VAS institute

The association between road safety and socioeconomic situation (SES)

An international literature review

Federal Public Service
Mobility and Transport

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CONTENTS

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Executive Summary

Measuring the association between SES and road safety

This report considers the relation between the socioeconomic situation (SES) of people and road safety, in particular their risk of being involved in a road crash. The report is based on a literature review carried out in 2016 and 2017. The area of the review was limited to the (Western) developed world. Most of the publications analysed were peer reviewed scientific articles published since 2000 – although some older studies have been included as well as some reports from the grey literature.

There is no consensus on the definition of SES – socioeconomic situation (or socioeconomic status). Most experts agree that the SES is based on a combination factors related the educational attainment, income and occupational status. It should be recognised, however, that in most studies analyzed not all these factors had been taken into account – in general because of a lack of data – and that often only one factor had been used as a proxy for SES.

In order to relate SES with road safety, in general at least two data sources are needed. First of all, data is needed on road crashes. Such data may be available from police records, insurance companies, hospital databases, mortality registers or surveys (health and travel surveys in particular). Most studies referred to in this report use police records, data from hospital information systems or mortality registers. Second, data needs to be collected for determining the SES of individuals involved in crashes. A wide variety of possible data sources for SES variables exist, of which the scope, availability and access varies considerably across countries. Sometimes some SES information can be found in the same data source as for the crashes, e.g. police and hospital records which include data on profession of injured people or on their area of residence, mortality registers which include both the cause of death and socio-economic information on the person who died, surveys with questions on both crash involvement as on SES variables, etc. In most of the studies reviewed, however, crash data had to be linked to other databases which included SES information, such as census data, employment related databases, area-based economic databases, and education registers.

Ideally, SES is measured at the level of an individual. However, for practical and privacy reasons it is often very difficult or impossible to obtain such information and link it to crash data. An alternative approach, is to use the "average" SES information of a certain area (census track, district, commune, city area, etc.) and link it to all inhabitants of that area. Such an area based approach has actually been used in many of the studies reviewed. Such an approach may not reflect the real SES category of an individual, and consequently it may well be that the observed association between SES and road safety is not correct. This phenomenon is called the ecological fallacy.

A weakness in many of the studies reviewed is that they do not control for factors that may explain part of most of the variation in road safety outcomes. In particular, only a limited number of studies have actually controlled for exposure to risk, in particular the distance travelled. So if a study finds some particular association between SES and road safety, e.g. that lower skilled people have relatively more road crashes than higher skilled people, such a result does not necessarily imply that their crash risk per km travelled is also higher.

Overall result

The overall picture emerging from this review is that in high income countries people from lower SES groups have a higher risk of being involved in road crashes than people from higher SES groups.

It is not possible, however, to generalise this overall finding to all countries and to all road user groups. Indeed there are situations where the general association does not apply and the relationship is even reversed. Thus, social inequality in road safety is a widespread phenomenon, but it is not universal and "generic".

Since many of the studies considered did not control for confounding factors such as exposure, it is also difficult to interpret the results correctly (or compare these with other results). Moreover, with the exception of

the UK and Sweden (and to a lesser extent also France and Spain), there are many European countries where hardly any scientific study on this topic has been. One hypothesis is that in some countries in which no such studies have been undertaken, the overall social gradient in relation to road crash involvement is relatively flat. Assessing the validity of this hypothesis was, however, beyond the scope of this report.

Age and gender related differences

The highest SES differences for crash risks are found with children. Despite the differences in data sources, data quality, data range, categorisations and confounding factors controlled for, there is overwhelming evidence from the studies reviewed that children from lower SES groups in general incur higher road crash risks than children from higher SES groups. This applies in particular to pedestrian crash risks. The strength of association between SES and road safety for children varies considerably between children's age. In general, the differences are small when children are only a few years old. The disparities increase when children start going to school. The differences may continue to grow or may shrink again.

SES-linked road safety differences tend to diminish with age. For adolescents (people aged 16-24) similar patterns as for children are found, but in general the association between SES and road safety is less strong. In some cases, even opposite tendencies have been found. Most probable this is related to the access to and use of particular modes of transport.

In those countries where the relationship between SES of adults and crash risks has been studied, in general lower SES is associated with higher crash risks. This is particularly the case for men. The difference is, however, often smaller than with children and adolescents – and in some cases no difference or even a reverse trend were found. Some of the differences in findings may be due to the lack of controlling for confounding factors such as exposure, vehicle type of type of road environment.

The currently available published research on elderly does not allow to make general statements about the association between SES and road safety for this age group.

A very consistent finding across many studies is that SES-based differences are often much more pronounced for men than for women. In other words, the increased crash risk for lower SES individuals is often lower for women than for men. It should be noted, moreover, that in some context there was no social gradient at all for women (although there was one for men) or even a reversed one.

Other key findings

Some other key findings from the review are:

- SES differences are more pronounced for pedestrian crashes than for car crashes. For cyclist crashes the general association might also be opposite to the general trend.
- In many cases the differences between low and high SES groups increase with the severity of the injury. The relative risk is higher for fatal than for non-fatal injuries.
- The extent of the SES linked differences for crash risks vary considerably between countries. The social gradient is steeper in some countries than in other. Often, this is related to similar gradients in other health areas.
- The association between SES categories and road safety is often very different between rural and urban areas.
- The association between individual SES characteristics and road safety is often stronger than it is the case for area based SES characteristics.

Contributory factors

Overall, the socioeconomic patterning of casualties and fatalities is influenced by a variety of mechanisms – and it is the interaction between those mechanisms and the extent to which these are present that leads to the observed differences. This also explains why the social gradient differs between age categories, travel modes, areas, countries and over time – and why it may sometimes may be reversed.

There are numerous factors that contribute to increased road crash risks or can help preventing these. Several of these can be associated directly or indirectly with the socioeconomic status of the road users. When the factors that increase road crash risks are positively associated with SES groups, then the extent of the prevalence of these factors will lead to an increased crash risk.

The report includes an overview of the most important – or at least the best documented and most discussed – risk factors that have been found to be associated with SES. Most of these factors tend to be more strongly associated with the lower SES groups, hence 'explaining' why in many contexts people from lower social classes have higher crash risks.

The most important contributory factors are related to differences in relation to:

- the access to cars and hence the implications for the use of transport modes
- the safety of vehicles (cars, motorcycles, mopeds, …)
- the length of trips (distance travelled per trip, per year, …)
- the hazardous nature of the environment and the trips.
- the extent of parental supervision of children
- the use of seatbelts
- the wearing of motorcycle, moped and bicycle helmets
- impaired driving
- speeding
- unlicensed driving
- access to and understanding of information
- health status and fragility
- hyperactivity of children.

Cultural groups

There are also differences related to cultural groups to which people belong. A 'cultural group' refers particularly to ethnic groups, migrants and people with a specific religion. In many contexts, people of such cultural groups predominantly belong to one SES layer – often one of the lowest SES levels. It would be mistaken, however, to link cultural differences in road safety outcomes exclusively to differences in SES. Also, other characteristics such as the areas in which groups of people live (and hence the exposure) can be a contributory factor to road crashes without being associated with SES levels – though they often are. Nevertheless, there is a lot of evidence that children in ethnic minorities are often more vulnerable to road crashes than other children.

Samenvatting

Meten van het verband tussen SES en verkeersveiligheid

Dit rapport gaat op zoek naar het verband tussen verkeersveiligheid en de sociaaleconomische situatie (SES) van mensen, in het bijzonder de kans om bij een verkeersongeval betrokken te geraken. Het is gebaseerd op een literatuuronderzoek dat uitgevoerd werd in 2016 en 2017. Qua bereik was het onderzoek beperkt tot de westerse, geïndustrialiseerde wereld. De meeste van de onderzochte publicaties waren wetenschappelijke artikelen (peer reviewed) van na 2000, hoewel ook enkele oudere studies en verslagen uit de grijze literatuur opgenomen werden.

Er bestaat geen consensus over de definitie van 'sociaaleconomische situatie' of status (SES). De meeste deskundigen zijn het erover eens dat de SES gebaseerd is op een combinatie van factoren die te maken hebben met het opleidingsniveau, het inkomen en de professionele status. Hierbij moeten we wel erkennen dat niet in alle geanalyseerde studies met alle factoren rekening gehouden werd, doorgaans bij gebrek aan gegevens, en dat vaak slechts één factor als een benadering voor SES gebruikt werd.

Om die SES vervolgens in verband te brengen met verkeersveiligheid zijn over het algemeen ten minste twee gegevensbronnen vereist. Om te beginnen zijn gegevens nodig over verkeersongevallen. Die kunnen afkomstig zijn uit politieverslagen, dossiers van verzekeringsmaatschappijen en ziekenhuizen, overlijdensregisters en enquêtes (vooral over gezondheid en mobilteit). De meeste studies waar dit rapport naar verwijst gebruikten gegevens van de politie, uit ziekenhuisinformatiesystemen en uit overlijdensregisters. Daarnaast moeten ook gegevens ingezameld worden om de SES te bepalen van de individuen die bij een ongeval betrokken waren. Voor die SES-variabelen zijn er, naargelang het betrokken land, grote verschillen in mogelijke bronnen, waarbij reikwijdte, beschikbaarheid en toegang aanzienlijk kan verschillen. Soms is de SES-informatie te vinden in het gegevensbestand van de ongevallen zelf. Dat is bijvoorbeeld het geval bij politie- en ziekenhuisdossiers, voor zover ze gegevens bevatten over het beroep of de woonplaats van de gewonden, bij overlijdensregisters die zowel de doodsoorzaak vermelden als de sociaaleconomische informatie over de overledene, of bij peilingen die vragen naar de betrokkenheid bij een ongeval en ook naar de sociaaleconomische variabelen. Bij de meeste studies die we gebruikten moesten de ongevallengegevens echter gelinkt worden aan andere databases met informatie over de SES, zoals kieslijsten, arbeidsgerelateerde gegevensbanken, geografisch gesitueerde economische databases en onderwijsregisters.

In het ideale geval wordt de SES gemeten op het niveau van het individu. Om praktische en privacyredenen is het echter vaak heel moeilijk of zelfs onmogelijk om dergelijke informatie te verkrijgen en te linken aan de ongevallengegevens. Een alternatief bestaat erin om de 'gemiddelde' SES-informatie van een bepaalde regio te gebruiken (kiesgebied, district, gemeente, stadsregio, enz.) en die te linken aan alle inwoners van dat gebied. Bij veel van de verwerkte onderzoeken is inderdaad een dergelijke gebiedsgebonden aanpak gehanteerd. Bij zo'n aanpak kan de werkelijke SES-categorie van een individu anders zijn en de waargenomen samenhang tussen SES en verkeersveiligheid bijgevolg incorrect. Dat fenomeen wordt 'ecologische fout' (ecological fallacy) genoemd.

Een zwak punt van veel van de onderzochte studies is dat ze factoren die een (groot) deel van de variatie in de resultaten op het vlak van verkeersveiligheid zouden kunnen verklaren, niet onderzoeken. In het bijzonder de risicoblootstelling en dan zeker de afgelegde afstand wordt maar in een beperkt aantal studies bekeken. Als uit een onderzoek een verband blijkt tussen SES en verkeersveiligheid, bijvoorbeeld dat lagergeschoolden relatief meer verkeersongevallen hebben dan de hoger opgeleiden, impliceert een dergelijk resultaat niet noodzakelijk dat ze per afgelegde kilometer ook een groter risico op een ongeval lopen.

Het globale resultaat

Het algemene beeld dat uit dit onderzoek ontstaat, is dat in landen met een hoog inkomen mensen uit groepen met een lagere SES een groter risico op verkeersongevallen lopen dan mensen uit de hogere sociaaleconomische klassen.

Toch is het niet mogelijk om die globale bevindingen te veralgemenen naar alle landen en alle groepen van weggebruikers. Er zijn immers situaties waarin het algemene verband niet opgaat en waar de relatie zelfs omgekeerd is. Sociale ongelijkheid in verkeersveiligheid is dus een wijdverspreid fenomeen, maar het is niet universeel en 'generiek'.

Aangezien veel van de verwerkte studies evenmin oog hadden voor verstorende factoren zoals blootstelling is het ook moeilijk om de resultaten correct te interpreteren (of met andere resultaten te vergelijken). Bovendien zijn er veel Europese landen, met uitzondering van het Verenigd Koninkrijk en Zweden (en in mindere mate ook Frankrijk en Spanje), waar nauwelijks enig wetenschappelijk onderzoek naar het onderwerp is gevoerd. Een mogelijke verklaring daarvoor is dat in sommige landen waar geen onderzoek plaatsvond de globale sociale gradiënt voor betrokkenheid bij verkeersongevallen redelijk vlak oogt. Die hypothese op haar geldigheid onderzoeken, viel echter buiten het bestek van dit rapport.

Leeftijds- en gendergebonden verschillen

De grootste SES-verschillen met betrekking tot het ongevallenrisico vinden we bij kinderen. Niettegenstaande de verschillen tussen de gegevensbronnen en in gegevenskwaliteit, gegevensbereik, categorisering en verstorende factoren, leveren de onderzochte studies overweldigend bewijsmateriaal voor het feit dat kinderen uit lagere SES-groepen doorgaans een groter risico lopen op een verkeersongeval dan kinderen uit de hogere SES-groepen. Dat geldt in het bijzonder voor het risico bij voetgangers. De kracht van het verband tussen SES en verkeersveiligheid bij kinderen schommelt aanzienlijk volgens de leeftijd van de kinderen. Over het algemeen zijn de verschillen klein bij kinderen van slechts een paar jaar. De kloof neemt toe wanneer de kinderen naar school beginnen te gaan. De verschillen kunnen blijven toenemen of terug afnemen.

Met SES samenhangende verschillen in verkeersveiligheid hebben de neiging af te nemen met de leeftijd. Bij adolescenten (tussen 16 en 24) zijn vergelijkbare patronen als bij kinderen te vinden, maar over het algemeen is het verband tussen SES en verkeersveiligheid minder uitgesproken. In bepaalde gevallen is zelfs een omgekeerde tendens te zien. Het waarschijnlijkste is dat dit te maken heeft met de toegang tot en het gebruik van bepaalde transportmodi.

In die landen waar de relatie tussen de SES van volwassenen en het risico op een ongeval onderzocht is, blijkt een lagere SES doorgaans samen te gaan met een hoger ongevallenrisico. Dat is zeker het geval bij mannen. Toch is het verschil vaak kleiner dan bij kinderen en adolescenten en in sommige gevallen zien we geen verschil of zelfs een omgekeerde trend. Bepaalde van die verschillen kunnen er mee te maken hebben dat onvoldoende rekening is gehouden met verstorende factoren als blootstelling, type voertuig of wegomgeving.

Op basis van het momenteel beschikbare, gepubliceerde onderzoek rond senioren kunnen we geen algemene uitspraken doen over een verband tussen SES en verkeersveiligheid in deze leeftijdsgroep.

Een zeer consistente vaststelling, over tal van studies heen, is dat op SES gebaseerde verschillen vaak meer uitgesproken zijn bij mannen dan bij vrouwen. De toename van het ongevallenrisico bij mensen op de lagere treden van de sociaaleconomische ladder is met andere woorden kleiner voor vrouwen dan voor mannen. Bovendien moeten we ook opmerken dat in bepaalde gevallen bij de vrouwen (in tegenstelling tot de mannen) soms helemaal geen sociale gradiënt te zien was, of zelfs een omgekeerde.

Andere belangrijke bevindingen

Andere belangrijke bevindingen uit het onderzoek zijn:

- De SES-verschillen zijn groter bij ongevallen met voetgangers dan met auto's. Ook bij fietsers kan het globale verband tegengesteld zijn aan de algemene trend.
- In veel gevallen nemen de verschillen tussen groepen met een lage en een hoge SES toe met de ernst van de verwondingen. Het relatieve risico is groter voor fatale dan voor niet-fatale verwondingen.

- De mate waarin we SES-gebonden verschillen in ongevallenrisico zien, verschilt aanzienlijk van land tot land. De sociale gradiënt is in sommige landen steiler dan in andere. Vaak gaat dat gepaard met gelijkaardige gradiënten voor andere gezondheidsaspecten.
- Ook tussen landelijke en stedelijke gebieden kan een groot verschil bestaan in de samenhang tussen sociaaleconomische categorie en verkeersveiligheid.
- De samenhang tussen individuele SES-kenmerken en verkeersveiligheid is vaak sterker dan het geval is voor de gebiedsgebonden SES-karakteristieken.

Welke factoren spelen nog mee?

Globaal gesproken worden sociaaleconomische patronen in (dodelijke) ongevallen beïnvloed door een waaier aan mechanismen en leidt de interactie tussen die mechanismen en de mate waarin ze zich voordoen tot de vastgestelde verschillen. Dat verklaart ook waarom de sociale gradiënt verschilt per leeftijdscategorie, vervoersmodus, regio, land en doorheen de tijd en waarom hij soms omgekeerd verschijnt.

Tal van factoren dragen bij tot verhoogde risico's op verkeersongevallen of kunnen helpen bij het voorkomen ervan. Verscheidene van die factoren kunnen rechtstreeks of onrechtstreeks in verband worden gebracht met de sociaaleconomische status van de weggebruikers. Als de factoren die het risico op een verkeersongeval doen stijgen positief met de SES-groep geassocieerd worden, zal de omvang van de prevalentie van die factoren tot een toegenomen ongevallenrisico leiden.

Het rapport omvat een overzicht van de belangrijkste, of in elk geval de best gedocumenteerde en meest besproken risicofactoren die met de SES bleken samen te hangen. De meeste van die factoren vertonen de neiging om eerder samen te gaan met de lagere sociaaleconomische groepen. Ze lijken bijgevolg 'uit te leggen' waarom mensen uit lagere sociale klassen in veel gevallen een hoger risico lopen op een ongeval.

De voornaamste bijdragende factoren hebben te maken met verschillen in:

- de toegang tot auto's en bijgevolg de implicaties van het gebruik van vervoersmodi;
- de veiligheid van voertuigen (auto's, motor- en bromfietsen, …);
- de lengte van de verplaatsingen (afgelegde afstand per verplaatsing, per jaar, …);
- de gevaarlijke aard van de omgeving en van de verplaatsingen;
- de mate van ouderlijk toezicht op kinderen;
- het dragen van de veiligheidsgordel;
- het dragen van een helm bij fietsers, brom- en motorfietsers;
- rijden met een beperking;
- te hard rijden;
- rijden zonder rijbewijs;
- toegang tot en inzicht in informatie;
- gezondheidstoestand en kwetsbaarheid;
- de hyperactiviteit van kinderen.

Culturele groepen

Er zijn ook verschillen naargelang de culturele groep waartoe mensen behoren. Een 'culturele groep' verwijst in het bijzonder naar de etnische groepen van migranten en mensen met een specifieke godsdienst. In veel omstandigheden behoren mensen van dergelijke groepen overwegend tot één sociaaleconomische laag, vaak een van de onderste. Het zou evenwel verkeerd zijn om culturele verschillen in verkeersveiligheid uitsluitend in verband te brengen met verschillen in SES. Ook andere kenmerken, zoals het gebied waar groepen mensen leven (en bijgevolg hun blootstelling), kunnen bijdragen tot het risico op verkeersongevallen, zonder dat er een verband moet zijn met het sociaaleconomische niveau, hoewel dat er vaak wel is. Veel wijst er niettemin op dat kinderen van etnische minderheden kwetsbaarder zijn voor verkeersongevallen dan andere kinderen.

Résumé

Mesurer le lien entre la situation socio-économique et la sécurité routière

Ce rapport traite de la relation entre la situation socio-économique (SSE) de la population et la sécurité routière, en particulier le risque d'accident. Ce rapport est basé sur des études de littérature menées en 2016 et 2017. Le domaine d'étude était limité au monde développé (occidental). La plupart des publications analysées étaient constituées d'articles scientifiques publiés depuis 2000 et reconnus par les pairs, même si des études plus anciennes en faisaient également partie ainsi que plusieurs rapports émanant de la littérature grise.

Il n'y a pas de consensus à propos de la définition de la SSE – situation socio-économique (ou statut socio-économique). La plupart des experts sont d'accord pour affirmer que la SSE se base sur une combinaison de facteurs ayant trait au degré d'enseignement, au revenu et au statut professionnel. Toutefois, il convient d'admettre que tous ces facteurs ne sont pas pris en considération dans la majorité des études analysées (c'est généralement dû à un manque de données) et que souvent un seul facteur a été utilisé comme variable pour la SSE.

Pour établir un lien entre la SSE et la sécurité routière, au moins deux sources sont requises en général. Premièrement, les données sur les accidents de la route. De telles données peuvent être obtenues sur base des rapports de police, des compagnies d'assurances, des bases de données des hôpitaux, des registres de décès ou d'enquêtes (enquêtes sur la santé et le voyage en particulier). La plupart des études dont il est question dans ce rapport ont recouru aux rapports de police, aux données hospitalières ou aux registres de décès. Deuxièmement, les données doivent être collectées pour déterminer la SSE des personnes impliquées dans les accidents de la route. Il existe une grande variété de sources de données possibles pour les variables SSE dont la portée, la disponibilité et l'accès varient d'un pays à un autre. Il arrive parfois que certaines informations liées à la SSE puissent être obtenues à partir de la même source de données que celle des accidents, par exemple, les dossiers de police ou hospitaliers qui incluent des données concernant la profession des personnes blessées ou leur domicile, les registres de décès qui comprennent à la fois la cause du décès et des informations socio-économiques sur la personne décédée, des enquêtes avec des questions sur l'implication dans l'accident et sur les variables SSE, etc. Dans la plupart des études consultées, les données d'accident devaient avoir un lien avec d'autres bases de données qui comportaient des informations SSE, comme des listes électorales, des bases de données liées à la profession, des bases de données économiques et des registres scolaires.

Idéalement, la SSE est mesurée au niveau de l'individu. Toutefois, pour des raisons pratiques et d'ordre privé, il est souvent difficile voire impossible d'obtenir de telles informations et de les corréler aux données d'accident. Une approche alternative consiste à utiliser les informations de la SSE « moyenne » d'une certaine région (circonscription électorale, district, commune, municipalité, etc.) et de les corréler à l'ensemble des habitants de cette région. Une telle approche a été utilisée dans bon nombre d'études consultées. Une telle approche ne reflète peut-être pas la réelle catégorie SSE à laquelle appartient un individu et, par conséquent, il se pourrait bien que l'association observée entre la SSE et la sécurité routière ne soit pas correcte. Ce phénomène est appelé erreur écologique.

De nombreuses études examinées comportent un inconvénient, à savoir qu'elles n'étudient pas les facteurs qui pourraient expliquer une (grande) partie des variations des résultats en matière de sécurité routière. Plus particulièrement, l'exposition au risque et, plus précisément, la distance parcourue, n'a été étudiée que dans un nombre limité d'études. Par conséquent, si une étude établit un lien entre la SSE et la sécurité routière, le fait que les personnes moins qualifiées soient relativement plus impliquées dans les accidents de la route que les personnes plus qualifiées, par exemple, ne signifie pas nécessairement que le risque d'accident par kilomètre parcouru soit également plus élevé

Résultats généraux

L'image globale ressortant de cette analyse est que dans les pays disposant d'un haut revenu, les personnes issues de groupes SE plus bas courent un risque plus élevé d'avoir un accident de la route que les personnes issues de groupes SE plus élevés.

Il n'est toutefois pas possible de généraliser ces résultats à l'ensemble des pays et à l'ensemble des groupes d'usagers. En effet, il y a des situations où l'association générale ne s'applique pas et où la relation est même inversée. Bref, l'inégalité sociale dans la sécurité routière est un phénomène répandu mais pas universel ni « générique ».

Etant donné que bon nombre d'études traitées ne tenaient pas compte des facteurs aggravants comme l'exposition, il est également difficile d'interpréter correctement les résultats (ou de les comparer à d'autres résultats). En outre, à l'exception du Royaume-Uni et de la Suède (et dans une moindre mesure de la France et de l'Espagne), nombreux sont les pays européens dans lesquels il n'y a quasiment pas eu d'études sur le sujet. Ce phénomène peut s'expliquer par le fait que dans les pays où aucune étude n'a été menée sur le sujet, le gradient social global est relativement plat par rapport à l'implication dans les accidents de la route. Néanmoins, l'évaluation de la validité de cette hypothèse n'entre pas dans le cadre de ce rapport.

Différences selon l'âge et le genre

Les différences socio-économiques les plus marquées en matière de risques d'accident sont observées chez les enfants. En dépit des différences au niveau des sources de données, de la qualité des données, de la portée des données et de la catégorisation des facteurs aggravants, il apparaît très clairement que les enfants issus de groupes SE plus bas courent, en général, plus de risques que les enfants issus de groupes SE plus élevés. Ceci s'applique plus particulièrement aux risques d'accident chez les piétons. L'ampleur du lien entre la SSE et la sécurité routière des enfants varie considérablement suivant l'âge de l'enfant. En général, les différences sont minimes lorsque les enfants n'ont que quelques années. L'écart s'agrandit lorsque les enfants commencent l'école. Les différences peuvent continuer à s'intensifier ou diminuer à nouveau.

Les différences en termes de sécurité routières liées à la SSE tendent à diminuer avec l'âge. On trouve chez les adolescents (âgés de 16 à 24 ans), des modèles similaires à ceux observés chez les enfants, mais, en règle générale, le lien entre la SSE et la sécurité routière est moins apparent. Dans certains cas même, des tendances opposées ont été enregistrées. Il est fort probable que cela soit dû à l'accès et à l'utilisation de certains modes de transport.

Dans les pays où la relation entre la SSE des adultes et le risque d'accident a été étudiée, une SSE plus faible est en général associée à un risque d'accident accru. Ceci vaut surtout pour les hommes. La différence est néanmoins moins marquée que chez les enfants et les adolescents. Dans certains cas, il n'y avait pas de différence ou une tendance inverse a été observée. Certaines différences au niveau des résultats peuvent s'expliquer par le fait que l'on n'a pas tenu compte des facteurs aggravants tels que l'exposition, le type de véhicule ou le type d'environnement routier.

Les études disponibles actuellement sur les seniors ne permettent pas de tirer de conclusions générales sur l'association entre la SSE et la sécurité routière pour ce groupe d'âge.

L'on constate dans les nombreuses études que les différences au niveau de la SSE sont souvent plus prononcées chez les hommes que chez les femmes. En d'autres termes, le risque accru d'accident pour les individus issus de groupes SE plus bas est aussi plus faible pour les femmes que pour les hommes. Il convient d'indiquer qu'il n'y avait pas du tout de gradient social pour les femmes (alors qu'il y en avait un pour les hommes) ou même un gradient inversé.

Autres résultats majeurs

D'autres résultats clés de l'étude :

- Les différences de SSE sont plus marquées pour les accidents impliquant des piétons que pour les accidents de voiture. Pour les accidents impliquant des cyclistes, l'association générale pourrait aussi être l'opposé de la tendance générale.
- Dans de nombreux cas, les différences entre les groupes SE faibles et élevés augmentent avec la gravité de la lésion. Le risque relatif est plus élevé pour les blessures mortelles que pour les blessures non mortelles.
- La mesure dans laquelle les différences liées à la SSE pour ce qui est du risque d'accident varie considérablement d'un pays à un autre. Le gradient social est plus raide dans certains pays que dans d'autres. Souvent, c'est lié à des gradients similaires dans d'autres aspects liés à la santé.
- Le lien entre les catégories SSE et la sécurité routière est souvent très différent entre les régions rurales et urbaines.
- Le lien entre les caractéristiques individuelles SSE et la sécurité routière est souvent plus prononcé que dans les caractéristiques SSE liées à la région.

Facteurs contribuants

Globalement, le modèle socio-économique des tués et blessés dans la circulation est influencé par de nombreux mécanismes et c'est l'interaction entre ces mécanismes et la mesure dans laquelle ils sont présents qui donnent lieu aux différences observées. Ceci explique aussi pourquoi le gradient social diffère selon la catégorie d'âge, le mode de transport, la région, le pays et le temps et pourquoi il peut aussi être inversé.

Il existe de multiples facteurs qui accroissent les risques d'accident ou peuvent les éviter. Certains d'entre eux peuvent être liés directement ou indirectement à la SSE des usagers de la route. Lorsque les facteurs augmentant les risques d'accident sont associés positivement aux groupes SE, l'ampleur de la prévalence de ces facteurs entraînera un risque accru d'accident.

Le présent rapport comporte un aperçu des facteurs de risque les plus importants – ou du moins les mieux documentés et les plus abordés, qui ont un rapport avec la SSE. La plupart de ces facteurs ont tendance à être associés avec les groupes SE plus bas, ce qui pourrait « expliquer » pourquoi les personnes issues des classes sociales inférieures sont exposées à un risque accru d'accident.

Les facteurs contribuants majeurs sont liés aux différences concernant :

- L'accès aux voitures et donc les implications concernant l'usage des modes de transport
- La sécurisation des véhicules (voitures, motos, cyclomoteurs…)
- La longueur des trajets (distance parcourue par trajet, par an…)
- La dangerosité de l'environnement et des trajets
- Le degré de surveillance parentale des enfants
- L'utilisation des ceintures de sécurité
- Le port du casque à moto, en cyclomoteur et à bicyclette
- La conduite sous influence
- La vitesse
- La conduite sans permis
- L'accès à l'information et sa compréhension
- L'état de santé et la fragilité
- L'hyperactivité des enfants

Groupes culturels

Il existe aussi des différences liées aux groupes culturels auxquels les gens appartiennent. Un « groupe culturel » réfère à des groupes ethniques, des migrants, et des personnes pratiquant une religion spécifique. Dans de nombreux contextes, des personnes issues de tels groupes culturels appartiennent majoritairement à une couche SSE – souvent une des couches les plus basses de SSE. Il serait toutefois erroné de corréler exclusivement les différences culturelles au niveau de la sécurité routière aux différences de SSE. En effet, d'autres caractéristiques telles que les régions dans lesquelles des groupes d'individus vivent (et donc l'exposition) peuvent être un facteur contribuant aux accidents de la route sans être associées aux niveaux de SSE – même si elles le sont souvent. Il s'avère néanmoins que les enfants issus de minorités ethniques courent plus de risques d'avoir un accident de la route que les autres.

1. Introduction

1.1. Purpose

The risk to be involved in a road crash depends on a number of factors. Well-known factors that affect the risk to get injured or killed in a road crash include exposure (in particular the distance travelled), the traffic density, the mode of transport, the state of the roads, age, gender and risky behaviour (e.g. drunk driving). Some of these, like "age" and "gender" are, strictly speaking not to be considered as contributory factors but rather as factors which are related to other factors such as risk attitudes or experience. For the most well-known factors, the causal relationships with road crashes has been well researched, in particular in the developed countries.

Less is known about the relationship between the socioeconomic situation of individuals and the risk of getting involved in a road crash. As will be illustrated in this review, some research has been carried out on this topic in several countries, but one can hardly speak of a systematic approach to this theme and even less so of a shared understanding between road safety researchers, experts and policy makers. The topic has not received much attention at international conferences on road safety.

The implication of this situation is that in most countries the possible impact of road safety measures on different socioeconomic groups is poorly understood and seldom explicitly considered when designing and deciding on policy measures. Rarely formal assessments are undertaken of whether a road safety policy measure is "fair" in relation to its impact on different socioeconomic groups – and in particular on whether it would improve or worsen current patterns of social inequality.

This document includes the results of a review of the literature on the relation between socioeconomic status (SES) and road safety, carried out in 2016 and 2017. The focus is on the crash and injury risks of people with lower income and lower educational attainment levels.

1.2. Scope and method

The identification of relevant studies was based on a combination of different methods. In a first step scientific articles were searched in the databases that are accessible through UCL Explore, the online scientific library of UCL (University College London). UCL Explore includes access to a very large number of databases with scientific literature (including e.g. Scopus, Science Direct, Pubmed, Web of Science, Taylor & Francis, Cochrane, etc.). The initial searches were undertaken in the period May-June 2016. Search terms different combinations of "road safety" on the one hand and "social inequality", "inequity", "deprivation", "poor" on the other hand. A second step, mostly undertaken in the period June-August 2016, consisted of identification of recent grey literature. This was done through contacting selected people in the international network of the author as well as through a query launched within the IRTAD-network. The references in the articles and reports gathered through the initial search proved to be an interesting base for identifying further relevant literature; a systematic check of the references was done for the reports and articles that had been published since 2010. In the course of 2017, some further articles were identified, based on feedback received on a draft version of this report.

For all these search methods, the focus was on the (Western) developed world, i.e. Western Europe, North America, Australia and New Zealand. Some interesting studies from other countries were also identified (Israel, South-Korea, Taiwan …) but only a few of these have been incorporated in the review. Overall, some 300 documents were identified that were entirely or partially devoted to the relationship between SES and road crashes. Most of the documents identified were written in English, although a limited number of documents in other languages (French, Dutch, German and Swedish) were incorporated in the study database – and also used in the literature review.

Not all the studies identified have been incorporated in this review. Priority was given to studies that have been published since the year 2000 – which actually implies that some of the information presented in this report goes back to the nineties. Some older studies have been included as well, either because of their historical value or because of the paucity of studies available on a particular topic.

It is always a challenge to structure the information in a logical way, since several dimensions are important to consider. Chapter 2 contains the core findings of this literature review. The findings on the relationship between SES and road safety are grouped first by age category – children; adolescents; adults; elderly – and within each age group by transport mode (whenever studies were available). Findings from European countries are always discussed first. The structure adopted made it possible to give the results of many studies a suitable place and facilitated the formulation of conclusions for combinations of age groups and transport modes. A disadvantage of the structure chosen is that it was more difficult to incorporate results that are not age dependent.

Chapter 3 provides an overview of the main factors that have been found to influence the relationship between SES and road safety. The factors have been grouped under three headings: (1) exposure to risk and exposure related factors; (2) attitudes, culture and behaviour; and (3) other contributory factors. Chapter 4 discusses some additional issues: gender differences, trends, and the implications of being injured – all in relation to SES. The references at the end follow the APA logic and include a doi-link or weblink where available.

1.3. Terminology

Different terms are used in the literature to refer to road crashes: road accidents, motor vehicle accidents, collisions, vehicle crashes or just accidents or crashes. Unless when directly quoting from a publication, we will use systematically the term "road crash", or simply "crash". A road crash in which at least one person is killed, will be called a fatal crash.

The term "fatalities" will be used for people who died after being involved in a road crash. For those that were injured, the term "casualties" will be used. It should be noted that many studies which are based on health data or hospital discharge registers use the term "injuries" in a much broader sense, including for injuries caused by accidents other than road crashes, such as falls and drowning. Actually, the casualties from road crashes constitute only a minority amongst the injuries registered in hospitals. The results that apply for the group of "injured people" as a whole may therefore not be applicable to casualties from road crashes.

When it comes to "socioeconomic status" several different terms are used in the literature: social class, socioeconomic status, social stratification, social group, socioeconomic situation, etc. These terms do not necessarily refer to the same categorisations and even for a particular term somewhat different interpretations may be given by experts. But actually the terms are often used interchangeably, despite their different theoretical bases (Bollen et al., 2001; Galobardes et al., 2006). We well systematically use the term socioeconomic situation, abbreviated as SES.

There is no full consensus in the scientific community on the definition and components of SES. Although many factors contribute to SES, most experts would agree that SES is based on a combination of education level, income and occupational status. Yet, in many of the studies reviewed in this report, only one or two of these dimensions are considered, often because no data is available on the other SES factors. In such cases, the distinguishing factor (e.g. educational attainment) will be used, rather than the term SES. Terms like "low social class", "disadvantaged", "poor" or "deprived" used by authors in their publications have often been replaced by "low SES" or "lower SES" in this text.

1.4. Types of data sources

1.4.1. Road safety indicators

In order to determine the link between road safety and SES, information is needed that captures both concepts.

The most obvious road safety indicators are statistics on the number of road crashes, casualties and/or fatalities. Such information can for most countries be found in or derived from police records, insurance files, hospital data or the death register. It should be noted that all these data sources suffer from some sort of underregistration (and sometimes also misclassification), and hence the statistics derived in general tend to give a biased picture of the reality. Police based registrations in general suffer from underregistration of crashes with vulnerable road users, in particular when no motorised vehicle is involved. For instance, based on a comparison of hospital data and police data in Belgium, it was shown that the police was informed of less than 1 in 5 of cyclists that were seriously injured in a road crash (Nuyttens, 2013). It should also be noted that in certain countries (e.g. the USA), only crashes with motorised vehicles are considered as road crashes (they are often called motor vehicle accidents). This implies that fir such countries single bike accidents, i.e. falls of cyclists in which no other vehicles are involved, are excluded from crash statistics. This phenomenon has a considerable impact on the numbers and distribution of road crashes – and hence on any SES-linked analysis that is based on such statistics.

In principle, hospital data are less prone to underregistration. In many countries, however, access to hospital data is difficult because of privacy issues. Access to insurance data (which anyway is restricted to crashes with insured vehicles) is often even more problematic. But even when access to hospital data is granted, it may sometimes be difficult to distinguish between injuries resulting from road crashes from those with other causes of injury.

Data on road traffic fatalities can also be found in mortality registers. Such national, regional or local registers include often information on the cause of death. A road crash may be listed amongst the possible causes of death, and hence mortality registers can provide information on road safety. It should be noted, however, that the categorisation of the causes of death may not be very transparent and may not include all traffic fatalities, in particular when the victims do not die on the spot, but rather later. When the person dies, the doctor attesting the cause of death may use a medical cause rather than the crash itself as a cause of death.

Insurance companies also include information on road crashes. However, such data is often very difficult to get access to and is moreover in most countries distributed across many different databases.

An alternative source of information on crashes are surveys or polls, which collect information on (self-declared) involvement in crashes. Although such information may be inaccurate and incomplete, it has the advantage that the data can be linked to other variables that have been gathered through the survey.

Another series of road safety indicators, which can be considered as a proxy or a predictor for the actual numbers of casualties, are the so-called road safety performance indicators. These refer to behaviour of road users, infrastructure characteristics or vehicle features which are known to be correlated with reduced road safety (e.g. drunk driving). Similarly, data on registered traffic offences and fines could be considered (under certain assumptions) as a proxy for road safety performance of particular groups of people. However, there appear to be few studies that have analysed the link between traffic offenses and SES characteristics.

1.4.2. SES indicators

SES is a multifaceted and composite concept; no single variable can capture all facets of SES. The measurement of SES should thus, in principle, be based on several different variables. For adults, the SES dimensions most frequently used are wealth, occupational status and educational attainment. These dimensions are typically operationalised by (annual) income, employment status/type of job, and highest degree obtained. In practice, especially the latter two are used in studies linking road safety to SES at individual level, since it is much more difficult to gather income information then employment and qualification data. Krieger et al. (1997) have pointed out that education is a popular SES measure in research given its easy measurement, its applicability to persons not in the active labour force and its stability over adult lifespan.

Information on SES may be available in the same database that contains road safety information (e.g. in the case of surveys or sometimes in police and hospital records). But more frequently it is necessary to link two or more databases, i.e. a database with road safety information and one or more database with data on SES. Such databases include census data, mortality data, employment related data, education registers, surveys, etc. In general, only a subset of SES variables are available in such databases.

It is not always possible to link SES information to individuals. An alternative is to link the "SES-level" of a particular area or neighbourhood to all inhabitants of that neighbourhood. In view of obtaining maximum validity of studies, ideally the smallest and most homogeneous defined areas should be used, in which populations are relatively homogenous with regard to social and economic characteristics (Krieger et al., 1997). However, in practice such fine level of aggregation may not be available. The larger the area, the more likely the variability of the SES within the area. As noted by Christie & Whitfield (2011): *"while it is likely that most people living in one of the most deprived areas could reasonably be considered disadvantaged, an individual-based measure of income-related poverty or socio-economic status might not place them in a similar relative ranking in the population."*

Area based SES information is often easier to obtain than individual SES information. Therefore quite a considerable number of studies on the association between SES and road safety have used the "area approach". The SES indicators used in such studies are typically composite indicators based on data such as the average unemployment rate, house ownership, vehicle ownership, value of house, income level, consumption, etc. in a particular area. For instance, in England, the Index of Multiple Deprivation (IMD) has been used (mentioned in Christie & Whitfield (2011)). Other indices used in some of the studies reviewed are the New Zealand Deprivation Index (Hosking et al., 2013) and the Index of Relative Socioeconomic Disadvantage in Victoria, Australia (Clapperton & Cassell, 2010).

Despite the possible heterogeneous nature of areas, using areas as a basis for SES analyses has some advantages over individual SES data. These advantages include (Krieger et al., 1997):

- the added contextual information which may be available such as safety, pollution, health, overcrowding, infrastructure and traffic, playgrounds, access to services, etc. – information that is often not available in databases linked to individuals
- the independence of age – it can be used for persons of all ages, from infants to retired adults
- the provision of a more stable estimate of people's relevant economic circumstances, compared to more volatile income data.

There are some other aspects to be considered when interpreting SES information. A first consideration concerns the determination of the SES of people in "non-adult" age groups. For children, in general the SES of their parents is used. Determining SES level is more challenging for young people or adolescents (typical age range 16-24). Both their educational attainment and income may be a poor indicator of their SES. But at the same time, the SES of the parents could be a poor indicator of the SES of the adolescents. A similar problem can be identified with older people, which may have low educational attainment but nevertheless a high SES. Disposable wealth or income and occupation before retirement (especially of men) may be an acceptable proxy. So, at different stages in life, different SES-indicators could be used. Galobardes et al. (2006) propose different sets of indicators by age group (see Figure 1).

A second consideration is that the SES distribution – and its impact in society – cannot be compared easily between countries, even within Europe. Being poor reflects different realities in Norway, Germany, Portugal or Bulgaria. Moreover, within a specific country, the SES indicators may reveal quite different realities depending on whether one lives in a city, a suburban or a remote rural area. More generally, it is often problematic to use the indicators used in high income countries in low and middle income countries.

Finally, as will be illustrated later in this report, it should be noted that SES often correlates strongly with other factors known to affect road safety such as remoteness, distance travelled, road safety culture, ethnicity, law compliance, etc. Many studies looking at the association between SES and road safety do not control for such variables (at best for only a few). This is sometimes justified, since in the end the difference between

SES categories are "real" – but it also makes it difficult to interpret the results and identify causal relationships.

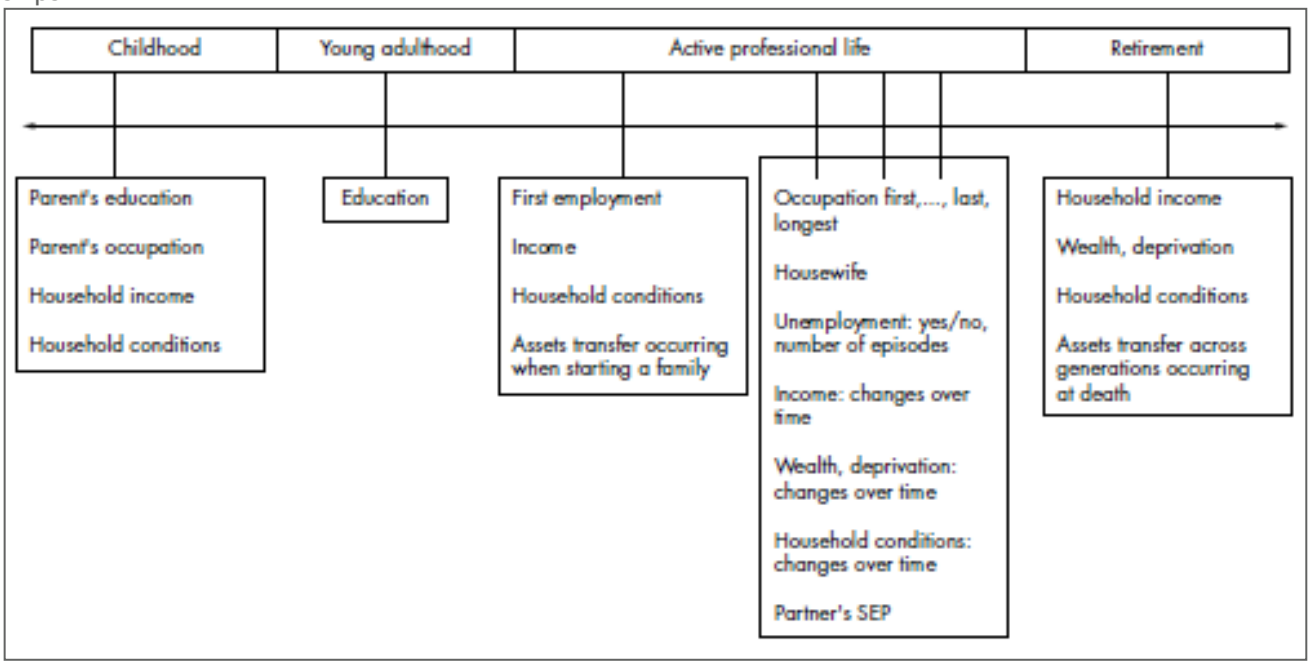

Figure 1: Possible indicators for SES during different life stages (Galobardes et al., 2006)

2. The interaction between SES and the risk on a road crash

This chapter presents an overview of the evidence gathered on the relation between SES and road crashes. More specifically it focuses on whether, and to what extent, people with low SES have higher risks on a road crash than people with high SES. In every section, the studies reviewed are listed by country – and within country by year, if more than one study is available – starting with European countries. When studies are available that cover different countries, they are listed first. Possible causes and explanations for the associations found will be discussed in the next chapter.

2.1. Results from general studies

2.1.1. Lower SES is associated with higher road crash risks

Quite a range of "general" studies from different countries point out that people with low SES have a higher risk of being involved in a road crash than people with high SES. With "general" we mean that such publications provide no or little results about particular age groups and/or road user categories[1]. It should be noted that most of these general studies did not control for exposure.

A cross-sectional ecological study within 15 **European** cities analysed socioeconomic inequalities in mortality due to injuries at the beginning of this century (Gotsens et al., 2013). The units of analysis were small areas within the cities. The authors found socioeconomic inequalities in injury mortality in the majority of cities. In the case of mortality due to road crashes, a significant positive association was found for men in six cities (Stockholm, London, Amsterdam, Rotterdam Madrid and Lisbon). It should be noted that differences were small and the relative risk was not very high, the highest value corresponding to Stockholm (1.175). For women, in general the relative risks were found to be smaller, and the associations less often significant.

Using locally available socioeconomic data and information contained in police records, Fleury et al. (2010) compared road crash rates and crash risks between deprived and other areas within Lille, a major city in the North of **France**. They found that the inhabitants of the most deprived urban areas [*zones urbaines sensibles*] had a 1.36 higher risk of involvement in a road crash than those in the other areas of the city.

In a study using national population registers and a household travel survey for the year 2000, Orozova-Bekkevold and Hels (2009) found for **Denmark** that people with only basic education had a 32% higher risk of being involved in a road crash compared to people with medium level education; the highest educated had a 14% lower risk than the medium educated group.

Nolasco et al. (2009) combined data from the Mortality Registry with area based socioeconomic indicators for three cities in **Spain** in order to calculate the mortality rates due to crashes per 100 000 person years during 1996-2003. They showed that these mortality rates were two to three times higher for men of the lowest SES groups compared to those of the highest SES group (three SES groups had been defined). For women, the differences between SES groups were much smaller for women.

Bingham (2011) linked socioeconomic information from **Swedish** national register data for a cohort of over 1,6 million people with their crash histories over a 14 year period. He concluded that increased crash risk was associated with lower SES and rural residence.

Using area based crash and socioeconomic data, Abdalla et al. (1997) showed that for the Lothian region in **Scotland**, road injuries were 1.9 times more frequent in the most deprived areas. Pedestrian casualties (all

[1] Studies which include such more detailed information will be discussed from Section 2.2 onwards)

ages) were 3.9 times more frequent. Another Scottish study, concerning its west coast, showed as well a relationship between road crashes and low SES (Chichester e.a., 1998).

A **Swiss** study (Spoerri et al., 2011) linked census data of over 5.5 million people with crash records. The authors found that road crash fatality indicators were 53% higher for low educated people compared to people with higher education degrees. The difference was highest for pedestrian (87%) and motorcycling (76%) accidents; on the other hand education level did not play a role with cycling accidents. An area based study (Panczak et al., 2012) led to the conclusion that the road crash risks in areas with the lowest SES scores was 2.42 higher than in areas high SES areas (comparison of 1st and 10th decile). An older **Swiss** study (Lehmann et al., 1990), based on death certificates data from 1979-82 had found out that at that time within the age group 30-49 the relative road crash risk of the group with the lowest SES was almost 3 times as high as the group with the highest SES.

Some studies in **Italy** came to similar conclusions. In an area based study combining census information with data from the regional mortality registry, Michelozzi et al. (1999) found out that in Rome the fatality risk for both males and females of the lowest SES levels was much higher (52% and 44% respectively) than that of people from the highest SES categories. Another Italian study, based on data from the Lazio region (Camilloni et al., 2013), found in relation to road injuries that people from the lowest SES level had relatively higher figures for emergency departments visits (+27%), hospital admissions (+19%) and fatalities (+78%). The effect of SES was much stronger with men (versus women) and young children (versus adults).

Factor et al. (2008) used a database that merged **Israeli** crash records from 1996 to 2004 with the 1995 Israeli census data. They were able to show that the probability of becoming severely injured or killed in a road crash decreased with increasing education level and social status of the household.

Many **American** studies point in the same direction. For instance an analysis of Denney and He (2014) on USA health survey and mortality data for 1986-2006 showed that both educational attainment and household income relate strongly to the road crash fatality risk: those with less than high school had 1.85 higher risks than those with more than high school education, and people from the lowest third of household income had 1.23 higher risks that people for the highest third or income. Another example (for Florida) by Huang et al. (2010) concluded that *"counties with higher median household income and lower unemployment rate are relatively safer in terms of severe-crash risk"*.

For **Canada**, Burrows et al. (2012) used cohort data from the 1991–2001 Canadian Census Mortality Follow-up Study (which linked 1991 census data to mortality data over a follow-up period of 10.6 years for 15% of the Canadians). They found out that men with low SES had a 2.3 increased risk of dying in a road crash. Education level and living area were more important factors than income and professional training. The association between SES and road fatalities was weaker with women.

For New South Wales (**Australia**) a recent study, based on matching postcodes from persons involved in crashes with an index of social disadvantage derived from census data, revealed a progressive increase in road casualty rate with increasing disadvantage of the areas of the people concerned (Cairney et al., 2016).

In **New Zealand**, Hosking et al. (2013) considered hospitalisation, mortality, census and household travel data. Using regression analysis they found out that for each decile increase in the New Zealand Index of Deprivation there was a 3-11% increase in casualty risk. The effect of deprivation was highest among adults aged 25-64 years (an 11% increase per decile).

2.1.2. Lower SES is not always associated with higher road crash risks

The findings listed in the previous section may give the impression that the increased risk of involvement in a road crash with decreasing SES is a universal trend, applicable to all countries, age groups and road user categories. Such an assertion can, however, not be made.

First, it is recalled that most of the studies listed in the previous section, did not control for exposure, i.e. distance travelled, since such information was often not available in the data sources used. In some of the studies no information on transport mode was available. Yet, it is common knowledge that both the distances travelled and the mode of transport are key factors predicting the crash risks. If exposure and mode of transport differ between SES groups – which is actually the case – one should be careful in interpreting the results.

Second, in most European countries the relationship between SES and road safety has hardly been analysed so far. This is even less so in middle and low income countries. Despite the quite substantial body of evidence in countries like Sweden and the UK (and to a lesser extent also France and Spain), there are many European countries where hardly any scientific study on this topic has been published in the scientific literature. We also found little substantial grey literature on this topic in countries like Germany, Belgium and the Netherlands (although the topic is sometimes touched upon briefly in some reports). One hypothesis is that in some countries in which no such studies have been undertaken, the overall social gradient in relation to road crash involvement is relatively flat (and hence it would not make sense to study this phenomenon in depth). Assessing the validity of this hypothesis is, however, beyond the scope of this report.

There is some evidence, however, that at least in some cases people with lower SES have not a higher or actually even a lower risk of involvement in a road crash. A few studies were found that either showed that there is hardly any overall relationship between SES and road safety, or were not able to demonstrate that such a relationship might exist. Also, some studies showed that after controlling for certain factors, such as remoteness and exposure, the differences between SES groups (almost) disappeared. Other studies concluded that SES was associated with road safety risks for men, but not for women. Finally, studies that look at different transport modes have found out that the social gradient may exist for certain transport modes but not for others. Thus, a simple social gradient in relation to road crash risk does not exist. By way of example, some of such *general* studies are listed below (in the next sections, we will also present studies that focus on particular age categories and transport modes). This list is not meant to be complete but rather to illustrate the argument that one should not generalise the assertion that lower SES is always associated with higher increased road safety risk.

For instance, based on an analysis of data from the **Norwegian** national household travel survey, Elvik (2009), concluded that the risk per individual still increases as income increases; but also that the relative fatality risk per kilometre of travel is almost the same for all income groups.

A similar result has been reported in a **French** study by Lenguerrand et al. (2008). In a study based on some 15,000 people in the GAZEL cohort (involving employees from different companies), they found that managers were more involved in road crashes than unskilled workers. Please note that road crashes in this study also included PDO (property damage only) crashes, which are much more numerous than injury crashes. Even after controlling for confounding factors such as exposure, male managers driving a car still had a crash rate 1.1 times higher than that of male unskilled workers; female managers had even a crash rate 1.4 times greater than unskilled female workers.

Results from the **Belgian** National Health Survey (Drieskens, 2015) show that the percentage of people reporting a road crash requiring medical care did not vary by education level. On the other hand, there were significant differences for the level of medical care needed after the crash: 78% of the lower qualified needed to be hospitalised against 48% of the higher qualified. It should be noted that the number of crashes reported in this survey was relatively low.

Baker et al. (1992) showed for the **USA** in the period 1979-81 a clear relationship between the fatality rates of vehicle occupants and the per capita income of the area. But for motorcyclists and bicyclists the fatality rate actually rose with the per capita income until it peaked near the middle of the range, and then declined.

A study in **New Zealand** (Blakely et al., 2007), based on a linkage of mortality and census data identified social gradients in road fatalities for men, but did not find such patterns for women.

For the state of Victoria in **Australia**, Clapperton & Cassell (2010) found out that the people with the greatest risk of a road injury were not the people from the first quintile (the most disadvantaged group) but rather those from the second and third quintiles, who were 36% more likely to be injured in a road crash than the people from the least disadvantaged group (the fifth quintile). In a more recent area based Australian study (Cairney et al., 2016) the highest fatalities and serious injuries rates in Victoria and South Australia were experienced by communities towards the middle of the range of disadvantage. This was an unexpected finding for the authors, who hypothesized that it might be due to factors such as having less access to vehicles and consequent greater public transport use, less work-related travel due to unemployment, or having limited income for leisure activities or shopping.

Please note that the phenomenon of a social gradient does also exist for other types of injuries and, more generally, for most types of diseases. However, for leisure and sports activities the social gradient has often the opposite inclination: the higher the SES, the highest the number of injuries from sports and leisure activities (see e.g. Simpson et al. (2005) and Ewert et al. (2016)). This finding underlines the importance of considering exposure to understand injury risks; these issues are also very important for road injuries and explain an important part of the variation across SES groups (see also Chapter 4). This is important to note since some studies do control for such factors, whilst other do not.

To conclude this section: although we found far more general and specific studies showing that lower SES groups have higher road crash risks than studies with opposite results, the few studies listed in this section illustrate that one cannot generalize the concept of a social gradient in road safety to all countries, transport modes and age groups. They also suggest that very different factors may influence and explain the relationship between SES and road casualties, and that in general no simple or unifactorial explanations can be given.

To understand better the relationship between SES and road safety, and in particular to what extent social inequality is present, it is therefore necessary to study sub-groups of road users. Once the relationships are clear for such sub-group, it becomes also more easy and relevant to identify possible causes in these cases – and eventually countermeasures (which is beyond the scope of this report).

The categorisation used in the next section is, first, by age category, and then by travel mode. Most of the results of the studies identified can be fitted into such a scheme. This structure remains, of course, a compromise and some findings from the literature do not fit well within it (e.g. when figures are available on pedestrians without age specification). It should also be kept in mind that several of the studies reported in the literature refer to situations of 20 to 30 years ago – a few even further in time. Since then, many factors that are important for road safety may have changed, as well as the SES distribution in the population itself. Such older studies have therefore often become less relevant today. Therefore, in this chapter we will focus on studies that have been published since 2000.

2.2. Children

2.2.1. General findings

In most of the studies considered below, children are defined as the age group 0 to 17 years. Please note however that some studies use other age groups to define children (e.g. [0-16] or [0-19]) whilst other studies only consider children of a certain age.

Road crashes affecting children, particularly as pedestrians, are the sub-group which has received most attention by researchers examining the association between SES and road safety. It is also the category where the social gradient is often the steepest of all. Nevertheless, it should also be recalled that fatal crashes with children aged 0-14 and those aged 15-17 represent in Europe only 2.6% and 2.4% respectively of all fatal crashes (ERSO [European Road Safety Observatory], 2016). So, a strong social gradient with children may not necessarily lead to a strong gradient for the totality of the population.

Laflamme et al. (2010) conducted a literature review on studies about the relationship between SES and (all kinds of) accidents with children for the period 1990-2009. Part of the review concerned road crashes with

children; 37 studies were identified, of which 26 relating to **European** countries (predominantly the UK and Sweden). Almost all the studies included in the review had found that children of lower SES groups were relatively more involved in a road crash than children from high SES groups. There was abundant evidence for this trend from all over the world when it came to child pedestrian casualties. Several of the studies reviewed will be listed below.

This section first shows results of studies which do not distinguish between travel modes (or that consider several travel modes). The subsequent sections deal with children as pedestrians, children as bicyclists and children in other travel modes.

Several **Swedish** researchers have considered child casualties and fatalities from road crashes. Engström et al. (2002) conducted a cross sectional study based on record linkage between several Swedish national registers, in order to examine the crash involvement of all Swedish children under 20 living in Sweden between 1990 and 1994. They concluded that injury rates were relatively low and that the socioeconomic differences were negligible in the 0–4 age group. Significant differences by SES (measured by parents' occupation) were observed from age 5 onwards. The highest absolute differences were found among 15–19 year olds. The accident rates were higher for boys than for girls and the difference by SES level was also higher for boys than for girls. For instance, the road crash risk of a son of an unskilled worker was almost three times as high as that of a daughter of parents classified as "high and intermediate salaried employees". Similar results have been reported in other Swedish publications (Hasselberg & Laflamme, 2004; Hasselberg, Laflamme, & Weitoft, 2001; Hjern & Bremberg, 2002).

On the other hand, in an area based study combining hospital inpatient data with area based socioeconomic information, Reimers et al. (2008) found for the 10 to 19 years for both 1994 and 2004 no clear association between material deprivation of children in a particular area and road crash casualties. Both aggravating and protective effects of SES were noted. For instance, boys living in areas with the highest levels of economic deprivation had a lower probability of becoming a road crash casualty than boys from better-off parishes.

In **France**, several authors have analysed road casualties of 14 to 17 year olds (Haddak, Pochet, Licaj, & Vari, 2010; Licaj, Haddak, & Pochet, 2010). They analysed road traffic casualties in the Lyon urban region in 2005-2006 using data from the Rhône Trauma Register. The authors found out that these occurred more frequently among children living in deprived areas. They also showed that the relative risks depend heavily on the modes of transport used and exposure; for instance, young people from deprived areas appear to be less involved in road crashes with powered two-wheelers, but this seemed to be associated with lower use of such vehicles.

Haddak (2012) also refers to other French studies (which could not be traced back) which had shown that for children and young people under 25 the road crash risk is higher in deprived areas [*zones urbaines sensibles - ZUS]* : overall the risk was 23% higher for boys and 28% higher for girls for the period 2001-2006. The odds also varied by age groups: for boys aged 5 to 9, the ratio was 1.56. On the other hand, for girls in the age group 15 to 19, no area based SES differences were found. The authors noted the important impact on the casualty figures of road crashes with mopeds and motorcyclists: for all other travel modes, children in deprived urban areas have higher rates of road crashes.

There is a considerable literature on the relationship between SES and children's' road crashes in the **United Kingdom**; however most of it focuses on child pedestrian injuries (which will be discussed in the next section). A general study published after 2000 comes from Northern Ireland (Belfast). Silversides et al. (2005) analysed almost 500 injuries in children aged 0-12 years presenting to four emergency departments serving North and West Belfast. They observed that for children up to 12 year living within the most deprived areas were particularly likely to be involved in road crashes compared to those of the least deprived areas (relative risk of 3.25).

A few studies in **Germany** have considered the social gradient in road safety for children in Germany. Using data from a health survey involving over 17,000 children in the period 2003-2006, Holte (2010) was able to demonstrate that the group of children which are hyperactive and have behavioural problems have the highest crash risk, and that this particularly important for children of lower SES groups. Other analyses on the

same data (Kahl et al., 2007) revealed also that both boys and girls from families with lower SES had higher crash rates than children from higher SES families.

In **Canada** Faelkner et al (2000) linked hospital data and census data for patients of two general hospitals in Ontario. They found that children from the lowest SES group in Ontario had a 50% higher crash risk than children from families with highest SES level. More recently, through linking hospital discharge data with census information, Oliver & Kolen (2009), showed that for rural areas in Canada children from lower income neighbourhoods had 28% higher hospital admission rates for road crash causes, compared to children from the richest neighbourhoods. In urban areas the highest admission rates were for children from middle income neighbourhoods. Another Canadian study (Gagné & Hamel, 2009) combining hospitalisation data with census data, considered children up to 14 years in Quebec in the period 2000 to 2004. The authors found that children from the least privileged areas have significantly higher relative risks than their peers from privileged areas.

A study based on hospital admission data in Victoria, **Australia** (Clapperton & Cassell, 2010) found that children in Quintiles 2 and 3 were almost twice as likely to suffer a road injury as children in the least disadvantaged quintile, Quintile 5.

Cohort analyses in **New Zealand** (Shaw et al., 2005) revealed socioeconomic differences in child mortality for children from 1 to 14 year old: the relative risk for the children (low income compared to high income) for being injured in road crashes was 1.36.

2.2.2. As pedestrians

As stated before, many authors from quite a range of countries have analysed child pedestrian crashes in relation to their socioeconomic status. With few exceptions, they point to a strong or even very strong association between lower SES and higher crash risks. As will be illustrated below, the increased relative risks nevertheless vary considerably across and within countries. This is related to differences in infrastructure, population density, traffic density, traffic culture, remoteness and the composition of the SES groups themselves. Another factor which can explain differences, not just between countries but also within countries, is how SES-indicators are defined and how many different SES categories are used. For instance, one may expect to see bigger differences between groups if deciles are used rather than quartiles. Also, some studies use adjusted odd ratios (i.e. relative risks after controlling for one or more factors) whilst others do not; in general, adjusted odd ratios are lower than non-adjusted ones. These remarks also apply to the other sections in this chapter, but this will not be recalled systematically.

The **United Kingdom** is no doubt the country where most research has been carried out on child pedestrian injuries, since the 80s already. A discussion and review of some of the older references, may be found in publications of Christie (Christie, 1995; Christie et al., 2010; Christie & Whitfield, 2011). In what follows we list the results of studies published since 2000.

Hippisley-Cox et al. (2002) examined hospital admission data from 1992 until 1997 for children aged 0-14 years in the Trent Region (UK). They found for wards (i.e. census tracts or units) with the highest deprivation scores a 3.65 higher rate of child pedestrian injuries than for the wards with the lowest deprivation scores. A similar result was obtained by Lyons et al. (2003) who used Welsh emergency admission data 1997-99 and found a 2.2 increased pedestrian crash risk for children from deprived areas compared to children from less deprived regions. Adams et al. (2005), using an area approach based on police data, found similar figures as well (2.7 for boys and 2.6 for girls).

Graham et al. (2005), using more sophisticated models in order to control indirectly for exposure, came to the conclusion that for England the child pedestrian casualty rate in the most deprived area was 4.1 times greater than the rate in the least deprived area. A 10% increase in the deprivation score of an area (measured by the IMD-index of multiple deprivation) was associated with a 3.8% increase in child pedestrian casualties and a 4.0% increase in child pedestrian fatalities and serious injuries. The study also showed that a social gradient existed for adults as well, but that was not as steep as the one for children.

The highest ratio has been reported in a study from Edwards et al. (2006), based on child mortality data provided by the national Office for Statistics for England and Wales. They concluded that around the year 2001 children up to 15 years old whose parents were in the lowest occupational category (NS-SEC8) were 20.6 more likely to be killed as a pedestrian than children from parents in NS-SEC1 (highest category); the sample was 205 and the confidence interval [10.6 - 39.9]. Although these rates are much higher than those found in other studies in the UK and elsewhere, it should be noted that many other studies for children use the state of the neighbourhood and not the occupation of the parents as SES-indicator; moreover, in this case there were also 8 categories, which is more than in many other studies. Mostly the same authors did a similar study in London, however now focusing on injuries and using the deprivation of the area as the SES-indicator (Edwards et al., 2006) – see also (Steinbach, Edwards, Green, & Grundy, 2007). For the period 1994 to 2004 the ratio of the child pedestrian injury rate among the most deprived tenth to that among the least deprived was 2.93. Extending the analysis to the whole of England for the period 1999-2004 Edwards and colleagues (2008) came to a ratio of 4.1 for children in deprived areas (lowest decile compared to highest decile).

For the area of North and West Belfast in Northern Ireland, Silversides et al. (2005) compared injury rates for children up to 12 years in 2001, using hospital emergency admission data. Comparing the results for the 20 most and 20 least deprived areas (using the Nobel Economic Deprivation Index) they found a 1.32 higher relative risk of pedestrian child injuries in the least deprived areas. This figure was, however, not statistically significant (partially caused by the low numbers considered).

In **Sweden** too, quite some research was conducted on child pedestrian injuries and the association with SES. Laflamme & Engström (2002) created a dataset of about 2.2 million children and adolescents (aged 0-19 years) living in Sweden at some time during 1990-4 by linking records from 13 Swedish national registers. They found that the pedestrian crash risk of children of unskilled workers was between 1.09 and 2.33 higher than that of children whose parents had intermediate or higher salaries, depending on their age – the highest rate was for the age group 5-9. A few years later Hasselberg and Laflamme (2004), after linking data from the Swedish Population and Housing Census of 1990 with the National Hospital Discharge Register for the years 1991–1999,
found t that children (aged 1-14) from the lowest income quartile had a 36% higher risk compared with families in the highest quartile.

In **Greece** Moustaki et al. (2001) analysed emergency admission data of pedestrian victims, aged 0–14 of a major children's hospital in Athens during the period 1996–98. They were able to demonstrate that children (up to 14 years) from poor communities within greater Athens in the period 1996-1998 had almost two times more pedestrian injuries than those of the richer areas.

For the Rhône Department in **France**, Haddak et al. (2010) used data from the Rhône Trauma Register to show that 14 to 17 year old boys from communes with deprived areas had a 2.88 higher risk to be involved in a pedestrian crash as boys from communes without such deprived areas; the figure for girls was very similar (2.67).

Using hospital data, Faelkner et al (2000) found that children from the lowest SES group in Ontario, **Canada** had a 50% higher crash risk than children from families with highest SES level. For urban areas in Canada Birken et al. (2006) analyzed census data and data from Statistics Canada and were able to demonstrate that for each unit change in economic quintile the pedestrian crash fatality risk changed with 13%. A more recent study by Oliver & Kolen (2009) using hospital data showed that in urban areas, decreasing neighbourhood income was systematically associated with increasing hospitalisations among pedestrians/cyclists after a road crash. The hospitalisation rate was four times higher for children from the poorest than those from the richest neighbourhoods. In rural areas a graded relationship was not apparent, but children from the lowest income neighbourhoods had higher rates than those from the richest neighbourhoods. Another Canadian study (Gagné & Hamel, 2009) considered children up to 14 years in Québec. They found that children from the least privileged areas had a 3.62 higher risk to be involved in a pedestrian road crash than children from privileged areas.

For New South Wales, **Australia** Poulos et al. (2007) examined hospitalisation separation data for the period 1999/2000–2004/2005. They observed that children aged up to 14 years from the most disadvantaged quintiles had higher risks (between 1.11 and 2.54, depending on age) on a pedestrian crash than children from the least disadvantaged quintiles. A review of studies on low speed vehicle incidents with children in Australia and New Zealand (Paul Anthikkat et al., 2013) revealed that in 7 out of 8 studies an increased risk for such crashes existed for children from the lowest SES groups.

2.2.3. As bicyclists

Compared to child pedestrian crashes, much less attention has gone to the association between SES and road safety for children as bicyclists. However, most of the studies available point in the same direction as those for pedestrian crashes of children.

In **Sweden**, Laflamme & Engström (2002) found that the cyclist road crash risk of children (from 5 year onwards) of unskilled workers was between 1.22 and 1.54 higher than that of children whose parents had intermediate or higher salaries, depending on their age – the highest rate was for the group 5-9. The differences between SES groups were less than for pedestrian crashes and were smallest in the age group 15 to 19.

Actually, in an analysis of road crashes with children (10-19) in the Stockholm region (Reimers & Laflamme, 2004), the authors found inverse relationships: adolescent boys living in low-SES areas had a significantly *lower* risk to be injured as bicyclists (and as moped riders) than those from the reference group. The same authors also analysed injuries of children up to 15 years in the Stockholm area (Reimers & Laflamme, 2005). For this group as well they observed a decreased risk of involvement in a bicycle crash with decreasing SES. This goes against results for the whole of Sweden found by Hasselberg & Laflamme (2004): they found that children from low SES groups had a 34% higher risk of being involved in a bicycle accident.

For the Trent region in the **United Kingdom**, Coupland et al. (2003) considered children aged 0-14 years who were admitted to hospital between 1 April 1992 and 31 March 1997. They calculated (adjusted) crash rate ratios of 1.2 to 1.8 in the period 1992-1997 for children of the most deprived areas (lowest quintile), compared to those of the least deprived. Based on hospital admission information, Edwards et al. (2008) estimated for England a relative risk of serious injuries in bicycle crashes of 3.0, when comparing rates for children (0-15) of the most deprived areas to those of the least deprived ones. In Belfast, Northern Ireland, a relative risk was found of 2.43 (Silversides et al., 2005).

As to the fatality risk in bicycle accidents, Edwards et al. (2006) came for England and Wales to an extremely high figure: compared to children of parents in NS-SEC 1 (highest occupational category), children of parents in NS-SEC 8 (lowest category) were 27.5 times more likely to be killed as a cyclist. It should be noted that the sample studied only included 56 cyclists' deaths in total and that the confidence interval was very large (6.4 to 118.2).
The already mentioned study of Gagné and Hamel (2009) on injuries of children in Québec, **Canada** showed that children from the least privileged areas had a 31% higher risks to be involved in a cyclist crash than children from privileged areas. Moreover, the relative risk was higher for bicyclist crashes involving motor vehicles (+75%). We also recall results from the study by Oliver & Kolen (2009), combining pedestrians and cyclists, showing that children form the lowest income neighbourhoods had higher hospital admission rates than those from the richest neighbourhoods.

For the Rhône Department in **France**, Haddak et al. (2010) showed that 14 to 17 year old children from communes with deprived areas had a 1.7 higher risk to be involved in a pedestrian crash than children from communes without such deprived areas.

Poulos et al. (2007) observed in New South Wales, **Australia** that children aged up to 14 years from the most disadvantaged quintile had a 30% higher risk on a cyclist injury than children from the least disadvantaged quintile. However, it was the second quintile were the relative risk was highest (+50%).

2.2.4. As vehicle occupants

The relationship between SES and road safety risks for children as vehicle occupants has only been considered in a few countries.

In **Sweden**, Laflamme & Engström (2002) showed that the risk of injury in a road crash as a motor vehicle occupant was between 1.23 and 1.96 times higher for children of unskilled workers than for children whose parents had intermediate or higher salaries, depending on their age (the age group with the highest relative risk was 15-19). Hasselberg and Laflamme (2004) obtained similar results. They were able to show that children (aged 1 to 14) of parents with lower SES indicators have higher risks of injury as car passengers than the children of parents with high SES indicators. The relative risk for children from unskilled workers (compared to intermediate and high level salaried employees) was 1.34; the relative risk of children with lowly educated parents (compared to those with higher education qualifications) was 1.53 and the children of the lowest income quartile group had a relative risk of 1.36 compared with those of the highest income quartile. However, in the already mentioned study of Reimers and Laflamme (2005) for the Stockholm region it was pointed out that, like for bicyclists, children from low SES areas had a lower risk of being injured as a motor vehicle occupant.

There are some **UK** results as well. From the study of Edwards et al. (2006) for England and Wales it appeared that, compared to children of parents in NS-SEC 1 (highest category), children of parents in NS-SEC 8 (lowest category) were 5.5 times more likely to be killed as a car passenger. In their follow-up studies on injuries (Edwards et al., 2008) the relative risk was a factor 2. Silversides et al. (2005) found for Belfast a relative risk of 2.88 between the most and least deprived areas.

For the Rhône Department in **France**, Haddak et al. (2010) showed that 14 to 17 year old boys from communes with deprived areas had a relative risk of 1.30 for involvement in a pedestrian crash compared to boys from communes without such deprived areas; the figure for girls (1.04) showed negligible differences between the areas.

In **Canada**, Oliver and Kohen (2009) did not find differences in urban areas in the vehicle occupant injury hospitalisation rate among children from the highest and lowest income neighbourhoods. On the other hand, children from middle income neighbourhoods had higher rates. The analyses of Gagné and Hamel (2009) for Québec showed a relative risk for the children from the most materially deprived areas of 1.69 compared to children from the least deprived areas.

In the **Australian** study of Poulos et al. (2007) it is shown that boys and girls (up to 14 years) from the most disadvantaged quintile have 1.84 and 1.80 higher risk than those of the least disadvantaged quintile; actually the figures are even higher for the children in the 2nd quintile.

It should be noted that most of these studies did not control for exposure.

2.2.5. As moped drivers or motorcyclist passagers

Only a few studies are available on the relation between SES and children involved in crashes as driver or passenger of powered two wheelers.

In the already mentioned **French** publication of Haddak et al. (2010) the authors showed that children in the more deprived areas had a lower risk of involvement in crashes with powered two wheelers. However, in a further study (Licaj et al., 2011) the authors also showed that, when controlling for exposure, young inhabitants of deprived areas had actually a higher injury risk with powered two wheelers.

Reimers and Laflamme (2005) found for the Stockholm region in **Sweden** that children from lower SES groups had also lower risks of getting involved in accidents with powered two-wheelers.

On the other hand, in New South Wales, **Australia**, a relative risk of 2.95 was found for children (up to 14 year) from the lowest SES quintiles (compared to the highest SES quintiles) to get involved in moped/motorcycle crashes (Poulos et al., 2007).

2.2.6. Conclusion on children

Despite the differences in data sources, data quality, data range, categorisations and confounding factors controlled for, the range of studies provides overwhelming evidence that children from lower SES groups in general incur higher road crash risks than children from higher SES groups.

However, quite considerable differences can be observed across countries and even within countries. These differences might reflect real differences between populations but could also be the result of differences in data quality, analysis methodology and operationalisation of the SES-concept. Yet, when comparing Sweden and the UK, the two European countries where most research has been undertaken (also before 2000, not listed in this review), it appears that differences between road injuries of different SES groups are bigger in the UK than in Sweden.

The results show that child pedestrian crashes are the road crashes where the differences between SES groups are most pronounced and where the notion of social gradient really makes sense. Children driving a bike or sitting in a car seem also to be affected by the general tendency that lower SES leads to lower road safety – albeit to a lesser extent than for pedestrian crashes. For children on mopeds or passengers on motorcycles there is not enough international evidence to come to general conclusions.

The studies available also suggest that the differences between lower and higher SES groups are more pronounced for severe injuries and fatalities – although this cannot be generalized again: in France the opposite tendency was observed (Licaj et al., 2011). It is clear, however, that in general the SES-linked differences are stronger for boys than for girls.

It is also important to underline that the SES-based differences are not uniform across different age groups of children. In general, the differences are small when children are only a few years old. The disparities increase when children start going to school. The differences may continue to grow or may shrink again, as illustrated by some of the studies listed in the previous sections.

Despite these overall tendencies, a number of studies and cases were identified in which no social gradient was apparent – sometimes for all children, sometimes only for girls – or in which even a reverse pattern was revealed. This is also a warning signal, since it suggests that one cannot assert that the overall trends found also apply to countries in which no or little research on child road crashes has yet been undertaken – and there are still many of such countries.

2.3. Adolescents

2.3.1. General findings

We define "adolescents" as people between 16 and 24 year old. The age group therefore overlaps somewhat with "older" children discussed above as well as with the adult category which will be discussed later. It should be noted that most studies on road crashes of adults include data on the younger adults but the data on young adults may not be analysed separately or reported on.

The studies of which results will be presented below focus fully or at least partially on some of the ages within the range 16-24. Alternative names are "young people" or "young adults"; in road safety often the terms "young drivers" or "novice drivers" is used, referring to car drivers that are in their early years after their driving licence. Although the age group 16-24 includes a relatively small part of the population, it has been extensively studied in the road safety literature, because it is an age group with high road crash risks. Several studies have also examined differences by SES categories.

It is not straightforward to define appropriate SES indicators for this age group. Should one refer to the SES of the parents or to that of the individual? And some indicators may be difficult to interpret. E.g. a 21-year-old person without higher education may be either an unskilled worker, or about to start working as an employee, or a student dreaming from a PhD at a later stage. So even more than for children data should be interpreted with care, especially when comparing results from different studies.

Most studies on adolescents and SES refer to a specific travel mode (more specifically to car driving) but we found a few which are more general. The trends which emerge are in line with those observed for children.

An analysis of **Finnish** data on 17-29 year olds from the Hospital Discharge Registers in the period 1998-2008 showed clear educational gradients for traffic injuries (Remes & Martikainen, 2015). For instance, people of this age group with only basic education appeared to have a 2 to 3 times higher risk for traffic injuries. Also, unemployed young people had about 50% higher road crash risks than employed people; students had lower risks.

In the **Netherlands** Bosma et al. (2007) linked data from a cohort study with hospital in the period 1994-2014. They concluded that a low educational or vocational qualification level of young people or their parents was strongly associated with an increased risk (relative risk of 3.49) on hospital admissions following an accident. It should be noted that this study did consider all kinds of accidents, not just road crashes.

As mentioned earlier, Engström et al. (2002) in **Sweden** found that from all children age groups, those aged 15 to 19 displayed the highest SES-effects.

Based on an analysis of hospital data for Victoria, **Australia**, Clapperton & Cassell (2010) showed that among young adults (aged 15 to 24 years), those from Quintiles 1 to 4 were at least 1.5 times as likely to have a road crash compared with Quintile 5 (the highest SES-group).

2.3.2. As car occupants

Although young car drivers are a well-known risk group in traffic, only a few studies have considered the relationship between SES and the road safety risk of young drivers. It should be noted however that young drivers are often included in studies on adult drivers (see section 2.4.3).

Through linking police records, census data and educational registers in **Sweden**, Murray (1998) found that lower educated young people were overrepresented amongst the car drivers involved in road crashes. The overrepresentation was more pronounced for males than for female drivers. Hasselberg & Laflamme (2003) found that children (16-23 year) of unskilled workers had a significantly higher risk of injury as car drivers com- pared with children of intermediate- and high-level salaried employees (1.62). Children of parents with only a basic compulsory school education had a higher risk of injury as young car drivers (1.76) compared with children who have highly educated parents. The same authors, using a cohort study approach of young people aged 18-26, found on the other hand no substantial differences between adolescents with one road injury and those with multiple injuries with regard to education or socioeconomic group (Hasselberg & Laflamme, 2005).

Laflamme & Vaez (2007) aimed to assess the independent contribution of individual, car and circumstantial features in severe and fatal car crashes involving young drivers. Using data from a longitudinal, register-based cohort study, they developed a model with different variables. When controlling for these variables – such as car safety and speed limit – the SES-based differences no longer impacted significantly on the relative risk of being severely injured or dying in a car-to-car crash. Such an analysis illustrates that the higher risks of young people of lower SES groups can at least partially explained by the circumstances in which they crash and the safety levels of their vehicle (see next chapter).

An analysis of fatal accident records in **France** revealed that blue collar workers (*ouvriers*) are overrepresented amongst the road fatalities of those younger than 30 years (Grossetête, 2010). 28.5% of the 15-29 who

died in a fatal crash in 2007 were blue collar workers, which is higher than their share in the population. Almost 50% of all blue-collar workers who died in a road crash were between 15 and 29 years old.

An **American** study (Males, 2009), based on FARS crash data, census data and Federal Highway Administration data for 1994-2007, concluded that driver age was not a significant predictor of fatal crash risk once several factors associated with high poverty status (more occupants per vehicle, smaller vehicle size, older vehicle age, lower state per-capita income, lower state population density, more motor-vehicle driving, and lower education levels) were controlled. According to the author, teenagers' high rate of fatal crash involvement stemmed more from their disproportionate concentration in poorer states and areas than it does to their young age.

More specifically for unlicensed young drivers in the USA, Hanna et al. (2012), using an area approach at the level of US counties, found a small but positive association between material deprivation and a fatal crash involving a young unlicensed driver (odds rate 1.19).

In New South Wales, **Australia**, Ivers et al. (2009) linked licence, carsh and questionnaire data and found out that the risk of crash-related hospitalization for 17 to 24 year old young drivers from low SES areas was about twice that of young drivers from high SES areas (see also Chen, Ivers et al. (2010) and Chen, Senserrick et al. (2010)). The differences between SES groups persisted even after controlling for a quite a range of different factors such as driving exposure and rural-urban differences.

2.3.3. As other road users

For other travel modes used by adolescents, only a few studies were found, all of them from **Sweden**; some of these have already been mentioned in section **Error! Reference source not found.** on children, since they included 15 to 19 year olds. Laflamme and Engström (2002) found for young people with low SES from this age group had also an increased *pedestrian* crash risk; the differences were, however smaller than with younger children. For the Stockholm region Laflamme et al. (2004) were able to demonstrate that whichever socioeconomic group they belong to, older boys (up to 18 years) did not register significantly higher relative risks than boys from the reference group.

Murray (1998) found that adolescents in Sweden of 16 to 22 years old with young men and women with low marks from compulsory school were less often involved in a *bicycle* accident that those with high marks. On the other hand, she also found that young men with low marks in their school-leaving certificate were involved in traffic accidents at an early age (16-17) as a *moped* rider or a *motorcyclist* more often than young men with high or average school marks.

Through combining census, police and hospital data, Zambon & Hasselberg (2006) were able to examine socioeconomic differences among young *motorcycle* drivers (aged 16-25) involved in road-traffic injuries in Sweden. They found that low socioeconomic positions increased the likelihood of getting injured in a crash – a pattern that was the same for both minor (+66%) and severe (+64%) injuries.

Another analysis (Hasselberg, Vaez, & Laflamme, 2005) indicated that there is a large age-dependent socioeconomic difference in injury risk from motor cycle crashes, with the highest incidence recorded among 17- and 18-year-olds in the lowest socio-economic group.

An area based study of Reimers & Laflamme (2004) showed that pre-adolescent and adolescent boys living in areas with relatively higher concentrations of poorer people socioeconomic precariousness and ethnic concentration in Stockholm had a 60% lower risk for injuries as a *moped* rider. On the other hand, in areas with a low concentration of people with strong educational and financial assets, injuries of young people as a moped rider were about 60% more frequent.

Such contrasting results indicate that no firm conclusions can be drawn without having additional information on the use of mopeds and exposure.

2.3.4. Conclusion on adolescents

When it comes to the relationship between SES and road safety, fewer studies have been undertaken for adolescents than for children. But most of these tend to confirm the trend found with children that lower SES indicators are associated with lower road safety. Often, however, the differences between SES groups are less pronounced than with children. Moreover, there a few studies pointing out that there is no significant difference between SES groups for particular transport modes, or that the tendencies are even reversed. These seemingly contrasting results are most probably linked to strong differences in access to vehicles and to exposure.

2.4. Adults

2.4.1. General findings

Adults are considered here as people aged 18+. The category does therefore overlap with those of the adolescents and the elderly (see next section). In this section, only studies will be considered which at least cover people that are neither adolescents nor older people. Please note that certain analysis may explicitly exclude these groups.

As for the other age groups, this section starts with some "general" studies on the relationship between SES-categories of adults and road safety, i.e. studies where the transport mode was not available or was not reported in the statistical results.

Using linkages of data from national, regional, and urban mortality registers with census data, Borrell et al. (2005) studied the relationship between educational level of the 30+ population and road crash fatalities in 8 European countries: Austria, Belgium, Denmark, Finland, Norway, Switzerland (German speaking part), the region of Madrid (Spain) and the cities of Turin (Italy) and Barcelona (Spain). Overall, it appeared that especially for men with a low educational attainment road fatality numbers were higher. In most countries studied, no such relationship was found for females. The relative risk appeared in most cases to be highest in the age group 30-49. Quite considerable differences were found between countries.

Given the fact that this is one of the few truly international comparisons, a figure from the publication is shown below (Figure 2).

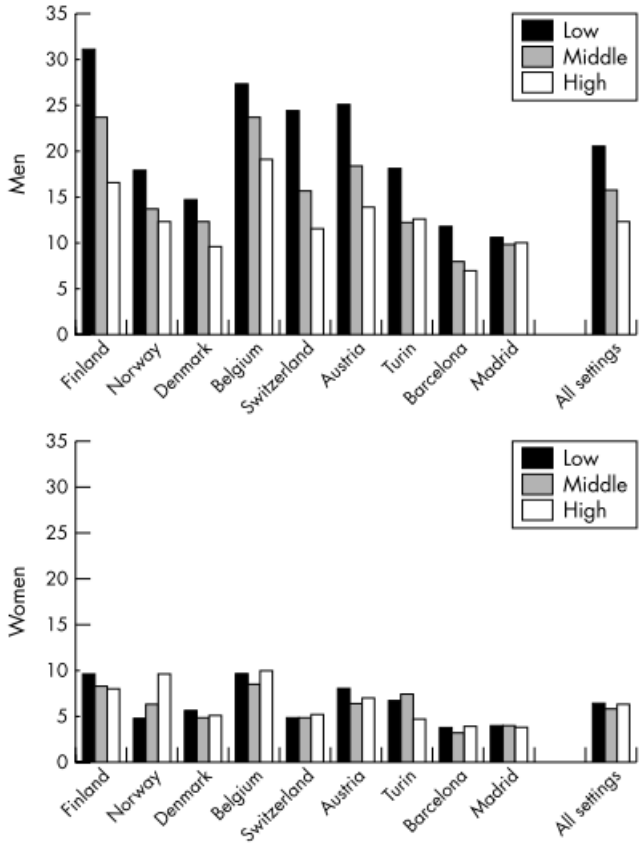

Figure 2. Standardized traffic mortality rates per 100 000 person years by educational level and sex – from (Borrell et al., 2005)

Since no details were available on transport modes and exposure, it remains difficult to interpret such figures. It is also likely that the quality of the data sources differed.

The main author of this study was also involved in studies relating to **Spain**. For Barcelona, Borrell et al. (2002) had found a clear link between educational levels and fatalities, in particular for the age group 20-34, where people with no schooling had an over 4 times higher risk of dying in a road crash than people with at least secondary education. However, this increased risk disappeared for those with low educational attainment in the age group 35-74. A later study in Barcelona (Ferrando et al., 2005) that focused on casualties rather than fatalities, using admission data in hospitals, revealed that men with low educational attainment had a 73% increased risk to get injured in a traffic crash compared to higher education graduates; the figure for women was even slightly higher (85%). The age group 20-34 had by far the highest relative risk, particularly amongst men. The authors also found that the unemployment rate of the neighbourhood played a small but significant role in the figures for men.

An interesting study comes from **Sweden**. Lawlor et al. (2006), using a linkage of birth register, death register and census data, analysed the link between the causes of mortality of adults and the economic class these people had when they were still a child (0-16). The authors calculated that for road crashes, adults who had been in a manual social class in early life had a higher fatality risk than those who were part of non-manual classes when they were young. The figures were 36% for male and 15% for female adults.

But not all European studies point in the same direction. For **France**, a study from Lenguerrand et al. (2008) found inverse relationships between SES and road safety risks – i.e. higher SES leading to higher crashes. They assessed the crash rate for managers, skilled workers and unskilled workers in two major French companies. Most of the people in their sample were between 50 and 60 years old. They found that managers had the highest crash rates, even after controlling for a number of confounding factors, the most important being annual driving distance. Please note, however, that the adjusted relative risks were relatively small, e.g. managers had an (adjusted) relative crash risk of 1.13 compared to unskilled workers. A recent French study (Brière et al., 2016) combined data from police records and from occupational accidents and found that crashes occurring during commute trips were highest amongst male middle management staff – between 0.6 and 0.7 crashes per 1000 employees, depending on the year, followed by blue collar workers ("*ouvriers*") – between 0.4 and 0.6 crashes per 1000 employees. Amongst women, the blue-collar workers had the highest crash rates, similar to those of men. It should be noted that none of these figures were controlled for exposure.

Using data from a **Swiss** household survey covering the 15+ population, Ewert el al. (2016), also showed that the people from the lowest income group had the lowest involvement in road crashes. Education level had no significant impact on road crash risks.

An ETSC report (ETSC (European Transport Safety Council), 2007) includes analyses from Elvik on **Norway** that has not been reported elsewhere. Using data from a household travel survey, it was illustrated that both travel and fatality risk increased with income range, peaking with the second wealthiest group. The wealthiest group had a fatality risk more than double that of the least wealthy group. However, when controlling for exposure (relative death risk per km), there were hardly any differences between income categories.

Thus, contrary to the findings of Borrell et al., these studies from different countries indicate that for adults an overall social gradient for road safety may not exist or even be reversed, in particular when exposure is controlled for. This underlines the importance to have access to information on travel modes and distance travelled, to correctly assess the situation.

There are some general American studies that suggest that the social gradient is more persistent in the **USA**. According to one study looking at the 25-64 population in 1995, using data from FARS accident database and the national transportation survey, the risk of a road crash fatality was 3.5 times higher for men without high school certificate, compared to men who completed high school; the relative risk for females was 2.8 (Braver, 2003). Steenland et al. (2003) combined census data and death certificates; he found somewhat lower values for the increased mortality risks: 2.7 for men and 1.6 for women amongst the population 20-64 in the period 1984-1997). Cubbin et al. (2000) looked at injury mortality characteristics of people aged 18-64 in the period 1987-1995, using data from the National Health Interview Survey (1987–1994) and the National Death Index. For men, they found that those who had not completed high school had a relative risk for road crash fatalities almost double as those with a high school certificate. Similar figures were found for other SES indicators such

as income and occupational status. For females, the figures were similar as for men (some rates were higher, some lower).

2.4.2. As pedestrians

Only a few studies published after 2000 include findings on the association between the SES of adults and the risk to be involved in a road crash as a pedestrian. These studies concern England and the USA only and point to adult pedestrians from lower SES groups having an increased road safety risk.

A study from Graham et al. (2005) analysed police records and detected an association between increased deprivation and higher numbers of pedestrian casualties across **England**. The pedestrian casualty rate for adults in the most deprived areas was 2.3 times greater than the rate in the least deprived areas, although the effect was smaller than for children. It should be noted that in this study, these rates were obtained after controlling for several factors including traffic volume.

A study from the **USA** (Ryb et al., 2007), based on interviews of patients at a trauma centre in Baltimore, showed that pedestrians who had died in an accident had a relatively lower income and were less educated than average. Unemployment was an aggravating factor. Another American study (Chakravarthy et al., 2010) for Orange County, California found that the percentage of the population living in households with low income (less than 185% of the federal poverty level) was the strongest predictor of pedestrian injuries. Negative binomial regression showed that with each 1 percent increase in the percentage of residents with low income was associated with a 2.8 percent increase in pedestrian crashes. Pedestrian crashes were 4 times more frequent in poor neighbourhoods; neither age of the population, education, English language fluency, nor population density explained the effect of poverty. An analysis of LaScala et al. (2000) using an area-based approach in the San Francisco area showed that pedestrian injury rates were related to a range of factors including unemployment and education.

2.4.3. As car drivers or car passengers

Several studies have analysed whether SES-linked differences are also observable in the crash involvement of adult drivers.

Ward, Lyons et al. (2007) looked at road crashes in the **UK** (2001-04). An analysis of mortality data of the Office for National Statistics (ONS) revealed that 20% of the road fatalities came from the lowest socioeconomic group, whilst they constituted only 13% of the population.

In the study by Hasselberg et al. (op.cit.) in **Sweden** some socioeconomic differences were found for overtaking or front-on collisions and for single-vehicle crashes; these are also the ones with higher crash morbidity ratios. For other types of crashes the differences between socioeconomic groups were smaller.

Nolasco et al. (2009) used an area-based approach when analysing mortality figures in three **Spanish** cities. They found that men from the lowest SES level had a higher car crash fatality risk than those of the highest SES level. The differences were not significant in one city. For women, no consistent pattern was found.

Within **France**, and more particularly the Paris metropolitan area, an analysis of police records (Grossetête, 2010) showed that although blue collar workers (*ouvriers*) represent only 12.1% of population 15+, 22.1% of the car drivers who died in a car crash were of this social group.

A recent **Belgian** study (Pirdavani et al., 2017), using a combination of zone based macroscopic variables and geo-coded crash data (2010-2012) for car occupants in 2200 zones in Flanders, found a negative association between casualties and 'income level' (a dichotomized variable), i.e. in poorer areas the risk of car occupants to be involved in crashes was higher – also after controlling for other variables such as car ownership. It should be noted that the impact of income was not very high and for some of the casualty types income was not a significant predictor at 90% confidence level.

In **Israel** Factor et al. (2008), after analysing data based on a linkage of census and crash records, found that the higher the level of education and the higher a driver's SES, the lower was the probability of involvement in a severe or fatal accident. Similar results were reported in a later study (Factor et al., 2010), which showed that drivers from low socioeconomic backgrounds are overrepresented in severe accidents with fatal outcomes.

A range of study results is available for the **USA**; only publications published after 2000 are listed here. Norris et al. (2000) used survey data from a cohort study in four cities in the south-eastern US. They found that people with post-secondary education were marginally more involved in road crashes, but fewer of these were serious. They found an increased risk for minor rather than serious crashes among, amongst other characteristics, people who were employed. On the other hand, economically secure persons had fewer road crashes and these were less serious than those of persons who had financial concerns.

Based on data from the American FARS crash database and a household travel survey, Braver (2003) could show that men with low education level had a death rate 3.5 times higher than that of men in the highest education level group; with females the ratio was 2.8. Another author (Males, 2009), using FARS, census and Federal Highway Administration data for 1994-2007, found that drivers living in states with lower per-capita income suffered significantly higher fatal crash incidence than those of the more affluent and wealthier state counterparts. An analysis of county differences in crash risks in Florida (Huang et al., 2010) found that, after controlling for a number of variables, including traffic density, the road safety status was worse for more deprived areas, characterised by lower income, lower educational level and higher unemployment rate, in comparison with relatively affluent areas.

Finally for the USA a study of Lee et al. (2014) is worth mentioning. There area-based study used police records and census data. The authors found that 'Median family income' had a negative relationship with the number of at-fault drivers. This is to be interpreted that drivers from low-income communities were more likely to cause traffic crashes.

Burrows et al. (2012) compared the fatality data from car collisions to both individual and area-level measures of SES in **Canada**. They found that, for men, road crashes with cars were associated with low education and low occupational status. Another Canadian study (Bell et al., 2012) in which car and motorcycle crashes were considered together, looked at hospitalisation rates and fatalities from motor vehicle collisions in British Columbia between 2001 and 2007. The age standardized relative risk ratios between the lowest and highest SES groups were 1.9 for hospitalisation and even 4.1 for fatalities.

On the basis of a cohort study in **New Zealand** (Whitlock et al., 2003) it could be shown that both occupational status and education level were associated with higher casualty risks. The association was strongest for the occupational status: the relative risk between the lowest and the highest group was 4.17. The similar relative risk figure was 2.26 for education level.

2.4.4. Conclusion on adults

Overall, research shows that in most countries where the relationship between SES of adults and crash risks has been studied, lower SES is associated with higher crash risks. This is particularly the case for men. The difference is, however, often smaller than with children and adolescents – and in some cases no difference or even a reverse trend were found. It should be noted that several of the studies did not control for confounding factors such as exposure, vehicle type of type of road environment, which makes it difficult to correctly interpret the figures.

2.5. Elderly

Older people are defined here as people aged 65 or more – although in some studies other thresholds are used. There are only a few studies in which the relationship between old age, SES and road safety has been analysed. Part of this is probably related to the observation that it is more difficult to use the traditional SES

indicators for this group – or that traditional SES indicators are less relevant for characterising the position of someone of high age. An additional reason for the paucity of studies is that the share of elderly in motorised traffic has been quite limited until the end of the last century, with in particular very few older females driving cars. This situation has of course changed since.

In **Europe**, Borrell has included data on the elderly in the already mentioned studies on injuries in Barcelona (Borrell et al., 2002) and in his international comparison (Borrell et al., 2005). In the first study on Barcelona, covering the period 1992-1998, he found a link between educational levels and road injuries, also for 75+. For men, the relative risk between the elderly with no schooling and those with at least secondary school diploma was 2.6. However, the opposite relationship was found for women, with a relative risk of 0.5. These differences are probably related to very different mobility patterns. In the international study (Borrell et al., 2005), when comparing low versus middle/high education, the authors also found for men relative risks of men aged 70+ to be higher than 1 for most countries/cities studied (except Austria and Madrid), but the rates were lower than for the other age groups and in most cases the confidence intervals included 1. For women, an even more diverse pattern was found, with in some countries/cities a relative risk above 1 and in others below 1. Here as well confidence intervals were very wide.

For Wales in the **UK**, Lyons et al. (2003) found that the hospitalisation rate for older people (75+) as a result of a pedestrian injury was about twice as high for people from deprived areas compared to those of affluent areas. However, for non-pedestrian road crashes, the hospitalisation rate was lower.

An analysis of hospital admission records by Clapperton & Cassell (2010) in Victoria, **Australia**, showed that older adults (65+) living in the *least* disadvantaged area (quintile 5) exhibited the highest injury hospitalisation rate for transport injuries.

In conclusion, the very few studies available on the relationship between SES of elderly and road safety in developed countries, do not show consistent patterns: both higher and lower risks are found for the lowest SES groups compared to the highest SES groups amongst the elderly.

2.6. Overall conclusions on the relationship between SES and road crashes

The overall picture that emerges from the review of studies discussed, is that in high income countries people from lower SES groups have a higher risk of being involved in road crashes than people from higher SES groups. This finding is, however not applicable universally and indeed there are situations where the general association does not apply and the relationship is even reversed. Thus, social inequality in road safety is a widespread phenomenon, but it is not universal and "generic".

More specific findings which result from the literature – and which seem to apply to many, but not necessarily to all high-income countries and regions are:

- The highest SES differences for crash risks are found with children – in almost all studies children from disadvantaged families and areas have much higher crash risks, in particular pedestrian crash risks.
- The strength of association between SES and road safety for children varies considerably between children's age.
- SES-linked road safety differences tend to diminish with age. For adults and elderly there may be hardly any difference or the association might even be reversed.
- SES differences are more pronounced for pedestrian crashes than for car crashes. For cyclist crashes the general association might also be opposite to the general trend.
- SES-based differences are often much more pronounced for men than for women – and in some cases, even opposite trends for women are found.
- In many cases the differences between low and high SES groups increase with the severity of the injury and the relative risk is higher for fatal than for non-fatal injuries.
- The extent of the SES linked differences for crash risks vary considerably between countries.
- The association between SES categories and road safety is often very different between rural and urban areas.

The studies from which these results emerge have used very different data sources and quite different methodologies. So, the differences between certain study outcomes could be the result of different analysis methods and the quality of the underlying data. Two main differences should be mentioned here. First, for the determination of the SES category, many studies have used area based measures, i.e. allocating an SES category to a person based on the area where he or she lives. This may not reflect the real SES category of an individual, and consequently it may well be that the observed association between SES and road safety is not correct. This phenomenon is called the ecological fallacy. From the review undertaken there is some indication that the association between individual SES characteristics and road safety is often stronger than is the case for area based SES characteristics.

A second important difference between the studies reviewed is that some results use merely descriptive statistics (whereby crash involvement is related to the size of the population) whilst others do control for other factors such as distance travelled. The latter is quite important since exposure has an important impact on crash risk. Moreover, many studies have shown that travel modes of SES groups differ considerably. It is hence important to look at the main "causes" or at least explanatory factors for the SES differences – which will be done in the next chapter.

3. Main factors contributing to SES-based differences in crash risks

3.1. Introduction

Although some of the studies listed in the previous chapter have tried to identify the factors and causes that might explain at least part of the observed SES based differences, e.g. by controlling for particular factors that explain part of the variation, the overall finding from the literature review is that the factors associated with elevated or decreased risks are poorly known and documented. Many authors have put forward hypotheses – which often seem plausible – but the extent to which the factors listed can explain the differences observed is often unknown.

Overall, the socioeconomic patterning of casualties and fatalities is influenced by a variety of mechanisms – and it is the interaction between those mechanisms and the extent to which these are present that leads to the observed differences. This also explains why the social gradient differs between age categories, travel modes, areas, countries and over time – and why it may sometimes may be reversed.

In their review on socioeconomic differences in injury risk Laflamme et al. (2009) stated that the distribution of explanatory risk factors and protective factors across socioeconomic groups has been studied to a limited extent only. Although their conclusion concerned all kinds of injuries, it certainly applies to injuries caused by road crashes as well. And as Christie and Whitfield (2011) state: "*There are relatively few studies focused on trying to develop a detailed understanding of the factors associated with the differences in injury and death among people from deprived areas. Most studies that have been conducted appear to have focused on the experience of children and young people as pedestrians and on the experience of young people as car occupants (whether as drivers or passengers) or motorcyclists. There is only limited robust evidence available on the factors associated with the higher risks experienced by other groups, such as people from minority ethnic populations, and very little on the experience of older people in disadvantaged areas.*"

It is well known that many factors contribute to road crash risks: infrastructure, distance travelled, behaviour, transport mode used, etc. If these factors are less or more prevalent with particular SES groups, than these differences can 'explain' the higher or lower risks of those SES groups. For instance, if people with low SES live in environments with high traffic density and/or poor road infrastructure, then we can expect that they will experience higher number of crashes than people living in areas with less traffic and better roads. And if a particular SES group travels a lot more than others, we should find relatively more crashes with them.

In what follows the main factors which have been suggested or proven to be a factor in explaining SES based differences will be listed and briefly discussed. Given the limited number of studies available which provide evidence, some studies which have put forward plausible hypotheses are also included and, unlike the previous chapter, studies published before 2000 are included if they contribute to the discussion of likely causal factors that may be still relevant today.

It is emphasized that the presentation of findings is limited to the different factors that are associated with the SES level and which could explain the differences described in the previous chapter. It should be noted that the factors which are important vary significantly in importance between age categories, travel modes and area characteristics. No attempt is made here to create a scientific model that would include these factors and the interactions amongst them. It is even questionable whether such a model could ever be constructed, unless one would limit it to a certain age group, travel mode and geographical area. And a reliable model should also be able to explain gender differences, which seems even more ambitious.

The next sections list the factors which have been shown or put forward to be associated with SES categories and crash risks. It is always difficult to structure such factors in a meaningful way. The order of factors (or groups of factors) listed does not relate to their possible impact. Actually, the effect of these factors varies considerably between age groups, travel modes, crash types, and countries/regions.

The contributory factors are presented in three main groups:

- Exposure to risk and exposure related factors
- Attitudes, culture and behaviour
- Other contributory factors

3.2. Exposure to risk and exposure related factors

It is well known that exposure to risk is one of the most decisive factors in explaining differences between crash risks. So, it should come as no surprise that SES-based differences in road safety may be linked to differences in exposure. Three types of exposure differences are discussed below:

- Differences in the access to cars and implications for the use of transport modes
- Differences in the length of trips
- Differences in the hazardous nature of the environment and the trips.

3.2.1. Access to cars and implications for the use of transport modes

It is obvious that the poorer you are, the less likely you can afford to have a car and pay for the associated costs, such as fuel, insurance and maintenance costs. Evidence for e.g. France is shown in (Licaj et al., 2012). The assertion holds also for access to motorcycles, and to a lesser extent also to mopeds and bikes. People who do not use cars but rather bikes or motorcycles for their transport – or go on foot – incur much higher risks than car occupants. For instance, a Belgian study (Martensen, 2014) showed that per km travelled, pedestrians have an 8 times higher risk of getting seriously injured (MAIS3+) or killed in a road crash than an average car occupant. The relative ratios that had been calculated for Belgium are even 23 for cyclists and 57 for motorcyclists and moped drivers. Of course, when you have no car, you are likely to drive fewer kilometres than when you would have one. But in general, this reduced distance travelled cannot compensate for the much higher crash risk.

Several studies (e.g. (Carlin et al., 1997; Roberts et al., 1996)) have illustrated that people from lower SES categories travel much more on foot than those from the higher categories. This applies in particular to children. Also Christie & Whitfield (2011) in their literature review linked the elevated risk of road casualties among people in disadvantaged communities to (amongst other factors) them being more likely to walk and less likely to be able to afford access to a car.

It should be noted, on the other hand, that people with no access to a car often make more use of public transport. And it is well known that buses, trams, metros and train are much safer vehicles than cars (for e.g. Belgium, see (Martensen, 2014)). So, limited or no access to cars may in such cases lead to improved road safety, more in particular in areas well deserved by relatively cheap public transport. The access to good public transport may well be one of the main reasons why the social gradient in road safety is less steep (or even flat or reversed) for low SES groups, compared to low SES groups living in other areas. Please note as well that using public transport may incur indirectly higher risks as well, since people may need to travel long distances on foot before they arrive at e.g. a train station. And some poorer people are stimm much more likely to walk and may never be able to afford public transport.

3.2.2. Differences in the length of trips

In general, higher SES groups travel (much) more kilometres by car (and often also using other transport modes) than do people from lower SES groups. This is illustrated in some of the studies which we already referred to (e.g. (ETSC (European Transport Safety Council), 2007) for Norway and (Fleury et al., 2010) for France. All other factors being equal, one would expect thus that higher SES groups experience higher numbers of crashes. And this is sometimes indeed the case, as was illustrated in some of the studies mentioned in the previous chapter. This applies when only travel by car is considered.

In certain cases, however, people from lower SES areas live in remote rural areas that are badly served by public transport and hence need to travel more than people from more wealthy areas. This situation, and hence the higher exposure to crash risk as car drivers, has e.g. been observed in areas of the USA (Cubbin & Smith, 2002) and in Australia (Helps and Harrison, cited by Cairney (2016)).

However, the most important exposure cause of SES differences is related to the observation that poorer people travel relatively more on foot than by car (which makes them much more vulnerable) and that their pedestrian trips are longer. This difference seems to apply for children in particular. Several authors have found that children from lower SES families have to walk longer and cross more streets during the day, in particular for their walking to and from school. See e.g. (A. Macpherson et al., 1998) for Canada and (Roberts et al., 1996) for New Zealand.

Overall thus, the social gradient in road safety can be linked to differences in distance travelled, in particular for people living in remote areas and people with no cars who need to walk a lot. However, there are many situations where such differences are negligible, or even the opposite situation occurs (people from high SES groups needing to travel more).

3.2.3. Differences in the hazardous nature of the environment

The previously mentioned fact that poorer children may have to cross more streets when walking to school, points to another dimension of exposure: the direct confrontation and possible collision with a much higher volume of traffic. In certain areas, particularly in large cities, people from lower SES groups may live in areas with dense and dangerous traffic. For California for instance (Gunier et al., 2003) found that block groups in the lowest quartile of median family income were three times more likely to have high traffic density than block groups in the highest income quartile. Other American authors (Cubbin & Smith, 2002) have also pointed out the increased traffic density as a source of SES-differences in road safety.

Based on a literature review, Brussoni et al. (2008 - unpublished) mention as well that children from deprived families *"… often tend to live in urban, densely populated, older style areas with long straight roads which give rise to high traffic volumes, high vehicle speeds and high incidence of on-street parking."*

In should be noted that in a British study using casualty data collected by the police (Steinbach, Edwards, & Grundy, 2013) it was found that for all transport modes injuries tended to occur closer to home in more deprived or urban areas; younger and older pedestrians and cyclists were also injured closer to home. Another interesting observation was made in a Canadian study (Yiannakoulias & Scott, 2013) that 'local' traffic, i.e. traffic by the people living in the neighbourhood, has a 'protective' effect on child pedestrian accidents in Toronto; they found that low income areas had higher volumes of non-local traffic.

The volume of traffic is just one dimension of a hazardous environment; another one is the quality of the road infrastructure and how it is used by cars and other road users. The authors of a literature review (Christie & Whitfield, 2011) came to the conclusion that the elevated casualty risk among people in disadvantaged communities is linked to a range of factors, including: living in more hazardous environments, such as older style developments, which give rise to higher vehicle speeds and high levels of on-street parking; living in areas with high levels of hazardous and illegal driving behaviour, such as driving while impaired, without a seat belt and driving without entitlement or insurance; and not having access to safe spaces and supervised facilities for children and young people, meaning there are less alternatives to the street as places to socialise and play outside the home. Such children are also more likely to play on the street.

Using police records for London, Steinbach et al. (2010) observed that ethnic minorities tend to live in more deprived areas, with poorer local road environments. Another UK study (Dissanayake, Aryaija, & Wedagama, 2009) found that road network characteristics and traffic characteristics in particular areas in Newcastle upon Tyne were significant predictors of road traffic casualties. A Canadian study by Morency et al. (2012) on Montréal concluded that the traffic volume and the roadway environment, such as the complexity of the intersections, can explain a substantial portion of the excess rate of road traffic injuries in the poorest urban areas.

3.3. Differences in attitudes and behaviour

3.3.1. Introduction

It has been argued in the literature that groups of people may differ in the way they appraise risks – and hence act and behave in different ways. A second argument put forward is that even if the risks are perceived similarly, the way of acting on it may be different (e.g. higher preparedness for risk taking). We list below some findings from the literature.

Several authors have developed models and explanations of how attitudinal and cultural differences lead to differences in road safety behaviour. Many of these models and approaches are based on or are linked to the theory of planned behaviour of Ajzen (1991). For related or other models see e.g. Ward (2007b) and Factor et al. (2008). Ward (2007), in a comparison of crashes in rural and urban areas, observed that crashes involving drivers from rural areas result from willingness and the deliberate decision of these drivers to drive unsafely (drinking and driving, speeding, not using seat belts), even when they understand there is a risk. Other authors (Sticher & Sheehan, 2006) link the higher incidence of road crashes by rural drivers partly to their inaccurate appraisal of risk factors and inaccurate information regarding crash risks.

Factor et al. (2008) stated that members of different SES groups may exhibit different levels of risk-taking behaviour when driving, because of differences in skills, habits and attitudes developed within this group. For instance, from their own analysis they concluded that certain religious groups have greater crash risks. This fatalist attitude (and hence less concerns about risk levels) towards injury and road crashes seems still quite pervasive in many developing countries where religion has a high impact on society. Let us give one example from Pakistan (Kayani et al., 2012). The authors found that in this country fatalistic beliefs are pervasive, are likely to present a barrier to road safety messages and hence contribute to risky road use.

Different SES groups – and cultural groups, see Section 3.4 – may display differences when it comes to risk taking and compliance with rules. This general finding also applies to crash risks and road safety rules. For instance, the higher willingness to take risks by children from lower SES groups is mentioned by Towner et al. (2005) as one of the five factors that lead to higher injuries of children from lower SES groups.

According to Christie (1995) there may be a poorer appreciation of risks among people from lower SES groups which may then subsequently translate into less child supervision or teaching of appropriate traffic behaviours. An American study (Shin, Hong, & Waldron, 1999) found that inner city youth had lower rates of parental seat belt use and was less often being told by parents to use their seat belts. They were also more likely to agree with the statement, *"there is no point in wearing seat belts since you have no control over your fate or destiny"* and found safety a less important motivating factor for seat belt use.

3.3.2. Parental supervision of children

When it comes to crashes with children, and in particular child pedestrian accidents, several authors have pointed out that children of lower SES groups are, on average, less accompanied by parents when walking or playing on public roads. It is recalled that children for low SES areas play much more on the street, because of the absence of safe and affordable playing areas at home or in the neighbourhood – see e.g. (Christie et al., 2007). A study on injured children found that these children routinely used the streets and sidewalks as play areas (Posner et al., 2002). Only a relatively small proportion of the children were hit while walking to school. The remainder were injured either while playing outdoors or while walking to other places.

In their review of the literature on the relationship between deprivation and child pedestrian injuries, Christie & Whitfield (2011) attributed the class-related differences in risk to children from deprived areas to (amongst other factors) being more likely to make journeys on foot and to make these journeys unaccompanied by an adult. Roberts et al. (1996) could show that at that time half of the children from SES groups went to school unaccompanied, whilst this was only one in six from the highest SES groups. White et al. (2000) found that

on journeys to and from school deprived children are less likely to be accompanied by an adult. An Australian study (Carlin et al., 1997) found that a higher level of walking was associated with lower levels of several indicators of socioeconomic status and observed that boys were significantly more likely to cross streets unaccompanied.

There are several factors that can explain why there is often less parental control with children in deprived areas. First, it is of course more difficult to exert parental control when children are playing outside on the street than at home or in the garden (Towner et al., 2005). But there are some other specific reasons, which have been listed in the literature (Christie & Whitfield, 2011; Haddak et al., 2010; White et al., 2000) that can explain why parental supervision is lower, such as more single parents, out of phase working hours, large family size, lower maturity of parents and poorer health conditions.

3.3.3. Seatbelt use

Despite the national differences in seatbelt laws and the moment when seatbelt wearing became compulsory, a quite consistent picture emerges when it comes to wearing of seatbelts: lower SES groups, and more specifically lowly educated people, are less willing to wear seatbelts than the rest of the population. This finding applies both to countries and time periods where wearing a seatbelt was compulsory and when it was not yet the case. The finding also applies to the correct use of child restraint systems.

An analysis of data of the Belgian National Health Survey of 1997 showed that the lowest SES groups had significantly higher numbers of young people (15-24 years old) not wearing their seatbelts (Leveque et al., 2004). Clarke et al. (2010), in an analysis of characteristics of fatalities in the UK, found that car drivers from the most deprived areas who had died in a crash, were twice as likely not to have worn a seat belt compared to fatalities from the most affluent areas; the differences were even more pronounced for passenger fatalities. From a survey amongst immigrants in Sweden (Forward et al., 2009) it emerged that people born in the Middle East, Northern Africa and Southern Europe were more likely not to use their seatbelts in densely populated areas. It can be assumed that many of these people belong to the lower SES groups in Sweden.

Similar results were found in some American studies. A paper by Strine et al. (2010) mentions that people with at least college education are 1.5 times more likely to always wear a seatbelt than people with high school education only (or less). An older American study (Shin et al., 1999) mentions that students from inner city schools, which are predominantly populated with students from lower social classes, reported less seatbelt use than students from the middle-class schools or private schools. A study on road crash fatalities in American accidents (Braver, 2003) showed that men in the lowest ranked education category were less than half as likely to have been wearing a seatbelt; for the women it was one-third less likely. Lernet et al. (2001), in a study of injured adults admitted to a trauma centre, found that seatbelt use was reported for 33% of those earning less than $20,000 per year and 55% of those earning over $20,000. A recent study (Vaughn et al., 2012) showed that non-seatbelt using passengers were significantly less likely to earn more than $50,000 per year or to have attended at least some college. For drivers, non-seatbelt users were significantly less likely to reside in households earning more than $75,000 per year; not having graduated from high school was also a predictor of non-seatbelt use.

Also outside Europe and the USA the findings point in the same direction. A study on young drivers in New Zealand (Begg & Langley, 2000) found that seatbelt users had higher academic qualifications. A study in the Turkish city Sakarya (Demirer et al., 2012) showed that increased level of education was associated with increased seat belt usage.

In conclusion, and although we cannot exclude that in countries where the linkage between seatbelt use and SES has not been examined there is no such link, all available evidence seems to point out that people from lower SES groups, and in particular lowly educated people, tend to use their seatbelts less than other groups in society.

3.3.4. Wearing of helmets

Although in most parts of the world, wearing of helmets is compulsory for motorcyclists, a minority of motorcyclists do not wear a helmet all the time. This phenomenon is much more pronounced for moped drivers (and may be also become a growing problem for drivers of fast e-bikes). The situation is more complex to grasp for cyclists, where in most countries helmet wearing is not compulsory (or only so for children).

We found only two studies which link helmet wearing to SES, and both concern cyclists. Kahl et al. (2007) found that low SES was associated with lower use of helmets by children cyclists (46% versus 63%). Macpherson et al. (2006) analysed in Canada the bicycle helmet use by children six years after the introduction of a law making it compulsory. They concluded that children riding in high income areas were significantly more likely to ride helmeted than children in low income areas.

It is clear that two studies are not enough for generalising this finding. However, they are consistent with the differences found for other passive safety measures such as seatbelt use (cf. § 3.3.3).

3.3.5. Impaired driving

When it comes to impaired driving (and particularly driving under the influence of alcohol), there are several studies that have considered the linkage with SES. All these studies, of which the most recent ones will be mentioned below, point in the same direction: impaired driving is more common amongst people with lower SES.

In the already mentioned English study by Clarke et al. (2010) the authors pointed out that in the most deprived areas, in over one in five of the fatal collisions alcohol or drugs was a contributory factor - compared with one in six for the least deprived areas. Similarly, Hasselberg et al. (2005) found for Sweden that drivers in the lowest ranked group were 1.2 times more likely to be involved in a crash when impaired than drivers in the highest ranked group.

Braver (2003) showed for the USA that men involved in a crash from the lowest education category were 1.5 times more likely to have a blood alcohol concentration (BAC) above 0.1; for women, it was even twice as high. Romano et al. (2006), after analysis of fatality data in several American states found that high income and education level have a protective influence on alcohol-related fatal motor vehicle crashes. In Canada Poulin et al. (2007) found out that the risk of adolescents to be a passenger in a car driven by a drunken driver was associated with the low SES of the neighbourhood where these adolescents lived.

Some studies in Australia and New Zealand also point in the same direction. Leal et al. (2006) found that people in Queensland with drink-driving convictions were more likely to have a low income and/or a low level of education. Indigenous drivers in Western Australia were more likely to have their licence revoked for high-level drunk driving (BAC > .08) than non-Indigenous drivers (Olney, 2007). A different type of result was found in another study (Senserrick et al., 2010): young drivers with high alcohol consumption, and who had used alcohol or marijuana before driving, were more likely to engage in pre-licensed driving. Morrison et al. (2002) observed that in New Zealand people from the lowest SES category has a significantly higher risk to involved in in a road crash were DUI was a contributory factor.

Of course one needs to be careful with generalising such findings, since police enforcement strategies and control of drivers may be biased towards particular areas or groups.

3.3.6. Speeding

Speeding, i.e. driving with an illegal or inappropriate speed level, has also been analysed in relation to SES level of the drivers. Unlike for seatbelt use and DUI, however, the evidence does not show a consistent pattern.

In the UK, Clarke et al. (2010) found that deliberate risk taking and speeding was more frequent a cause of fatal accidents in the most deprived areas, compared to the least deprived. It should be noted of course that such speeding behaviour was not necessarily demonstrated by people living in those areas. From a survey in Sweden by Forward et al. (2009) it emerged that people born in Sweden and in the Western World were more likely to drive 65 km/hour in a 50km/hour zone in densely populated areas and showed a more forgiving attitude to this kind of traffic offence. Shinar et al. (2001) found in an American study that the number of people who stated that they observed the speed limit all the time *decreased* with increasing education and income. A study from New Zealand (Begg & Langley, 2000), based on self-reported behaviour of 21 year olds, showed that these did not differ significantly by SES level as far as crash experiences and thrill-seeking activity was concerned.

So overall, unlike for seatbelt use and DUI of alcohol, there is insufficient evidence from the literature for the hypothesis that speeding of car drivers is linked in a systematic way to the SES of the drivers. In some cases, people from higher SES groups speed more.

3.3.7. Unlicensed driving

Although unlicensed driving is not a cause of road crashes, the phenomenon itself is related to contributory factors such as the absence of proper driving skills or past risky behaviour that has led to the withdrawal of the driving licence. It could also be an indication of unwillingness to comply with regulations, at least for young people.

Based on self-reported behaviour, an American survey found, that teenagers without a driving licence who drive had a higher involvement in a range of other high risk behaviours than those who did not drive, or those who were licensed and drove (Bingham, 2011). These behaviours included driving after drinking or travelling with a driver who had been drinking, driving or travelling in a vehicle without a seatbelt, and indicators of mental health problems. Driving unlicensed was postulated to be an indicator of behavioural undercontrol and of increased risks to healthy social development.

Another example is the already mentioned Australian study by Senserrick et al. (2010). A greater proportion of low SES drivers (aged 17 to 24) reported that they had engaged in prelicensed driving than moderate and high SES drivers. This relationship was 'explained' by factors such as remoteness, risky driving behaviour, alcohol consumption and use of marijuana or other drugs.

Clarke et al. (2010) also noted in their study on fatal crashes in a number of English areas that there were six times more licence violations amongst these crashes in the most deprived areas in comparison to the least deprived. Plunkett (2008) found in Western Australia that Indigenous drivers involved in fatal crashes were nearly eight times as likely as non-Indigenous drivers to be unlicensed.

Although the number of studies on the relationship between unlicensed driving, SES and crash risks is limited, the above results at least allow to formulate the hypotheses that often (1) unlicensed driving is a predictor of increased crash risk; and (2) unlicensed driving is associated with lower SES.

3.4. Differences related to cultural groups

3.4.1. The interaction between culture, SES and road safety

The search for articles and reports concerning the link between SES and road safety, yielded a considerable number of studies that looked at the association between 'cultural groups' and road safety. By 'cultural group' we refer particularly to ethnic groups, migrants and people with a specific religion.

In many contexts, people of particular cultural groups such as ethnic minorities and immigrants predominantly belong to one SES layer – often one of the lowest SES levels. In cases where such an association was obvious (or supported by figures) this has already been referred to. Potential explanations for this are: (1) people

from cultural group X belong predominantly to SES group N; (2) people of SES group N have a higher than average risk to be a casualty in a road crash; and hence (3) people from cultural group X have a higher than average road crash risk.

It would be mistaken, however, to link cultural differences in road safety outcomes exclusively to differences in SES. As stated by Towner et al. (2005), *"As with socio-economic factors, culture should not be seen as a source of explanation for inequalities, but as a contributory factor that needs to be explained."* Also other authors stress the need to search for proximate factors of culture that increase exposure to injury risk – see e.g. (Thomson & Tolmie, 2001). As we already saw in Section 3.3, culture determined behaviour – risk taking, law compliance, supervision of children, drink driving, … – itself is a contributory factor to crash risks, and it goes without saying that particular attitudes and behaviour are more common in certain cultural groups – since values, attitudes and behaviour are almost by definition factors that distinguish cultures. Also, other characteristics such as the areas in which groups of people live (and hence the exposure) can be a contributory factor to road crashes without being associated with SES levels – though they often are.

'Culture' can also be seen here in a broader context and refer to national and regional cultures. The publications resulting from the ESRA studies (see www.esranet.eu) have illustrated that attitudes and self-declared behaviour vary considerably between countries and can explain a considerable part of the variation between countries. Already a few decades ago Hillman et al. (1990) noted differences between German and English children in terms of exposure to risk which stem from variations in culture. These included at that time the greater supervision of children on streets in Germany; the observation of children by other adults when their behaviour fell below the behavioural norms expected; and the German law which forbids children to use the street for play.

Gaygisiz (2009) refers to several authors who have identified particular values, attitudes and/or traits which have been shown to be associated positively or negatively with road safety risks: uncertainty avoidance, individualism, power distance, masculinity, embeddedness, hierarchy, affective autonomy, intellectual autonomy and egalitarianism (see the author's article for more explanation of these terms). Since some of these values and opinions are more prevalent in certain cultural groups than in others, they can explain some of the differences between cultural groups. The same principle applies, of course, to socioeconomic groups were some of these values and attitudes are more prevalent.

Even within European countries where different languages are spoken (e.g. Belgium and Switzerland) there are often considerable and significant differences between the groups speaking different languages when it comes to road safety, which is mirrored by differences between their attitudes and self-declared behaviour – see e.g. (Meesmann & Schoeters, 2016) – although other factors also contribute to the differences, like geography, exposure and SES.

In the next paragraphs we mention several studies that link culture to road safety, but always in contexts where SES differences are present. Since in such studies cultural characteristics and socioeconomic status may be highly interlinked, it could well be that in some cases, the factor "culture" as a predictor for road safety risks would disappear when controlled for SES and/or area – or vice versa. This has been done in a few studies, implying that culture itself does not play a major role in addition to SES and/or area characteristics. For instance, Braver (2003) compared the relative death rate per 10 million vehicle trips for groups with different SES. Although he found some differences across the ethnic groupings (white, black and Hispanic), these were relatively small compared to the effects of education.

Other studies, however, have shown that even after controlling for such factors, culture can still 'explain' an important part of the variation in crash risks. For instance, Christie et al. (2008) examined the relationship between ethnicity and road safety in low SES areas in the UK. They found that Black, Asian and Minority Ethnic (BAME) adults in these areas were significantly more likely to report that they had been injured in a road crash compared to the majority population living in these areas; the BAME group had also more access to a car. These findings illustrate that the relationship between ethnicity and road safety cannot be simply explained by SES related factors only.

To conclude, the factors that contribute to the variation in road safety performance between different cultural groups are (1) not just linked to their culture, and (2) depend on the interaction of many other factors – in general including the SES status. Analysing these factors and their interaction is, however, far beyond the scope of this report.

3.4.2. Ethnic minorities

Most countries in the world include ethnic minorities – some countries could even be considered being composed entirely of a range of ethnic minorities, because none of the ethnic groups is dominant or includes the majority of the population. In some countries people are classified officially or unofficially as belonging to ethnic (or religious) groups, which in general facilitates research and analysis on the differences between these groups. In other countries, it is quite sensitive or even forbidden to make such classifications, since this is seen to be linked to racist attitudes and undesirable segregation of people.

Often, ethnic minorities belong to the lower SES groups, both in terms of educational level, income and occupation. It should be noted, however, that this not always the case and that certain minorities, e.g. Europeans in Africa, or Asian people in the USA, may on average have much higher SES status than the majority population.

Nevertheless, there is a lot of evidence that children in ethnic minorities are often more vulnerable to road crashes than other children. Thomson and Tolmie (2001) showed in a review that in almost all countries where data were available, children of ethnic minorities had an above average risk of being involved in a pedestrian injury. The trend observed at that time applied to quite a range of different countries, including Sweden, the UK, the USA, Israel, Singapore and New Zealand. It should be noted however, that it is difficult to disentangle in the studies reviewed the cultural from the SES factors. The authors could not conclude whether the effect of ethnic background is fully absorbed by the 'traditional factors' that also hold for the majority populations, or that these factors operate differently in different ethnic groups, or that other factors come into play to create additional risk for ethnic minority children.

Other more recent studies tend to confirm these trends. An example is a London based study suggesting that some Black community groups were not aware of the elevated risk of injury and did not want to be stigmatised as a 'problem' group (Steinbach et al., 2007). Christie and Whitfield (2011) found some evidence to suggest that parental perception of the risks children face in traffic is different in 'non-White' families than among the White population. Pressley et al. (2007) showed that Black and American Indian/Alaskan Native children have fatal crash risks that are significantly higher than those of white children.

The general trend for children seems also to apply to adults, at least in countries where the relationship between ethnic minority status and road crash risks has been studied. In Israel, for instance, studies have shown that crash risks are much higher amongst the Arab drivers than with Jewish drivers (Factor et al., 2008; Moran et al., 2010). For New Zealand there are several studies pointing out that Maori and Pacific Islander ethnic groups have higher crash rates than European and Asian people (Blakely et al., 2007; Hosking et al., 2013; Mortimer, 2010). Similar results were also found for Australia concerning Aboriginal and Torres Strait Islander people (Henley & Harrison, 2010).

It should be noted that different ethnic groups within a country may perform differently in terms of road crash risks, even when having a similar SES distribution. A now somewhat dated study from the Netherlands (Junger & Steehouwer, 1990) found that Moroccan and Turkish children were more often than Dutch children involved in a collision with a car, but Surinamese children were less often or at the same rate as Dutch children. In an English study (Steinbach et al., 2007) the interaction between social deprivation and ethnicity on road crashes was analysed for children in London. The authors found that, while for white and Asians children the crash risks increased from the least deprived to the most deprived areas, no such trend was observable for Black children. Another English study (Edwards et al., 2008) found no relationship between deprivation and risk for Black children, but there was a strong link for Asian children. These findings suggest that children in these communities may use the roads differently from those in other communities.

Differences between ethnic groups have also been observed in the USA (Campos-Outcalt et al., 2003). They found that in Arizona the only ethnic group to have consistently higher fatal road crash rates were American Indians. The ranking of different ethnic groups varied by gender and type of area (urban versus rural).

A final point to be made in relation to road safety performance of ethnic minorities is that differences in road safety performance may also differ between transport modes – this may be linked to access and exposure. For instance, in a Dutch study (Stirbu et al., 2006) ethnic minorities appeared to have an above average fatality risk for pedestrian and car crashes, but below average for cyclists and motorcyclists. The study also noted differences in risks between ethnic groups. An Australian study (Falster et al., 2013) concluded that Aboriginal status, after controlling for factors associated with the geographical location, was not associated with higher risk for a car crash, but was related to higher crash risk as a pedestrian and as a cyclist (the study did not control for exposure to these travel modes). In Arizona, USA as well, it was found that the crash rate for American Indians was particularly high for pedestrian crashes. The different findings in these countries illustrate again the complex interaction of cultural factors and other factors when it comes to the explanation of road safety.

3.5. Other contributory factors

3.5.1. Safety of vehicles

Poorer people who own a car, tend to have cars that are older and less expensive. This implies that these cars are equipped with fewer or less developed safety systems than the cars of more affluent people. Poorer people tend to spend less on maintenance of their cars, which, together with the older age, increases the risk of technical failure. Fleury et al. (2010) showed that in a French region, the cars involved in crashes in deprived areas were older than those in the more affluent areas. For another French region similar observations were made (Haddak et al., 2012).

Another example is a study from the USA by Girasek & Taylor (2010) who showed that upper-income individuals had higher availability of vehicle safety features and cars that were younger than those of lower income people. In a Swedish study on the characteristics of crashes of young drivers (Laflamme & Vaez, 2007) the authors showed that at least part of the higher risk of lower social class people could be explained by *"[…] the circumstances in which they crash and the (relatively poor) level of safety of the car they are driving."* In Australia, road crash fatalities of young drivers of low SES groups were significantly more likely (when compared to high SES groups) to be associated with driving an older vehicle (as well as with other factors) (Chen, Senserrick, et al., 2010).

These findings for cars have also been asserted for motorcyclists. Zambon and Hasselberg (2006) state that *"In respect of motorcycles, the lower risk for people from higher socio-economic groups may be attributable to them being more likely to have accessed better driving training, be able to afford newer and safer vehicles, be more able to maintain them, to use safety equipment, […]".*

It should be noted, however, that because of increasing sophistication of cars and the more stringent legal requirements for safety features, that over the last decades vehicle safety has probably become less important as a factor that can explain SES based differences in road crashes. In Sweden some authors (Laflamme et al., 2005) came to the conclusion that *"[improved car safety]'s potential for reducing risk differentials between socioeconomic groups is far less significant".*

3.5.2. Access to and understanding of information

Cubbin & Smith (2002) have pointed out that access to information varies by SES level. Low SES individuals have often less information about factors contributing to injuries, are less likely to believe that certain types of injuries are preventable and hence also less likely to take effective preventive measures. Based on their literature review on road user safety and disadvantage, Christie & Whitfield (2011) concluded that the higher road crash risks of people in disadvantaged communities could (amongst other factors) be contributed to their low

levels of understanding about the risks and not accessing information about facilities and services, in particular parents. An example of such a situation comes from a Canadian study (Snowdon et al., 2008) on the knowledge of caregivers on correctly using car safety seats for their children. The survey revealed that caregivers with higher levels of education were more likely to report correctly using car safety seats.

It should also be pointed out that low SES groups include higher numbers of people with lower than average intelligence, who may also have more difficulties in understanding (road) safety issues. In Sweden, Batty et al. (2009) analysed the association between IQ and injury mortality and the extent to which IQ might explain SES based differences in injury mortality. They found that the relative risk of road injuries was 2.2 times as high in the lowest IQ group (out of 4) compared to the highest. IQ was also shown to explain a sizable portion of the relationship between social class and injury mortality (19% for own social class and 38% for parental social class).

Murray (1998) also found out for Sweden that car drivers [16-22] who had been involved in traffic accidents had school marks that were below the average of men in the population. Similar findings applied to motorcyclists and, especially, moped riders. The opposite, however, applied to cyclists (which seems to be in line with other Swedish studies suggesting that higher SES groups do cycle much more).

Of course, it is not the lower IQ or qualification level itself which should be seen as the direct cause of a increased crash risk. There are complex socio-cultural mechanisms at play which link such characteristics to higher crash levels – some of which have already been discussed, such as the places where people live, access to transport and understanding of risks. It is beyond the scope of this report to discuss these relationships and interactions.

3.5.3. Health status and fragility

It is well known that, overall, lower SES groups have lower health status and this may at least indirectly contribute to higher crash risks and/or higher severity of injuries. Cairney et al. (2016) nicely summarize this : *"Poor health and/or the medications used to treat it could possibly impair a person's abilities as a road user, placing them at greater risk. At a very general level, people affected by impaired health can be more susceptible to fatigue and lapses in concentration. In the more specific case of physical and cognitive impairments, the person may not be able to afford the assessments and advice or the physical modifications required to keep them driving safely. In the case of travel as a pedestrian or public transport passenger, sensory impairment or mobility restrictions may place them at risk crossing roads or boarding or alighting from vehicles."*

3.5.4. Hyperactivity of children

Analysing data from a comprehensive health survey amongst children in Germany, Holte (2010) showed that children who are hyperactive and have behavioural problems have the highest crash risk, and that this higher risks is particularly important for children of lower SES groups.

3.6. Conclusions on contributory factors to SES differences in road safety

There are numerous factors that contribute to increased road crash risks or can help preventing these. Several of these can be associated directly or indirectly with the socioeconomic status of the road users. When the factors that increase road crash risks are positively associated with SES groups, then the extent of the prevalence of these factors will lead to an increased crash risk.

In this chapter the most important – or at least the best documented and most discussed – risk factors are listed that have been found to be associated with SES. Most of these factors tend to be more strongly associated with lower SES groups than with higher SES groups, hence 'explaining' why in many contexts people from lower social classes have higher crash risks. Living in hazardous environments, less access to cars and more exposure as a VRU (in particular children), safety attitudes, seatbelt use and drunk driving seem to be the factors that most often contribute to the higher involvement in road crashes.

The empirical findings have, however, also shown that some risk factors may be more associated with higher social classes, more specifically speeding and the distance travelled as car driver or cyclist.

It is thus clear from the above that the extent of social inequality in road safety can vary a lot and depends on many factors. And behind these factors there are again other factors that explain why people behave in a particular way or why they choose to live a in particular area or use particular transport modes. It was not the purpose of this report to analyse and discuss the mechanisms why people behave in a certain way; the interested reader is referred to some publications such as (Steinbach et al., 2010), (Factor, Williams, & Kawachi, 2013) and (Moran et al., 2010). From such studies it appears that risky behaviour is the result of much more complex mechanisms that must be addressed to prevent crash involvement in the future.

Data limitations and methodological constraints seem to make it virtually impossible to bring all these factors together in an integrated statistical model. Yet, when focussing on specific areas, travel modes and age groups, it seems possible to construct such models and, provided the relevant data are available, understand which factors can explain the SES linked differences in road safety outcomes and performance. This is essential in order to be able to decide on appropriate measures.

4. Some other dimensions of social differences in road safety

4.1. Gender differences

It is well known from the international body of knowledge on road safety, that women's safety performance on the road is in general much better than that of men. This is often explained women showing a higher concern for safety and by their safer driving behaviour. Women are more rule compliant and take less risks in traffic. They also drive less kilometres than men. The net result is that men are overrepresented in road crashes, even when controlled for confounding factors such as exposure.

It was already mentioned in the previous chapters that the SES based differences in road safety, as well as the contributory factors, differ between men and women. In other words, the increased crash risk for, say, lower SES individuals is not necessarily the same for men as for women. Actually, a lot of empirical evidence shows that, in general, the social gradient is lower for women than for men. It should be noted, moreover, that in some context there was no social gradient at all for women (although there was one for men) or even a reversed one.

In the recent Belgian study (Pirdavani et al., 2017) analysing the impact of various zone-based characteristics on crash risks for car occupants in Flanders, it was found that the effects of car ownership and income level are less pronounced for women than for men. The authors put forward the hypothesis that the underlying cause of this difference is that mode choice is gender biased and that women use cars less than man.

Nolasco et al. (2009) observed that whilst men in some Spanish cities had a higher risk for road crash fatalities if they belonged to the lowest SES groups, this difference was less obvious or almost inexistent for women. In an Italian study, Michelozzi et al. (1999) found that males from the lowest SES levels in Rome had a much higher chance (52%) of being killed in a road crash, compared to people from the highest SES categories; for females, the figure was somewhat lower but still significant (44%). Another study, based on data from the Lazio region (Camilloni et al., 2013), found that people with low SES had higher figures for emergency departments visits, hospital admissions and fatalities, but that these differences were less pronounced with women than with men. A study from Greece (Moustaki et al., 2001) showed that boys – but not girls – who reside in less wealthy towns are overrepresented in pedestrian injuries.

On the other hand, Swedish studies found a similar social patterning for both men and women (Laflamme & Eilert-Petersson, 2001) (Hasselberg et al., 2001). The international study from Borell et al. (2005) showed even a reversed trend for Norway, where the highest education women had the higher injury rates. Possibly these results are related to the fact that Sweden and Norway, from many societal perspectives, are much more equal societies than in the rest of the world.

The gender factor in SES differences has also been observed outside Europe. For Canada, Burrows et al. (2012) found that the association between SES and road fatalities was weaker with women than with men. Please note however that a much older and probably now dated study (Dougherty et al., 1990) found at that time larger socioeconomic differences in traffic injuries for girls than for boys. In Australia Turrell and Mathers (Turrell & Mathers) observed that the social gradient in road crashes was higher with boys (relative risk of 2.26 of the lowest SES group) than with girls (1,83). A study from New Zealand (Blakely et al., 2007) found that males with lower incomes had a consistently higher road traffic injury mortality rate than males with higher incomes, but that no such pattern was apparent among females.

Overall, these findings (as well as those from several other studies not reported here) clearly indicate that in general the social gradient in road safety is steeper for men than for women. The differences between men and women seem smaller in countries which have the lowest crash risks and where the differences in crash risks between men and women are already small.

These results would suggest that the difference in behaviour in traffic is smaller between women (including girls) from different SES groups than it is with men. An interesting observation is that also the overall difference between men's and women' safety performance would diminish if controlled for SES.

4.2. Trends

Another interesting question is whether and to what extent the social gradient in road safety has evolved over time. There is not much evidence in the literature to respond to this question. There are a few studies, which will be listed below, but they refer to different countries and time periods. Moreover, the time periods are relatively small compared to the time periods that mark social and sociological evolutions.

A study about evolutions between 1981 and 1991 in England and Wales (Roberts & Power, 1996) showed that the risk of involvement in a fatal road crash had decreased less for children of the lowest SES group (-2%) than for children of the highest SES category (-37%). Thus, SES mortality differentials had increased during this period. On the other hand, a specific study in relation to children in Trent with long bone fractures as a result of crashes did not notice changes in socioeconomic gradients in the period 1992-1997 (Coupland et al., 2003). Adams et al. (2005) found for the Northeast of England that between 1983 and 2003 the SES based differences in road traffic injuries of children had decreased. A Scottish study (West & Sweeting, 2004) also found a reduction in SES differentials with pedestrian injuries.

A recent French study that analysed data on work related road crashes (Brière et al., 2016) found that between 2004 and 2012 the road crash rate during home-work trips had decreased the most for blue collar workers; for other professional groups the rate had decreased less or even increased. So, in this case SES based differences had decreased over time. None of these figures were controlled for exposure.

In a study covering the evolution of road crashes in the USA between 1995 and 2010, based on crash records and travel survey data, Harper et al. (2015) found larger road crash fatality decreases among the more highly educated and some evidence of fatality increases among the least educated. For children up to 4 years, another American study (Pressley et al., 2007) concluded that between 1981 and 2003 differences between ethnic groups had decreased for certain injury causes (pedestrian accidents) but had widened for others (motor vehicle occupants).

By analysing hospital discharge data for the Canadian province Manitoba, Brownell et al. (2010) found that between 1986 and 2006 the SES gradient for children's injury hospitalisations due to road crashes increased – but this evolution was not linear over time. On the other had Birken et al. (2006) found for all unintentional injuries (including those caused by road crashes) that the social gradient in Canada had decreased significantly from 1971 to 1998 for children up to 14 years living in urban areas (60% of population).

An Australian study (Turrell & Mathers, 2001), using mortality data found evidence for males of increased mortality inequality between 1985-87 and 1995-97 for motor vehicle traffic accidents (all age groups); for females increases were observed for certain age groups (15-64) but decreases for other ages (0-14). A more recent study (Chen, Senserrick, et al., 2010) analysing fatal road crashes between 1997 and 2007 did not observe trends in SES differentials over that period.

So, there is no clear trend emerging from these studies and it is not possible to predict future trends based on what is currently available in the literature. Anyway, it remains difficult to interpret the results of the studies listed, in particular the older studies, because in most countries the average education level and in generally also the average income of people has increased over the last decades. In Western countries, moreover, the share of manual jobs has been decreasing systematically. So, what had to be understood by a low, middle or high socioeconomic status in 1980 may for many countries be quite different from what it means today. Concepts like social inequality and deprivation evolve over decades and cannot be compared properly – just like today, the lower SES quartile in Belgium is quite different from the lower SES quartile in Bulgaria.

It should also be noted that road safety meant something different some decades ago than it does now – in terms of the numbers, distribution and characteristics of road traffic casualties. Over this period the numbers

of casualties decreased considerably; this also means that even with persistent SES differences, in general the vulnerability has also considerably decreased for those with the highest relative risks.

4.3. Implications of involvement in road crashes

A somewhat neglected aspect of the relationship between road safety and SES is to what extent people form particular SES groups are better or worse off after the crashes. There is not much evidence on this topic, but the few studies that are available seem to indicate that people with low SES, when hospitalised after a road crash, suffer longer and have a higher risk of dying.

A Dutch study on the consequences of children involved in road crashes in the Groningen area (Sturms et al., 2002) showed that children from low SES groups suffered more and longer after the crash, with more severe implications for their quality of life in several areas. Ali et al. (2013) found in the USA that patients in lower wealth quartiles had significantly greater unadjusted inpatient mortality compared with the wealthiest quartile. An Australian (Chen et al., 2012) found out that hospitalisation costs of poor young adults (17-25) in New South Wales were about 10% higher than those of middle and high income groups. For Canada Moore et al. (2015) concluded that patients who suffer from high social and/or material deprivation and are admitted to hospital for traumatic injury have longer acute care length of stay in a universal-access health care system. It should be noted that the findings reported do not differentiate between different causes of injury (and hence include also non-road crash courses).

The differences in the Canadian study seems at least partially due to the longer distance between the living areas of the patients and the hospitals, leading to longer time periods between the incident and the medical treatment. Also Cubbin & Smith (2002) noted that rural residents have reduced access to quality trauma care, which may disproportionately affect the poor.

Another explanation for the differences in outcomes is that the severity of the injuries in higher in low SES areas and/or with people with low SES. Cairney et al. (2016) mention that poorer health and fitness affect the probability of surviving a crash and the ability to recover afterwards. And Traynor (2009), based on analysis of crash data for Ohio concluded: *"The estimates uniformly support the hypothesis that after controlling for other influences, severe injury and fatality risks to people involved in crashes are lower for crashes that occur in counties with better economic conditions than for crashes that occur in less prosperous counties."*

A related question is whether the road crash itself can lead to a decrease in the SES ranking. No studies that have addressed this question. Cairney et al. (2016) made some observations about this question which seem quite plausible and which are in line with anecdotal evidence and oral feedback received from experts*: "In some cases […] social disadvantage is inflicted as a result of road trauma, as may be the case where a family's main income earner is prevented from working for a long period, or an individual's life choices are constricted as a result of injuries sustained in a crash. In developed countries, the legal system backed by a well-developed insurance industry generally ensures that individuals are not thrust into poverty as a result of road trauma, although individual aspirations may be constrained in ways that can never fully be compensated. In countries which do not have such arrangements, injuries sustained in road crashes can inflict severe financial hardship."* To this could be added that people from higher SES groups in generally have more means and support mechanisms to cope with or compensate for the restrictions following a severe injury.

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