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Impairments, diseases, age and their relative risks of accident involvement: Results from meta-analysis

Truls Vaa

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Summary:
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Tittel: Tilstander, sykdommer, alder og relativ risiko for innblanding i ulykker: Resultater fra meta-analyse

Forfatter(e *Truls Vaa*

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Sammendrag:
Rapport nr R1.1 i EU-prosjektet IMMORTAL er en meta-analyse av sykdommer, tilstander og alder som kan tenkes å ha sammenheng med en forhøyet ulykkesrisiko. Rapporten er basert på en litteraturgjennomgang av studier som har evaluert helserelaterte risikofaktorer og det er lagt spesiell vekt på de sykdommer og tilstander som er nevnt i Annex III i Council Directive on driving licences (CD 91/439/EEC). Rapporten gir også en oversikt over nasjonale bestemmelser i endel europeiske land mht medisinske undersøkelser og selvrapport helsetilstand ved søknad om og fornyelser av førerkort.

62 studier er gjennomgått og 298 enkeltresultater har vært grunnlag for utvidet meta-analyse og beregninger av relativ risiko for å bli innblandet i en veitrafikkulykke. Alle hovedkategorier av sykdommer og tilstander i Annex III (nyresykdommer unntatt) viste statistisk signifikante økninger i relativ ulykkesrisiko. Disse varierte mellom 9 og 100% økning i relativ risiko.

Language of report: English

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Forord

Prosjektet *Impaired Motorists, Methods Of Roadside Testing and Assessment for Licensing* (IMMORTAL) er et prosjekt under EUs 5. rammeprogram. Det omhandler betydningen for trafikksikkerhet av ulike helserelaterte forhold hos bilførere. Prosjektet gjennomføres av et konsortium bestående av 10 institusjoner fra 7 land, og ledes av Universitetet i Leeds (School of Psychology). Landene som deltar er Danmark, England, Nederland, Norge, Spania, Tsjekkia og Østerrike. Fra Norge deltar TØI og SINTEF. Prosjektet ble startet opp i 2003 og skal avsluttes i 2005. Sentrale problemstillinger som skal behandles i prosjektet er:

- Kroniske og akutte tilstander hos førere som kan påvirke kjøreatferd og ulykkesrisiko (herunder: Sykdom og medikamentbruk, alkohol og narkotika, synsfunksjoner, trøtthet m fl)
- Vurdere kriterier (toleransenivåer) for tilstander som kan medføre risiko
- Skaffe kunnskapsunderlag for å formulere en europeisk policy vedrørende helsemessige krav til førerkortkandidater og kontroller av føreres tilstand ute i trafikken
- Beregning av nytte-kostnadsforhold ved eventuell innføring av restriksjoner angående sykdommer og gitte tilstander

Den foreliggende rapport omhandler den første av de ovennevnte problemstillinger. Resultatene vil kunne gi mer forskningsbasert kunnskap om ulike risikorelaterte tilstander hos førere, som grunnlag for beslutninger om krav til førerkort og nødvendige undersøkelsesprosedyrer i den forbindelse.

Rapporten er skrevet av forsker Truls Vaa. Leder for IMMORTAL-prosjektet ved TØI er forskningsleder Fridulv Sagberg. Forskningsleder Rune Elvik har hatt ansvaret for kvalitetssikring av rapporten og avdelingssekretær Trude Rømming har sørget for utforming og layout.

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Transportøkonomisk institutt

Sønneve Ølnes
konstituert instituttsjef

Rune Elvik
forskningsleder

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62 reports, mainly case-control studies, have been reviewed giving a total of 298 results that serve as basis for calculations of relative risks of being involved in road accidents. All main categories of impairment except renal disorders were associated with a statistical significant increase in the risk of being involved in a road accident. Estimates of relative risks of impairments according to the main categories described in Annex III, were as follows:

Table A: Relative risks of accident involvement of medical conditions according to main categories in CD 91/439/EEC - Annex III. Results from meta-analysis (Relative risk of drivers not having a given medical condition = 1,00)

Main category	*Relative risk*	*95% CI*	*p-value***	*Number of results*
Vision impairment	1,09*	(1,04; 1,15)	0.000	79
Hearing impairment	1,19*	(1,02; 1,40)	0.649	5
Arthritis/Locomotor disability	1,17*	(1,004; 1,36)	0.002	12
Cardiovascular diseases	1,23*	(1,09; 1,38)	0.000	48
Diabetes mellitus	1,56*	(1,31; 1,86)	0.000	25
Neurological disease	1,75*	(1,61; 1,89)	0.000	22
Mental disorders	1,72*	(1,48; 1,99)	0.000	33
Alcoholism	2,00*	(1,89; 2,12)	0.210	3
Drugs and medicines	1,58*	(1,45; 1;73)	0.000	68
Renal disorders	0,87	(0,54; 1,34)	0.076	3
Weighted average across all categories	1,33*	(1,28; 1,37)	0.000	298

Source: TØI report 690/2003

*) The relative risk is statistically significant at a level of $\alpha < 0.05$

**) Test for homogeneity: If $p < 0.05$, data is considered heterogeneous and a random-effect model is used

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The weighted average across all main categories is 1,33, which means that a driver with a given medical condition comprised by Annex III would have a 33% higher risk of accident involvement than a driver without that given condition. The relative risks for all main categories are significantly higher than 1,00, except for renal disorders.

None of the main categories show a relative risk of more than 2,00, the highest being 'Alcoholism'. However, the reliability of this estimate could be questioned as the number of results which the estimate is based on, is only 3.

The categories can be grouped in two parts that may be labelled *high-risk impairments* and *low-risk impairments*. High-risk impairments exhibit relative risks that are significantly higher than low-risk impairments. *Alcoholism, neurological diseases, mental disorders* and *drugs and medicines* all belong to the high-risk group, while *vision impairment, arthritis/locomotor disability, hearing impairment,* and *cardiovascular diseases* all belong to the low-risk group. *Diabetes mellitus* lay in-between the high-risk and the low-risk group with a relative risk of 1,56.

Estimating relative risks of sub-groups of the main categories, some sub-groups came out with the relative risks that were of the same magnitude as high-risk impairment group of the main categories: These were *(Severe) mental disturbances, psychotropic substances (alcohol included), drugs assumed to be abused* and *epilepsy/sudden disturbance of consciousness* with relative risks of 2,01 – 1,96 - 1,96 and 1,84 respectively.

Several other conditions were also considered. These were: *Depression, sleep apnoea /narcolepsy, AD(/HD), benzodiazepines, cannabis* and *opiates.* Sleep apnoea/narcolepsy came out with a relative risk of 3,71. This is the highest relative risk of all conditions considered. It is also significantly higher than all other categories but *depression, cannabis* and *opiates*. The rest were of middle magnitude, i.e. about the same as *diabetes mellitus*.

The highest relative risks of all conditions considered, are associated with age and gender. Young male drivers (aged 16-19) have a relative risk of being involved in an injury accident of about 7, compared to the group with the lowest risk (male drivers aged 45-54). Young female drivers (aged 16-19) have a relative risk of accident involvement of about 3,2 compared to the lowest female group (women aged 35-54). Male drivers aged 75+ have a relative risk of about 3,2, and women aged 75+ about 3,1 compared to the groups of males and females with the lowest accident risks, respectively.

Estimates of relative risks which are based on few results must be interpreted with caution. This concern especially hearing impairment, alcoholism, angina, depression, sleep apnoea/narcolepsy, and use of cannabis, analgesics/opiates, antidepressants. Including more results in these groups may change the estimates and confidence intervals.

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Sammendrag:

Tilstander, sykdommer, alder og relativ risiko for innblanding i ulykker: Resultater fra meta-analyse

Rapport nr R1.1 i EU-prosjektet IMMORTAL er en meta-analyse av sykdommer, tilstander og alder som kan ha sammenheng med en forhøyet ulykkesrisiko. Rapporten er basert på en litteraturgjennomgang av studier som har evaluert helserelaterte risikofaktorer. Det er lagt spesiell vekt på de sykdommer og tilstander som er nevnt i Annex III i Council Directive on driving licences (CD 91/439/EEC). Rapporten gir også en oversikt over nasjonale bestemmelser i endel europeiske land mht medisinske undersøkelser og selvrapport helsetilstand ved søknad om og fornyelser av førerkort. Landene som inngår i denne oversikten er Danmark, England, Nederland, Norge, Spania og Østerrike.

62 undersøkelser, for det meste case-control studier, er gjennomgått og 298 enkeltresultater har vært grunnlag for meta-analyse og beregninger av relativ risiko for å bli innblandet i en veitrafikkulykke. Alle hovedkategorier av sykdommer og tilstander i Annex III (nyresykdommer unntatt) viste statistisk signifikante økninger i relativ ulykkesrisiko. Estimater for relativ risiko for de hovedkategorier som inngår i Annex III er som følger:

Tabell A: Relativ risiko for ulykkesinnblanding for hovedkategorier av medisinske tilstander i CD 91/439/EEC - Annex III. Resultater fra meta-analyse (Relativ risiko for førere som ikke har en gitt medisinsk tilstand = 1,00)

Hovedkategori	***Relativ risiko***	***95% KI***	***p-verdi*****	***Antall resultater***
Synssvekkelser	1,09*	(1,04; 1,15)	0.000	79
Hørselsvekkelser	1,19*	(1,02; 1,40)	0.649	5
Artritt/lbevegelseshemminger	1,17*	(1,004; 1,36)	0.002	12
Hjerte-/karlidelser	1,23*	(1,09; 1,38)	0.000	48
Diabetes mellitus	1,56*	(1,31; 1,86)	0.000	25
Nevrologiske lidelser	1,75*	(1,61; 1,89)	0.000	22
Mentale lidelser	1,72*	(1,48; 1,99)	0.000	33
Alkoholisme	2,00*	(1,89; 2,12)	0.210	3
Narkotiske stoffer og medisiner	1,58*	(1,45; 1;73)	0.000	68
Nyresykdommer	0,87	(0,54; 1,34)	0.076	3
Vektet gjennomsnitt over alle hovedkategorier	1,33*	(1,28; 1,37)	0.000	298

Kilde: TØI rapport 690/2003

*) Relativ risiko er statistisk signifikant på 5%-nivå ($\alpha < 0.05$)

**) Test for homogenitet Hvis $p < 0.05$, er data bedømt som heterogene og en random-effektmodell er benyttet

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Det vektede gjennomsnitt over alle hovedkategorier var 1,33, hvilket betyr at en bilfører med en gitt medisinsk tilstand som inngår i Annex III i gjennomsnitt vil ha 33% høyere ulykkesrisiko enn en bilfører som ikke har en slik tilstand.

Ingen av hovedkategoriene viste en høyere relativ risiko høyere enn 2,00, - den høyeste var alkoholisme. Dette estimatet må imidlertid vurderes med forsiktighet da antallet resultater som det bygger på bare er 3.

Resultatene kan grupperes i 2 undergrupper som kan benevnes "høyrisiko-" og "lavrisiko-tilstander" og der høyrisiko-tilstander hadde signifikant høyere relativ risiko enn lavrisiko-tilstandene. *Alkoholisme, nevrologiske lidelser, mentale lidelser*, og *narkotiske stoffer og medisiner* hører alle til høyrisiko-tilstandene, mens *synssvekkelser, hørselssvekkelser, atritt/bevegelseshemminger* og *hjerte-/karlidelser* alle hører til lavrisiko-tilstandene. *Diabetes mellitus* ligger mellom disse to undergruppene med en relativ risiko på 1,56.

Noen av undergruppene under hovedkategoriene hadde relative risikoer på samme nivå som høyrisiko-tilstandene. Disse var (alvorlige) *mentale forstyrrelser, psykotrope substanser (alkohol inkludert), antatt misbruk av medisinske stoffer,* og *epilepsi/plutselige bevissthetsforstyrrelser.* Disse undergruppene hadde relative risikoer på hhv 2,01 – 1,96 - 1,96 og 1,84.

Materialet ga også mulighet for å beregne relativ risiko for endel andre tilstander. Disse var *depresjon, søvnapné/narkolepsi,* samt bruk av *cannabis* og *opiater*. Søvnapné/narkolepsi hadde en relativ risiko på 3,71 og har med dette den høyeste relative risiko av alle ***medisinske*** tilstander og sykdommer som ble vurdert.

De høyeste relative risikoer av alle tilstander som er vurdert har imidlertid sammenheng med bilføreres kjønn og alder. Unge mannlige førere (alder 16-19 år) har en relativ risiko for å bli innblandet i ulykke på ca 7 sammenlignet med den aldersgruppen av førere som har lavest risiko, dvs menn i alderen 45-54 år. Unge kvinnelige førere har en relativ risiko på ca 3,2 sammenlignet med gruppen av kvinnelige førere med lavest risiko (kvinner i alderen 35-54 år). Menn i alderen 75+ har en relativ risiko på ca 3,2, mens kvinner i samme aldersgruppe har 3,1, når det sammenlignes med de grupper av hhv menn og kvinner som har den laveste risikoen.

Estimater for relative risikoer som er basert på få resultater må tolkes med forsiktighet. Dette gjelder spesielt hørselssvekkelser, alkoholisme, angina, depresjon, søvnapné/narkolepsi, bruk av cannabis, analgesia/opiater og antidepressiva. En inkludering av flere resultater i disse gruppene vil kunne endre estimater og konfidensintervaller.

1. BACKGROUND AND OBJECTIVES

1.1 GENERAL BACKGROUND OF PROJECT IMMORTAL

IMMORTAL specifies a *research programme* concerning the accident risk associated with different forms of driver impairment and the identification of 'tolerance levels' applied to licencing assessment and roadside impairment testing (including drug screening).

The technical and scientific objectives of IMMORTAL are to:

1. Investigate the influence of chronic and acute impairment factors on driving performance and accident risk;
2. Recommend criteria ('tolerance levels') for high risk categories of impairment;
3. Provide key information to support formulation of European policy on licencing assessment and roadside testing.

The present deliverable addresses objective no 1. The central concept here is **impairment factors.** [1]

1.2 AGEING, MENTAL ILLNESS AND DISEASE

Available evidence suggests that the medical condition of drivers is an important factor when assessing fitness to drive and the ability to drive safely (Metzner et al 1993). In a Norwegian retrospective study based on 230 forensic reports of drivers involved in fatal car accidents, it was found that as many as 27 drivers (12%) died from natural causes, the main cause being acute cardiovascular disease (Alvestad and Haugen 1999). In an additional 17 cases (7%) serious cardiac disease, CNS pathology or diabetic complications contributed significantly to the accidents. Raised blood alcohol level was found in 21% of the drivers, hepatic steatosis was observed in 16% of all drivers, most of whom were not under the influence of alcohol. Suicide was recorded in 6 cases (2,5%). Suicide was also suspected to be the cause in additional cases. In a Swedish county, Mälardalen, a similar investigation based on in-depth study of 196 accidents was done in 2000 (Sagberg and Assum, 2000). The study found that 20% of the road users had taken alcohol, drugs or medicine that could have had impact on their behaviour leading to the accident.

However, medical conditions should not necessarily be considered as the most important factor associated with the number of road accidents. In fact, in the Norwegian retrospective study, the accidents that were caused by acute cardiovascular disease all happened at low speeds or by running off the road without comprehensive injuries. Excessive speed is by far considered as the most important contributing factor associated with road accidents. It is a well-established fact that the number of accidents varies systematically with levels of driving speeds: A lowering of the driving speed levels leads to a reduction in the number of accidents

[1] The headline of the Technical Annex text seems to separate between (mental) illness and disease. The concept 'illness' then seem to be associated with 'mental' and it follows that 'disease' could be associated with 'somatic'. Such a distinction will, however, not be followed throughout the report as the literature does not use such a distinction.

(Elvik et al 1997). It is overwhelmingly documented that drink driving impairs driving ability. Use of alcohol is by far the most important single risk factor contributing to road accidents. A BAC of 0,1% to 0,149% means an increased risk of a fatality of about 100 compared to sober drivers (Glad and Vaas 1993). [2]

It is generally agreed among traffic researchers that it is difficult to attribute accidents to single causes only. In-depth accident studies frequently show that accidents have multi-factorial causes. It is more fruitful to speak of and identify risk factors, i.e. factors that vary systematically with the number of accidents. Speed is mentioned as one risk factor, alcohol is another. Medical condition and the use of medicinal drugs are other groups of possible risk factors. On the other hand, it is important to recognize that people with medical conditions may need pharmacological treatment: An untreated medical condition could be more risky in traffic than when treated with appropriate medication. And in many cases the medical condition will remain for an extended period of time, in some cases for the rest of the life.

Special concern exists regarding ageing and the older driver. Calculations of accident risks for Norwegian drivers show that the risk of injury varies very little for drivers in the 10-year cohorts 35-44, 45-54, 55-64, 65-74, where it varies between 0,12 and 0,17, while it rises 3-4 times to 0,47 for drivers aged 75 and above (Sagberg and Glad 1999).[2] Three specific aspects dealing with the older driver are of great relevance. First, the health of the drivers: As they become older, the ability to drive safely could be reduced. Second, morbidity, and hence the use of medicines, increases with age, and medical factors adverse to safe driving may be multiplied and synergistic. Third, the assessment of drivers with dementia poses special problems especially with respect to the fact the average age of the driving population is rising.

One of the aspects dealing with medical conditions and driving, is that there is limited knowledge on their role on fitness to drive and accident risk. This is logical as we are dealing with many types of impairments. Differences between drivers always exist and may increase with age. Hence, medical conditions among older drivers and fitness to drive, is a complex matter. Finally, many older drivers are very healthy people, while others may have several disorders. On the other hand, 'the older drivers of today' seem to be healthier if compared with previous generations of the same age. New knowledge regarding how to stay healthy, more focus on health behaviour, avoidance of risk factors associated with unhealthy life styles, better treatment and better medicines, are all factors that contribute to a more healthy population of today.

1.3 OBJECTIVES OF TASK R1.1

The description of the task R1.1 is as stated in the Technical Annex:

- *Literature review of impairment and accident risk associated with ageing, illness and disease. The deliverable will document the results from task R.1.1, which consists of an updated literature review and meta-analyses of health-related risk factors. The analyses will partly be based on research reports compiled for the Norwegian Traffic Safety Handbook.*

[2] The risk is given as the number of injuries/fatalities per million km of driving and refers to Norwegian risk figures per 1997.

This report will consider impairments and medical conditions stated in the licence requirements of the European Union, i.e. the medical conditions as stated in Council Directive on driving licences - CD 91/439/EEC (The Council of the European Communities, 1991). Annex III of the Council Directive describes minimum standards of physical and mental fitness for driving a power-driven vehicle. The following aspects are listed in Annex III:

- Sight
- Hearing
- Locomotive disability
- Cardiovascular diseases
- Diabetes mellitus
- Neurological diseases
- Mental disorders
- Alcohol
- Drugs and medical products
- Renal disorders
- Miscellaneous provisions

Most of these aspects are further divided into subgroups and a more specific detailed description of the aspects in Annex III is listed in table 2. Some aspects that go beyond the ones mentioned in Annex III are especially mentioned in the Technical Annex. These are:

- (Clinical) Depression
- Attention Deficit/Hyperactivity Disorder (AD/HD) syndrome
- Different levels/types of learning difficulty associated with light mental retardation
- Flu
- Sleep apnoea
- Use of benzodiazepines
- Cannabis
- Opiates
- Cocaine

The two listings given above, will in sum be the aspects considered in the present deliverable, i.e. to the extent that these aspects are considered and evaluated in studies collected for the present review.

1.4 MAIN RESEARCH ISSUES

In practice, various types of diseases, including the effects of medical treatment, can affect fitness to drive. It is conceivable that many medical-pharmacotherapy conditions could impair the ability to drive to some extent, as well as that untreated medical conditions could impose more risk than if treated with appropriate pharmacotherapy. However, clear evidence regarding accident risk of different medical conditions may lack, making it difficult for decision-makers to decide that certain levels of impairment is unsafe in reference to some given criteria. For this reason, the CD 91/439/EEC faces problems in the implementation of guidelines for impairment. The main research issues should hence be to investigate the following:

- Is there evidence that certain physical or mental impairment, especially those conditions mentioned in CD 91/439/EEC, are associated with an elevated accident risk by drivers who carry them?
- If so, is it possible to assess the relative accident risk for drivers carrying a certain physical or mental impairment compared to drivers not carrying the impairment?

By '*physical or mental impairment*' is meant any state or condition, illness or disease, chronic or acute, that have been evaluated with regard to a possible increased accident risk for a driver carrying that given impairment. The concept includes diseases, any use and abuse of alcohol, psychotropic drug, medicinal or chemic substance, as well as impairment associated with the processes of ageing.

Considering the large amount of literature in this field, some issues must be excluded. The following are not considered in the present review:

- Acute illnesses and their impact on accidents: As mentioned some drivers die at the wheel. This issue is not considered further in the present review.
- Studies merely describing prevalence or incidence of a given medical condition in a country or state are not discussed in the present review.
- A substantial part of the literature is dealing with a certain medical condition or substance and its effect on driving behaviour or test score only, i.e. without data on accidents. This type of studies is not considered further in the present review.

As a conclusion, only studies that present accident data, preferably in a case-control design, are comprised by the present review. This means that a given study must present a type of data that enables estimation of relative risk of a certain medical condition or substance. Such estimates will then serve as input for subsequent meta-analysis.

1.5 IMPAIRMENTS CONSIDERED IN NATIONAL MEDICAL EXAMINATIONS AND SELF-REPORTS

1.5.1 National medical examinations

The partners of the IMMORTAL consortium come from a total of 7 countries: Austria, the Czech Republic, Denmark, the Netherlands, Norway, Spain, and the United Kingdom. In a consortium meeting in Lyngby, Denmark, in September 2002, it was agreed to give an overview of the aspects addressed in the national medical examination form and driver self report forms that is required to be filled in for all applicants of a driver's licence. Table 1 gives an overview of national requirements regarding national medical examination and self-reporting of medical conditions in the countries of the IMMORTAL consortium:

Table 1: Requirements of medical examination and self report in IMMORTAL countries

	Austria	***Czech Rep.***	***Denmark***	***Netherlands***	***Norway***	***Spain***	***UK***
Self report?	yes	-	yes	yes	yes	no	yes
Medical examination?	yes	-	yes	yes	(no)	yes	(no)

Source: TØI report 690/2003

Austria, Denmark, and the Netherlands all require that both a driver self report is filled in and a medical examination is performed. However, the number of conditions varies substantially between the countries. In Spain there is a comprehensive mandatory medical-ophtalmological-psychological evaluation. There are about 2000 Medical Psychological Centers that perform medical-psychological evaluation in about 2 million drivers every year. It is mandatory to take a new medical-psychological evaluation every 10 years up to 45 years of age and then more frequently. In Spain a medical examination is mandatory and no self-report is used.

In UK, only a self-report is required as UK does not undertake formal physical or medical examination for any licence holder or applicant of licence categories A, B, B+E + subcategories A1 and B1 as a matter of routine, whatever the age of the individual. However, if one or more of the medical questions on the self-report form are ticked, to confirm that the driver/applicant does have one of the listed conditions, then the Driving and Vehicle Licencing Agency (DVLA) will send a specific medical enquiry form to the driver, specific for that condition. Thus, if the person declares "Diabetes" then a form "Diab1" is sent to the person to complete. With his/her signed consent the DVLA then approaches the person's own doctor or specialist for further information. Even then, a formal examination (in the physical sense) may not be required.

The Norwegian procedure resembles the UK procedure. If only ‘no’-s are ticked on the self report, no medical examination is required. If the applicant uses glasses or correcting lenses, an examination of vision is required, either by a optician or by a medical doctor. If there are other ‘yes’-s on the self report, a medical examination for that condition is required.

The aspects addressed in national medical examinations and national self-reports are listed in the tables below.[3] In Table 2 all aspects mentioned in the Annex III of EU Council Directive on driving licences are listed (CD 91/439/EEC, The Council of the European Communities, 1991). In the table, Annex III is broken down in order to show how the various aspects are specified. The concepts used in Table 2 should mirror the ones used in Annex III. Only requirements regarding ‘Group 1-drivers’ are listed, i.e. driving licence categories A, B, B+E + subcategories A1 and B1.

All countries have certain national requirements that are not comprised by the Council Directive and some countries may have used concepts that could be similar but not identical to the ones used in the Annex. To retain national idiosyncrasies the aspects addressed in the various countries are listed after Table 2. Concerning the national forms, some of the questions used in the medical examinations as well as in the self-report forms, may have addressed several aspects in the same question. Again, to retain national idiosyncrasies, aspects addressed in the national forms are listed as completely as possible. If aspects are more or less identical between Annex III and the national medical examination, a ‘yes’ is filled in in Table 2. (A ‘(yes)’ is used when national requirements are similar, but not identical to subgroups in Annex III.)

[3] The requirements of the Czech Republic are unknown.

*Table 2: Required national medical examinations compared to Annex III in CD 91/439/EEC *)*

Licencing requirements/restrictions specified in EU Council Directive CD 91/439/EEC	***Austria***	***Czech Rep.***	***Denmark***	***the Netherlands***	***Norway***	***Spain***	***UK***
Mandatory medical examination?	yes	no data	yes	yes[12]	no[16]	yes	no
V-1: Field of vision (R) (>120°)	yes		yes	yes		yes	
V-2: Twilight vision (R)						yes	
V-3: Progressive eye diseases (R)						yes	
V-4: Binocular visual acuity [1]						yes	
Hearing	yes		yes			yes	
Locomotor disability [2] ***Physical handicap***	(yes)		yes			yes	
Cardiovascular diseases (CD) [3] ***- CD subgroups:***	yes		yes			yes	
CD-1: Serious arrythmia	(yes)					yes	
CD-2: Abnormal arterial blood pressure	(yes)			(yes)		yes	
CD-3: Suffering from angina	yes					yes	
CD-4: Myocardial infarction						yes	
Diabetes mellitus [4]	yes		yes	(yes)		yes	
Neurological diseases (ND) [5] ***ND subgroups:***	yes		yes			yes	
ND-1: Diseases/surgical intervention affecting the central/peripheral nervous system						yes	
ND-2: Epilepsy/sudden disturbance of state of consciousness, other seizures [6]	yes		yes			yes	
Mental disorders (MD) [7] ***MD subgroups:***	yes		yes			yes	
MD-1: Severe mental disturbances	(yes)					yes	
MD-2: Severe mental retardation	(yes)		(yes)			(yes)	
MD-3: Severe behavioural problems due to ageing (dementia)	yes					(yes)	
MD-4: Personality defects leading to seriously impaired judgment/behaviour/adaptability	(yes)					(yes)	
Alcohol [8] ***(abuse of)***	yes		yes			yes	
Drugs and medicinal products [9] DMP subgroups:	yes					yes	
DMP-1: (Dependent on) psychotropic substances (alcohol included)	(yes)					yes	
DMP-2: Regularly abuse of psychotropic substances (not dependent)	(yes)		yes			yes	
DMP-3: Regularly use of psychotropic substances which hamper driving						yes	
DMP-4: All other medicinal products which affect the ability to drive			yes			yes	
Renal disorders [10] Serious renal insufficiency	yes		yes			yes	
Miscellaneous provisions: Organ transplant or artificial implant [11]	yes					yes [13]	

Source: TØI report 690/2003

*) If aspects are more or less identical between Annex III and the national medical examination, a 'yes' is filled in in table 2. (A '(yes)' is used when national requirements are similar, but not identical to subgroups in Annex III.)

Comments and footnotes to table 2

ME: A medical examination is required if applicant has one or more of the medical disabilities mentioned in EC Council Directive 91/439/EEC – Annex III
M: Mandatory
R: Requirement if mandatory examination requires further investigation ('Reason to doubt that applicant's vision is adequate')
[1].Binocular vision of at least 0,8 in the better eye, and at least 0,5 in the worse eye. Monocular vision is accepted if visual acuity is at least 0,6 (with corrective lenses if necessary)
[2] Unspecified, licence may be issued if opinion is based on competent medical authority.
[3] Defined as '***serious arrythmia'*** in EC Council Directive 91/439/EEC – Annex III. In case of '***abnormal arterial blood pressure'***: Question of licence assessed with reference to other results from the examination. Generally speaking, no issue of licence if ***suffering from angina*** during rest or emotion. Having suffered from ***myocardial infarction***: Should be subject to authorized medical opinion
[4] Licence may be issued if drivers are subject to authorized medical opinion and regular medical check-ups
[5] No issue of driving licences if drivers suffer from a serious neurological disease, unless the application is supported by authorized medical opinion. Neurological disturbances associated with **diseases or surgical intervention affecting the central or peripheral nervous system** which lead to sensory or motor deficiencies and affect balance and coordination, must be subject to periodic assessment in the event of risk of deterioration.
[6] Driving licences shall not be issued to drivers suffering or liable to suffer from epileptic seizures or other sudden disturbances of the state of consciousness. Licence may be issued if drivers are subject to authorized medical opinion and regular medical check-ups (no seizure in the last two years is mentioned as a rule of decision to allow licencing)
[7] Driving licences shall not be issued to, or renewed for, applicants or drivers who suffer from: **Severe mental disturbance**, whether congenital or due to disease, trauma or neurosurgical operations, **severe mental retardation**, - **severe behavioural problems due to ageing**; or **personality defects leading to seriously impaired judgment, behaviour or adaptability**, unless their application is supported by authorized medical opinion and, if necessary, subject to regular medical check-ups.
[8] Driving licences shall not be issued to applicants or drivers who are dependent on alcohol or unable to refrain from drinking and driving. After a proven period of abstinence and subject to authorized medical opinion and regular medical check-ups, driving licences may be issued to applicant or drivers who have in the past been dependent on alcohol
[9] Driving licences shall not be issued to applicants or drivers who are **dependent on psychotropic substances** or who are not dependent on such substances but **regularly abuse** them. Driving licences shall not be issued to applicants or drivers who **regularly use psychotropic substances, in whatever form, which can hamper the ability to drive safely** where the quantities absorbed are such as to have an adverse effect on driving. This shall apply to **all other medicinal products or combinations of medicinal products which affect the ability to drive**.
[10] Driving licences may be issued or renewed for applicants and drivers suffering from **serious renal insufficiency** subject to authorized medical opinion and regular medical check-ups.
[11] Subject to authorized medical opinion and regular medical check-ups, driving licences may be issued to applications who have had an organ transplant or an artificial implant which affects the ability to drive.
[12] VOD, VOS and VODS with/without correction
[13] Renal transplantation

1.5.2 Special requirements/restrictions in the national, medical examinations

Austrian requirements
- Body size
- General lack of health
- Body handicap: Missing limbs
- Vision defects (acuity and visual field)
- Monocular
- Lack of auditory acuity
- Disorder/Illness in equilibrium (balance) organs
- Diabetes
- Nervous complaint, neurosis, epilepsy
- Psychic and psychological diseases and handicaps
- Alcohol, illicit drugs and medicament dependence or abuse
- Kidney diseases
- Other functional unfitness

Austria: Traffic-psychological deficiency
- Mental lack of maturing
- Above average decrease of performance
- Repeated driving test failure

Norwegian requirements
- Epilepsy or other brain function disturbances [1]
- serious mental illness, mental retardation, or personality deviance[2]
- Abuse of alcohol or other drug
- Medication in doses that affect vigilance
- Diabetes mellitus
- Coronary heart disease, blood disease, or myocardial infarction [3]
- Reduced power or coordination in legs, arms or impairment of grip[8]
- Reduced vigour which is not stationary
- Other illnesses or diseases (making the applicant unfit for driving)
- Optical correction necessary?
- Vision field disappearance on one or both eyes? [4]
- Manifest double vision? (Diplopia)

UK requirements:
UK has no mandatory medical examination (but may be required, dependent on medical condition ticked in self-report)

Dutch requirements [7]
- Symptoms or suspicion indicating unsuitability for driving?
- General physical condition?
- General psychological condition?
- Sufficient use of spinal column and 4 limbs to drive a motor vehicle?
- What are the blood pressure values?
- Sharpness of vision: VOD and VODS with/without correction
- Limitation of field of vision?
- Result of urine examination for glucose?

Danish requirements [5]
- Eye disease
- Reduced hearing
- Illness or deformity in organs of movement
- Heart or cardiovascular disease [6]
- Diabetes – untreated
- Diabetes treated with tablets
- Diabetes treated with insulin
- Epilepsy
- Consciousness disturbance or giddiness
- Other neurological illness
- Mental illness, mental retardation, etc
- Alcohol abuse
- Use of psychotropic substances
- Use of medication that is dangerous in traffic
- Renal disease (renal reduction)
- Other disease or health reduction with impact on driving ability

Spanish requirements
- Visual acuity
- Visual field
- Colour blindness
- Night blindness
- Eyelid motility
- Eye motility
- Blepharospasm
- Diplopia
- Visual field defects
- Auditive acuity
- Cardiac insufficiency
- Angina
- Myocardial infarction
- Arrythmia
- Hypertension
- Aneurysms
- Peripheral arterial disease
- Severe trombopoenia
- Anaemia (different types)
- Polycytemia and blood cancer
- Anticoagulant drug therapy
- Chronic renal failure
- Haemodialysis
- Renal transplantation
- Disnoea
- Other respiratory disorders
- Obstructive sleep apnoea syndrome
- Diabetes mellitus
- Hypoglucemia
- Hyper-/Hypothyroidism
- Adrenal disorders
- Neurological disorder associated with lack of consciousness and motor coordination
- Epilepsy and other seizures
- Disorder of standing
- Muscle-skeletal disorder
- Cerebrovascular disease
- Dementia and organic brain syndrome
- Schizophrenia
- Depression (mood disorder)
- Sleep disorders
- Personality disorders
- Learning disability
- Alcohol abuse
- Alcohol dependence
- Alcohol-induced disorders (delirium, dementia, psychosis, etc)
- Regular drug/medication use
- Drug/medication abuse
- Drug/Medication dependence
- Drug induced disorders (delirium, dementia, psychosis, etc)
- Motor-perceptive-fitness
- Stimation of movement
- Visual-motor coordination
- Multiple reaction time
- Intelligence practice
- Other types of disorders

Notes to special requirements in the national medical examinations

[1] The question 1a in the Norwegian medical examination form is: Have the applicant had attacks of brain functions disturbances (including epilepsy and disturbances of consciousness of other or unknown cause? (IF 'yes' a specialist's approval is necessary). 1b: Have the applicant had attacks mentioned in 1a during the last 12 months? 1c: Have the applicant had attacks mentioned in 1a during the last 10 years? 1d Have the applicant had attacks mentioned in 1a after being 18 years of age?

[2] The mental illnesses listed are all listed in the very same question and the concepts used in the Norwegian medical examination are "… serious mental illness, substantial mental retardation, personality deviance (note: Not 'defects' as in Annex III). It is asked whether they lead to "… reduced judgement, control of impulses or behavioural disturbances that can be dangerous in traffic".

[3] The Norwegian question on coronary heart diseases uses the concepts: 'symptom-giving heart disease', 'coronary disease' or 'not easily controllable blood disease'. The applicant is then asked if s/he have gone through a myocardial infarction. If so, a certificate from a specialist is needed.

[4] It is asked about vision field disappearance on one or both eyes. If yes, a certificate from an eye specialist is needed. All applicants are asked if there has been a major reduction in vision or vision field on one eye the last 6 months. In a separate question it is asked whether there has been a substantial reduction of vision or vision field on one eye during the last 6 months.

[5] If yes on any of the illnesses/states listed, further examination is required

[6] If yes, the diagnosis should be stated, blood pressure should be considered and time of myocardial infarction should be given, if any.

[7] Results sent to Central Driving Test Organisation

[8] The applicant is asked about reduced power or coordination in legs, arms or whether the grip in one or both hands is impaired

1.5.3 National self-reports

All countries except Spain have a mandatory self-report for driver's licence applicants, as shown in Table 1. Several medical conditions are addressed and it varies between countries as shown in table 3. Note that CZ-column is empty because of no information from the Czech Republic has been available, while the Spanish column is empty because there is no mandatory self-report for Spanish drivers.

Table 3: Medical conditions addressed in national driver self-report forms for driving licence applicants

Self reported states and illnesses (I suffer from../I have …/ I carry.. /I take… (etc))	**A**	***CZ***	***DK***	***(EC)***	***NL***	***N***	***ESP***	***UK***
Abuse of alcohol (dependent on, misused)					yes [6]	yes		yes
Abuse of other drug(s) than alcohol (dependent on, misused)					yes [6]	yes		yes
Abuse of medicines					yes [6]			
Abuse of chemical substances (dependent on, misused), hallucinogenic					yes [6]	yes		yes
Attacks of giddiness/fainting			yes		yes [4]			yes
Attacks of unconsciousness (N: Last 12 months)	yes					yes		yes [1]
Balancing disturbances/dizziness					yes			
Brain surgery, brain tumours or severe head injury [2], brain disease					yes[5]			yes
Confusion ('Serious problems of ….')								yes
Consciousness disturbances					yes [4]			
Diabetes	yes		yes		yes [7]	yes		yes
Double vision (dipoplia)			yes					
Drunkenness or other craze	yes							
Epilepsy/epileptic event			yes		yes [4]			yes
Eye operations, treated by eye doctor, laser					yes			
Fitted with pacemaker, defibrillator or anti-ventricular device								yes
Glasses/Contact lenses	yes		yes			yes		
Heart and blood disease/operation			yes		yes [7]			
Heart pain (angina, easily provoked by driving)								yes
High blood pressure					yes [7]			
Hyperventilation (serious)					yes [4]			
Kidney disease					yes [7]			
Lung disease					yes [7]			
Memory ('A serious problem with …')								yes
Mental illnesses, (severe) mental disorder, psychiatric illness, psychiatric disturbances, mental illnesses			yes		yes[5]			
Neurological disease, disease in nervous system	yes		yes		yes[5]			yes
Night-blind	yes		yes					
Other illnesses that could make you unfit for driving [3]					yes [3]	yes		
Parkinson's disease								yes
Reduced mobility/function in arms or legs					yes	yes		yes
Reduced visual acuity or visual field on one or both eyes						yes		
(Regularly) using medicines	yes				yes [8]	yes		
Severe mental handicap								yes
Serious/Severe mental disorder, psychiatric illness, psychiatric disturbances, mental illnesses					yes[5]			yes
Sleepiness (abnormal), sleep apnoea, narcolepsy					yes			yes
Stroke (if yes, major or minor? When?)								yes
Vigour in arms and legs			yes					
Vision limitations, colour blindness, monocularity					yes			yes
Visual field losses	yes							yes
Visual disability affecting both eyes								yes

Source: TØI report 690/2003

1 UK: Asks about fainting and blackouts
2 Any type(s) that required hospital treatment
3 Last question on Norwegian self report form, as well as Dutch self report form
4 NL: States asked in the same question
5 NL: States/illnesses asked for in the same question
6 NL: States asked for in the same question (Includes also: stupefying drugs)
7 NL: States asked for in the same question
8 NL: Several medicines that can '**negatively effect driving skills'**, are listed: Sleeping pills, tranquillizers, anti-depressives, anti-psychotics, stimulants, etc.

2. CONTRIBUTION OF DRIVER IMPAIRMENT TO ROAD ACCIDENTS

2.1 ABOUT THE STUDIES REVIEWED

Partners of IMMORTAL, i.e. University of Leeds, University of Valladolid, University of Maastricht, the SWOV, KuSS, DtF and TØI have all supplied the author with reports and/or references on the given subject. In addition, a literature research was performed and the search profile used gave 8.708 hits (TRANSPORT database). Of these, some 1.500 of the abstracts were considered and approximately 13% were considered to be of relevance for the present task (which does not necessarily mean that they contain results that are applicable for meta-analysis). It also became apparent that a consideration of all 8.708 abstracts just was not possible given the limited resources allocated for the present task. Some studies had been compiled for use in the Norwegian Traffic Safety Handbook in advance of project IMMORTAL. In sum, the above supplies of reports and references resulted in a 30-page list of references, i.e. about 410 references. A substantial part had no accident data, lacked control group, addressed only behaviour in real traffic or simulator, performance on tests, incidence, prevalence, etc., leaving a final subset of 62 reports considered to be of relevance and of such a quality that they could serve as the base for subsequent meta-analyses.

2.2 APPROACHES TO QUANTIFYING THE CONTRIBUTION OF DRIVER HEALTH IMPAIRMENTS TO ROAD ACCIDENTS

In a draft of deliverable P1 to the IMMORTAL consortium, Elvik discusses methods of quantifying relative accidents risks of given impairments (Elvik 2002). Three approaches have been used in these studies considered by Elvik:

1. Case-control studies, in which drivers who have a certain condition or impairment are compared with respect to accident involvement to drivers that do not have this condition or impairment;
2. Correlational studies, in which the statistical relationship between variables describing medical conditions and variables describing accident involvement is estimated;
3. In-depth studies of accidents, in which an attempt is made to determine whether acute illness or other medical conditions may have contributed to causing an accident.

In case-control studies, the effect of a given condition on accident rate is usually assessed in terms of an accident rate ratio:

$$\text{Accident rate ratio} = \frac{\left(\frac{\text{Number of accidents involving drivers with condition X}}{\text{Kilometres of driving for drivers with condition X}}\right)}{\left(\frac{\text{Number of accidents involving drivers without condition X}}{\text{Kilometres of driving for drivers without condition X}}\right)}$$

If the value of the accident rate ratio is greater than 1, the condition is associated with an increased risk of accident involvement. The higher the accident rate ratio, the greater is the contribution of a certain factor to the accident involvement of the drivers who are exposed to the factor. The term **relative risk** is often used to denote an accident rate ratio, and relative risk is also the concept that is throughout the present study.

The results of studies employing these three different approaches are not directly comparable. As Elvik points out, a large majority of evaluation studies are done as case-control studies. One central objective of project IMMORTAL is to assess the relative risks of certain physical and mental impairments. Case-control studies are more or less designed to be able to give estimates of relative risks. Hence, case-control studies will be given priority when selecting appropriate studies for meta-analysis from the sub-sample of studies that have addressed effects of given physical and mental impairments on accidents.

For an estimate of relative risk to give a valid measure of the contribution of a certain medical condition to road accidents, it is important that all other factors affecting accident involvement are as similar as possible in the groups of drivers that are compared with respect to a certain medical condition. Inadequate control for potential confounding factors is a major shortcoming of many studies that have evaluated the effects of impairments on driver accident rates (Elvik 2002).

Confounding factors is also an important shortcoming in the present study. In the appendix (pages 38-48) all reviewed studies are listed. One of the columns lists the confounders that have been controlled for. As can be seen, age is the most common confounding factor for which the effect of a given condition is controlled, while mileage is a confounding factor controlled for in only 15 of the 62 studies reviewed. Hence, for the rest of the studies, the estimation of relative risks is done under the assumption that mileage is approximately the same for drivers driving with condition X (case group) as for driver without condition X (control group). Such an assumption could be questioned. There is no doubt this is an important shortcoming of the present report.

2.3 ABOUT META-ANALYSIS AS METHOD

2.3.1 Deciding between models

The basic entity of a meta-analysis is a *result*. By a *result* is meant an estimate of the change in the number of accidents, odd ratio, accident risk, or, as in the present case: Relative risk. Meta-analysis may be described as a procedure for summing up all the individual results from different studies on a given variable, by a weighted average. The weights of each of the results are calculated in such a way that the statistical uncertainty in the weighted average is minimised. This is done by assigning a statistical weight, which is inversely proportional to the variance of each of the individual results (Fleiss 1981). The weights in turn depend on the accident counts, which mean that the more accidents an individual result is based on, the higher is the statistical weight of that result. One study may comprise more than one result. The 62 studies reviewed in the present context comprise a total of 388 results.

There are two methods of combining estimates of effects in meta-analysis. These are referred to as the *fixed-effect* model and the *random-effect* model. A fixed-effect model is assumed when the use of a given medicinal drug, or having a specific medicinal condition, is supposed

to have the same effect or consequence across contexts that may vary – for example across countries, cultures, sub-groups, times, etc. The effect of a given condition would naturally not be exactly the same from context to context, some variation would be expected, but under a fixed-effect model the variation is regarded as random, not systematic. A random-effect model would be more appropriate where the effect of a given condition is considered to vary systematically.

An assumption that a fixed-effect model would provide the best fit in the present situation should, however, be questioned. For example is it reasonable to believe that there have been improvements in medicine, better medical and psychological treatments, better medical drugs, etc – over the years. Effects of a given medical condition reported in the 1960's or the 1970's could hence be substantially different than when considered or evaluated in the 1990's.

2.3.2 Distribution of results according to publication year and country

Some properties of the present data set can be investigated in more detail. These are publication year and country. These properties are presented in Tables 4 and 5, respectively. The oldest paper, which was reviewed was published in 1964. However, nearly 75% of all the studies are published in 1990 or later.

Table 4: Decade of publication of 62 studies evaluating relative risks of accident involvement of certain medicinal conditions and/or using certain medicinal drugs (The studies comprise 388 results)

Decade	***Number of results***	***Percentage (%)***
1964 – 1969	33	8,5
1970 – 1979	37	9,5
1980 – 1989	29	7,5
1990 – 1999	193	49,7
2000 – 2002	96	24,7
Total	388	100,0

Source: TØI report 690/2003

Table 5 presents the distribution of number of results according to country. The 62 studies have been done in 19 different countries, but as much as 70% were done in the USA. Breaking the distribution down into continents we see that 9% were done in Australia, 11% in European countries and as much as 80% in North America.

Table 5: Distribution of studies according to country where relative risks of having certain medicinal conditions and/or using certain medicinal drugs have been estimated (62 studies - 388 results)

Country	***Number of results***	***Percentage (%)***
Australia	20	5,2
Canada	36	9,3
Denmark	1	0,3
Finland	8	2,1
France	1	0,3
Germany	2	0,5
the Netherlands	4	1,0
New Zealand	14	3,6
Norway	3	0,8
Spain	1	0,3
Sweden	19	4,9
Switzerland	1	0,3
United Kingdom	4	1,0
USA	274	70,6
Total	388	100,0

Source: TØI report 690/2003

2.3.3 Testing the data set for homogeneity

There could also be other sources of variance than publication year and country. Some of the impairment groups comprised by Annex III, for example vision and cardiovascular diseases, could contain so many different medical conditions that the span of conditions in itself would be a source of systematic variation.

The fixed effects model of analysis is based on the assumption that there is no systematic variation in effects in the set of studies considered. To test the validity of this assumption, would be the same as deciding whether the dataset is homogenous. Homogeneity indicates a high degree of equality between the results, measured by the variance (Everitt 2002). A small variance indicates homogeneity, large variance heterogeneity.

A test for homogeneity is done by an operator (Q), which is χ^2-distributed. If this test statistic is statistically significant, i.e. if a hypothesis of homogeneity is rejected, a random-effects model of analysis would be preferred. In a random-effect model, the statistical weight assigned to each result is modified to include a component reflecting the systematic variation of estimated effects (Shadish and Haddock 1994). If the data set is considered to be homogenous, a fixed-effect model is used, and no extra variance component is added. Applying a random-effect model will normally give a wider level of confidence than in the case of a fixed-effect model. Hence, a test for homogeneity is applied for all main groups and subgroups whenever it is apllicable (i.e. when there is data in a given group or subgroup).

2.4 RELATIVE RISKS: RESULTS FROM META-ANALYSIS

The 62 studies comprise a total of 388 results. Of these, 298 address the main groups and sub-groups mentioned in CD 91/439/EEC Annex III. Another 47 results address conditions and drugs especially mentioned in the IMMORTAL Technical Annex. The rest, 39 results, addresses other conditions and drugs not comprised by the present report (cancer and pulmonary diseases, among others). The presentation of results from the present study will then be grouped in three parts:

1. Relative risks of ***main groups*** of EU Council Directive on driving licences (CD 91/439/EEC)
2. Relative risks of ***subgroups*** of EU Council Directive on driving licences (CD 91/439/EEC)
3. Relative risks of additional medical/psychological conditions and substances (conditions and substances mentioned in the Technical Annex of IMMORTAL)

When we consider a given disease or impairment, we do not know to what extent that given disease or impairment is treated. It is rather seldom that the reports explicitly separate between when a condition is untreated and when it is treated. We have then, for the most part, grouped impairment sub-groups together regardless of treatment. An example: If visual acuity is reduced, reductions of visual acuity is put together in one main group, regardless of whether drivers use corrective lenses or not, simply because most studies do not have that level of detail regarding treatment of a given condition.

Further, if a driver has a given medical condition, say hypertension, we cannot infer that the driver uses some (specified) medicinal drug. But, if it is stated that a driver uses a certain drug, say beta-blocker, we can infer that the driver has a cardiovascular disease.

The relative risks according to the above groups are presented in Tables 6, 8 and 9, respectively. A ‘-‘ indicate that no data exists for the given group.

2.4.1 Relative risks for main medical condition groups listed in CD 91/439/EEC

Table 6 presents the estimates of relative risks for the main groups of medical conditions described in EU Council Directive on driving licences (CD 91/439/EEC).

Table 6: Relative risks of accident involvement of medical conditions according to main categories in CD 91/439/EEC - Annex III (Relative risk of drivers not having a given medical condition = 1,00)

Main category	***Relative risk***	***95% CI***	***p – value*****	***Number of results***
Vision impairment	1,09*	(1,04; 1,15)	0.000	79
Hearing impairment	1,19*	(1,02; 1,40)	0.649	5
Arthritis/Locomotor disability	1,17*	(1,004; 1,36)	0.002	12
Cardiovascular diseases	1,23*	(1,09; 1,38)	0.000	48
Diabetes mellitus	1,56*	(1,31; 1,86)	0.000	25
Neurological diseases	1,75*	(1,61; 1,89)	0.000	22
Mental disorders	1,72*	(1,48; 1,99)	0.000	33
Alcoholism	2,00*	(1,89; 2,12)	0.210	3
Drugs and medicines	1,58*	(1,44; 1;73)	0.000	68
Renal disorders	0,87	(0,54; 1,34)	-	3
Weigthed average/no of results	1,33*	(1,28; 1,37)*	0.000	298

Source: TØI report 690/2003

*) The relative risk is statistically significant at a level of $\alpha < 0.05$
**) Test for homogeneity: If $p < 0.05$, data is considered heterogeneous and a random-effect model is used

The weighted average across all main categories is 1,33, which means that a driver with a given medical condition comprised by Annex III would have a 33% higher risk of accident involvement than a driver without that given condition. The relative risks for all main categories are significantly higher than 1,00, except for renal disorders.

None of the main categories show a relative risk of more than 2,00, the highest being 'alcoholism' with a relative risk of 2,00.

The categories can be grouped in two parts that may be labelled *high-risk impairments* and *low-risk impairments*. High-risk impairments exhibit relative risks that are significantly higher than low-risk impairments. *Alcoholism*, *neurological diseases*, *mental disorders* and *drugs and medicines* all belong to the high-risk group, while *vision impairment*, *arthritis/locomotor disability*, *hearing impairment*, and *cardiovascular diseases* all belong to the low-risk group. *Diabetes mellitus* lay in-between the high-risk and the low-risk group with a relative risk of 1,56.

A majority of the main categories comprise a considerable number of results. Exceptions are hearing impairment, Alcoholism and renal disorders. The relative risks of these categories should be considered with caution. The data of all main categories except hearing impairment is appraised as heterogeneous.

Vision impairment: The relative risk weighted across all vision subgroups is 1,09 – which means that drivers with any kind of vision impairment on the average have a 9% higher risk of accident than drivers without any impairment of vision. However small, the difference between impaired and unimpaired drivers is statistically significant ($p < 0.05$).

The main category of vision impairment comprises the following aspects/impairments of vision:

- Astigmatism

- Binocular vision problems (unspecified)
- Cataracts (several disorders)
- Central 30 degree radius visual field sensitivity (0 vs > 10)
- Corrective lenses for far vision
- Corrective lenses for near vision
- Corrective lenses (any use)
- Diplopia
- Disability glare (≤0 vs >0)
- Far vision score <75%
- Glare sensitivity
- Glaucoma
- Hypermetropia
- Low scores on vision screening test of visual acuity, horizontal visual field, contrast sensitivity
- Macular degeneration
- Monocularity/Monocular vision
- Myopia
- Near vision score <75%
- New lenses at last optometry exam
- New multifocal lens Rx
- New single vision lense Rx
- Other ophtalmological disorders (several)
- Peripheral vision score <75%
- Peripheral 30-60 degree radius visual field sensitivity (0 vs > 10)
- Post-cataract surgery: Without lens implant
- Post-cataract surgery: With lens implant
- Presbyopia
- Reductions in visual acuity
- Reductions in binocular static visual acuity
- Refractive disorders
- Rethinopathy
- Retinal disorders
- Stereoacuity (<500 arcsec vs ≥500)
- Unaided and aided reduction of visual acuity
- Use of bioptic telescopic lenses

A comment on the so-called 'Useful field of view': A number of studies have addressed 'UFOV' or 'Useful field of view' (Ball and Owsley 1991; Ball et al 1993; Ball and Owsley 1994; Owsley et al 1998a). Especially, a 'reduction of UFOV of more than 40%' has resulted in relative risks of accident involvement of more than a factor of 7 (Elvik et al 1997), which really is considerable when compared to the relative risks in table 6. It is, however, difficult to understand what a 'reduction of UFOV of more than 40%' actually means as the calculation is done by an algorithm in data program (Edwards et al 2002).

It is rather easy to associate UFOV with the more common 'visual field' or peripheral vision, which apparently is wrong. Having considered reports on UFOV for the present review, UFOV seems to be related, not to vision as one of the senses as such, but rather to the cortical structures that govern vision, to attention and information processing. UFOV seem to be more a measure of cognitive impairment that affects attention than an impairment or reduction of vision. Because this concept is rather diffuse, and because of a possibility to mix the concept with the more commonly used 'field of vision' or 'vision field', it is decided not to include studies on UFOV in the review of literature in the present context.

Hearing impairment: Hearing impairment is associated with a relative risk of 1,19, which is statistically significant. The calculation is based on only 5 results. It comprises the following conditions:

- Deafness
- Loss of hearing/diagnosed hearing impairment
- Use of prescribed hearing aid

Arthritis/Locomotor disability: Arthritis is in this context interpreted as having moving/locomotor disabilities. The relative risk of accident for this group is 1,17, which is statistically significant. The medical conditions included are the following:

- Functional motor problems
- Musculoskeletal
- NSAID
- Prescribed drugs - rheumatoid
- Rheumatoid arthritis/arthritis
- Using anti-arthritic medicinal drugs

Cardiovascular diseases: Drivers with cardiovascular diseases have a relative risk of accidents of 1,23 compared to drivers without. This increase of 23% is statistically significant. The medical conditions comprised in this main category are the following:

- ACE inhibitor
- Angina pectoris
- Anti-coagulant
- Arrythmias
- Arteriosclerosis
- Atrial fibrillation
- Beta-blocker
- Both diabetes and coronary heart disease
- Calcium channel blocker
- Cardiac failure
- Cardiovascular disease
- Cardiovascular (using drugs against)
- Cardio and cognitive (problems)
- Conduction-system abnormalities: First-degree AV-block
- Conduction-system abnormalities: Second- or third-degree AV block
- Conduction-system abnormalities: Left bundle branch block
- Conduction-system abnormalities: Right bundle branch block
- Conduction-system abnormalities: Left anterior hemiblock
- Coronary artery bypass graft
- Coronary heart disease: Primary cardiac arrest
- Coronary heart disease only
- Diuretic
- ECG abnormalities: Atrial fibrillation
- ECG abnormalities: Paroxysmal supraventricular tachycardia
- ECG abnormalities: Premature ventricular contractions
- ECG abnormalities: Sinus bradycardia

- ECG (conduction system) abnormalities
- Any of above ECG abnormalities
- HMG-CoA reductase
- Hypertension
- Hypertension (treated)
- Myocardial infarction
- Pacemaker
- Rheumatic heart disease
- Unspecified heart disease

Diabetes mellitus: Having diabetes is associated with e relative risk of 1,56 compared to drivers without diabetes. The difference is statistically significant. The following sub-categories are comprised in the main category of diabetes mellitus:

- Both diabetes and coronary heart disease
- Diabetes (mellitus)
- Diabetes: Treated with insulin
- Diabetes: Treated with oral hypoglemics
- Diabetes: Treated with diet alone
- Diabetes: Diagnosed within last 5 years
- Diabetes: Diagnosed over 5 years ago
- Diabetes only
- Diabetic neuropathy
- Diabetic retinopathy
- Oral hypoglycemics

Neurological disease: Drivers with neurological disease have a relative risk of 1,75 compared to drivers without neurological disease. The difference is statistically significant. The following sub-categories are included:

- Brain injury (traumatic)
- Cerebrovascular disease (stroke)
- Diabetic neuropathy
- Epilepsy
- Lapses of consciousness
- Neurological disease (other): Syncope
- Neurological disease (other): Dizziness, etiology unknown
- Neurological disease (other): Seizures
- Neurological disease (other): Head injury
- Neurological disease (other): Subdural hematoma
- Neurological disease: Other neurological condition
- Parkinson's disease
- Stroke

Mental disorders: Mental disorders is indeed a heterogeneous group and there is a vide variety of disorders considered. Having a mental disorder is associated with a relative risk of 1,72 compared to drivers without any mental disorder. The difference is statistically significant. No subgroup with

psychosis, mental retardation, or personality defects (leading to impaired judgement) was registered. Mental disorders include the following:

- Alzheimers disease
- Anxious/depressive disorder
- Cardio and cognitive (impairment)
- CNS depressants (using)
- Cognitive impairment
- Cognitive impairment (low MMSE score)
- Conduct disorder
- Cyclic antidepressants (using)
- Dementia
- Depressive symptoms
- Mental problems
- Mental status examination (poor score)
- Psychiatric out-patients
- Psychiatric
- Use of 1-2 prescribed drugs - psychiatric
- Use of 3 prescribed drugs – psychiatric
- Use of antidepressant drugs

Alcoholism: This category comprises drivers identified as 'alcoholic'. The relative risk of alcoholic drivers is calculated to be 2,00. That is not the same as to say that they were drunk when they were involved in an injury accident (we have no reason to infer that they were). Further, this estimate is based on only three results and should interpreted with caution.

Drunken driving: The studies also comprise drivers having been using alcohol alone or together with other substances as cannabis, benzodiazepines or 'drugs'. The relative risk of drunken drivers w/o additional substances is estimated to 1,92 (95%-CI: 1,43; 2,57). However, this estimate is based on only 4 results and we doubt the general validity of this estimate as a relative risk of 'only' 1,92 is very low compared to the high, elevated risks associated with drunken driving found in other studies. There are other estimates that give a very different picture of the relative risks associated with drunken driving. We put forward some results from a Norwegian study that illustrates the possible invalidity of the relative risk for drunken driving found in the present study (Glad 1985).

Table 7: Relative risk of accident involvement and being killed in personal injury accidents for drivers with different levels of alcohol concentration in blood. (relative risk = 1,00 for drivers with BAC = 0. Source: Glad, 1985).

Blood Alcohol Level %	Involved in personal injury accident	Killed
0	1	1
0,050 – 0,099	10	13
0,100 – 0,149	25	100
+ 0,15	65	500

Source: TØI report 690/2003

Even low BACs, i.e. 0,050 - 0,099 %, are associated with a relative risk of accident involvement of as high as 10, which is more than 5 times higher than the one found in the present study. In general, it could also be questioned whether it is meaningful to do meta-analysis on groups which, as in the present case, contain as few results as 3 and 4.

Drugs and medicines: This is also a very heterogeneous group, as it comprises a wide variety of drugs and medicines. Besides, there is no separation between use and abuse. The relative risk of this main category is estimated to be 1,58, which is statistically significant. The following are included:

- ACE inhibitor
- Analgesics
- Antihistamines
- Anti-arthritic (medicines)
- Anticoagulant
- Barbiturates
- Benzodiazepines: New users
- Benzodiazepines: Repeat users
- Beta-blocker
- Calcium channel blocker
- Cardiovascular (medicine)
- Chemotherapeutic agents
- CNS depressants
- Cyclic antidepressants
- Diabetes: Treated with insulin
- Diabetes: Treated with oral hypoglemics
- Diabetes (medicine)
- Diuretic
- Drug abuse
- Gastric ulcers (medicines)
- Glycoside
- Gout (medicine)
- HMG-CoA reductase
- Hormones
- LSD
- Marihuana
- Opiates
- Opioid analgesics
- Oral hypoglycemics
- Other arthritis
- Other glaucoma
- Other hallucinogens (unspecified)
- Other heart
- Other hypertension
- Respiratory disorders (medicine)
- Speed
- Stimulants

- Tranquilizers
- Use of benzodiazepines
- Use of benzodiazepines: Long half-life
- Use of benzodiazepines: Short half-life
- Use of diazepam
- Use of prescribed drugs - rheumatoid
- Use of prescribed drugs - psychiatric
- Vasodilator

Renal disorders: The only main category, which was not associated with an increased relative risk is renal disorders. There are, however, few results in this category, which simply includes the following:

- Kidney disease
- Renal disease

Miscellaneous provisions: The final of the main categories of Annex III is labelled 'miscellaneous provisions' and covers 'organ' and 'artificial implant'. There is only one result in this category, pacemaker, but the data is too limited to calculate any meaningful relative risk for this category.

2.4.2 Relative risks of main category sub-groups listed in CD 91/439/EEC

In Table 8 all main categories and sub-categories are listed and relative risks presented for those categories where data exists. As can be seen, there is no data for three sub-categories: Twilight vision, severe mental retardation, and personality defects leading to seriously impaired judgement, behaviour or adaptability.

A remark regarding mental disorders: Annex III requires **'severe'** mental disorders, retardation, and behaviour due to ageing (dementia) but, as can be seen, '(Severe)' is written within parenthesis in Table 8. That is because we really cannot tell whether the disorders considered and estimated are 'severe' or not.

We cannot separate well between use and abuse, which only in few instances is stated explicitly. However, judged from the substances used, it could be **assumed** what is use and what is abuse. In Table 8 we have made such a separation between **assumed use (**of medicinal drugs) and **assumed abuse**. The relative risks were 1,49 and 1,96 respectively. Moreover, these relative risks were also significantly different, which may support that the assumption is valid. The following categories were assumed to be associated with abuse: Drug abuse, LSD, marihuana, opiates, other hallucinogens (unspecified), speed, stimulants). The rest are assumed to be medicinal products used as prescribed (see list above, under section ***Drugs and medicines***).

Sub-groups coming out with the highest relative risks were *Mental disorders, Psychotropic substances (alcohol included), Drugs assumed to be abused* and *Epilepsy/sudden disturbance of consciousness* with relative risks of 2,01 – 1,96 - 1,96 and 1,84 respectively. However, none of these sub-group relative risks are significantly higher than the ones found for the main category high-risk impairments (Table 6).

Several of the sub-group relative risks are based on few results and should therefore be appraised with caution.

Table 8: Relative risks of medical conditions according to subgroups in Annex III (in CD 91/439/EEC – The Council of the European Communities, 1991)

	Relative risk	95% Confidence interval	p – value **	Number of results
Vision	1,09 *	(1,04; 1,15)	0.000	79
V-1: Field of vision	0,90	(0,69; 1,17)	0.299	4
V-2: Twilight vision	No data	-		-
V-3: Progressive eye diseases	0,86	(0,50; 1,49)	0,922	4
V-4: Binocular visual acuity	1,13 *	(1,05; 1,22)	0.000	39
Hearing: No subgroups	1,19 *	(1,02; 1,40)	0.649	5
Locomotor disability/Physical handicap	1,17 *	(1,004; 1,36)	0.002	12
Cardiovascular diseases (CD) - CD subgroups:	1,23 *	(1,09; 1,38)	0.000	48
CD-1: (Serious) arrythmia	1,27 *	(1,09, 1,47)	0.959	14
CD-2: Abnormal arterial blood pressure	1,03	(0,86; 1,22)	0.020	8
CD-3: Suffering from angina	1,52 *	(1,10; 2,09)	0.986	3
CD-4: Myocardial infarction	1,09	(0,62; 1,92)	0.233	2
Diabetes mellitus	1,56 *	(1,31; 1,86)	0.000	25
Neurological diseases (ND) ***ND subgroups:***	1,75 *	(1,61; 1,89)	0.000	22
ND-1: Diseases/surgical intervention affecting CNS or periph-eral nervous system (incl stroke, traumatic brain injury etc)	1,35 *	(1,08; 1,67)	0.000	11
ND-2: Epilepsy/sudden disturbance of state of consciousness, other seizures	1,84 *	(1,68; 2,02)	0.000	8
Mental disorders (MD) ***MD subgroups:***	1,72 *	(1,48; 1,99)	0.000	33
MD-1: (Severe) mental disturbances	2,01 *	(1,60; 2,52)	0.000	10
MD-2: Severe mental retardation	No data	-		-
MD-3: (Severe) behavioral problems due to ageing (dementia)	1,45 *	(1,14; 1,84)	0.000	18
MD-4: Personality defects leading to seriously impaired judgment/behaviour/adaptability	No data	-	0.000	-
Alcoholism (abuse of)	2,00 *	(1,89; 2,12)	0.210	3
Drugs and medicinal products subgroups:	1,58 *	(1,45; 1,73)	0.000	68
Drugs assumed to be abused	1,96*	(1,70; 2,25)	0.000	22
Medicinal products/drugs assumed to be used as prescribed	1,49 *	(1,35; 1,64)	0.000	58
Psychotropic substances (alcohol included)	1,96 *	(1,74; 2,20)	0.000	23
(Cyclic) Antidepressants	1,42 *	(1,33; 1,52)	0.454	5
(Opoid) Analgesics	1,21 *	(1,08; 1,36)	0.637	4
Antihistamines	1,10	(0,91; 1,32)	0.200	4
Benzodiazepines (diazepam included)	1,54 *	(1,24; 1,90)	0.000	14
Renal disorders Serious renal insufficiency	0,87	(0,54; 1,34)	0.076	3
Weighted average across all main groups	1,33 *	(1,28; 1,37)	0.000	

Source: TØI report 690/2003

*) The relative risk is statistically significant at a level of $\alpha < 0.05$

**) Test for homogeneity: If p < 0.05, data is considered heterogeneous and a random-effect model is used

2.4.3 Relative risks of selected medical/psychological conditions

In the Technical Annex of project IMMORTAL some medical conditions, psychological conditions, and substances are especially focused within different activities in the project. We have therefore searched for results that could give an idea of relative risks regarding these special conditions. Table 9 presents these relative risks. For three conditions/substances mentioned in the Technical Annex no data was found.

All conditions considered have elevated relative risks that were statistically significant. Sleep apnoea is on the top with 3,71 and AD/HD and use of benzodiazepines were at the bottom, both with a relative risk of 1,54. It should be noted that sleep apnoea is the condition with the highest relative risk of all impairments considered in the present report.

Table 9: Relative risks of selected medical/psychological conditions and substances

Sight subgroups:	Relative risk	95% Confidence interval	p-value **	Number of results
Depression/depressive symptoms	1,67 *	(1,10; 2,55)	0.834	4
Sleep apnoea/narcolepsy	3,71 *	(2,14; 6,4)	0.000	8
AD(/HD)	1,54 *	(1,12; 2,13)	0.000	11
Flu	No data	-		-
Learning difficulty associated with light mental retardation	No data	-		-
Benzodiazepines (diazepam included)	1,54 *	(1,24; 1,90) *	0.000	14
Cannabis	1,70 *	(1,06; 2,74)	0.000	5
Cocaine	No data	-		-
Opiates	1,83 *	(1,38; 2,53)	0.073	5
Numbers of results - selected groups				47

Source: TØI report 690/2003

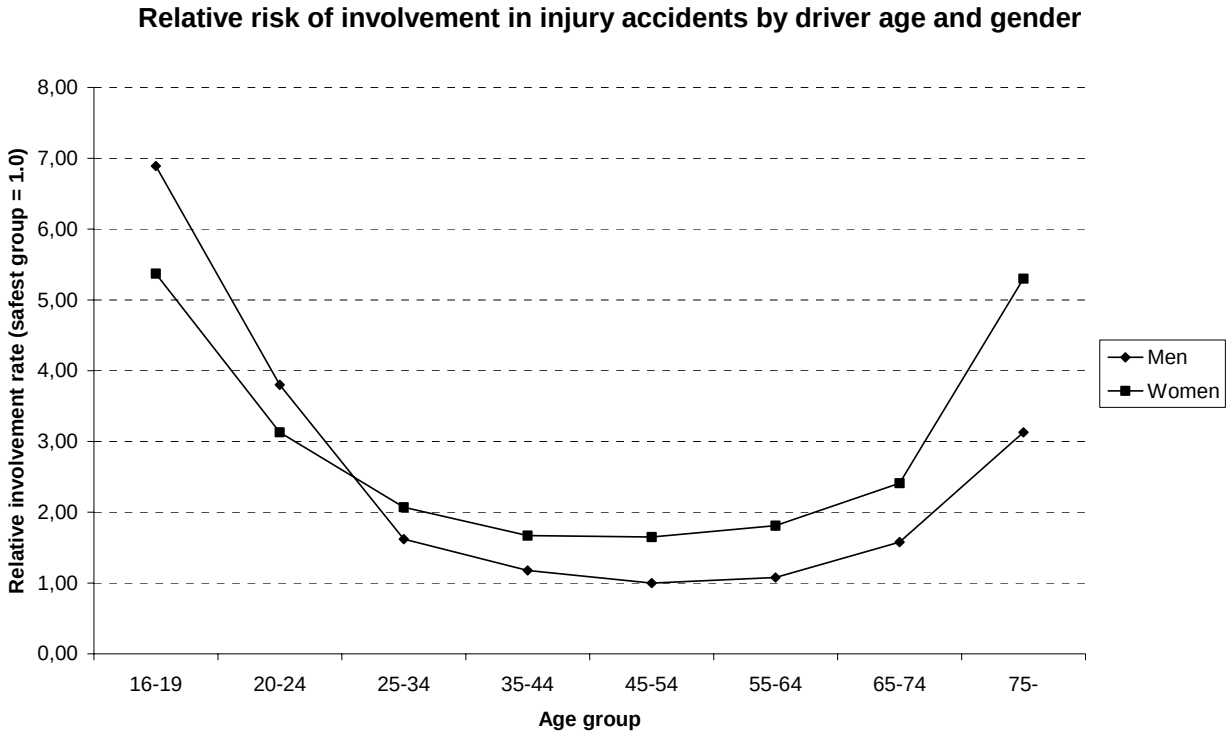
*) The relative risk is statistically significant at a level of $\alpha < 0.05$
**) Test for homogeneity: If p < 0.05, data is considered heterogeneous and a random-effect model is used

2.4.4 Age, ageing and relative risk of involvement in injury accidents

In most OECD Member countries, older adults comprise the fastest growing segment of the population, and in many countries one in four persons will be aged 65 or above in 2030 (OECD, 2001). Four aspects dealing with the older driver are of great relevance. First, the health of the drivers: As they become older, reaction time increases and the ability to drive safely is reduced. Second, morbidity and use of medicines, increases with age. Third, drivers with dementia increase and cognitive impairment also means reduced ability to process information and make decisions. Forth, older road users have increased frailty, making them more susceptible to serious injury.

The present task is to consider effects of age on relative risk of being involved in a road traffic accident, but should this task be limited to discuss the effects of age and ageing *per se*? This question is raised because age is indirectly addressed already by considering medical conditions associated with ageing. The prevalence of cardiovascular diseases, neurological

diseases, and dementia increases with age. Any relative risk being estimated for these main categories of diseases, as well as some specific sub-categories, would in fact be estimates of diseases that interacts with age. Hence, we will not try to estimate relative risks of ageing per se, i.e. age stripped for any kind of psychological or medical condition or use of medicinal drugs. Such a specialised sub-group would perhaps be difficult to find. In our view, it would be more relevant to consider accident risks distributed according to age regardless of any medical condition, i.e. for age sub-populations (cohorts) of drivers regardless of any medical condition that would be included in a given age cohort.



Source: TØI report 690/2003

Figure 1: Relative risk of involvement in injury accidents by driver age and gender (Source: Elvik, 2002)

For the present purpose, we will limit the question of ageing to presenting estimates of accident risk distributed according to age cohorts. We think this is justified also because it gives the opportunity to compare risk of accidents according to age with relative accident risks according to given medical conditions. In a draft version of Deliverable P1 to the IMMORTAL consortium, Rune Elvik has considered the question of risk involvement according to age (cohorts) and also to gender (Elvik 2002). Elvik has reviewed surveys based on travel behaviour in nine countries, by which he is able to calculate average, relative risk of involvement in an injury accident according to age and gender (figure 1). Figure 1 presents relationships derived from the following studies:

- Mercer (1989): Canada
- Bernhoft (2001): Denmark
- Fontaine (1988): France
- Hautzinger and Tassaux (1996): Germany

- Broughton (1988): Great Britain
- Bjørnskau (2000): Norway
- Nilsson (2002): Sweden
- Massie, Campbell and Williams (1995): USA
- Diamantopoulou, Skalova, Dyte and Cameron (1996): Victoria, Australia

All these studies have investigated the relationship between the age and gender of car drivers and their involvement in injury accidents. In each study, the lowest involvement rate found in any cohort was set equal to 1.0. Involvement rates for other cohorts were then expressed relative to this value. The results of the nine studies were then averaged. Figure 1 presents the average relative accident involvement rate of men and women based on these nine studies.

The results of the nine studies were remarkably consistent. Accident involvement rate is a U-shaped function of driver age, both for men and for women. In young drivers, men tend to have a higher average accident rate than women. From about the age of 30, the mean accident rate is higher for women than for men. The mean accident involvement rate, all ages taken together is higher for women than for men (Elvik, 2002).

Two main tendencies can be seen from figure 1. Firstly, the risk decreases from the youngest age cohort until the risk reaches its bottom for drivers aged 45-54. This is primarily a consequence of driving experience, but there is also an age component interacting with experience. This positive interaction has its boundaries as it reaches its limit at ages around 45-54. Secondly, for older age cohorts, the relative risk is consistently increasing. This increase is interpreted primarily as an effect of ageing per se, but, as it is not controlled for other variables than gender, also most likely an effect of increasing prevalences of psychological and medical conditions associated with the processes of ageing.

Women are generally considered to be more careful drivers than men, and are charged for traffic offences much less often than men. Despite this, there may be a number of reasons why the mean injury accident rate tends to be higher among women than among men. Firstly, women drive less than men. Accident involvement rate per kilometre of driving is not independent of the distance driven, but decreases as driving distances increase. Secondly, women tend to drive smaller cars than men. Small cars do not give as good protection against injury in an accident as larger cars. Thirdly, women tend to drive more in towns and cities, where the risk of accidents is higher than in rural areas. Fourthly, it is possible that, in given situations, women may choose a form of behaviour which does not correspond well with the behaviour which the majority of drivers would expect, and which therefore comes as a surprise to other road users (Bjørnskau 1994).

2.5 CONFOUNDING FACTORS

Knowledge of the exposure is vital in assessing a relative risk. However, it is relatively frequent that the exposure, or mileage, has not been controlled for when calculating a given relative risk. Of the 62 studies reviewed, exposure has only been controlled for in 15 studies (24 %). In 8 studies (13%) no factors have been controlled for at all. The most common factors that have been controlled for are age, sex and place of residence. In 44 (71%) of the studies, confounding because of age has been controlled for, 25 (40%) of the studies have controlled both for age and sex. In 37 of the 62 studies (60%) the researches have been able

to control for more than one confounding factor. The following is a list of confounding factors controlled for in the studies reviewed: [4]

A = Age
S = Sex
O = Occupation
OD = Other diseases/medical condition
M = Mileage
MS = Mental status
L = Age of licence
R = Place of residence
E = Ethnic group
D = Alcohol use
RTM = Regression (towards the mean)
I = Co-morbidity
Y = Education
W = Marital status
ToD = Time of day
DoW = Day of week
LOC = Location
BMI = Body mass index
VRD = Visual refraction disorders
SS = Sleep schedule
ASL= Average standard of living
MER=Mother emotional responsiveness (1 ADHD study only)
PC=Parental changes (1 ADHD-study only)

[4] This list can be applied when considering the overview of all studies comprised by the review in Appendix

3. SUMMARY AND CONCLUDING REMARKS

62 reports, mainly case-control studies, have been reviewed in order to calculate relative risks of being involved in injury accidents for certain physical and mental impairments. Special focus has been put on the main categories and sub-categories addressed in Annex III of EU Council Directive CD 91/439/EEC. The weighted average across all main categories is 1,33, which means that a driver with a given medical condition comprised by Annex III would have a 33% higher risk of accident involvement than a driver without that given condition. The relative risks for all main categories are significantly higher than 1,00, except for renal disorders.

None of the main categories show a relative risk of more than 2,00, the highest being 'Alcoholism'.

The categories can be grouped in two parts that may be labelled *high-risk impairments* and *low-risk impairments*. High-risk impairments exhibit relative risks that are significantly higher than low-risk impairments. *Alcoholism*, *neurological diseases*, *mental disorders* and *drugs and medicines* all belong to the high-risk group, while *vision impairment*, *arthritis/locomotor disability*, *hearing impairment*, and *cardiovascular diseases* all belong to the low-risk group. *Diabetes mellitus* lay in-between the high-risk and the low-risk group with a relative risk of 1,56.

Estimating relative risks of sub-groups of the main categories, some sub-groups came out with relative risks that were of the same magnitude as high-risk impairment group of the main categories: These were *(Severe) mental disturbances*, *psychotropic substances (alcohol included)*, *drugs assumed to be abused* and *epilepsy/sudden disturbance of consciousness* with relative risks of 2,01 – 1,96 - 1,96 and 1,84 respectively.

Several other conditions were also considered. These were: *Depression, sleep apnoea/ narcolepsy, AD(/HD), benzodiazepines, cannabis* and *opiates.* Sleep apnoea/narcolepsy came out with a relative risk of 3,71. This is the highest relative risk of all medical and psychological conditions considered. It is also significantly higher than all other categories. The rest were of middle magnitude, i.e. about the same as *diabetes mellitus*.

However, the highest relative risks of all conditions considered, are associated with age and gender. Young male drivers (aged 16-19) have a relative risk of being involved in an injury accident of about 7, compared to the group with the lowest risk (male drivers aged 45-54). Young female drivers (aged 16-19) have a relative risk of accident involvement of about 3,2 compared to the lowest female group (women aged 35-54). Male drivers aged 75+ have a relative risk of about 3,1, and women aged 75+ 3,25 compared to the groups of males and females with the lowest accident risks, respectively.

There are several shortcomings and limitations associated with the results presented in this study:

- ***Number of studies***: The 62 studies reviewed do not include all studies that may be of relevance the specific task addressed in this report. Including more results to the meta-analyses may give other estimates of relative risks than the ones presented. However, the relative risks of most of the main categories are based on a considerable number of results.

- ***Number of results***: Estimates of relative risks, which are based on few results, must be interpreted with caution. This concern especially hearing impairment, alcoholism, angina, depression, sleep apnoea/narcolepsy, and use of cannabis, analgesics/opiates, and antidepressants. Including more results in these groups may change the estimates and confidence intervals.
- ***Confounding factors***: The degree of control for confounding factors is clearly unsatisfactory. This is especially true for exposure (mileage), which is only controlled for in 24% of the studies. Hence, for most studies, the estimation of relative risks is done under the assumption that mileage is approximately the same for drivers driving with condition X (case group) as for drivers driving without condition X (control group).
- ***Degree of treatment***: When we have considered a given impairment, we do not know to what degree that given impairment is treated. It is rather seldom that the reports explicitly separate between when a given impairment is treated and when it is untreated. For the most part, conditions belonging to the same category are grouped together regardless of degree of treatment.
- ***Severity***: In some instances in Annex III the degree of severity is addressed, especially regarding mental disorders. It is rather seldom that the reviewed studies specifies degree of severity for the conditions addressed in a particular study.
- ***Drugs and medicines***: It is difficult to separate between use and abuse of certain drugs and medicines unless this is especially specified in the study. This difficulty is especially true for benzodiazepines.
- ***Co-morbidity***: In some cases co-morbidity is specified, as for example when a driver has both a cardiovascular disease and a cognitive impairment. In such cases the result is categorised both as a cardiovascular disease and as a mental disorder. However, for the most part, co-morbidity is not addressed as an issue at all.
- ***Refusals***: The relative risks that are estimated in the present study may be underestimated because of drivers refusing to participate by not delivering a sample or refusing to confirm that they actually had a medical condition and/or that they used a certain drug.

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APPENDIX

Authors	*Year*	*Country*	*Design*	*Health Impairment, medical condition, substance, considered*	*Confounders controlled **)*
Coppin, Peck *)	1964	USA	Case-control	Deafness	A,S,O,M
Coppin, Peck	1964	USA	Case-control	Deafness	A,S,O,M
Waller *)	1965	USA	Case-control	Cardiovascular disease	A,S,M
Waller	1965	USA	Case-control	Diabetes	A,S,M
Waller	1965	USA	Case-control	Epilepsy	A,S,M
Waller	1965	USA	Case-control	Cardiovascular disease	A,S,M
Waller	1965	USA	Case-control	Diabetes	A,S,M
Waller	1965	USA	Case-control	Epilepsy	A,S,M
Ysander *)	1965	SWE	Case-control	Cardiovascular disease	A,S,L
Ysander	1965	SWE	Case-control	Diabetes	A,S,L
Ysander	1965	SWE	Case-control	Renal disease	A,S,L
Ysander	1965	SWE	Case-control	Loss of hearing	A,S,L
Waller *)	1967	USA	Case-control	Cardiovascular disease	A,M
Waller	1967	USA	Case-control	Cognitive impairment	A,M
Waller	1967	USA	Case-control	Cardio and cognitive	A,M
Crancer,Quiring *)	1968	USA	Case-control	Cardiovascular disease	A,S,R
Crancer,Quiring	1968	USA	Case-control	Diabetes	A,S,R
Crancer,O'Neall	1969	USA	Case-control	Arteriosclerosis	A,S,R
Crancer,O'Neall	1969	USA	Case-control	Hypertension	A,S,R
Crancer,O'Neall	1969	USA	Case-control	Rheumatic heart disease	A,S,R
Crancer,O'Neall	1969	USA	Case-control	Unspecified heart disease	A,S,R
Ysander *)	1970	SWE	Case-control	Diabetes	A,S
Bø et al *)	1975	NOR	Case-control	Use of diazepam	None
Hofstetter	1976	USA	Cross-section	Visual acuity <25% (15-19 = 20/20)	A
Hofstetter	1976	USA	Cross-section	Visual acuity <25% (20-24 = 20/20)	A
Hofstetter	1976	USA	Cross-section	Visual acuity <25% (25-29 = 18/20)	A
Hofstetter	1976	USA	Cross-section	Visual acuity <25% (30-39 = 16/20)	A
Hofstetter	1976	USA	Cross-section	Visual acuity <25% (40-49 = 14/20)	A
Hofstetter	1976	USA	Cross-section	Visual acuity <25% (50-59 = 12/20)	A
Hofstetter	1976	USA	Cross-section	Visual acuity <25% (60-69 = 10/20)	A

Authors	*Year*	*Country*	*Design*	*Health Impairment, medical condition, substance, considered*	*Confounders controlled*
Hofstetter	1976	USA	Cross-section	Visual acuity <25% (70-+ = 8/20)	A
Mäki,Linnoila	1976	FIN	Case-control	Rheumatoid arthritis	A,R
Mäki,Linnoila	1976	FIN	Case-control	Psychiatric out-patients	A,R
Mäki,Linnoila	1976	FIN	Case-control	Use of 1-2 prescribed drugs - rheumatoid	A,R
Mäki,Linnoila	1976	FIN	Case-control	Use of 3 prescribed drugs - rheumatoid	A,R
Mäki,Linnoila	1976	FIN	Case-control	Use of 1-2 prescribed drugs - psychiatric	A,R
Mäki,Linnoila	1976	FIN	Case-control	Use of 3 prescribed drugs - psychiatric	A,R
Smart,Fejer	1976	CAN	Survey	Tobacco	A
Smart,Fejer	1976	CAN	Survey	Alcohol	A
Smart,Fejer	1976	CAN	Survey	Marihuana	A
Smart,Fejer	1976	CAN	Survey	Barbiturates	A
Smart,Fejer	1976	CAN	Survey	Opiates	A
Smart,Fejer	1976	CAN	Survey	Tranquilizers	A
Smart,Fejer	1976	CAN	Survey	LSD	A
Smart,Fejer	1976	CAN	Survey	Other hallucinogens (unspecified)	A
Smart, Fejer	1976	CAN	Survey	Speed	A
Smart, Fejer	1976	CAN	Survey	Stimulants	A
Hills,Burg	1977	USA	Cross-section	Binocular static visual acuity (<6/12)	A
Honkanen et al	1980	FIN	Case-control	Use of diazepam	None
Hingson et al	1982	USA	Survey	Marihuana at least 6 times/month	A,S,M,D, W
Hingson et al	1982	USA	Survey	Marihuana at least 15 times/month	A,S,M,D
Janke	1983	USA	Case-control	Use of bioptic telescopic lenses	A,S
MacPherson et al	1984	AUS	Case-control	Analgesics	A, D (all failed BAC test)
MacPherson et al	1984	AUS	Case-control	Chemotherapeutic agents	A, D (all failed BAC test)
MacPherson et al	1984	AUS	Case-control	Antihistamines	A, D (all failed BAC test)
MacPherson et al	1984	AUS	Case-control	Anti-arthritic	A, D (all failed BAC test)
MacPherson et al	1984	AUS	Case-control	Cardiovascular	A, D (all failed BAC test)
MacPherson et al	1984	AUS	Case-control	CNS depressants	A, D (all failed BAC test)
MacPherson et al	1984	AUS	Case-control	Diabetes	A, D (all failed BAC test)
MacPherson et al	1984	AUS	Case-control	Gout	A, D (all failed BAC test)

Authors	*Year*	*Country*	*Design*	*Health Impairment, medical condition, substance, considered*	*Confounders controlled*
MacPherson et al	1984	AUS	Case-control	Respiratory disorders	A, D (all failed BAC test)
MacPherson et al	1984	AUS	Case-control	Gastric ulcers	A, D (all failed BAC test)
MacPherson et al	1984	AUS	Case-control	Vitamins	A, D (all failed BAC test)
George et al	1987	CAN	Case-control	Sleep apnea	A,S
Findley et al	1988	USA	Case-control	Sleep apnea	None
Friedland et al	1988	USA	Case-control	Alzheimers disease	A
Muggler-Bickel	1988	SCH	Case-control	Intelligence (reduced, unspecified)	M
Findley et al	1989	AUS	Case-control	Sleep apnea (mild, moderate, severe)	
Ball,Owsley	1991	USA	Case-control	Mental status examination (poor score)	None
Hansotia,Broste	1991	USA	Cohort study	Diabetes	A,S
Hansotia,Broste	1991	USA	Cohort study	Epilepsy	A,S
Barkley et al	1993	USA	Case-control	Attention deficit hyperactivity disorder	
Benzodiazepine group	1993	FRA	Cross-section	Use of benzodiazepines	D
Cooper et al	1993	CAN	Case-control	Cognitive impairment	A,S,R
Decina,Staplin	1993	USA	Cross-section	(16-20)/Visual acuity, horizontal visual field (>140), contrast sensitivity	A
Decina,Staplin	1993	USA	Cross-section	(21-45)/Visual acuity, horizontal visual field (>140), contrast sensitivity	A
Decina,Staplin	1993	USA	Cross-section	(46-55)/Visual acuity, horizontal visual field (>140), contrast sensitivity	A
Decina,Staplin	1993	USA	Cross-section	(56-65)/Visual acuity, horizontal visual field (>140), contrast sensitivity	A
Decina,Staplin	1993	USA	Cross-section	(66-75)/Visual acuity, horizontal visual field (>140), contrast sensitivity	A
Decina,Staplin	1993	USA	Cross-section	(76+)/Visual acuity, horizontal visual field (>140), contrast sensitivity	A
Drachman,Swearer	1993	USA	Case-control	Alzheimers disease	A,S,R
Janke	1993	USA	Cross-section	Alcoholic	A,S
Janke	1993	USA	Cross-section	Mental problems	A,S
Janke	1993	USA	Cross-section	Physical problems	A,S
Janke	1993	USA	Cross-section	Lapses of consciousness/epilepsy	A,S
Janke	1993	USA	Cross-section	Drug abuse	A,S
Beylich et al	1994	NOR	Cross-section	Use of diazepam	None
Gresset,Meyer	1994	CAN	Case-control	Visual acuity 6/12 or 6/15	A,S,M
Gresset,Meyer	1994	CAN	Case-control	VA 6/12 or 6/15 and monocular	A,S,M
Koepsell et al	1994	USA	Case-control	Myocardial infarction	A,S,R

Authors	*Year*	*Country*	*Design*	*Health Impairment, medical condition, substance, considered*	*Confounders controlled*
Koepsell et al	1994	USA	Case-control	Angina pectoris	A,S,R
Koepsell et al	1994	USA	Case-control	Coronary artery bypass graft	A,S,R
Koepsell et al	1994	USA	Case-control	Arrythmias	A,S,R
Koepsell et al	1994	USA	Case-control	ECG (conduction system) abnormalities	A,S,R
Koepsell et al	1994	USA	Case-control	Hypertension	A,S,R
Koepsell et al	1994	USA	Case-control	Cerebrovascular disease (stroke)	A,S,R
Koepsell et al	1994	USA	Case-control	Dementia	A,S,R
Koepsell et al	1994	USA	Case-control	Depression	A,S,R
Koepsell et al	1994	USA	Case-control	Arthritis	A,S,R
Koepsell et al	1994	USA	Case-control	Diabetes mellitus	A,S,R
Koepsell et al	1994	USA	Case-control	Diabetes: Treated with insulin	A,S,R
Koepsell et al	1994	USA	Case-control	Diabetes: Treated with oral hypoglemics	A,S,R
Koepsell et al	1994	USA	Case-control	Diabetes: treated with diet alone	A,S,R
Koepsell et al	1994	USA	Case-control	Diabetes: diagnosed within last 5 years	A,S,R
Koepsell et al	1994	USA	Case-control	Diabetes: Diagnosed over 5 years ago	A,S,R
Koepsell et al	1994	USA	Case-control	Diabetes only	A,S,R
Koepsell et al	1994	USA	Case-control	Both diabetes and coronary heart disease	A,S,R
Koepsell et al	1994	USA	Case-control	Coronary heart disease:Primary cardiac arrest	A,S,R
Koepsell et al	1994	USA	Case-control	ECG abnormalities: Atrial fibrillation	A,S,R
Koepsell et al	1994	USA	Case-control	ECG abnormalities: Paroxysmal supraventricular tachycardia	A,S,R
Koepsell et al	1994	USA	Case-control	ECG abnormalities: Premature ventricular contractions	A,S,R
Koepsell et al	1994	USA	Case-control	ECG abnormalities: Sinus bradycardia	A,S,R
Koepsell et al	1994	USA	Case-control	Conduction-system abnormalities: First-degree AV-block	A,S,R
Koepsell et al	1994	USA	Case-control	Conduction-system abnormalities: Second- or third-degree AV block	A,S,R
Koepsell et al	1994	USA	Case-control	Conduction-system abnormalities: Left bundle branch block	A,S,R
Koepsell et al	1994	USA	Case-control	Conduction-system abnormalities: Right bundle branch block	A,S,R
Koepsell et al	1994	USA	Case-control	Conduction-system abnormalities: Left anterior hemiblock	A,S,R
Koepsell et al	1994	USA	Case-control	Any of above ECG abnormalities	A,S,R
Koepsell et al	1994	USA	Case-control	Pacemaker	A,S,R
Koepsell et al	1994	USA	Case-control	Hypertension	A,S,R
Koepsell et al	1994	USA	Case-control	Coronary heart disease only	A,S,R

Authors	*Year*	*Country*	*Design*	*Health Impairment, medical condition, substance, considered*	*Confounders controlled*
Koepsell et al	1994	USA	Case-control	Neurological disease (other): Syncope	A,S,R
Koepsell et al	1994	USA	Case-control	Neurological disease (other): Dizziness, etiology unknown	A,S,R
Koepsell et al	1994	USA	Case-control	Neurological disease (other): Seizures	A,S,R
Koepsell et al	1994	USA	Case-control	Neurological disease (other): Head injury	A,S,R
Koepsell et al	1994	USA	Case-control	Neurological disease (other): Subdural hematoma	A,S,R
Koepsell et al	1994	USA	Case-control	Neurological disease: Other neurological condition:	A,S,R
Koepsell et al	1994	USA	Case-control	Other medical condition: Cronic pbstructive pulmonary disease	A,S,R
Koepsell et al	1994	USA	Case-control	Other medical condition: Asthma	A,S,R
Koepsell et al	1994	USA	Case-control	Other medical condition: Cancer	A,S,R
Leveille et al	1994	USA	Case-control	Benzodiazepines (1/3)	A,S,R
Leveille et al	1994	USA	Case-control	Benzodiazepines (2/3)	A,S,M,R,I,Y,E,W
Leveille et al	1994	USA	Case-control	Benzodiazepines (3/3)	A,S,M,R,I,Y,E,W
Leveille et al	1994	USA	Case-control	Cyclic antidepressants (1/3)	A,S,M,R,I,Y,E,W
Leveille et al	1994	USA	Case-control	Cyclic antidepressants (2/3)	A,S,M,R,I,Y,E,W
Leveille et al	1994	USA	Case-control	Cyclic antidepressants (3/3)	A,S,M,R,I,Y,E,W
Leveille et al	1994	USA	Case-control	Opioid analgesics (1/3)	A,S,M,R,I,Y,E,W
Leveille et al	1994	USA	Case-control	Opioid analgesics (2/3)	A,S,M,R,I,Y,E,W
Leveille et al	1994	USA	Case-control	Opioid analgesics (3/3)	A,S,M,R,I,Y,E,W
Leveille et al	1994	USA	Case-control	Antihistamines (1/3)	A,S,M,R,I,Y,E,W
Leveille et al	1994	USA	Case-control	Antihistamines (2/3)	A,S,M,R,I,Y,E,W
Leveille et al	1994	USA	Case-control	Antihistamines (3/3)	A,S,M,R,I,Y,E,W
Marottoli et al	1994	USA	Cohort study	Visual acuity (<20/40)	A, R
Marottoli et al	1994	USA	Cohort study	Use of antidepressant drugs	A, R
Marottoli et al	1994	USA	Cohort study	Depressive symptoms 1-15	A, R
Marottoli et al	1994	USA	Cohort study	Depressive symptoms 16-+	A, R
Marottoli et al	1994	USA	Cohort study	Cogn. imp: MMSE score 23-25 vs 26-+	A, R
Marottoli et al	1994	USA	Cohort study	Cogn. Imp: MMSE score 15-22 vs 26-+	A, R
McCloskey et al	1994	USA	Case-control	Glaucoma	A,S,R +(M, Y)
McCloskey et al	1994	USA	Case-control	Cataracts (several disorders)	A,S,R +(M, Y)
McCloskey et al	1994	USA	Case-control	Retinal disorders	A,S,R +(M, Y)
McCloskey et al	1994	USA	Case-control	Corrective lenses (any use)	A,S,R +(M, Y)

Authors	*Year*	*Country*	*Design*	*Health Impairment, medical condition, substance, considered*	*Confounders controlled*
McCloskey et al	1994	USA	Case-control	Refractive disorders	A,S,R +(M, Y)
McCloskey et al	1994	USA	Case-control	Other ophtalmological disorders (several)	A,S,R +(M, Y)
McCloskey et al	1994	USA	Case-control	Unaided visual acuity (20/15 or 20/20)	A,S,R +(M, Y)
McCloskey et al	1994	USA	Case-control	Unaided Visual acuity (20/25 or 20/30)	A,S,R +(M, Y)
McCloskey et al	1994	USA	Case-control	Unaided Visual acuity (20/40)	A,S,R +(M, Y)
McCloskey et al	1994	USA	Case-control	Unaided Visual acuity (20/50 or 20/60)	A,S,R +(M, Y)
McCloskey et al	1994	USA	Case-control	Unaided Visual acuity (20/70 or greater)	A,S,R +(M, Y)
McCloskey et al	1994	USA	Case-control	Hearing impairment ever diagnosed	A,S,R +(M, Y)
McCloskey et al	1994	USA	Case-control	Use of prescribed hearing aid	A,S,R +(M, Y)
McCloskey et al	1994	USA	Case-control	Aided visual acuity (20/15 or 20/20)	A,S,R +(M, Y)
McCloskey et al	1994	USA	Case-control	Aided visual acuity (20/15 or 20/20)	A,S,R +(M, Y)
McCloskey et al	1994	USA	Case-control	Aided visual acuity (20/15 or 20/20)	A,S,R +(M, Y)
McCloskey et al	1994	USA	Case-control	Aided visual acuity (20/15 or 20/20)	A,S,R +(M, Y)
McCloskey et al	1994	USA	Case-control	Aided visual acuity (20/15 or 20/20)	A,S,R +(M, Y)
McCloskey et al	1994	USA	Case-control	Post-cataract surgery: Without lens implant	A,S,R +(M, Y)
McCloskey et al	1994	USA	Case-control	Post-cataract surgery: With lens implant	A,S,R +(M, Y)
McCloskey et al	1994	USA	Case-control	Rethinopathy	A,S,R +(M, Y)
McCloskey et al	1994	USA	Case-control	Macular degeneration	A,S,R +(M, Y)
McCloskey et al	1994	USA	Case-control	Corrective lenses for far vision	A,S,R +(M, Y)
McCloskey et al	1994	USA	Case-control	Corrective lenses for near vision	A,S,R +(M, Y)
McCloskey et al	1994	USA	Case-control	New lenses at last optometry exam	A,S,R +(M, Y)
McCloskey et al	1994	USA	Case-control	New single vision lense Rx	A,S,R +(M, Y)
McCloskey et al	1994	USA	Case-control	New multifocal lens Rx	A,S,R +(M, Y)
McCloskey et al	1994	USA	Case-control	Myopi	A,S,R +(M, Y)
McCloskey et al	1994	USA	Case-control	Hypermetropia	A,S,R +(M, Y)
McCloskey et al	1994	USA	Case-control	Presbyopiaq	A,S,R +(M, Y)
McCloskey et al	1994	USA	Case-control	Astigmatism	A,S,R +(M, Y)
McCloskey et al	1994	USA	Case-control	Monocular vision	A,S,R +(M, Y)
McCloskey et al	1994	USA	Case-control	Diplopia	A,S,R +(M, Y)
McCloskey et al	1994	USA	Case-control	Optometry exam present in medical record	A,S,R +(M, Y)
McCloskey et al	1994	USA	Case-control	DOL certificate in medical record	A,S,R +(M, Y)

Authors	*Year*	*Country*	*Design*	*Health Impairment, medical condition, substance, considered*	*Confounders controlled*
McCloskey et al	1994	USA	Case-control	Vision trialer present in DOL record	A,S,R +(M, Y)
McCloskey et al	1994	USA	Case-control	Corrective lenses required for licence	A,S,R +(M, Y)
Findley et al	1995	USA	Case-control	Sleep apnea/narcolepsy (untreated)	A,S
Findley et al	1995	USA	Case-control	Sleep apnea/narcolepsy (untreated)	A,S
Fitten et al	1995	USA	Case-control	Alzheimers disease	A
Haraldsson et al	1995	SWE	Before-after	Untreated sleep apnea (before)	M
Haraldsson et al	1995	SWE	Before-after	Treated sleep apnea (after)	M
Lewandowski	1995	GER	Case-control	Static visual acuity (<0,7)	None (prof drivers)
Lewandowski	1995	GER	Case-control	Enhanced glare sensitivity	None (prof drivers)
Barkley	1996	USA	Case-control	Attention deficit hyperactivity disorder	A,S,Y, SES
Trobe et al	1996	USA	Case-control	Alzheimers disease	A,S,R
Trobe et al	1996	USA	Case-control	Alzheimers disease	A,S,R
Johansson	1997	SWE	Case-control	Hypertension (treated)	A,S,R,M
Johansson	1997	SWE	Case-control	Reduced MMSE score (below 28)	A,S,R,M
Johansson	1997	SWE	Case-control	Visual acuity below 0,8	A,S,R,M
Johansson	1997	SWE	Case-control	Cardiac failure	A,S,R,M
Johansson	1997	SWE	Case-control	Myocardial infarction	A,S,R,M
Johansson	1997	SWE	Case-control	Angina pectoris	A,S,R,M
Johansson	1997	SWE	Case-control	Atrial fibrillation	A,S,R,M
Johansson	1997	SWE	Case-control	Claudicatio intermittens	A,S,R,M
Johansson	1997	SWE	Case-control	Mild dementia (CDR > 0 vs CDR = 0)	A,S,R,M
Johansson	1997	SWE	Case-control	Dementia (MMSE $\leq$ 24 vs MMSE > 24)	A,S,R,M
Maag et al	1997	CAN	Case-control	Binocular vision problems (unspecified)	A,R,M,I, O,OD
Maag et al	1997	CAN	Case-control	Binocular vision problems (unspecified)	A,R,M,I, O,OD
Maag et al	1998	CAN	Case-control	Binocular vision problems (unspecified)	A,R,M,I, O,OD
Nada-Raja et al	1997	NZL	Cohort study	ADHD symptoms	A
Nada-Raja et al	1997	NZL	Cohort study	Conduct disorder	A
Nada-Raja et al	1997	NZL	Cohort study	Anxious/depressive disorder	A
Owsley et al	1998	USA	Cohort study	Visual acuity worse than 20/40	A,M,E, OD, MS
Owsley et al	1998	USA	Cohort study	Contrast sensitivity (reduced)	A,M,E, OD, MS

Authors	*Year*	*Country*	*Design*	*Health Impairment, medical condition, substance, considered*	*Confounders controlled*
Owsley et al	**1998**			**Stereoacuity (<500 arcsec vs ≥500)**	**A,M,E, OD, MS**
Owsley et al	1998			Central 30deg radius visual field sensitivity (0 vs > 10)|	A,M,E, OD, MS
Owsley et al	1998			Peripheral 30-60deg radius visual field sensitivity (0 vs > 10)|	A,M,E, OD, MS
Owsley et al	1998			Disability glare (≤0 vs >0)	A,M,E, OD, MS
McGwin et al	2000	USA	Case-control	Hypertension (high blood pressure)	A,S,E,M
McGwin et al	2000	USA	Case-control	Heart disease (unspecified)	A,S,E,M
McGwin et al	2000	USA	Case-control	Stroke	A,S,E,M
McGwin et al	2000	USA	Case-control	Cancer	A,S,E,M
McGwin et al	2000	USA	Case-control	Arthritis	A,S,E,M
McGwin et al	2000	USA	Case-control	Cataracts	A,S,E,M
McGwin et al	2000	USA	Case-control	Glaucoma	A,S,E,M
McGwin et al	2000	USA	Case-control	Diabetes	A,S,E,M
McGwin et al	2000	USA	Case-control	Kidney disease	A,S,E,M
McGwin et al	2000	USA	Case-control	Diabetic retinopathy	A,S,E,M
McGwin et al	2000	USA	Case-control	Diabetic neuropathy	A,S,E,M
McGwin et al	2000	USA	Case-control	Near vision score <75%	A,S,E,M
McGwin et al	2000	USA	Case-control	Far vision score <75%	A,S,E,M
McGwin et al	2000	USA	Case-control	Peripheral vision score <75%	A,S,E,M
McGwin et al	2000	USA	Case-control	Cognitive impairment	A,S,E,M
McGwin et al	2000	USA	Case-control	Hypertension (high blood pressure)	A,S,E,M
McGwin et al	2000	USA	Case-control	Heart disease (unspecified)	A,S,E,M
McGwin et al	2000	USA	Case-control	Stroke	A,S,E,M
McGwin et al	2000	USA	Case-control	Cancer	A,S,E,M
McGwin et al	2000	USA	Case-control	Arthritis	A,S,E,M
McGwin et al	2000	USA	Case-control	Cataracts	A,S,E,M
McGwin et al	2000	USA	Case-control	Glaucoma	A,S,E,M
McGwin et al	2000	USA	Case-control	Diabetes	A,S,E,M
McGwin et al	2000	USA	Case-control	Kidney disease	A,S,E,M
McGwin et al	2000	USA	Case-control	Diabetic retinopathy	A,S,E,M
McGwin et al	2000	USA	Case-control	Diabetic neuropathy	A,S,E,M

Authors	*Year*	*Country*	*Design*	*Health Impairment, medical condition, substance, considered*	*Confounders controlled*
McGwin et al	2000	USA	Case-control	Near vision score <75%	A,S,E,M
McGwin et al	2000	USA	Case-control	Far vision score <75%	A,S,E,M
McGwin et al	2000	USA	Case-control	Peripheral vision score <75%	A,S,E,M
McGwin et al	2000	USA	Case-control	Cognitive impairment	A,S,E,M
McGwin et al	2000	USA	Case-control	NSAID	A,S,E,M
McGwin et al	2000	USA	Case-control	ACE inhibitor	A,S,E,M
McGwin et al	2000	USA	Case-control	Beta-blocker	A,S,E,M
McGwin et al	2000	USA	Case-control	Oral hypoglycemics	A,S,E,M
McGwin et al	2000	USA	Case-control	Diuretic	A,S,E,M
McGwin et al	2000	USA	Case-control	Hormones	A,S,E,M
McGwin et al	2000	USA	Case-control	Glycoside	A,S,E,M
McGwin et al	2000	USA	Case-control	Calcium channel blocker	A,S,E,M
McGwin et al	2000	USA	Case-control	Insulin	A,S,E,M
McGwin et al	2000	USA	Case-control	Anticoagulant	A,S,E,M
McGwin et al	2000	USA	Case-control	HMG-CoA reductase	A,S,E,M
McGwin et al	2000	USA	Case-control	Benzodiazepines	A,S,E,M
McGwin et al	2000	USA	Case-control	Vasodilator	A,S,E,M
McGwin et al	2000	USA	Case-control	Antidepressants	A,S,E,M
McGwin et al	2000	USA	Case-control	Other hypertension	A,S,E,M
McGwin et al	2000	USA	Case-control	Other arthritis	A,S,E,M
McGwin et al	2000	USA	Case-control	Other heart	A,S,E,M
McGwin et al	2000	USA	Case-control	Other glaucoma	A,S,E,M
Longo et al	2000	AUS	Case-control	Alcohol only	None
Longo et al	2000	AUS	Case-control	Cannabis only (THC)	None
Longo et al	2000	AUS	Case-control	Alcohol and cannabis	None
Longo et al	2000	AUS	Case-control	Benzodiazepines only	None
Longo et al	2000	AUS	Case-control	Stimulants only	None
Longo et al	2000	AUS	Case-control	Alcohol and benzodiazepines	None
Woodward et al	2000	NZL	Cohort study	Minor attentional difficulty at age 13	A,S,M,L,E,I,MA,ASL,MER,PC
Woodward et al	2000	NZL	Cohort study	Moderate attentional difficulty at age 13	A,S,M,L,E,I,MA,ASL,MER,PC
Woodward et al	2000	NZL	Cohort study	Serious attentional difficulty at age 13	A,S,M,L,E,I,MA,ASL,MER,PC

Authors	*Year*	*Country*	*Design*	*Health Impairment, medical condition, substance, considered*	*Confounders controlled*
Woodward et al	2000	NZL	Cohort study	Very serious attentional difficulty at age 13	A,S,M,L,E,I,MA,ASL,MER,PC
Woodward et al	2000	NZL	Cohort study	Minor attentional difficulty at age 13	A,S,M,L,E,I,MA,ASL,MER,PC
Woodward et al	2000	NZL	Cohort study	Moderate attentional difficulty at age 13	A,S,M,L,E,I,MA,ASL,MER,PC
Woodward et al	2000	NZL	Cohort study	Serious attentional difficulty at age 13	A,S,M,L,E,I,MA,ASL,MER,PC
Woodward et al	2000	NZL	Cohort study	Very serious attentional difficulty at age 13	A,S,M,L,E,I,MA,ASL,MER,PC
Lings	2001	DEN	Cohort study	Epilepsy	A,S,R,M, OD
Longo et al	2001	AUS	Case-control	Benzodiazepines	None
Mathijssen et al	2002	NL	Case-control	Cannabis	None
Mathijssen et al	2002	NL	Case-control	Opiates	None
Mathijssen et al	2002	NL	Case-control	Benzodiazepines	None
Neutel	1998	CAN	Cohort study	Benzodiazepines: New users	A
Neutel	1999	CAN	Cohort study	Benzodiazepines: Repeat users	A
Adler et al	2000	USA	Case-control	Parkinsons disease	A
Bedard et al	1998	CAN	Case-control'	Alzheimers disease	
Hemmelgarn et al	1997	CAN	Nested case-control cohort study	Use of benzodiazepines: Long half-life	A,S,R,OD
Hemmelgarn et al	1998	CAN	Nested case-control cohort study	Use of benzodiazepines: Short half-life	A,S,R,OD
Owsley et al	2002	USA	Prospective cohort study	Cataract	
Schultheis et al	2002	USA	Case-control	Brain injury (traumatic)	A,S,Y.L
Connor et al	2002	NZL	Case-control	Sleep apnea (triad of symptoms)	A,S,D,Y,E
Connor et al	2003	NZL	Case-control	Acute sleepiness (< 5 hours)	A,S,D,Y,E
Connor et al	2004	NZL	Case-control	Cronic sleepiness ((Epworth scale)	A,S,D,Y,E
Cummings et al	2001	USA	Case-control	Drowsiness (acute sleepiness_ > 12 hrs last 48 hrs	A,TOD,DOW,LOC
Cummings et al	2002	USA	Case-control	Drowsiness: Sensation of falling asleep	A,TOD,DOW,LOC
Teran-Santos et al	1999	ESP	Case.control	Sleep apnea (Apnea-hypopnea $\geq$ 5)	A,D,BMI,L,VRD,VoM,SS
Withaar, Brouwer	1999	NL	Case-control	Dementia (based on MMSE-score: Revoked average:21.8 (vs 24,7))	S,M
Vernon	2002	USA	Case-control	Diabetes	A,S,R,M
Vernon	2002	USA	Case-control	Diabetes	A,S,R,M
Vernon	2002	USA	Case-control	Cardiovascular disease	A,S,R,M
Vernon	2002	USA	Case-control	Cardiovascular disease	A,S,R,M

Authors	*Year*	*Country*	*Design*	*Health Impairment, medical condition, substance, considered*	*Confounders controlled*
Vernon	2002	USA	Case-control	Pulmonary	A,S,R,M
Vernon	2002	USA	Case-control	Pulmonary	A,S,R,M
Vernon	2002	USA	Case-control	Neurologic diseases	A,S,R,M
Vernon	2002	USA	Case-control	Neurologic diseases	A,S,R,M
Vernon	2002	USA	Case-control	Epilepsy	A,S,R,M
Vernon	2002	USA	Case-control	Epilepsy	A,S,R,M
Vernon	2002	USA	Case-control	Learning, memory	A,S,R,M
Vernon	2002	USA	Case-control	Psychiatric	A,S,R,M
Vernon	2002	USA	Case-control	Psychiatric	A,S,R,M
Vernon	2002	USA	Case-control	Alcohol and drugs	A,S,R,M
Vernon	2002	USA	Case-control	Alcohol and drugs	A,S,R,M
Vernon	2002	USA	Case-control	Visual acuity	A,S,R,M
Vernon	2002	USA	Case-control	Visual acuity	A,S,R,M
Vernon	2002	USA	Case-control	Musculoskeletal	A,S,R,M
Vernon	2002	USA	Case-control	Musculoskeletal	A,S,R,M
Vernon	2002	USA	Case-control	Functional motor	A,S,R,M

Source: TØI report 690/2003

*) Studies referred to in Larsen (1976)
**) See section 2.2 for explanation of codes