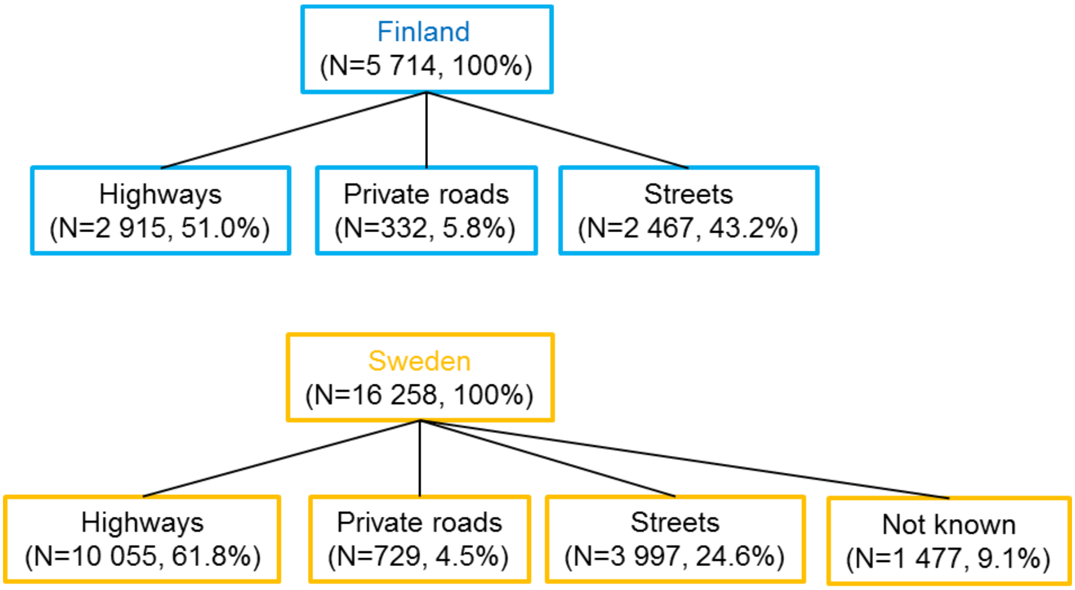


Figure 11. Average yearly number and share (%) of injury accidents by road type in Finland and Sweden in 2009–2013 (Statistics Finland 2015, Swedish Transport Agency 2015).

Table *5* compares the number of injured people to the number of fatalities, in order to assess how the recording of injuries differs between Finland and Sweden. If the severity of accidents were the same in both countries, one would expect the total number of injured persons per fatality to be roughly the same. Table *5*, however, shows the figure to be 2.8 times higher in Sweden (77 vs. 28). On the other hand, the total number of injured per fatality in Finland is 2.7 times higher than the number of severely injured per fatality in Sweden (28 vs. 10) (Table *5*). These findings suggest that the numbers of injured people are not directly comparable in Finland and Sweden; the average severity of an injury in Finland is somewhere between severely injured and all injured in Sweden. In the following, total numbers of injured people are presented as background information for fatalities.

Table 5. Number of injured persons per fatality in 2009–2013 (Statistics Finland 2015, Swedish Transport Agency 2015).

Number of injured persons per fatality	Finland,(1) all injured	Sweden,(1) all injured	Sweden,(2) severely injured
Public highways	20	64	9
Non-highway (other) roads	51	128	16
All roads	28	77	10

(1) Everyone injured in a road accident as reported by the police
(2) Severely injured as reported by the police

Shares of injured people by traffic unit type on public highways and other roads are presented in Figures *12* and *13*. These figures suggest the following:

- The share of injuries on public highways is evidently higher in Sweden (66%) than in Finland (55%, see Figure *12* legend). The total number of injuries is significantly higher in Sweden than in Finland: on public highways in Sweden the number of injury accidents is 3.7 times and on other roads 2.3 times higher than in Finland.
- Injuries in passenger cars are dominant on other roads but even more so on public highways, where more than two out of three injuries are incurred by persons in cars. However, on other roads, injuries to unprotected road users are relatively common as well (pedestrians, bicyclists and powered two-wheelers).
- The share of fatalities in cars is lower in Sweden than in Finland on both public highways and other roads. The occurrence is just the opposite for fatalities (Figures *9* and *10*).

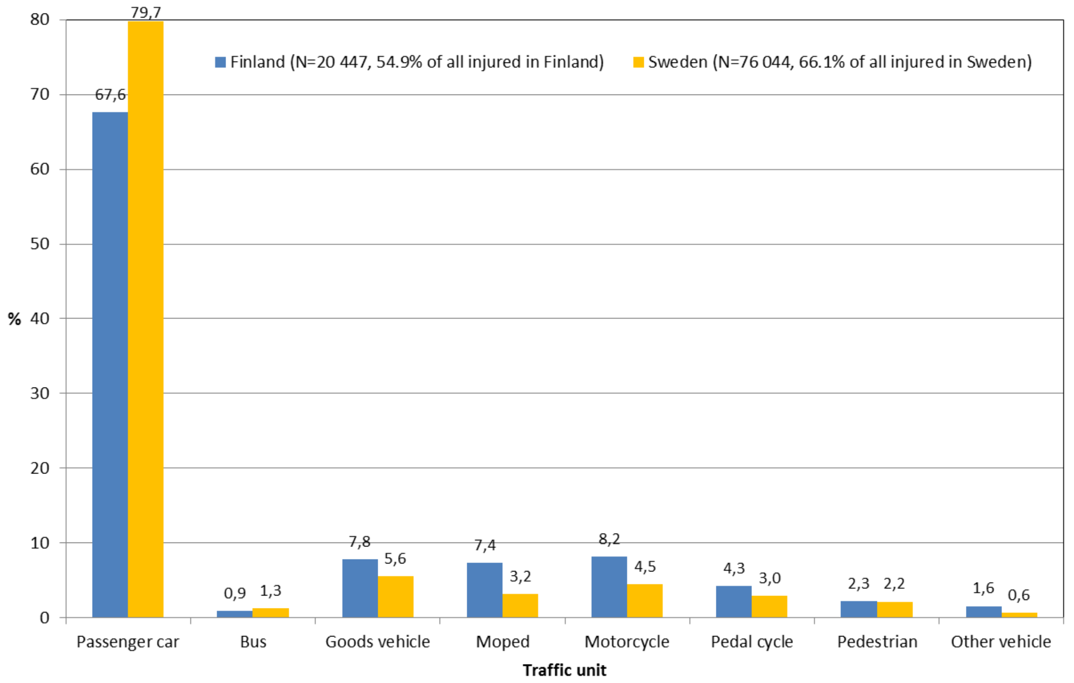


Figure 12. Share of injured people (%) by traffic unit on public highways in Finland and Sweden in 2009–2013 (Statistics Finland 2015, Swedish Transport Agency 2015).

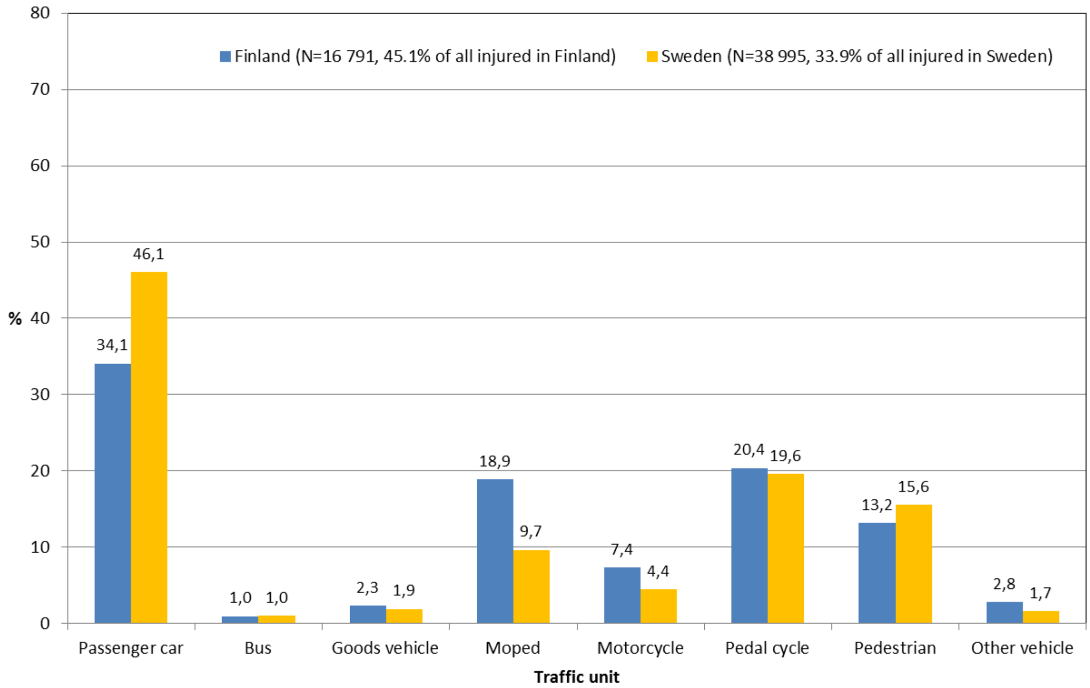


Figure 13. Share of injured people (%) by traffic unit on non-highway roads in Finland and Sweden in 2009–2013 (Statistics Finland 2015, Swedish Transport Agency 2015).

4.1.2 Fatality rates and vehicle kilometres

Fatality rates (fatalities per motor vehicle kilometre) were calculated based on national exposure statistics and accident statistics (Table *6*). Calculated fatality rates in Finland are much higher than in Sweden on public highways (28.1% higher) as well as on streets (57.3% higher).

Table 6. Fatality rate (fatalities per 100 million motor vehicle kilometres) in 2009–2013 (Statistics Finland 2015, Swedish Transport Agency 2015, Finnish Transport agency 2015, Trafikanalys 2015).

	Public roads	Streets(1)	All roads
Finland(2)	0.56	0.27	0.47
Sweden(3)	0.44	0.17	0.36

(1) Calculated from streets only to match with exposure (Note: for Sweden excluded 56 fatalities, for which road type was unknown)
(2) Motor vehicle mileage 270 030 million kilometres/5 years and share of vehicle kilometres on public highways 67.4% (Finnish Transport agency 2015)
(3) Motor vehicle mileage 382 654 million kilometres/5 years and share of vehicle kilometres on public highways 70.7% (Trafikverket 2015, Trafikanalys 2015)

Another main factor behind the higher fatality figure in Finland is the higher number of vehicle kilometres per population. Specifically, the number of motor vehicle kilometres per person in 2009–2013 was 8 480 km/year in Sweden and 23.3% higher in Finland, at 10 460 km/year (Finnish Transport agency 2015, Trafikanalys 2015). The difference is remarkable.

4.2 Safety potential for Finland

4.2.1 Defining safety gaps

We use analysis of the number of fatalities by traffic unit to demonstrate the idea of safety potential. In Table *7*, the main safety figures for 10 traffic units are compared between Finland and Sweden. Dividing the yearly fatality numbers (columns 2 & 3 in Table *7*) by the population of the county gives the population risk (columns 4 & 5). The total population risk for Finland (52.3) is 58% higher than that for Sweden (33.0), as seen in column 6. The safety potential is defined as the number of yearly reduced fatalities if the population risk for Finland were the same as in Sweden. Population risks would be equal if the yearly number of fatalities in Finland were reduced by 99 fatalities. Evidently, the safety potential for Finland is greatest for people killed in cars, but considerable also for pedestrians and bicycles.

Table 7. Number of fatalities, fatality rates per population and potential for fatality reductions (Statistics Finland 2015, Swedish Transport Agency 2015).

	Fatalities in 2009–2013/y(1)		Fatalities per population(2)		Relative population	Reduction if(4)
Traffic unit	Finland	Sweden	Finland	Sweden	risk in Finland(3)	Swe average in Fin
Passenger car	158	163	30.6	18.1	169	64
LGV(5)	9	8	1.8	0.9	200	5
HGV(5)	7	5	1.4	0.5	274	5
Pedestrian	34	44	6.5	4.9	134	9
Bicycle	21	21	4.0	2.3	175	9
Moped	8	8	1.6	0.9	179	4
Motorcycle	23	40	4.5	4.5	101	0
Bus	1	1	0.2	0.2	125	0
Tractor	3	2	0.5	0.2	253	2
Other vehicle	6	5	1.1	0.6	181	3
Total	270	298	52.3	33.0	158	99

(1) Yearly average of road fatalities in 2009–2013
(2) Road fatalities per million inhabitants, year (Fin=5.16 and Swe=9.03 million people)
(3) Fatalities per population in Finland compared to Sweden (Index for Sweden=100)
(4) Yearly reduction of fatalities in Finland, if No. of fatalities per population same as in Sweden
(5) LGV = light goods vehicle (max 3 500kg), HGV = heavy goods vehicle (over 3 500kg)

Figure *14* shows the number of fatalities per population by accident type in Finland and Sweden. Head-on and single accidents are the two most dangerous accident types in both Finland and Sweden, causing more than half of all fatalities in each country (54.6% and 55.5%, respectively). Importantly, they are also the two accident types with the greatest safety potential for Finland. If their population risk were the same as in Sweden, 36 head-on fatalities (including six overtaking fatalities) and 23 single accident fatalities would be prevented in Finland. Table *8* shows that the safety potential due to a major dip in head-on accidents would be greatest in January–April and for single accidents in May–August .

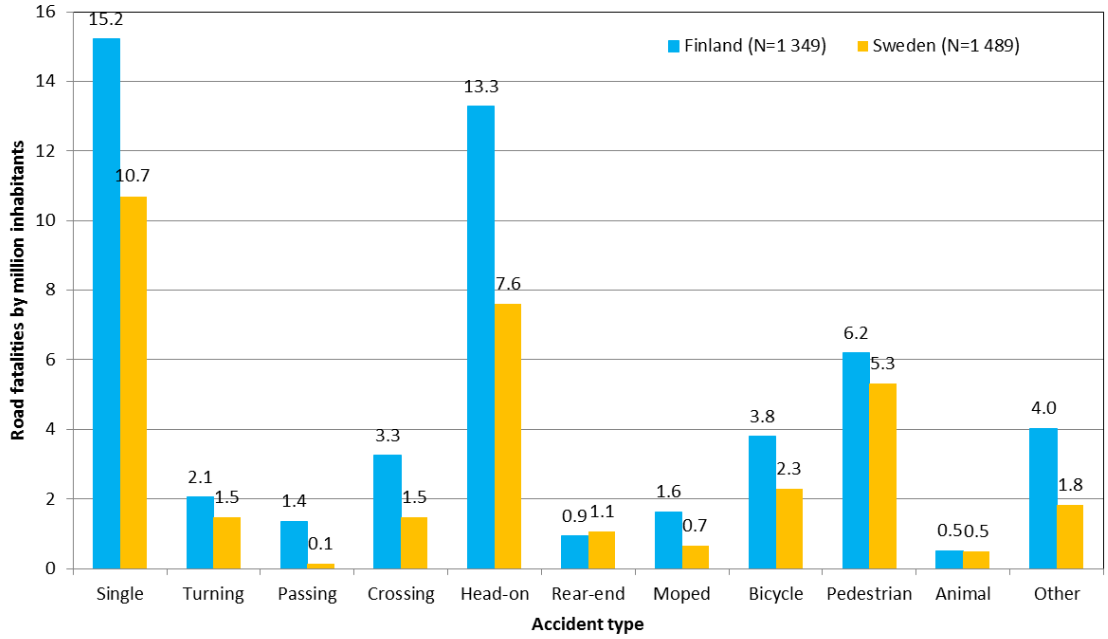


Figure 14. Number of fatalities per population by accident type in Finland and Sweden in 2009–2013 (Statistics Finland 2015, Swedish Transport Agency 2015).

Table 8. Safety potential for yearly fatalities in Finland by accident type and month if the number of fatalities per population were the same as in Sweden (Statistics Finland 2015, Swedish Transport Agency 2015).

Accident type	Month						Total
	JAN-FEB	MAR-APR	MAY-JUN	JUL-AUG	SEP-OCT	NOV-DEC	
Single	0	1	8	9	5	1	23
Turning & crossing	2	2	3	4	-1	2	12
Head-on & overtaking	10	9	5	4	3	4	36
Rear-end	1	0	0	-1	-1	0	-1
Moped	0	0	2	0	2	0	5
Bicycle	0	1	1	2	3	0	8
Pedestrian	0	0	1	-1	1	2	5
Other	1	1	3	2	1	2	12
Total	15	14	24	21	13	13	99

In Section 3.3, age groups 15–17 and 18–20 years were recognised as having the greatest relative population risk compared to the SUN countries. Fatalities in those age groups by traffic unit are compared in Figure *15*. The figure shows that the high population risks in Finland compared to Sweden for 15–17-year-olds are caused mainly by moped and motorcycle fatalities and for 18–20-year-olds mainly by car fatalities. In fact, the safety potential for 15–17-year-olds in Finland is four moped and three motorcycle fatalities yearly, and for 18–20-year-olds 12 car fatalities yearly.

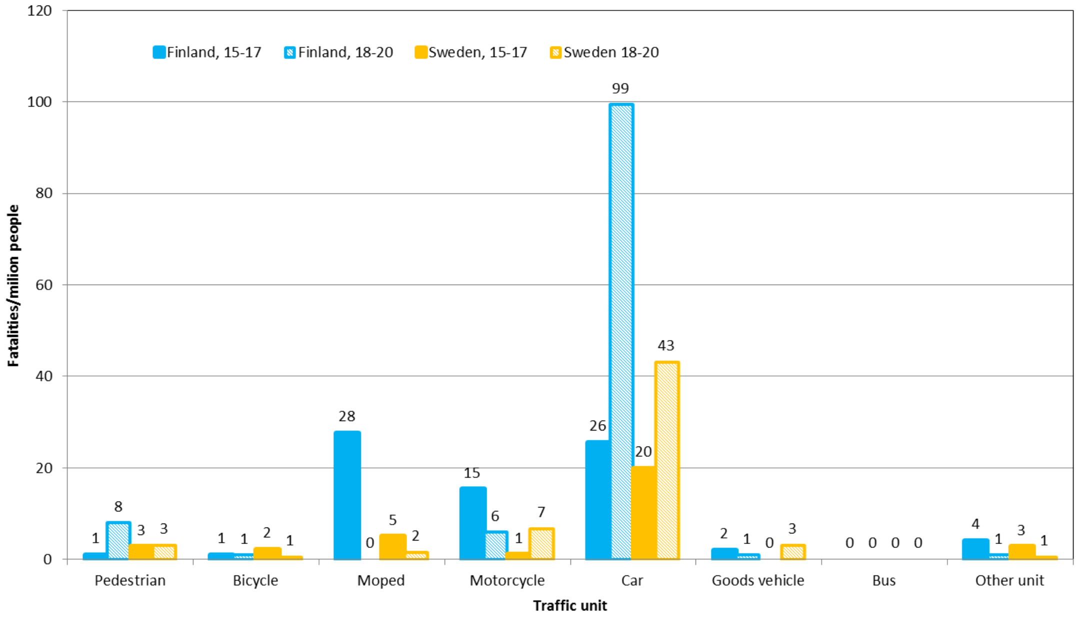


Figure 15. Number of fatalities per population for Finnish highest-risk age groups by traffic unit in Finland and Sweden in 2009–2013 (Statistics Finland 2015, Swedish Transport Agency 2015).

In the following (Sections 4.2.2 through 4.2.4.), the safety potential is presented by traffic unit type.

4.2.2 Fatalities in cars and goods vehicles

Risk and kilometres driven

For passenger cars and goods vehicles, estimates are available for total kilometres in Finland and Sweden (Finnish Transport Agency 2015, Trafikanalys 2015). Using these exposure data, one can estimate fatality risks per vehicle kilometre by traffic unit (Table 9).

For Finland, having the same population risk as Sweden would mean 74 fewer car and goods vehicle fatalities per year. This figure derives from two sources:

(1) having the Swedish fatality risk per vehicle kilometre would prevent 50 fatalities (Table 9); and

(2) having the Swedish number of vehicle kilometres per person (8 371 instead of 10 347) would prevent an additional 24 fatalities per year.

For Finland this would drop the number of fatalities per year in cars and goods vehicles from 174 to 100, suggesting a safety potential of 74. It should be noted that in Table 9, the total is not exactly equal to the sum of individual rows. This resulted from a different share of vehicle kilometres among traffic units. Vehicle kilometres per population are higher in Finland for cars and heavy goods vehicles but lower for light goods vehicles compared to Sweden.

Table 9. Number of fatalities, fatality rates per vehicle kilometre and potential for fatality reductions (Statistics Finland 2015, Swedish Transport Agency 2015).

Traffic unit	Fatalities in 2009–2013/y(1)		Fatalities per vehicle km(2)		Relative risk per kilometres in Finland(3)	Reduction if(4) Swe average in Fin
	Finland	Sweden	Finland	Sweden		
Passenger car	158	163	3.4	2.6	131	38
LGV(5)	9	8	2.4	1.0	232	5
HGV(5)	7	5	2.3	1.0	232	4
Total	174	176	3.3	2.3	140	50

(1) Yearly average of road fatalities in 2009–2013
(2) Road fatalities per 1 000 million vehicle kilometres
(3) Fatalities per vehicle kilometre in Finland compared to Sweden (Index for Sweden=100)
(4) Yearly reduction of fatalities in Finland, if No. of killed per kilometre same as in Sweden
(5) LGV = light goods vehicle (max 3 500 kg), HGV = heavy goods vehicle (over 3 500 kg)

Counterparts in fatalities

Fatalities by traffic unit are presented above in Table 9. To identify the role of other involved traffic units, the number of fatalities in counterparts per number of own unit fatalities is analysed in Figure *16*.

When a heavy goods vehicle is involved in a fatal accident, more than 90% of killed people are in opposite traffic units. For light goods vehicles this share is around 60% and for cars around 20%. These results suggest that fatalities in counterpart units should be also considered when analysing the meaning of cars and especially heavy goods vehicles for road safety. In Finland the share of goods vehicles as a counterpart to a killed person is somewhat higher than in Sweden, but for cars the reverse is true (Figure *16*). However, these differences are too small to draw any strong conclusions.

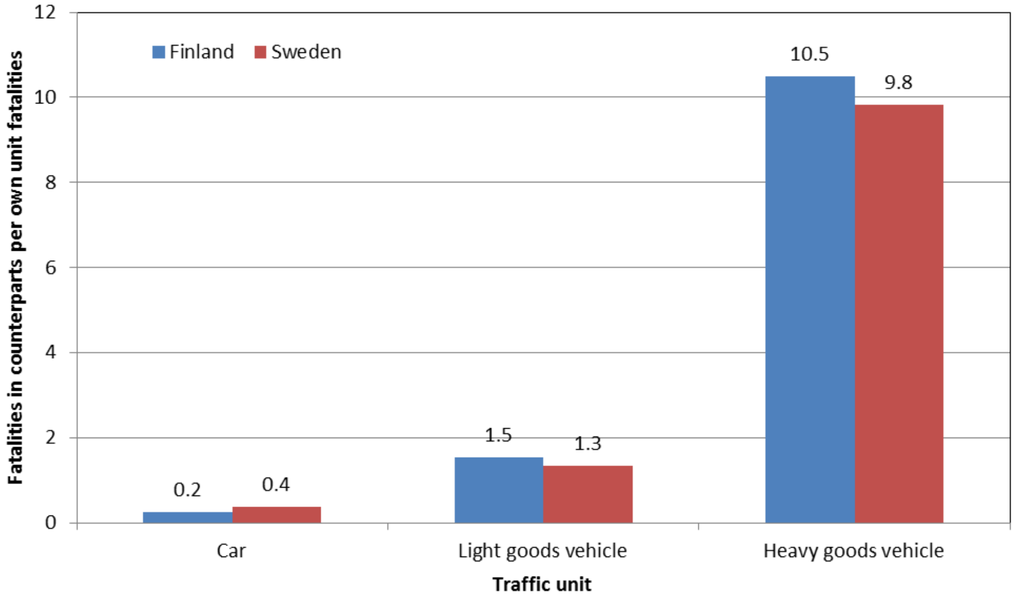


Figure 16. Number of fatalities in counterparts per number of own unit fatalities in Finland and Sweden in 2009–2013 (Statistics Finland 2015, Swedish Transport Agency 2015).

The safety potential for cars and goods vehicles by counterpart unit is shown in Table *10*. The safety potential in Finland for fatalities in cars is highest in accidents with heavy goods vehicles (35 fatalities yearly), followed by single car accidents (16 fatalities) and accidents with other cars. The safety potential for light and heavy goods vehicles is substantially lower.

Table 10. Safety potential for yearly fatalities in Finland for car and goods vehicle fatalities by counterpart units if the number of fatalities per population were the same as in Sweden (Statistics Finland 2015, Swedish Transport Agency 2015).

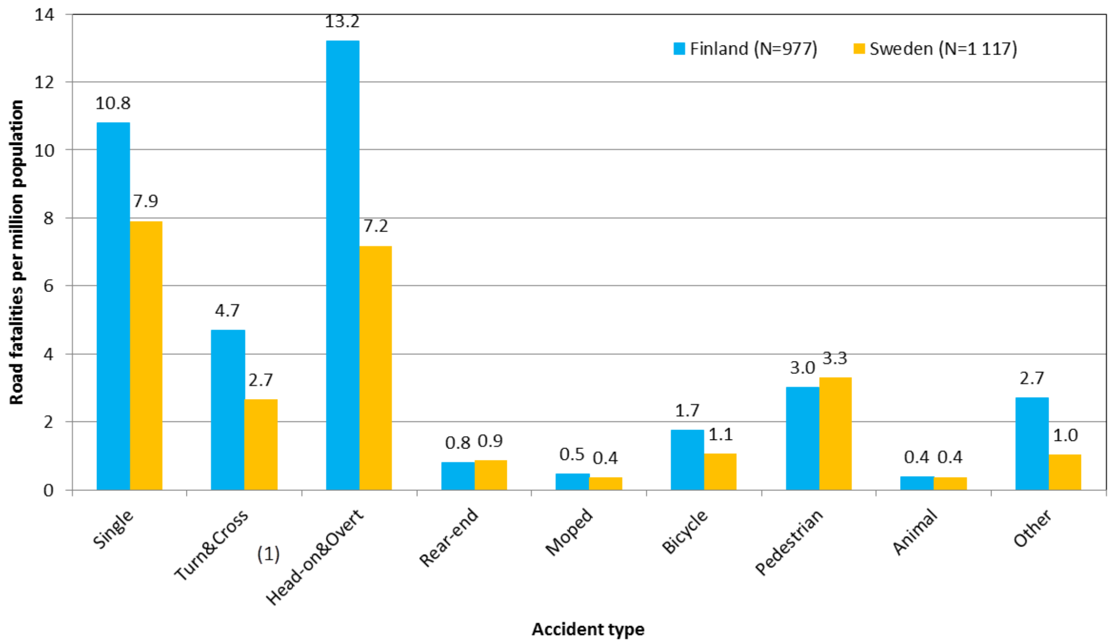
Unit of the killed person	Other units involved in accident					Total
	None(1)	Car	LGV(2)	HGV(2)	Other	
Car	16	8	4	35	1	64
LGV(2)	1	1	0	2	1	5
HGV(2)	1	1	0	1	0	4
Total	18	10	5	38	2	74

(1) Single accidents
(2) LGV = light goods vehicle (max 3 500 kg), HGV = heavy goods vehicle (over 3 500 kg)

In the following sections we analyse accidents and persons involved in all fatal accidents where at least one car or goods vehicle is involved. In practice this means including fatal accidents in which cars and goods vehicles are counterpart units to those of the persons killed.

Fatal accident types involving a car or goods vehicle

The number of fatalities per population in accidents involving a car is presented by accident type in Figure *17*. The graph suggests that Finland has a safety potential in fatal single, crossing-related as well as head-on and overtaking accidents involving a car. In fact, frequencies of fatal overtaking accidents are very small compared to head-on accidents. From all the fatal accidents including a car, only pedestrian and rear-end accidents are slightly more common per population in Sweden than in Finland.



(1) Turn&Cross = turning and crossing. Head-on&Overt = head-on and overtaking.

Figure 17. Number of fatalities per population by accident type in accidents involving a car in Finland and Sweden in 2009–2013 (Statistics Finland 2015, Swedish Transport Agency 2015).

The magnitude of the safety potential in Finland was calculated using the population risk differences (Figure *17*) and actual yearly fatality numbers in Finland. These safety potential figures for accidents involving cars or goods vehicles are presented in Table *11*. Note that potentials are not directly additive, as several vehicles are related to one fatality; this is also why the column *Car or GV* is higher than the sum of columns *Car*, *LGV* and *HGV* in Table *7*.

The results show that the most substantial safety potential is for accidents involving cars, followed by heavy goods vehicles. The most sizable potential is for head-on and overtaking accidents, followed by single vehicle accidents and intersection related accidents.

Further analysis reveals that most of the safety potential (77.3%) is on public highways. We can reasonably assume that most of the difference is attributable to the extensive network of middle-barrier roads in Sweden, and probably offers the most extensive safety potential for Finland (Hytönen & Peltola 2016).

Table 11. Safety potential for yearly fatalities in Finland by type of involved vehicle if the number of fatalities per population were the same as in Sweden (Statistics Finland 2015, Swedish Transport Agency 2015).

Accident type	Accidents involving Car	LGV(1)	HGV(2)	Car or GV(3)
Single	15	1	1	17
Turning & crossing	10	3	9	12
Head-on & overtaking	31	6	31	36
Rear-end	0	-1	1	0
Moped	1	1	1	3
Bicycle	4	1	0	5
Pedestrian	-1	0	6	5
Animal	0	0	0	0
Other	9	2	4	10
Total	68	13	54	87

(1) LGV = light goods vehicle (max 3 500 kg)
(2) HGV = heavy goods vehicle (over 3 500 kg)
(3) Any car or goods vehicle

Drivers in fatal accidents

It is common to analyse fatalities by gender and age to investigate driver characteristics, usually considering only the killed vehicle drivers themselves. However, our analysis was extended to all the drivers involved in a fatal accident. This extension in the case of car drivers is shown in Table *12*. The results indicate that analyses considering only killed vehicle drivers themselves underestimate the role of car drivers in accidents. In fact, in this case they would ignore 45% of the Finnish and 59% of the Swedish car drivers involved in fatal accidents (Table *12*). Further, the underestimation would cause bias, because all the accidents causing fatal injuries to counterpart persons are ignored, among them most collisions with pedestrians.

Table 12. Gender of car driver by role in fatal accidents in Finland and Sweden in 2009–2013 (Statistics Finland 2015, Swedish Transport Agency 2015).

Gender	Finland: Got killed him/herselfself(1)	Finland: Involved in fatal accident(2)	Sweden: Got killed him/herselfself(1)	Sweden: Involved in fatal accident(2, 3)
Male	484	837	461	1075
Female	96	223	118	332
Total	580	1060	579	1423

(1) Drivers who were themselves killed
(2) Drivers of cars involved in fatal accidents
(3) Gender of 16 drivers in fatal accidents in Sweden unknown

The safety potential figures for Finnish fatal accidents involving cars by gender of the driver are presented in Table *13*. The results show that the safety potential for Finnish car drivers is much higher for men than for women. Further, the highest safety potential is related to head-on collisions and single accidents.

Table 13. Safety potential for yearly fatalities in Finland by gender of the car driver if the number of fatalities per population were the same as in Sweden (Statistics Finland 2015, Swedish Transport Agency 2015). Note: population risk figures calculated using people aged at least 18 years by gender.

	Gender of car driver		
Accident type	Male	Female	Total
Single	12	-2	10
Turning and Crossing	5	2	7
Head-on and overtaking	23	3	26
Rear-end	-1	0	-1
Moped	0	1	1
Bicycle	2	1	4
Pedestrian	-2	-1	-2
Animal	0	0	-1
Other	8	2	10
Total	46	6	52

To analyse the safety potential of car drivers by age and gender, population risk for involvement as car drivers in fatal accidents is displayed by driver age and sex in Figure *18*. The results show that especially in the early ages of the car driving career, and especially so for Finland, male population risk appears to be higher than female. The risk of male drivers at 70 years or older seems to be higher than for somewhat younger drivers in Finland but not in Sweden.

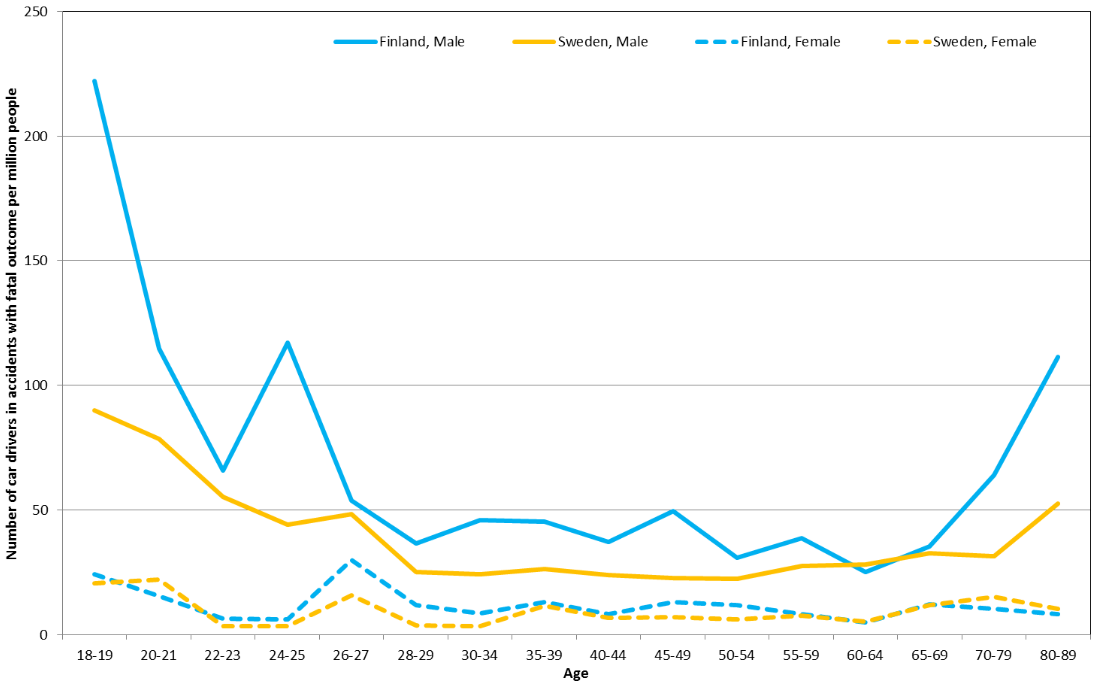


Figure 18. Number of fatalities per population by age group of the involved car driver in Finland and Sweden in 2009–2013 (Statistics Finland 2015, Swedish Transport Agency 2015).

Based on the population risks in Figure *18*, a safety potential comparison of car drivers by age and gender is presented in Table *14*. As suggested by the population risks, Finland has a safety potential especially for young (<=25 years) and elderly (>70 years) male car drivers. The potential is highest at the age of 18–19; in Finland yearly, 263 young men per million population were driving a car in a fatal outcome accident, while the respective figure for Sweden was 126. This is equivalent to a potential of nine fatalities yearly.

Table 14. Safety potential for yearly fatalities in Finland by gender and age of a car driver if the number of fatalities per population were the same as in Sweden (Statistics Finland 2015, Swedish Transport Agency 2015). Note: population risk figures calculated using the number of people of that age group by gender.

	Gender of car driver		
Age	Male	Female	Total
18-19	9	1	10
20-21	3	0	3
22-23	0	0	0
24-25	6	0	6
26-27	0	2	2
28-29	1	0	1
30-34	4	2	5
35-39	3	0	3
40-44	0	0	0
45-49	6	2	8
50-54	3	0	3
55-59	4	0	5
60-64	-1	1	0
65-69	-2	-1	-3
70-79	8	-1	7
80-89	4	0	4
Total	47	6	54

There is no data available on driving kilometres by age. However, some indication can be acquired by analysing the number of driving licences by number of population by age group (Figure *19*). The main results indicate that Swedish people aged 24 or less drive less than their counterparts in Finland. The opposite is true for people aged 65 or more. However, driving licences include licences for mopeds and motorcycles, which somewhat affects the results, although the proportion of car kilometres is dominant for people aged 18 or more.

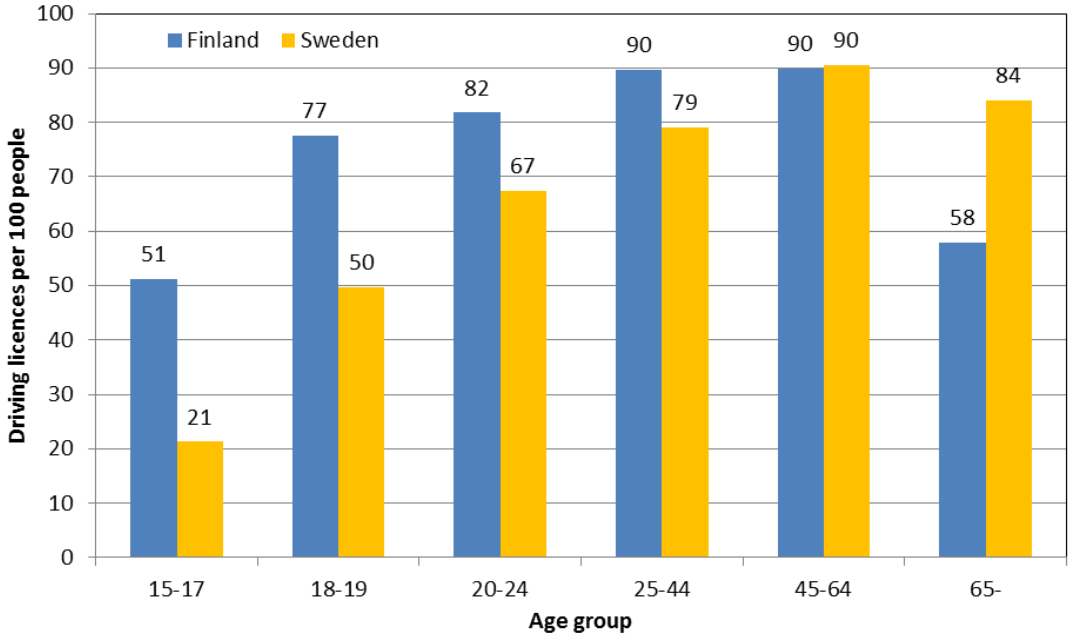


Figure 19. Number of driving licences per 100 people by age group in Finland and Sweden in 2009–2013 ((Finnish transport safety agency 2016; Swedish Transport Agency 2016; Eurostat 2015).

Speed limits on public highways

Speed limit systems in Finland and Sweden are different, implying that a safety potential by speed limit cannot be directly analysed. In addition, there was no specific information available from Sweden for speed limits by road type, for example. However, a comparison of fatalities on public highways is shown in Figure *20*. The results suggest the following general conclusions:

- In Sweden different speed limit values are represented more often than in Finland. This is related to changes in the Swedish speed limit system over the past few years (Vadeby & Forsman 2013).
- The most common speed limit in Finnish accidents is 80 km/h (54.1% of all fatalities and 42.7% of all injuries). In Sweden the most common speed limit in accidents is 70 km/h (34.5% of all fatalities and 32.8% of all injuries).
- In both countries speed limits in fatal accidents are higher than those in injury accidents.
- Average speed limits in Finland are somewhat higher than those in Sweden for fatal and injury accidents, e.g. 79.9 km/h in Finland and 78.9 km/h in Sweden for fatal accidents.

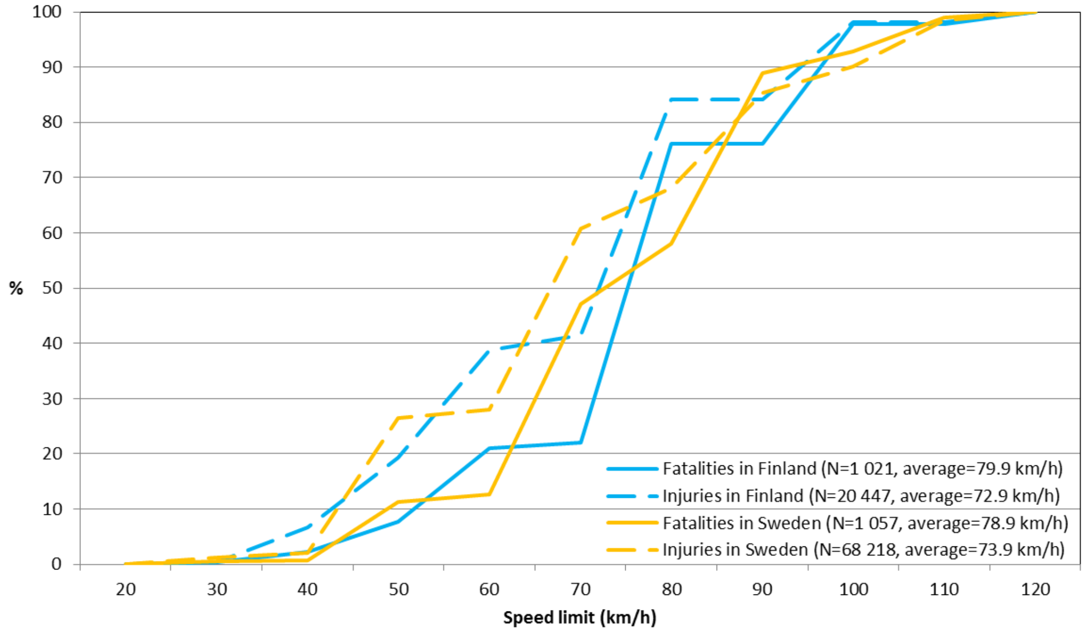


Figure 20. Cumulative distribution (%) of speed limits in fatal accidents and injury accidents on public highways in 2009–2013 (Statistics Finland 2015, Swedish Transport Agency 2015).

Other factors

Information in the STRADA database on driving under the influence of alcohol is derived from police reports only, and is not checked against official investigations. We therefore did not use that information in our analyses, even when such information was available in the Finnish accident data.

Several additional comparisons were made to analyse the Finnish safety potential for cars and goods vehicles. These analyses suggested that the number of fatalities is relatively higher in Finland in the following conditions, and hence includes a safety potential for Finland:

- Summer months
- Peak hours
- Working days and Saturday
- Daylight.

4.2.3 Fatalities among pedestrians and bicyclists

Risk and kilometres travelled

In a COST action (2015) travel survey, data was harmonised between countries and it was estimated that in Finland one person travels an average daily distance of 1.24 km on foot and 0.86 km on a bicycle. In Sweden, the respective figures are somewhat lower with 1.11 and 0.68 km per day per person. The number of pedestrian and cyclist fatalities and their fatality rates per kilometre based on these estimates are given in Table *15*. For Finland, having an equivalent population risk to Sweden would mean nine fewer bicycle and nine fewer pedestrian fatalities per year. These figures derive from two sources:

(1) having the Swedish fatality risk per person kilometre would prevent six bicycle and six pedestrian fatalities (Table *15*); and

(2) having the Swedish number of pedestrian and bicycle kilometres per person would prevent an additional three bicycle and three pedestrian fatalities per year.

For Finland this would drop the number of fatalities per year for pedestrians and bicyclists from 55 to 37, meaning a safety potential of 18.

Table 15. Number of fatalities and fatality rates per person kilometre for pedestrians and bicyclists (Statistics Finland 2015, Swedish Transport Agency 2015, COST 2015).

Traffic unit	Fatalities in 2009–2013/y(1)		Fatality risk per person km(2)		Relative risk per kilometre in Finland(3)	Reduction if(4) Swe average in Fin
	Finland	Sweden	Finland	Sweden		
Bicycle	21	21	13	9	138	6
Pedestrian	34	44	14	12	120	6
Total	55	65	14	11	126	11

(1) Yearly average of road fatalities in 2009–2013
(2) Road fatalities per 1000 million person kilometres
(3) Fatalities per kilometrage in Finland compared to that in Sweden (Index for Sweden=100)
(4) Yearly reduction of fatalities in Finland, if No. of killed per kilometrage same as in Sweden

A further analysis reveals that most of the safety potential for Finnish pedestrian fatalities is on other roads, mainly streets (eight out of nine yearly fatalities). Also most of the potential for bicycle fatalities is on other roads (six out of nine fatalities).

Counterparts in fatalities

When a pedestrian or bicyclist is involved in a fatal accident, they account for 95% of the fatalities in this type of accident in both countries.

Table *16* shows that the safety potential in Finland for pedestrian fatalities is highest in accidents with heavy goods vehicles (six fatalities yearly) and for bicyclists with cars (four fatalities). In fact, in Sweden cars are more often involved in pedestrian accidents than in Finland, causing for Sweden a safety potential of two killed pedestrians in collisions with cars. Overall, these figures are too low to result in any strong conclusions.

Table 16. Safety potential for yearly fatalities in Finland for pedestrian and bicycle fatalities by counterpart unit if the number of fatalities per population were the same as in Sweden (Statistics Finland 2015, Swedish Transport Agency 2015).

Unit of the killed person	Other units involved in accident					Total
	None(1)	Car	LGV(2)	HGV(2)	Other	
Pedestrian	0	-2	0	6	4	9
Bicycle	1	4	1	0	3	9
Total	1	2	1	7	7	18

(1) Single accidents
(2) LGV = light goods vehicle (max 3 500 kg), HGV = heavy goods vehicle (over 3 500 kg)

Age and gender

The number of fatalities per million people by gender for pedestrians and bicyclists in Finland and Sweden is shown in Table *17*. Fatality rates per population are higher for males than for females. This is the case for both countries and for pedestrians and bicyclists. However, the gender differences are not as high as for car drivers (see Figure *18*).

Table 17. Number of fatalities per million population for pedestrians and bicyclists by gender and country (Statistics Finland 2015, Swedish Transport Agency 2015).

	Male		Female		Total	
Traffic unit	Finland	Sweden	Finland	Sweden	Finland	Sweden
Pedestrian	7.1	5.7	5.6	3.9	6.3	4.8
Bicycle	4.9	2.8	2.9	1.6	3.9	2.2
Total	12.0	8.5	8.5	5.5	10.2	7.0

The number of fatalities per million people by age group in Finland and Sweden for pedestrians and bicyclists is shown in Figure *21*. The difference between the curves shows that the safety potential for Finland is especially high among people aged 66 years or above. In fact, half of the potential of nine pedestrian and nine bicycle fatalities per year is in these age groups: the Swedish population risk in Finland would reduce the yearly number of pedestrian fatalities at the age of 66 or above from 16 to 12. The corresponding drop for bicyclists would be from 10 to five.

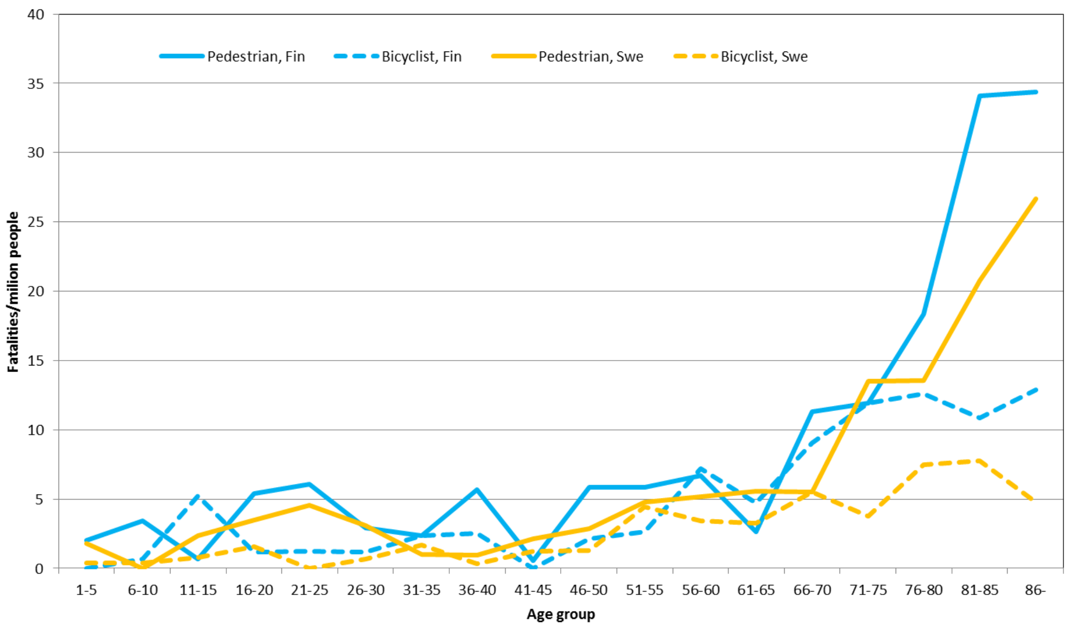


Figure 21. Number of pedestrian and bicyclist fatalities per million population by age group (Statistics Finland 2015, Swedish Transport Agency 2015).

4.2.4 Fatalities relating to mopeds and motorcycles

Risk and kilometres travelled

In the COTS action, kilometres travelled were estimated for mopeds and motorcycles also. However, an estimate of person kilometres is available only as a total for mopeds and motorcycles (COST 2015), suggesting that moped and motorcycle kilometres in Finland are more than double those in Sweden (0.67 vs. 0.32 km per person per day).

We completed the estimate with the assumption that the share of person kilometres on public highways equals the share of moped and motorcycle fatalities on public highways in Finland and Sweden together. The results based on this data are presented in Table *18*. For Finland, having an equivalent population safety to Sweden would mean four fewer motorcycle and moped fatalities per year. This figure derives from two sources:

(1) having the Swedish fatality risk per person kilometre would actually add 26 fatalities (Table *18*); and

(2) having the Swedish number of moped and motorcycle kilometres per person (0.32 kilometres per day per person instead of 0.67 kilometres) would prevent 30 of those fatalities yearly.

In Finland this would drop the number of fatalities per year for moped and motorcycle passengers from 32 to 28, meaning a safety potential of four yearly. The potential for moped fatalities is equally high on public highways and other roads, with two fatalities per year on each. There is no safety potential for Finland related to motorcycle fatalities in total.

Table 18. Number of fatalities and fatality rates per person kilometre for moped and motorcycle passengers (Statistics Finland 2015, Swedish Transport Agency 2015, COST 2015).

	Fatalities in 2009–2013/y(1)		Fatality risk per person km(2)		Relative risk per	Reduction if(4)
Road type	Finland	Sweden	Finland	Sweden	kilometer in Finland(3)	Swe average in Fin
Public highways	22	38	23	48	48	-24
Non-highway roads	10	10	31	39	79	-3
Total	32	48	25	46	55	-26

(1) Yearly average of road fatalities in 2009–2013
(2) Road fatalities per 1000 million person kilometres
(3) Fatalities per kilometrage in Finland compared to that in Sweden (Index for Sweden=100)
(4) Yearly reduction of fatalities in Finland, if No. of killed per kilometre the same as in Sweden

Counterparts in fatalities

When a motorcycle is involved in a fatal accident, the rider/passenger is killed in more than 97% of cases in both countries. Analogously, when a moped is involved in a fatal accident, the rider/passenger is often the killed party (in Finland 86% and in Sweden 93% of cases). In Finland, four pedestrians were killed in accidents involving a moped over a period of 5 years, whereas no such accidents occurred in Sweden.

The safety potential for riders/passengers on motorcycles and mopeds by counterpart unit is shown in Table *16*. The safety potential in Finland for moped fatalities is quite evenly distributed among counterpart units. The number of motorcycle fatalities per population is higher in Sweden in collisions with cars (three fatalities) but lower with other counterpart units. Overall, the figures are too low to result in any strong conclusions.

Table 19. Safety potential for yearly fatalities in Finland for moped and motorcycle fatalities by counterpart unit if the number of fatalities per population were the same as in Sweden (Statistics Finland 2015, Swedish Transport Agency 2015).

Unit of the killed person	Other units involved in accident					Total
	None(1)	Car	LGV(2)	HGV(2)	Other	
Moped	0	0	1	1	1	4
Motorcycle	1	-3	0	1	0	-1
Total	1	-2	1	3	1	3

(1) Single accidents
(2) LGV = light goods vehicle (max 3 500 kg), HGV = heavy goods vehicle (over 3 500 kg)

5 Discussion

The main aim of this study was to identify factors behind Finland having a poorer road traffic accident record compared to Sweden. An additional aim was to update some of our earlier country-wise safety comparisons in 2006–2010 between Finland and the best performing European countries Sweden, the UK and the Netherlands. In the following, the main results are discussed and our conclusions outlined. In addition, we share our experience on using an advanced tool designed for analysing disaggregate accident data, instead of general statistical tools typically used such as the European Care/CADaS database.

5.1 Finland vs. the best in Europe

The results showed that the three SUN countries (Sweden, UK and the Netherlands) are still performing much better than Finland in terms of road safety. Specifically, their population risks in 2009–2013 were 31 (SE), 31 (UK) and 33 (NL) fatalities yearly per million population compared to 50 in Finland. Consequently, had the fatality rate per population in Finland been as low as the average in the SUN countries, 111 fatalities would have been prevented, or 41% of the country's yearly figure of 271. This finding suggests that there is a huge road-safety potential in Finland and the gap between Finland and the SUN countries in 2009–2013 was wider than in 2006–2010. (The main contributing factors for this difference found in our earlier study (Luoma et al. 2013) were discussed in section 1.)

Compared to the SUN average, the most substantial reduction in fatalities (85 fatalities annually) could be achieved for cars if the fatality rate per population were as low in Finland as the SUN average. However, in relative terms the number of fatalities per population in Finland is especially high in goods vehicles (3.1 times the SUN average), on mopeds (2.6 times the SUN average) and in cars (2.2 times the SUN average). In terms of age, population risks in Finland are especially high in the age groups 15–17 years (2.3 times the SUN average) and 18–20 years (1.7 times the SUN average).

The country-wise results with additional comparisons by NUTS2 areas within countries suggest that high population density and good safety are interrelated in terms of a low number of fatalities per population. However, Sweden, which has a low average population density, has achieved a good safety record. The main conclusions are that (1) there is a great safety potential for Finland, and (2) Sweden is the number one choice among the SUN countries for safety comparison with Finland, to define more specific aspects of the safety potential.

5.2 Finland vs. Sweden

The results showed that by comparison with Sweden, in Finland there is a safety potential of 99 yearly fatalities. Two thirds of the potential is on public highways (69%) and one third (31%) on other roads. Most of the fatalities on other roads have occurred on streets in Finland (73%) as well as in Sweden (64%).

The results based on comparison of numbers of motor vehicle kilometres suggest that the number of fatalities per vehicle kilometre is 30% higher in Finland than in Sweden. In addition, the number of motor vehicle kilometres per person was 23% higher in Finland than in Sweden (10 460 km/year vs. 8 480 km/year). We can conclude that Finland has a safety potential in reducing the number of vehicle kilometres, as well as reducing their fatality risk. In Finland, more effective safety measures are therefore recommended to reduce the fatality risk. Good Swedish urban planning has probably led to a more limited need to use cars, contributing to a lower exposure to road accidents. However, advanced urban planning is a structural factor that is hard to achieve quickly (Luoma & Sivak 2014). Nonetheless, long-term development is recommended, and other related means are available as well, such as developing public transport and encouraging people to use it, alongside telecommuting, etc.

Comparison of the traffic units of killed persons suggests that compared to Sweden, Finland has the highest potential for fatality reduction (64 fatalities yearly) for cars. However, Finland has an overrepresentation of travellers in heavy goods vehicles (population risk 2.7 times that in Sweden) and light goods vehicles (population risk 2.0 times that in Sweden) and on mopeds and bicycles (population risk 1.8 times that in Sweden).

The main conclusion from accident type comparisons was a huge potential for reducing head-on fatalities, as well as single vehicle fatalities, in Finland. Specifically, head-on and single accidents are the two most dangerous accident types in both Finland and Sweden, causing more than half of all fatalities in each country. Importantly, they are also the two accident types with the greatest safety potential for Finland. If their population risk were the same as in Sweden, 36 head-on fatalities (including six overtaking fatalities) and 23 single accident fatalities would be prevented in Finland. Furthermore, the safety potential for Finland for fatalities in cars is highest in accidents with heavy goods vehicles. We acknowledge that the results of this comparison might be slightly biased, since Finland does not omit suicides from its road accident statistics as Sweden has done since 2010. However, the safety potential for Finland, even considering head-on accidents alone (30 fatalities yearly), is substantially higher than the total number of fatalities excluded in Sweden as suicides (on average 21 in 2009–2013). Overall, we can reasonably assume that most of the difference is attributable to the extensive network of middle-barrier roads in Sweden. They would probably offer the most extensive safety benefit for Finland also. Another key factor is that the Swedish road safety policy does not allow high speed limits such as 100 km/h on main roads with no middle-barrier. In Finland the speed of 100 km/h is allowed on many roads without middle barriers, especially from April to October when wintertime speed limits are not in force (Peltola 2015).

Age groups 15–17 and 18–20 years were identified as having the greatest relative population risk in Finland. Population risks for these ages were compared by traffic unit, and we conclude that in Finland the safety potential among 15–17-year-olds is four moped and three motorcycle fatalities and among 18–20-year-olds 12 car fatalities annually.

Our results suggest that in both countries, the population risk of a male being involved in a fatal accident as a car driver is much higher than for respective females. Comparing the age and gender of car drivers involved in fatal accidents revealed that Finland has a safety potential especially among young (<=25 years) and elderly (>70 years) male car drivers. The potential is highest for novice car drivers; achieving the same population safety as in Sweden would save every year nine fatalities in accidents involving an 18–19-year-old man as a car driver.

Because speed limit systems in Finland and Sweden differ, a safety potential analysis could not be performed. However, our results indicate that average speed limits in both fatal and injury accidents are higher in Finland than in Sweden. Therefore it is likely that accidents in Finland occur at higher speed than in Sweden. Given the strong relationship between speed and accidents/accident severity (e.g. Elvik 2005), this tentative finding is important.

Travel survey data shows that the daily average number of pedestrian kilometres per person is a bit higher in Finland (1.24 km) than in Sweden (1.11 km). The same concerns bicyclist kilometres per person (Finland 0.86 km vs. Sweden 0.68 km). These estimates suggest that for Finland, having the Swedish fatality risk per person kilometre would prevent six bicycle and six pedestrian fatalities per year. Further, having the Swedish number of pedestrian and bicycle kilometres per person with the current risk level would prevent an additional three bicycle and three pedestrian fatalities. In Finland this would drop the number of fatalities per year among pedestrians and bicyclists from 55 to 37, suggesting a safety potential of 18. Most of this safety potential is on other roads, primarily streets.

Our results indicated that Finland has a safety potential of six yearly pedestrian fatalities in collisions with heavy goods vehicles. Respectively, in Sweden cars are involved in pedestrian accidents more often than in Finland, causing a safety potential for Sweden of two fatalities per year among pedestrians in collisions with cars.

Travel survey data suggests that in Finland the daily average number of kilometres per person on mopeds and motorcycles is more than double that in Sweden (0.67 vs. 0.32 km per person per day). These estimates suggest that for Finland, having the Swedish fatality risk per person kilometre would actually add 26 fatalities, but cutting the number of moped and motorcycle kilometres per person to the Swedish level would prevent 30 fatalities. This would drop the number of fatalities per year on mopeds or motorcycles in Finland from 32 to 28, meaning a safety potential of four moped riders every year. However, given the challenge of travel surveys in obtaining reliable data, these results should be viewed as potential trends.

Several of the above results emphasize the importance of focusing road safety measures on large target groups in addition to identified risk groups. This was also one of the main conclusions of our earlier study (Luoma et al. 2013).

Overall, our comparisons of road safety in Finland and Sweden show that a generally recognised safety difference in these countries can be analysed in detail, and that there are several specific areas of safety potential for Finland. Further comparisons between Sweden and Finland are recommended, and should include (1) road register data from Sweden in order to analyse differences by road environment (2) comparison of severity of injuries and (3) comparison of road accidents by speed limit.

5.3 Finnish and Swedish accident data

We compared police-reported accident data only, because in Finland there is no hospital data on road accidents available for the time period (2009–2013) included in the present analyses. However, this type of data is under preparation for 2014. Comparing detailed data between countries reveals the pros and cons in different datasets. Our main findings related to the compared datasets are as follows:

- Finland should consider removing suicides from official road accident statistics, as Sweden has done since 2010 and is suggested by UNECE, ITF and Eurostat (2009).
- Finland should complete the system to combine hospital data with police-reported accident data. The system should be developed to enable complementation and remedying of police-reported data on the consequences of accidents, especially (1) poorly recorded accidents like bicycle accidents and (2) severity of injuries using MAIS3+ criteria as suggested e.g. by OECD/ITF (2015).
- Information on driving under the influence of alcohol in the STRADA database (Sweden) is based on police reports only, and is not checked against official investigations. Doing so, as is currently the case in Finland, would be extremely useful as it is well known that a number of road accidents are alcohol related in all motorized countries.
- Swedish data does not include any verified data on road conditions at the time of accident. Even the information on road type is based on police reports only and is lacking data. Additionally some person-related data (e.g. driving licence) and vehicle-related data (e.g. age and weight of the vehicle) would be useful in Swedish data. Validated road data in both countries for the time of accident as well as additional person- and vehicle-related data would allow us to conduct several useful comparisons.

5.4 Advanced use of disaggregated data

One of our main conclusions is that advanced use of disaggregated data provides more options than programmes created for analysing e.g. European-wide accident data. Two specific examples of this are as follows:

- When analysing the role of e.g. car drivers in accidents, one should focus on all fatalities resulting from accidents. Specifically, considering only the killed car drivers themselves underestimates the overall role of car drivers in accidents. Thus counterpart persons should be included in the analyses as well. For example, in our data 45% of the Finnish and 59% of the Swedish car drivers involved in fatal accidents would have been ignored if we had analysed killed car drivers only. Further, the underestimation would have caused bias, because all the accidents causing fatal injuries to counterpart persons would have been ignored, among them most collisions with pedestrians
- Using advanced analysis of disaggregated data allows for modification of data as described in Table 2. Although the accident types did not match perfectly, the Swedish types could be modified into their Finnish equivalent. The modifications were based primarily on the involvement of unprotected road users.

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