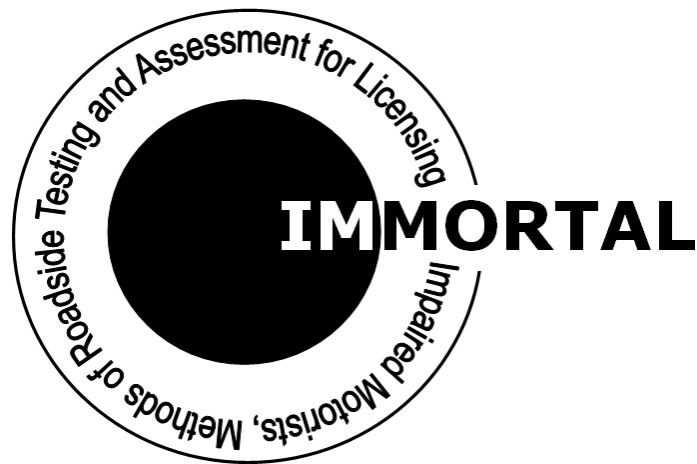


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IMMORTAL

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GLOSSARY OF ABBREVIATIONS AND ACRONYMS

In alphabetical order

ADAS	Advanced Driver Assistance Systems
ADHD	Attention Deficit Hyperactivity Disorder
Alcolock	Alcohol Ignition Interlock
AWAKE	EU-Project: System for Effective Assessment of Driver Vigilance and Warning According to Traffic Risk Estimation
BAC	Blood Alcohol Concentration
CBA	Cost Benefit Analysis
CD	Council Directive
CDV	Transport Research Center, Czech Republik
CEE or EEC	European Economic Community
CERTIFIED	EU-Project: Conception and Evaluation of Roadside Testing Instruments to Formalise Impairment Evidence in Drivers
CNS	Central Nervous System
CONSENSUS	EU-Project: Promoting consensus in assessing driving ability of People with Special Needs
Drugs	Medicinal drugs and illegal drugs
DTF	Danish Transport Research Institute, Denmark
DUI	Driving under the Influence
DVLA	Driver and Vehicle Licensing Agency
ETSC	European Transport Safety Council
EU	European Union
FIT	Field Impairment Test
ICADTS	International Council on Alcohol, Drugs and Traffic Safety
IMMORTAL	EU-Project: I mpaired M otorists, M ethods of R oadside T esting and A ssessment for L icensing
KuSS/KfV	Austrian Board for Safety and Prevention, Austria
LMR	Light Mental Retardation
MC	Motor Cyclists
MD	Medical Doctors
MDMA	3,4-methylenedioxymethamphetamine (ecstasy)
ROSITA	EU-Project: Roadside Testing Assessment
SCL 90	Clinical Questionnaire for screening of psychiatric symptoms
SDLP	Standard Deviation of Lateral Position
SINTEF	Foundation for Scientific and Industrial research at the Norwegian Institute of Technology, Norway
SSRI	Specific Serotonin Reuptake Inhibitor
SWOV	SWOV Institute For Road Safety Research, The Netherlands
TOI	Institute for Transport Economics, Norway
TRB	Transportation Research Board
TRL	Transport Research Laboratory, United Kingdom
UM-BBI	Brain Behaviour Institute, Maastricht University , The Netherlands
URP	User Representation Panel
UVA	University of Valladolid, Spain
WHO	World Health Organization

EXECUTIVE SUMMARY

IMMORTAL (Impaired Motorists, Methods of Roadside Testing and Assessment for Licensing) is a special EU research programme dealing with the accident risk associated with different forms of driver impairment. The project aims to investigate the influence of chronic and acute impairment in order to make a more accurate risk assessment, to recommend criteria for high risk categories, and to provide key information to support EU Policy on licensing and roadside testing.

The IMMORTAL consortium comprised 10 partners from a range of European institutions with multi-disciplinary expertise.

Co-ordination of IMMORTAL Project was first done by University of Leeds, and since October 1st 2004 taken over by the Danish Transport Research Institute.

- University of Leeds, School of Psychology (UNIVLEEDS), United Kingdom
- SWOV Institute for Road Safety Research (SWOV), The Netherlands
- Austrian Board for Safety and Prevention (KuSS/KfV), Austria
- Danish Transport Research Institute (DTF), Denmark
- Institute of Transport Economics (TOI), Norway
- Foundation for Scientific and Industrial Research at the Norwegian Institute of Technology (SINTEF), Norway
- University of Valladolid, Department of Pharmacology and Therapeutics (UVA), Spain
- Transport Research Centre (CDV), Czech Republic
- Transport Research Laboratory (TRL), United Kingdom
- Brain Behaviour Institute, Maastricht University (UM-BBI), The Netherlands

The workload of IMMORTAL was divided into several tasks; working groups co-operated on the subjects on national and international level.

Acute and chronic impairment was investigated by case control and field studies, experiments, interviews, literature analyses and literature reviews.

IMMORTAL research essentially contributed to the information about drug driving, with regard to the guidelines for driver assessment, the effects on driving performance of various acute and chronic impairments (e.g. diabetes, depression), and the evaluation of methods to assess the effect of certain diseases on fitness to drive.

Among the most important results are the following:

Concerning prevalence:

The field studies and case control studies point at an increase of drug driving. The predominating substances were cannabis, benzodiazepines and alcohol. There is special need for action in regard to alcohol with $BAC \geq 1,3g/l$, combination of alcohol with other drugs, and mixed consumption of drugs. In one region studied 8% of drivers who were tested accounted for more than 35% of the serious injuries; predominantly 18-24 year-old male drivers were represented. Enhanced enforcement, reinforced road-side testing, reliable

screening instruments, training of the police for detection of impairments, prosecution and rehabilitation of alcohol and drug impaired drivers with high risk should be a consequence of IMMORTAL results. IMMORTAL showed in particular that the roadside tests using saliva samples are not yet perfected and that the combination of alcohol and drugs especially should be paid more attention at police controls.

On the basis of the IMMORTAL result, the zero tolerance discussion concerning drugs does not seem appropriate: For illegal drugs that are taken alone, and with the exception of heroin, zero tolerance legislation would however seem to be an overreaction resulting in very high cost and few road safety benefits. In order to establish realistic, risk-related legal thresholds broader EU-wide epidemiological studies are needed. For medicinal drugs, IMMORTAL researchers suggest therapeutic levels as adequate legal thresholds for the time being.

For further research in the area of prevalence, consistent standards in the countries and support by the law in the collection of relevant data would be necessary.

Concerning relative risk:

Diseases included in the Annex III of the Council Directive on the Driving Licence (CD 91/439/EEC) show a relative risk of accident involvement of 1,33 (weighted average across all categories). However, the relative risk of individual groups of diseases varies greatly. Those falling into the high risk category include: Alcoholism, neurological diseases, mental disorders, drugs and medicines. The IMMORTAL study also highlighted stroke and myocardial infarction, sleep disturbances, mobility disorders and visual deficiencies as potential sources of impairment. These research results allowed a further approach toward the identification of risk factors and further development of licensing policy.

Concerning fitness to drive and licensing:

In a field study based on driver assessment at regular intervals, 17% of all drivers who had applied to renew their licence were assessed to be fit only with restrictions, whereas about 32% of persons over 64 years were considered fit with restrictions. IMMORTAL has also shown that the assessment of fitness to drive can be diverse even within one category of diseases. This speaks for an individual assessment at which individual compensation abilities can also be tested. Best practise models of several countries could provide a sound working basis for medical and psychological assessment in the context of licensing.

Concerning evaluation of assessment methods:

Only some of the tests and some of the driving simulator tasks show reliable results. Here, a critical examination of the methods used should take place. When considering the results of several studies, the conclusion can be drawn that individual driver assessment with reliable and valid medical and psychological procedures has to be the aim. In this context, it also became apparent that the presence of a medical condition should not a priori lead to the judgement that a person is not fit to drive. That is only the case with a few disorders. Rather, a critical examination of the individual case is called for, to determine the extent to which sufficiently favourable physical and psychological preconditions exist, or to what extent deficiencies (e.g. arthritis, learning difficulties, diabetes mellitus, visual deficiencies) can be counterbalanced by individual compensation abilities and/or strategies. A multidisciplinary approach is recommended regarding fitness to drive assessment.

Concerning experiments:

Diseases and medication: Depression and the medication of depression with SSRI (specific serotonin reuptake inhibitors) have significant effects on driving behaviour. Suffering from cold and cold medication also affect driving performance. The impairing effect of cold remedy medication (low doses) on road tracking performance is particularly noteworthy. The addition of pseudoephedrine to the cold remedy formulation does not fully compensate for the sedative potential of diphenhydramine.

Acute impairment: It can be said for MDMA and driving behaviour that with single doses in the region of 75 and 100 mg, an improvement of psychomotor performance becomes apparent, situational awareness and spatial memory, however, are clearly impaired. Impairments caused by concomitant alcoholisation cannot be remedied.

Both young and older drivers lack adequate knowledge about the effects of drugs and medicines and potential interactions. Here, action needs to be taken as well: Dissemination of knowledge by practitioners, schools, etc.

In the case of fatigue and sleepiness, it has turned out that creation of consciousness and education of drivers is highly needed and promising countermeasures should be further developed to prevent those especially serious crashes due to fatigue. Experts stated that the only possibility to prevent traffic accidents due to fatigue is sufficient sleep.

Concerning Cost-Benefit-Analysis of three countermeasures:

Mandatory eyesight testing has proved to have a negative socio-economic yield, if withdrawal of the driving licence is the only sanction imposed. Here, too, an assessment of the individual compensation abilities on the basis of a medical and psychological examination is recommended.

Increased random breath testing and alcolocks seem to be promising measures, showing a positive socio-economic benefit.

The highlights of IMMORTAL

A look back at the initially defined aims of IMMORTAL shows that:

- Concerning the prevalence of psychoactive drugs, there are indications by the IMMORTAL research that the proportion of drugged drivers has increased and that mixed consumption has become more frequent. By means of case control studies a more accurate risk assessment was made possible.
- Furthermore, prosecution of DUI is urgently needed in case of alcohol especially for drivers with high BACs, and drivers with combinations of drugs and alcohol and more than one drug.
- Legal framework for both prosecution and further research is important and still has to be established in some cases.
- Concerning illness and diseases, it became apparent that the degree of impairment not only differs depending on the medical condition, but also may clearly vary individually. Individual compensation abilities can be crucial factors in the context of assessing the fitness to drive. This result speaks for two things: (1) To measure the identified, especially risky medical conditions and (2) To assess individually to which extent driving fitness exists.

- For the assessment, both medical and psychological variables have turned out to be relevant.
- Regarding the intervention methods, frequent Random Breath Testing and Alcolocks are promising measures. A drug recognition method tested in the context of IMMORTAL still needs further improvement, also the saliva test devices seemed yet to be error-prone. Since it turned out that the combination of alcohol and drugs and the combined consumption of different drugs have increased, it is vital that, besides impairment by alcohol, also the impairment by drugs is recorded. This means that alongside Random breath test devices, also good screening instruments should be available to clarify the impairment by drugs.
- Concerning licensing procedures, consistent, reliable, and valid standards are sought after. Here, work can be continued on the basis of the findings of the odds ratios of medical conditions.
Target group-specific proceeding is also recommended on the basis of the IMMORTAL results.
Medical expertise turned out to be an important contact that on one hand should be informed about the specific effects of medicines on driving performance (see e.g. IMMORTAL research concerning cold medication, SSRI) and on the other hand has to relay this information to the patients.
- Concerning criteria for high risk categories, IMMORTAL yielded important starting points: For illegal drugs that are taken alone, and with the exception of heroin, zero-tolerance legislation would, however, seem to result in very high costs and hardly any road safety benefits.
- For most medicinal drugs, like antidepressants, benzodiazepines, codeine, barbiturates and even morphine, therapeutic levels may be adequate as legal limits, at least for the time being.

The recommendations provide starting points for different areas: Licensing, legislation, and measures. Here, it becomes clear which findings are further needed, both on the political level and in the field of research.

Where to find IMMORTAL reports:

The different deliverables can be viewed, respectively downloaded at the IMMORTAL website www.immortal.or.at. General information regarding the project, the partners and the procedures can be found there as well.

1. INTRODUCTION

IMMORTAL (**I**mpaired **M**otorists, **M**ethods of **R**oadside **T**esting and **A**ssessment for **L**icensing) is a special research programme dealing with the accident risk associated with different forms of driver impairment.

These objectives focus on two problem areas:

- (a) **Chronic impairment**, resulting from physical illness, mental illness, or physical deficiencies. This aspect has got important impact on driver licensing.
- (b) **Acute impairment** as a result of medicines, drugs and alcohol (alone or in combination of each other). This mode of impairment concerns first of all the traffic act.

IMMORTAL attempts to find a considerably more accurate risk assessment with the potential aim to identify “tolerance levels”, which can be applied to licensing assessment and roadside impairment testing (and also drug screening).

IMMORTAL has got the following technical and scientific objectives:

- Investigation of the influence of chronic and acute impairment on driver’s performance and the accident risk related to it;
- Recommendation of criteria (“tolerance levels”) for high risk categories of impairment;
- Provision of key information to support formulation of European Policy on licensing and roadside testing.

IMMORTAL is innovative in case of several aspects:

- The multi-disciplinary expertise and European representation of the consortium,
- The range of impairment factors considered and the comprehensive nature of the research;
- The inclusion of a User Representation Panel,
- The relevance to EU policy and standardisation,
- The range of research methodologies applied,
- The specification, verification, and exploitation of testing and assessment protocols, and
- The methods of dissemination and exploitation of programme results.

IMMORTAL started on 1 January 2002 and lasted till 30 June 2005. The work-plan is structured in “work-packages”.

This report is structured as follows:

First, the project procedure and the project areas are described. After this, all the results of the IMMORTAL research areas are brought together in a separate chapter. Yet another section deals with the recommendations and the exploitable results. Annex 1-3 includes the executive summaries of all IMMORTAL deliverables.

1.1 THE AIM OF IMMORTAL

Immortal is focused on two societal needs that both contribute to quality of life: Mobility and safety.

Aims of IMMORTAL can be outlined in three sections:

- To provide evidence on driver impairment to get knowledge about the size of the problem in the driving population and to identify problems regarding traffic safety risks.
- To propose intervention methods regarding driver impairment. This may concern restrictions in driver licensing or impairment thresholds for drugs.
- To support the Commission regarding policy in giving Directives on driving licensing and suggestions for driver impairment laws.

Therefore, IMMORTAL should deliver a variety of exploitable results to comprehensive knowledge concerning the influence of acute and chronic impairing factors that may be used in policy decisions and to recommendations on how to examine chronically impaired people seeking (re)licensing, and assess drivers for acute impairment (at roadside).

1.2 THE IMMORTAL CONSORTIUM

The consortium of IMMORTAL comprises 10 partners from a range of European institutions with multi-disciplinary expertise.

- School of Psychology, University of Leeds, UK
- SWOV Institute for Road Safety Research, The Netherlands
- Austrian Board for Safety and Prevention, Austria
- Danish Transport Research Institute, Denmark
- Institute of Transport Economics, Norway
- Foundation for Scientific and Industrial Research at the Norwegian Institute of Technology, Norway
- Department of Pharmacology and Therapeutics, University of Valladolid, Spain
- Transport Research Centre, Czech Republic
- Transport Research Laboratory, UK
- Brain Behaviour Institute, Maastricht University, The Netherlands

The University of Leeds was in charge of the co-ordination of IMMORTAL until 30 September 2004. The Danish Transport Research Institute took over the co-ordination in the remaining period, and is also the contact institute in the period after the project has been finalised.

But there were also external partners who contributed to IMMORTAL work. An expert panel conducted external reviews of deliverables, and a panel of user representation allowed to have a shared view on workshops and contributed to exploitation of results.

1.3 CO-OPERATION WITHIN THE IMMORTAL CONSORTIUM

Working groups were set up, cross national and national that dealt with the conception and the implementation of the respective tasks and discussed results and recommendations. Meetings were held at regular intervals.

There were meetings, conferences and seminars to discuss and disseminate results:

- Conference papers (Workshop at the ICADTS Conferences T2002 and T2004)
- Conference poster (at international Conferences, see Chapter Exploitation and Dissemination)
- Publication in scientific journals (e.g. Forensic Science International)
- Seminars (Consensus Workshop in Valencia, exchange of information with EC activities and projects, Pompidou Group)
- Newsletter (e.g. The reporter, ETSC Newsletter, TRENDS in Pharmacological Sciences)

Two already completed EU projects were consulted, because they were able to provide an important data basis for IMMORTAL: the projects CERTIFIED (Brookhuis et al., 2000) and ROSITA (www.rosita.org).

CERTIFIED dealt with the conception and evaluation of roadside testing instruments to formalise impairment evidence in drivers. The project was aimed to contribute to the existing data base concerning drugs and traffic safety. It should support the development of methods for roadside testing applicable to driver impairment (illicit and licit drugs).

ROSITA - roadside testing assessment – dealt with the role of roadside drug testing in EU traffic safety. The topics addressed ranged from the compilation of an inventory of drugs and medicines that are suspected to have a detrimental impact on road user performance, to an inventory about the state of the art of roadside testing and the user and legal requirements across EU member states connected to it, to the development of a methodology and experimental design for evaluation of different equipment, and recommendations derived from the results of the different work packages.

1.4 WORKSTRUCTURE AND DELIVERABLES

The work within the project was divided into 3 large areas:

The work-packages were separated into administration (A), research (R), and policy functions (P).

- The administrative functions (A) included project co-ordination, quality assurance, and dissemination/ exploitation.
- The research work-packages (R) focused on chronic impairment from ageing, mental illness and disease as well as acute impairment from drugs, alcohol and medicines.
- The policy function (P) provided workshops on these and other impairment factors (i.e., fatigue, visual & perceptual deficiencies) and considered relevant countermeasures, including licensing and impairment testing

The deliverables of the project are listed below in table 1. In the Annexes 1-3, the Executive Summary of each report (deliverable) is presented. If you want to read the whole reports, please visit www.immortal.or.at, where all the deliverables are available.

Table 1 List of IMMORTAL Deliverables

Deliverable	Title	Author(s)	Institution
A3.2	Final programme report	W. Klemenjak, E. Braun, J. Alvarez, I.M. Bernhoft, L. Fjerdingen	Austrian Board for Safety and Prevention, Austria, . University of Valladolid, Spain, Danish Transport Institute, Denmark, SINTEF, Norway
R1.1	Impairments, diseases, age and their relative risks of accident involvement	T. Vaa	Institute of Transport Economics, Norway
R1.2	Driver health and crash involvement	F. Sagberg	Institute of Transport Economics, Norway
R1.4	Medical condition and fitness to drive	F.J. Alvarez, M.C. del Rio, I. Fierro, A. Vicondoa and M. Ozcoidi	University of Valladolid, Centro de Reconocimiento del Ilustre Colegio Oficial de Medicos de Navarra, Gabinete Psicotecnico; Spain
R1.5	Effects of depression and antidepressant therapy on driving performance	J.A.J. Schmitt, M. Wingen, W.J. Riedel and J.G. Ramaekers,	Brain & Behaviour Institute, Experimental Psychopharmacology Unit, Maastricht University, The Netherlands
R1.6	Effects of diabetes on driving performance	V. Rehnova, J. Weinberg and R. Kotal	Traffic Research Centre CDV, Traffic Academy DA CR; Czech Republic
R1.7	Development of licensing assessment protocols for elderly drivers with Arthritis	C.M. Wood, N.L. Read, G.R.J. Hockey, P. Prong, G. Conway and A. Parkes	University of Leeds, Institute of Psychological Sciences, Leeds UK
R1.8	Assessment of fitness to drive amongst patients with learning difficulties	C. Bjorkli, M. Flö, G.D. Jenssen, T. Ryum and P. Zeiner	Foundation for Scientific and Industrial Research at the Norwegian Institute of Technology (SINTEF), Norway
R1.9	Ageing, illnesses and diseases – A synthesis	F.J. Alvarez	University of Valladolid, Spain
R4.1	Review of impairment and accident risk for alcohol, drugs and medicines	E. Braun and R. Christ	Austrian Board for Safety and Prevention, Austria
R4.2	The prevalence of drug driving and relative risk estimations. A study conducted in The Netherlands, Norway and the United Kingdom	T. Assum, SC Buttress, B. Sexton, R.J. Tunbridge, J. Oliver, M.P.M. Mathijssen, S. Houwing	TOI, Norway, TRL, UK, University of Glasgow, SWOV, The Netherlands

R4.3	Drugs in accident involved drivers in Denmark	I.M. Bernhoft	Danish Transport Research Institute, Denmark
R4.4	Experimental studies on the effects of licit and illicit drugs on driving performance, psychomotor skills and cognitive function	J.G. Ramaekers, K.P.C. Kuypers, C.M. Wood, G.R.J. Hockey, S. Jamson, H. Jamson and E. Birch	Brain & Behavior Institute, Faculty of Psychology, Maastricht University, The Netherlands; School of Psychology, University of Leeds, UK
R4.6	Drugs and alcohol in traffic – A Synthesis of Results	I.M. Bernhoft	Danish Transport Research Institute, Denmark
P2	Detailed cost benefit analysis of potential impairment countermeasures	W. Vlakveld, P. Wesemann, E. Devillers, R. Elvik and K. Veisten	SWOV- Institute for Road Safety Research, The Netherlands; Institute of Transport Economics, Norway
P4.1	Report on Workshop 1 "Vision and perceptual deficiencies as a risk factor in traffic safety"	L. Fjerdingen, G.D. Jenssen, L. Lervag, L.J. van Rijn, T. Vaa, A. Kooijman, B. Bjerre and H. Arnljot	SINTEF, Norway
P4.2	Fatigue, sleepiness and reduced alertness as risk factors in driving	F. Sagberg, P. Jackson, H.P. Krüger, A. Muzet and A.J. Williams	Institute of Transport Economics, Norway, Awake Ltd. UK, University of Würzburg, Germany, CNRS-CEPA Strasbourg, France, St. Thomas Hospital London, UK.
P4.3	The use and usability of CD 91/439 on Driving Licensing	F.J. Alvarez, T. Gomez, and I. Fierro	University of Valladolid, Spain
P4.4	Proceedings of 4th workshop "Cost benefit analysis on impairment countermeasures"	P. Weseman, W. Vlakveld and E. Devillers	SWOV Institute for Road Safety Research, Netherlands
P8	Policy synthesis report	L. Lervag, G.D. Jenssen and L. Fjerdingen	SINTEF, Norway

2. RESULTS OF IMMORTAL TASKS

IMMORTAL has gained knowledge in different ways; as Bernhoft (2005a) points out: Methods used within IMMORTAL were literature reviews (to get knowledge of state of the art), questionnaires and interviews, case control studies and experiments.

The problem areas covered by the project are quite different. The project focused on accident risk, fitness to drive, impairment factors and cost-benefit analyses concerning special traffic safety measures.

(1) Accident risk:

To cover this aspect and gain knowledge, multiple approaches were used

- Literature review concerning drug impairment (including alcohol);
- Meta-analysis concerning diseases, age, drug-impairment (including alcohol);
- Crash culpability study (carried out by questionnaires) focussing on diseases and medication;
- Case control study (performing road side controls and investigating hospital cases) to explore drug impairment (including alcohol);
- Accident causation study (carried out by doing qualitative interviews) concerning disease, drug impairment (including alcohol);
- Workshops to cover visual problems and perceptual deficiencies and fatigue.

(2) Fitness to drive:

The objectives concerning driver licensing comprised

- Medical-psychological assessment (drivers visiting medical test centres);
- Experiments with older arthritic drivers (to prove validity of laboratory tests of driving abilities);
- Assessment of fitness to drive among patients with learning difficulties and diabetes;
- Workshop to assess the use and usability of CD91/439 for driver licensing.

(3) Impairment factors

Different experiments were carried out to identify impacts of substances and diseases on driving performance

- Driving experiments in simulator (in the case of persons with learning difficulties, depression, diabetes and cold medication)
- On-road experiments (in the case of ecstasy in the intoxication and the withdrawal phase and the combination of ecstasy and alcohol)

(4) Cost-benefit analyses

- CBA of various impairment countermeasures (these were: Eyesight testing, increased road side breath testing, zero BAC limit for young drivers and alcolocks for drivers convicted for DUI)
- Workshops for discussion on CBA method and use of CBA analyses regarding impairment countermeasures.

For the description of the results of the respective studies, the order of the numbering of the deliverables is predominantly maintained. We are aware that the classification in chronic and acute impairment is not a strict one, as it was presented in the beginning of the project: Not every disease is chronic, medicinal drugs are closely related to diseases and cannot be dealt with in connection with acute impairment alone. Thus, it becomes clear that the lines between the different areas are blurred and that overlaps and reciprocal interactions exist.

2.1 CHRONIC IMPAIRMENT

The first part of the IMMORTAL project covers predominantly aspects of chronic impairment.

2.1.1 Meta-analysis “Diseases and risk of accident involvement”(D-R1.1)

At the initial point of IMMORTAL research, there was the Meta Analysis carried out by Vaa (2003) concerning impairments, diseases, age and their relative risks of accident involvement. For this analysis, Vaa mainly considered case-control-studies; altogether, 62 studies served as basis for the assessment of the relative risks of accident involvement.

In the Council Directive on Driving Licence CD91/438/EEC, the following impairments/diseases are listed: Sight, hearing, locomotive disability, cardiovascular diseases, diabetes mellitus, neurological diseases, mental disorders, alcohol, drugs and medicines, renal disorders¹.

Except for the renal disorders, in all main categories a statistical significant increase of being involved in a road accident became apparent (Vaa 2003, 2005)²

Table 2: *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) Vaa 2003, p.ii.*

Main category	Relative Risk
Vision impairment	1,09
Hearing impairment	1,19
Arthritis/Locomotor disability	1,17
Cardiovascular diseases	1,23
Diabetes mellitus	1,56
Neurological disease	1,75
Mental disorders	1,72
Alcoholism	2,00
Drugs and medicines	1,58
Renal disorders	0,87
<i>Weighted average across all categories</i>	<i>1,33</i>

Therefore, low risk exists with: Vision impairment, arthritis/locomotor disability, hearing impairment, and cardiovascular diseases, diabetes mellitus is in the middle range, and: Drugs and medicines, mental disorders, neurological diseases and alcohol are categorised as high risk impairments.

¹ In case of renal disorders, only 3 studies served as data basis. Therefore more studies are needed. Missing statistical significance might be due to the small number of studies.

² In case control studies – as Vaa (2003, 2005) states – the effect of a given condition on accident rate is assessed as follows: Accident Rate Ratio = (number of accidents involving drivers with condition X : Kilometres of driving for drivers with condition X) : (number of accidents involving drivers without condition X : Kilometres of driving for drivers without condition X)

Concerning vision impairments, it makes sense to look at the specific disorders with respect to the relative risk, because there are noticeable differences: While the relative risk is 0,96 when vision is corrected by contact lenses (and is thus practically as high as with a person without vision impairment), (heavily) reduced night time vision has a relative risk of 1,66. This means that persons with a severe impairment of night time vision have a 66% higher accident risk.

As it will be referred to later, the relative risk for ADHD patients should be mentioned here: It is 1,54, and when taking medications (if applied as prescribed): 1,49. For cyclic antidepressants the relative risk, calculated by Vaa is 1,42 (based on 5 results), and for depression and depressive symptoms an elevated risk of 1,67 was found, based on 4 results (Vaa 2005). The research of IMMORTAL covered the impact of depression and antidepressants on driving in a separate study (please see chapter 2.1.2.3.)

It is essential to note the following: According to Vaa's analyses, the average relative risk is 1,33, i.e. a driver with a medical condition has a 33% higher risk compared to a driver without this medical condition³. None of the main categories reaches a relative risk as high as 2,00, as is the case with alcoholism. Under the influence of alcohol (addiction to alcohol) exists – on the basis of the 3 studies analysed by Vaa - a twice as high accident risk. When looking at further specific risks, one disorder stands out in particular: Sleep apnoea/narcolepsy. Here, a relative risk of 3,71 arises. This disease shows a significantly higher risk than the other conditions considered.

Vaa (2005) further tries to relate these results to other parameters that influence the relative risk, e.g. age, but also gender, use of mobile phones while driving, etc. He presents the following ranking:

Table 3: Relative risks of accident involvement of selected states/conditions (Vaa 2005)

State/condition	Relative risk
Drunken driving – BAC + 0,15 % (sober = 1,00) (Glad 1985 cited in Vaa 2005)	65
Drunken driving – BAC 0,100 – 0,149 % (sober = 1,00) (Glad 1985 cited in Vaa 2005)	25
Driver of MC (driver of personal vehicle = 1,00) (Elvik et al 1997 cited in Vaa 2005)	13,2
Drunken driving – BAC 0,050 – 0,099 % (sober = 1,00) (Glad 1985 cited in Vaa 2005)	10
Male drivers aged 16-19 compared to male drivers aged 45-54 (Elvik 2002 cited in Vaa 2005)	5,3
Drivers with sleep disorders/sleep apnoea/narcolepsy (Vaa 2003)	3,71
Male drivers aged 75+ compared to male drivers aged 45-54 (Elvik 2002 cited in Vaa 2005)	3,1
Female drivers aged 75+ compared to female drivers aged 35-54 (Elvik 2002 cited in Vaa 2005)	3
Female drivers aged 16-19 compared to female drivers aged 35-54 (Elvik 2002 cited in Vaa 2005)	3
Road surface covered with ice/snow compared to dry road (Elvik 1997 cited in Vaa 2005)	2,5
Mobile telephone use (Sagberg 1998 cited in Vaa 2005)	1,72
Road surface covered with wet snow compared to dry road (Elvik et al 1997 cited in Vaa 2005)	1,5
Driving in darkness compared to daylight (Elvik et al 1997 cited in Vaa 2005)	1,5
Average of main conditions of Annex III - CD 91/439/EEC (Vaa 2003)	1,33
Driving on wet road compared to dry road (Elvik et al 1997 cited in Vaa 2005)	1,3

³ With exception of renal disorders.

This table clearly demonstrates that relative risk increases considerably with higher levels of alcohol. Drivers of motor cycles (MC), compared to drivers of personal cars, have the third highest risk.

Alcohol concentrations in the interval 0.5 g/l – 1.0 g/l are associated with a relative risk of 10. Further, it becomes clear that a high relative risk is related to age. Male drivers aged 16 to 19 have - compared to male drivers aged 45 to 54 – a five times higher accident risk. This ranking should on no account divert from the fact that already the low-risk topics lead to a risk increase of 33% or more.

These data apply to single conditions, i.e. co- or multimorbidity is not included. Nonetheless, it may be assumed that the relative risk is additionally increased (additively or even exponentially – this has to be clarified in further studies), if a person has multiple diseases or if a person, suffering from an illness, is under the influence of alcohol.

For the assessment of this issue, 2 aspects are vital: Prevalence (and with it exposure) and relative risk. As Vaa (2003, p. 26) states, „exposure has only been controlled in 15 studies”.

2.1.2 IMMORTAL Research in case of diseases

2.1.2.1 Medical disorders and roads accidents (D-R1.2)

To look further into the subject of prevalence and risk, a special study was conducted in Norway: Here, high risk conditions with a very low prevalence from the societal point of view did not pose the central problem. Rather, the design of this study seemed to be a very appropriate approach to detect risk factors with large impact on traffic safety in terms of number of crashes. Crashes refer to both prevalence and the associated relative risk. The main question of the study was: Which impairments have the largest effect on the *number of crashes*.

Sagberg (2003) analysed the relative crash involvement risk associated with diagnosed medical conditions, subjective symptoms and the use of some medicines. Ideally, data are derived about accidents and exposure of drivers with and without the risk factor, and exposure data are available (e.g. annual mileage).

The assumption in the present study was the following: Prevalence of a risk factor among not-at-fault drivers in crashes is proportional to its prevalence in traffic (“induced exposure”).⁴ The study was based on a self report questionnaire that was sent by mail to approx. 15000 drivers, the rate of return was about 30%, 4448 questionnaires were available for analysis. It concerned persons that were recently involved in an accident. The survey was anonymous. In addition to the information about the accident and the person, data about driving experience, medical conditions, parameters concerning hearing and vision, subjective symptoms and use

⁴ Case Control Estimation of relative risk (Sagberg 2003, 2005): $OR_f = \frac{G_f / G}{I_f / I}$

OR_f = the odds ratio for factor f ; G_f = number of guilty drivers (*cases*) with risk factor f present during the crash; G = number of guilty drivers without risk factor f ; I_f = number of innocent drivers (*controls*) with risk factor f present during the crash; I = number of innocent drivers without factor f

of medicines were collected. The relative risk was weighted for age and annual mileage. The following significant health related risk factors present themselves:

Table 4: Relative risks in terms of odds ratio of accident involvement of medical condition, adjusted for age and annual mileage (Sagberg 2005) .

Category	At fault (n=2226)	Not at fault (n=1840)	Adjusted odds ratio	Accident reduction potential (% of all accidents)
Non medicated diabetes	16	8	3,08	0,3
History of myocardial infarction	67	31	1,77	1,3
Cerebral haemorrhage (stroke)	36	13	1,93 (not significant)	0,9
Using glasses when driving	1040	728	1,26	7,2
Myopia	508	367	1,22	2,9
Sleep onset insomnia	88	43	1,87	1,6
Frequent tiredness	178	114	1,36	1,8
Anxiety	22	14	3,15	0,2
Feeling depressed	31	14	2,34	0,6
Taking antidepressants	64	36	1,70	0,9

The condition “drivers who had suffered a stroke” showed a high relative risk but the result was not statistically significant. Sagberg further points out that relative risk estimates of a similar value were also found for Parkinson’s disease and multiple sclerosis, “but the prevalence of these diseases in the driver sample was too low for the estimates to reach statistical significance.” (Sagberg 2005). Therefore he quotes special targeted studies. For epilepsy, no significant relative risk presented itself, either. This may be due to the presence of efficient procedures for health examination, with the result that persons at risk are selected away from the driver population. Further, Sagberg detected the overall tendency that those drivers who stated an additional or several additional medical conditions had a higher risk than drivers without impaired health. That was also the case, for example, when the single conditions did not show significant results.

If comparing the figures of Vaa (2003, international data of the meta analysis, see above) and Sagberg (2003), only small differences in the size of the relative risk present themselves.

Table 5: Comparison of present relative risk estimates with results from meta-analysis done by Vaa.(95% confidence interval in parenthesis) (Sagberg 2003, p. 15).

Medical condition	Vaa (2003)	Sagberg (2003)
Impaired vision	1.09 (1.04 – 1.15)	1.11 (1.02 – 1.22)
field of vision	0.90 (0.69 – 1.17)	1.30 (0.30 – 4.31)
visual acuity	1.13 (1.05 – 1.22)	1.17 (1.08 – 1.26)
Hearing disorder	1.19 (1.02 – 1.40)	1.12 (0.92 – 1.37)
Locomotor disability	1.17 (1.04 – 1.36)	1.52 (1.03 – 2.23)
Cardiovascular diseases	1.23 (1.09 – 1.38)	1.09 (0.92 – 1.30)
arrhythmia	1.27 (1.09 – 1.47)	1.01 (0.64 – 1.60)
hypertension	1.03 (0.86 – 1.22)	1.03 (0.84 – 1.28)
angina pectoris	1.52 (1.10 – 2.09)	1.75 (0.93 – 3.30)
History of myocardial infarction	1.09 (0.62 – 1.92)	1.71 (1.10 – 2.65)
Diabetes	1.56 (1.31 – 1.86)	1.01 (0.68 – 1.49)
Neurological diseases	1.75 (1.61 – 1.89)	1.79 (0.57 – 5.61)*
Epilepsy	1.84 (1.68 – 2.02)	1.04 (0.34 – 3.17)
Depression	1.67 (1.10 – 2.55)	1.79 (0.93 – 3.45)**

* Parkinson's disease and multiple sclerosis.

** In this study depression was defined as feeling depressed once a week or more

In summary, it can be stated that, according to Sagberg, health problems among drivers do not appear to be a major safety problem in Norway. This might be due to the fact that most cases of high risk conditions (e.g. epilepsy and diabetes type 1) are detected early and treated adequately. Whether a similar picture can be drawn for other countries or whether this situation is specific to Norway remains to be seen.

Nonetheless, on the basis of Sagberg's data which is in good agreement with Vaa's data - particular attention should be paid to the following medical conditions: Sleep related problems, depression and other mental disorders, diabetes type 2, impaired vision (particularly myopia), history of myocardial infarction and of stroke.

2.1.2.2 Medical predictors at time of licensing (D-R1.4)

Another IMMORTAL study (Alvarez et al. 2004) addressed medical conditions and fitness to drive. Here, the starting point was an analysis of medical-psychological assessment of fitness to drive and accident risk among Spanish drivers⁵, that is, at the time of the issue or renewal of the driving licence. Both medical and psychological status are considered in this assessment. It is a screening procedure, where a medical-psychological team (doctor, ophthalmologist and psychologist) decides on fitness to drive.

5234 drivers were included in this study. The drivers had visited one of two Spanish Medical Driver test centres to renew their driving licence or obtain it for the first time. This is mandatory in Spain: Every ten years up to age of 45, every 5 years between 46 and 70 and every 2 years from 70 years on non-professional drivers have to undergo this examination (Professional drivers have to undergo this check up within shorter periods). 3741 men and 1493 women, covering all age groups, were included, but also the variables professional and non-professional drivers were covered.

⁵ Information about the study and its limitations, please see Alvarez et al. (2004, p. 73f)

Alvarez et al. (2004) state that 32,6% of the tested drivers suffer from an illness; 16,7% of all drivers were considered fit with restrictions. Regarding medical conditions (7,1%) that cause these restrictions, there are – first of all – diabetes and alteration in mobility, then hypertension, hypercholesterolemia, and respiratory system conditions. Causes for assessment not to be fit for driving are psychiatric illnesses, diseases of locomotor system and renal illnesses. Restrictions on basis of eyesight problems are 8,2%, hearing problems 1,9% and psychological cause 0,7%.

5% of the persons who applied for the first time for a driving licence were assessed fit with restrictions. As for the group of persons older than 64 years, 31,5% were judged with restrictions as sufficiently fit, 2,2% were not fit to drive.

Concerning the restrictions imposed, very diverse measures were taken: 647 persons were given a reduction of the validity period of their driving licence, 260 a speed restriction, 233 a mechanical restriction and 91 persons another kind of restriction.

32,6% of the examined persons suffered from some kind of pathology or illness. Alvarez et al. give the following medical conditions and percentages:

Table 6: Alvarez et al. (2004, p. 59): Pathological processes present in drivers

Medical condition	Percentage in whole group of drivers
Cardiovascular illnesses	11,6
Metabolic and endochrinous illnesses	8,9
Arterial hypertension	8,5
Other causes	7,2
Hypercholesterolemia	4,1
Diabetes mellitus	3,9
Illnesses of locomotor system	3,7
Illness of respiratory system	2,8
Mental and behavioural disorders	2,6
Haematological illnesses	1,8
Neurological and muscular illnesses	1,6
Disorders related to substances	0,8
Illness of the renal system	0,6

Furthermore, it was interesting to find how diagnosed illnesses were linked to the final result of the medical examination, and with it to the assessment of fitness to drive. Medical pathological groups are a framework for the sum of single illnesses. E.g. cardiovascular disorders are composed by cardiac insufficiency, rhythm disorders, coronary pathologies, arterial hypertension and so on. Those single disorders show variations of assessment to drive (see Alvarez et al. 2004, p.60f).

Here, it turns out that there are several types of illnesses that do not necessarily result in restrictions at the issue of the driving licence. Further, it can be stated, even because of the variation within the different types, that an individual assessment is definitely needed for clarification.

On closer examination of the psychological part of the assessment, it becomes apparent that it plays a minor part regarding fitness in the Spanish study. 99% of the persons of the sample were “fit” regarding the psychological screening. 8 persons were not fit, 37 fit with restrictions.⁶

Concerning the medication status, Alvarez et al. were able to observe the following in the examined sample: 34,1% are taking some kind of medication. Diseases and medication increase with age. The most frequently consumed medicaments concern cardiovascular system (10,3%), central nervous system (9,3%) and alimentary tract and metabolism (7,3%).

2.1.2.3 Depression and medicated Depression (D-R1.5)

In the relevant studies, depression is consistently depicted as a special and endangering condition for drivers. Therefore, depression and its treatment was included as an object of research in the IMMORTAL project. Schmitt, Wingen, Riedel and Ramaekers (2004), see also Ramaekers (2005) conducted studies in the Netherlands.

Depression as a common mental disorder has known cognitive deficits. But there is little knowledge about the impact of depression on driving ability. Also, antidepressant treatment may affect the performance of the driver.

Schmitt et al. compared actual driving performance of 24 patients with unipolar depressive disorder with and without treatment and 23 patients, who had also unipolar depressive disorder and had been treated with SSRI (Selective Serotonin Reuptake Inhibitors) -type antidepressants⁷ for 6 to 52 weeks, to matched controls. There was also a third group of patients tested, who had received SSRI treatment for less than three weeks⁸.

To assess driving performance, two standardised on road tests were used: the standard deviation of the lateral position (SDLP) and the car following test. Severity of depression was measured by various depression scales, and there were also cognitive tests to assess memory, attention and psychomotor speed.

Schmitt et al. (2004) found that depression is associated with a significant reduction in driving ability (as measured by SDLP). In the case of antidepressant treatment, one could expect that it may counteract a possible negative influence of depression on driving performance. The study showed that successful treatment of depression with a SSRI-type antidepressant alleviated the depressive symptoms and also improved driving ability. But: Performance of the SSRI treated group was still (significantly) worse than that of matched controls.

But one vital point has to be noted: “Specifically in the first weeks of antidepressant treatment before the therapeutic effect is apparent, antidepressants may have no positive or even additional detrimental effects on driving ability” (Ramaekers 2005, p6). This effect may be caused by mild adverse cognitive side effects of SSRI -type antidepressants.

⁶ Authors noted that the psychological examination only included some psycho-motoric tests, it seems that the current cut off scores should be reviewed and a full psychological examination should be carried out.

⁷ Citalopram, Fluoxetine, Paroxetine, sertraline, Venlafaxine, Fluvoxamine

⁸ The data collection for this group is still going on, so we can't report results here.

2.1.2.4 Diabetes Mellitus (D-R1.6)

The study of Rehnova, Weinberger and Kotal (2005) also dealt with a special group of drivers⁹: Persons with diabetes mellitus¹⁰ – a lifelong illness – and the impact of this illness on driving performance. In particular, correlations with fatigue and effects of alcohol were also to be examined. Are there special risk parameters and sensitive areas for patients with diabetes? To answer these questions, both a laboratory psychological assessment (relevant psychic functions¹¹, personality aspects, case history (driver record, but also psychosocial problems, diabetes parameters) and a driver simulator test were conducted.

In the simulator test, three groups of drivers were compared:

- (1) Drivers suffering from diabetes mellitus
- (2) Drivers under the influence of alcohol (BAC 0,05%)
- (3) Control group.

The accident rate of diabetes patients in the simulator driving test was higher in one aspect: Their ability to handle critical situations was considerably weaker than the ability of the controls. There was a tendency towards aggressiveness (it is not explicated if it was the way of driving or verbal comments of the probands) in the persons with diabetes, and a decline of concentration and onset of fatigue at the end of the test.

As could be shown, the most sensitive functions were attention and those functions depending on visual perception. There was also a tendency of slower reaction for patients with diabetes (also: Lower space orientation and imagination). In case of personality assessment, there was a significant impairment: Emotional instability, tendency to fatalism and depression, lower self-control, disadvantageous perception of life reality were given in the whole group of diabetes patients.

There was also a correlation between absolute dose of insulin and general level of driving skills and ability to act in standard risk/critical situations: The higher the dose the lower the score (that means worse quality of driving behaviour). Concerning psychological assessment, it could be shown that no significant impairment of basic psychical function is present (overall), but some cases had serious deterioration (especially concerning cognitive functions, attention and personality).

The alcohol group showed a decline of driving ability in all functions necessary for safe driving. They showed aggressiveness and inappropriate reactions in critical situations and there was an early onset of fatigue, whereas the probands of the diabetes group showed nearly identical performance to that of the control group, with the exception of decline of concentration and onset of fatigue towards the end of the simulator test.

2.1.2.5 Arthritis and elderly drivers (D-R1.7)

Wood, Read, Hockey, Pring and Conway (2005) investigated whether a laboratory test can be used as a valid predictor of driving ability in older arthritic drivers. Arthritis is a common condition in older drivers, the disease causes constraint of movement and aches and thus influences driving performance.

⁹ For detailed description of sample, please see Rehnova et al. (2005, p.10ff).

¹⁰ Persons participating were diabetes patients with relative fitness and compensated DM 1, absence of health complications.

¹¹ As there were: intellect, attention, concentration, visual memory, orientation in space, reaction.

This work is a simulator study (test – retest reliability study). The purpose was to verify if significant training effects exist for the laboratory tests¹², and if driving measures obtained in the simulator reflect driving performance or if they reflect unfamiliarity with simulator testing (at first drive). 30 older arthritic drivers had to do cognitive and physical tasks and were tested on the Leeds driving simulator¹³. A test-retest design was used.

Before analysing data from the new study, the authors looked at comparative experiments – and found similar distribution and results in the same range. Drivers were – according to their results on driving ability and performance - divided into two groups: Safe drivers and risky drivers. The assignment of drivers to one or other group was based on physical performance measures (specific to their arthritis) and cognitive measures (specific to their age-related cognitive deficits). The results show that as well a poor cognitive component of the condition as physical deficits result in risky driving.

The analysis showed that a combination of the physical measure “Rapid Pace Walk” and the cognitive measure “Useful Field of View” was the best combination of tests to predict the ability to drive safely in a driving simulator.

It has to be noted that some of the laboratory tasks and some of the driving simulator tasks generated no reliable results.

2.1.2.6 Learning difficulties and ADHD (D-R1.8)

The next study of the IMMORTAL Project covered assessment of fitness to drive amongst patients with learning difficulties (Bjorkli, Flo, Jenssen, Ryum, Zeiner 2004; Jenssen 2005). Mental status and cognitive skills are important requirements for driving performance. “Yet scientific research has not been able to point out a causal relationship between such parameters and safety of driving for drivers with Learning Difficulties in the categories of Attention Deficit Hyperactivity Disorder (ADHD) and Light mental retardation (LMR)”, Jenssen and Flo (2005) state. The particular objective of this study was to explore the impact of specific dysfunctions of ADHD and LMR on driving performance and accident risk.

For the study about LMR, a double blind experimental design was adopted. The subjects passed through the following examinations: Medical examination, neuropsychological assessment, examination of social functioning, driving simulator test, computer-based test on comprehension of risk and on-road test.

It became apparent that lack of motivation, slow reaction time and severe attention problems were discovered by driving expertise and school assessment, but not by medical and neuropsychological expertise¹⁴. On the other hand, epilepsy (which, unless controlled, is incompatible with driving) was only identified in the medical expertise. These overall findings point out the necessity to incorporate all areas when assessing the persons of this specific target group individually: School, psychology, medicine and real driving behaviour.

¹² If this was the case, this test wouldn't be useful, because results are not reliable in predicting driving performance.

¹³ For details of the sample please see Read et al. (2005). It has to be noted that 57% of the older drivers could not complete the simulated drive due to simulator sickness.

The authors point out that they are not content with the sample size of 30 regarding the generalisation of the conclusions.

¹⁴ Here, the specificity of the chosen tests should be inspected more closely (suited to predict fitness to drive; Bjorkli et al. 2004, p.56).

In case of ADHD, the following was examined: ADHD presents itself in specific behaviour symptoms, e.g. distractibility, concentration problems, hyperactivity and impulsivity. Previous studies¹⁵ have shown an increased accident risk. But it is not clear whether this increased accident risk is due to ADHD symptoms directly, due to confounding factors, or the effect of medication. 17 patients and 28 healthy drivers participated in the study and a double-blind design¹⁶ was used. Effects of medication¹⁷ were also studied.

The analysis indicates that a high score on psychiatric symptoms¹⁸ has an effect on several variables. Patients with higher scores had more variance of speed when driving without active treatment. When patients had medication, their speed variance decreased. The same effect was identified concerning steering wheel angle.

In summary, there are large similarities between the ADHD group and the reference group in this study¹⁹. This is an unsatisfying result insofar as it cannot explain why ADHD drivers have – as studies have shown – accidents more frequently. The data of this study indicate that ADHD patients were quite cautious and very attentive²⁰. Alongside setting variables, it is also assumed that the ADHD sample was not representative. The authors draw the conclusion that ADHD patients cannot and must not be refused as a rule. Rather, an individual assessment of the preconditions is advised here, too. Medication seems to have an effect towards safer driving (see above, e.g. reduction of speed variance).

2.1.3 Synthesis of results concerning ageing, illness and disease (D-R1.9)

The aim of this task was to link the results of the various tasks in work package R1 “Ageing, mental illness and medical diseases” and to provide recommendations for further action (Alvarez 2005). The report focuses on requirements for acquiring a driving licence and the assessment of chronic impairment of fitness to drive.

There should be special focus on regulating conditions with a high prevalence (even if they are associated with low to moderate risk) in order to reduce number of crashes. Specific attention should be paid to: Neurological disorders, psychiatric disorders, drug and alcohol related problems, and diabetes mellitus. Furthermore, there should be focus on visual deficiencies, mobility disorders and cardiovascular deficiencies, although they have low risk, but high prevalence. At last, attention should be paid to specific disorders, so as sleep apnoe. Information about these issues should be widely available.

Further on Alvarez emphasises the need for further research (in the case of e.g. assessment across countries), information to drivers regarding risks, consensus of pre-requisites of safe driving, cut off scores, and clear clinical criteria. He emphasises that assessment of fitness to drive should be individualized taking into account the existence of compensation strategies, because the existence of a disease in a driver does not directly imply his/her incapacity to drive.

¹⁵ See e.g. Vaa (2003): relative risk for ADHD 1,54 (based on 11 results)

¹⁶ For details concerning design, medication, please see Bjorkli et al. (2004).

¹⁷ These are amphetamine, methylphenidate

¹⁸ SCL 90 contains 90 items for self report of psychological/psychiatric symptom patterns

¹⁹ In some driving parameters ADHD patients of this sample showed slightly even better skills!

²⁰ As Bjorkli et al. (2004, p. 42) point out: “yet the impression during clinical screening was that the group [of ADHD drivers] was well functioning and high level of coping their symptoms.[...] The SCL-Score was higher than the control group, but compared to distributions in Norwegian and American samples, the scores were within normal range[...]”

2.2 ACUTE IMPAIRMENTS

The next part of the IMMORTAL project covered predominantly aspects of acute impairment – but we have in mind that there are many interactions with the research issues mentioned above.

2.2.1 Literature review concerning acute impairment (D-R 4.1)

The starting point for this field of research was a literature review concerning impairment and accident risk for alcohol, drugs and medicines (Braun and Christ, 2002), to capture the state of the art and important recommendations from previous studies concerning these issues. This survey dealt not only with current international publications of the different topics, but also with the results of the preceding EU projects CERTIFIED and ROSITA.

The report provides results and recommendations for the following areas (see next section):

Epidemiological studies

These studies aim at gaining information about the prevalence of impaired driving on the basis of three different approaches: Descriptive studies by studying a representative sample according to defined criteria, responsibility analysis studies and studies with control groups.

In Europe, many prevalence studies have been carried out, but the lack of consistent standards make comparisons between them difficult.²¹ Therefore, it is difficult to gauge the true extent of the problem. A high refusal rate, for example, can strongly obscure the number of the actually impaired drivers.

With regard to the substances, alcohol predominates, followed by medicines (above all benzodiazepines) and illegal drugs, but there are variations in the proportions depending on the focus of the studies: Roadside surveys, injured drivers or fatalities.

Risk assessment

However, epidemiological studies are the basis for the risk assessment of the different substances - hence the necessity of conducting them with standards as high as possible and with controlled general conditions. In the project CERTIFIED (Tunbridge et al., 2000), the following risk classification results were found:

High risk:	Alcohol, benzodiazepines, cannabis with alcohol
High-moderate risk:	Cocaine
Moderate risk:	Cannabis, amphetamines
Low-moderate risk:	Opiates, methadone, antihistamines
Low risk:	Antidepressants

The extended approach, as derived from CERTIFIED, (cited in Braun und Christ, 2002) took into account A: impairment effects, B: prevalence in population and C: association with accidents that includes hazard, population exposure and likelihood of outcome, should also be mentioned here. The outcome of this is the following prioritisation:

- High priority for alcohol, benzodiazepines
- Medium priority for amphetamines, opiates, cocaine and cannabis; and
- Low priority for methadone, antihistamines and antidepressants.

²¹concerning the issue of lacking standards in the survey, see Braun and Christ (2002, p. 9ff and p. 82)

Legislation

is quite different all over Europe. Whereas legislation concerning alcohol is well established in the individual countries with respective measures and sanctions (even if further harmonisation certainly ought to be aspired to here), in the field of drugs, not only great differences, but also great deficits concerning the legislation exist. With regard to prosecution of drugged driving, most states require proof of impairment due to the use of illegal drugs.

Identification of impairment

Many international studies and the works for ROSITA have shown that drugs can produce very diverse effects. The effects of alcohol - especially on driving performance – are particularly well investigated.

These effects have to be known, but it is furthermore vital to be acquainted with the interactions of substances, because drivers very often consume several drugs simultaneously. The effects of cannabis manifest themselves, among other things, in a slow manner of driving and impaired attention, whereas the effects of ecstasy are e.g. risky driving and speeding.²²

If co-consumption occurs, the following effects are to be expected (Möller 1998, in Braun and Christ 2002):

Alcohol and benzodiazepines:	Over-additive depressant effect
Alcohol and opiates:	Additive depressant effect
Alcohol and cocaine:	Weakening or intensifying effect (depending on the effect phase)
Amphetamines and cocaine:	Additive inciting effect

From this presentation, it becomes apparent that the police require intensive training to be able not only to recognise the different types of drugs and their effects, but also to identify the interactions (suspicion, presentation of evidence).

Methods to assess impairment

Here, different approaches are introduced:

(a) Roadside evaluation procedures

The implementation of drug recognition programmes should be included in the police practice (depending on legal status)

(b) Drug screening methods

There exist a number of pretest possibilities, mainly based on urine analysis (proof that substances have actually been taken, but no determination of acute impairment). Concerning acute impairment, cues are only available through blood and saliva analysis.

According to ROSITA project, urine tests are validated, but there are some undecided points concerning implementation and legislation. Devices for testing saliva and sweat are still in development.

(c) Medical examination

The general physical condition is not very meaningful regarding a drug influenced state. To identify signs of drug impairment special education and training of the physicians is required. Therefore only specialists, like neurologist or psychiatrist, are able to do this examination as stated by Battista et al. (1999), cited in Braun and Christ (2002).²³

²² for details please see Braun and Christ 2002, p.38 ff

²³ Medical Doctors who are trained to identify signs of drug use and impairment.

Driver assessment and Rehabilitation

Traffic psychological diagnostics and rehabilitation can clearly lower the recidivism rate and are therefore very sensible measures. However, a specific legal framework is necessary for this purpose.

On the basis of the literature review, numerous recommendations were drafted at the end (see Chapter 3). An attempt was made to consider at least some of these recommendations in the subsequent IMMORTAL research studies.

2.2.2 IMMORTAL Research concerning prevalence and forms of acute impairment

2.2.2.1 Prevalence of drug driving and relative risk estimations (D-R4.2)

The prevalence of drug driving was to be determined in three countries: In the Netherlands, in Norway and in the United Kingdom (Assum et al., 2005). Further, the question was to be resolved whether drivers using one or more of eight defined drug groups have a higher accident risk than drivers not using these drugs. It was intended - if possible - to quantify this risk.

In the Netherlands, additionally, an observational method for detection of drug impaired drivers was tested. The predictive value of this method was satisfactory (83%), but the sensitivity was rather low (61%). Therefore, improvement is necessary. The design used in the Netherlands was a case control study to be able to calculate the risk²⁴; 3799 drivers were stopped and tested.

Among the general driving population, cannabis, benzodiazepines and alcohol were the prevailing substances. Drug abuse was primarily found in male drivers aged 18-24. 17,5% were positive for illegal drugs. Psychoactive prescription drugs were strongly concentrated in female drivers aged 50 and older: 11,3% were positive.

35% of the people who had serious injuries were tested positive for a drug or alcohol. Here, it has to be especially emphasised that drug free BAC levels $\geq 1,3\text{g/l}$, drug/alcohol combinations at BAC levels $\geq 0,8\text{g/l}$ and drug/drug were particularly represented (13%, 8%, 7% of the serious injuries), and therefore showed especially high odds ratios.²⁵ The authors assume that alcohol and/or illegal drugs account for even more than 35% of serious road injuries in the Tilburg police district.

A case control study was also conducted in Norway. This study met severe practical problems in collecting data from the general driving population, and especially from injured drivers. 410 drivers were tested, out of these one was positive for benzodiazepines, two for cannabis and one for opiates. 28 persons refused to give a saliva specimen. No driver was positive for alcohol (BAC limit in Norway: 0,2 g/l).

As the total number of cases and controls was small, it was difficult to compute odds ratios for any of the priori defined drugs. However, data makes it nonetheless quite plain that accident risk increases severely (exception: Cannabis only). But no statement was possible

²⁴ A random roadside sample versus a hospital sample.

²⁵ 8% of drivers out of general driving population account for 35% of all serious injuries.

about amphetamines, ecstasy, cocaine und alcohol alone, because these substances were not to be found within the control group.

In the study in UK, 1312 drivers were stopped and tested at the roadside (Glasgow, Scotland). 40 drivers refused to participate. Ecstasy and cannabis were found to be the drugs with the highest prevalence.²⁶ Due to technical and procedural problems, analysis of alcohol was not included. The study in UK was limited to calculate the prevalence of drug drivers in the general driving population because the medical ethics committees in Scotland did not allow to take body fluid samples from injured drivers.

In these three studies, problems due to national differences and practical problems became apparent. Therefore, it is difficult to compare the results. However, the higher prevalence of psychoactive drugs in The Netherlands may be explained by the case that use of cannabis is not a criminal offence in The Netherlands, and blood and urine are more sensitive to detect cannabis and benzodiazepines than oral fluids.

2.2.2.2 Drugs in Traffic Accidents (D-R4.3)

In the context of a qualitative analysis, Bernhoft (2005c) dealt with the contribution of drugs to traffic accidents as well as the characteristics and attitudes of drug positive, accident involved drivers. For data collection, drivers who had been injured in traffic accidents were interviewed and in order to detect impairment, saliva and/or blood analysis was conducted²⁷.

333 patients were included in the study. 26 persons self-reported drug use. These persons had taken a range of medicinal drugs, but of the illicit drugs, only cannabis was reported by this group. Drug consumption was proven in 26 more cases, 23 of which were used for further analyses. Regarding medicinal drugs, benzodiazepines predominated; with illegal drugs, it was primarily cannabis, clearly less common were amphetamines.

15 persons were positive for one drug, in four of these cases alcohol had been consumed (over legal limit in Denmark: 0.5 g/l). The other 8 patients were found positive for two drugs, 5 (of these 8) persons had additionally consumed alcohol and were above the legal limit.

23 interviews were carried out with drivers who were proved positive or had reported drug use were analysed. In 6 of 12 interviews with drug positive drivers it is assumed that their impairment contributed to the accident.

Concerning characteristics of drug positive drivers, it can be stated that they are mostly male, the first group of young people are well functioning, they are in training or working, they are non academics and they used illicit drugs. The other group was middle aged or older, early retired, used prescribed drugs and there was former alcohol dependency. Most of the interviewees used a seatbelt or crash helmet.

²⁶ The collection method used the "Omnisal" device (obtained from Cozart Bio Science) to collect 1 ml oral fluid (Assum et al. 2005, p.70).

²⁷ For description of sample please see Bernhoft (2005c). Analysis of specimen was done by Screening (Cozart Micro plate EIA kit) and GC-MS and LC-MS/MS. The problematic thing was that in the saliva screening, false positive judgements resulted frequently.

Concerning knowledge about drugs and attitudes, the interviews showed the following results: Young persons have knowledge from school, they don't mix drugs and alcohol, but they think that alcohol is worse than drugs when driving. Middle aged and older persons are not aware of enhanced risk and had some knowledge. They were very concerned about their medicine use, took prescribed medicines, but some were also impaired by alcohol.

2.2.2.3 MDMA and Alcohol (D-R 4.4)

The extensive analysis by Ramaekers et al. (2004), see also Ramaekers and Kuypers (2005) deals with acute impairment by ecstasy and co-consumption of alcohol.

The first aim of the study was to investigate acute effects of MDMA - ecstasy, one of the most widely-used drugs – and methylphenidate (amphetamine) on actual driving performance and cognition (i.e. visuospatial attention and memory), and the effects of MDMA on driving and cognition in the withdrawal phase. It was a double-blind, placebo controlled, 3 way cross-over study, 18 recreational MDMA users (9 male and 9 female, aged 21 – 39 years) participated.²⁸

1.5 to 2.5 hours and 3 to 5 hours after drug consumption, cognitive and driving tests were carried through. On the following day (24 hours later), there was a repetition of the tests. Actual on-the-road tests measured road tracking and car following (specified variables in the test).

Results showed that MDMA and methylphenidate significantly decreased standard deviation of lateral position (SDLP) relative to placebo while driving. SDLP was not affected by treatment or period during withdrawal 24 hours later. Additionally, MDMA intoxication decreased performance in the car following test in terms of over-reaction of the subjects' response to speed decelerations of the leading vehicle. In the cognitive tests (spatial and verbal memory tasks), there were very important results:

- A single dose of MDMA of 75 mg produced impaired performance in spatial tasks and verbal memory tasks

The authors state that this result indicates a reduction in driver's situation awareness or spatial orientation. In summary, the data indicate that MDMA seems to stimulate such properties which may improve driving performance in some aspects, but also cause impairments in others.

The second study of Ramaekers and Kuypers (Ramaekers et al., 2004) covered interaction effects of MDMA and alcohol on actual driving, psychomotor performance and risk taking behaviour. The starting point of this study was the evidence that MDMA is frequently taken in combination with other recreational drugs, such as alcohol. The effects on performance are unclear.

18 recreational users of MDMA were tested within a double-blind, placebo-controlled, 6-way cross over study. The treatments consisted of MDMA 0, 75 and 100 mg with and without alcohol (achieved blood alcohol concentration 0,05 g/dl during driving). The laboratory test of psychomotor function and risk taking behaviour were carried out 1.5 to 2.25 hours after intake of MDMA. The actual driving test was done 3 to 5 hours after drug consumption.

²⁸ For details and implementation of experiments, representativeness of sample, please see Ramaekers et al. (2004).

The results showed the following:

- MDMA improved performance in Road tracking test
- MDMA 100 mg stimulating effect was more prominent with alcohol
- MDMA 75 mg stimulating effect did not change with co-consumption of alcohol.
- MDMA did not affect performance in Car following Test
- MDMA did not affect performance of measured psychomotor function
- MDMA did not affect results in the test measuring risk taking behaviour.
- Alcohol alone increased SDLP, brake reaction time and tracking performance.
- Alcohol decreased inhibitory control (Stop signal task)
- Alcohol alone increased inhibitory control in a gambling paradigm of impulsivity.

In summary, the authors state that MDMA is a stimulating drug that may facilitate certain aspects of the driving task, even when combined with a low dose of alcohol. But this compensation was limited to a single parameter and was never sufficient to fully overcome alcohol impairment in all driver related tasks.

2.2.2.4 Cold virus and medication (D-R 4.4)

Acute impairment by cold and cold medicines was studied by Wood, Hockey, Jamson, Jameson and Birch (Ramaekers et al., 2004). Common cold infections are widespread, and symptoms can last one day to two weeks. Several studies have shown impairment of attention and psychomotor performance due to infection. Many cold sufferers also take some kind of medicine to relieve their symptoms.

In a single blind 2x2 between-subjects study, 96 participants were tested. Persons who had a common cold were compared to baseline and with and without medication. Medication was typical: Diphenhydramine hydrochloride 25 mg., Paracetamol 1000mg and Pseudoephedrine hydrochloride 45 mg. The laboratory tests took place 0,25 to 1 hour after intake of placebo or medication.

After 1,25 to 2,5 hours, the persons were tested using the Leeds driving simulator. The results concerning cognitive tests show similarity to previous results: Persons suffering with a cold virus had slower reaction times and impaired visual search abilities. They reported increased subjective fatigue and had higher depression scores. Medication did not affect performance on the cognitive task and subjective fatigue was not higher.

Results from the simulator were mixed:

- Lateral control and secondary tasks were often impaired by medication;
- Some results suggest that cold sufferers with medication could perform well in longitudinal control;
- Drivers seemed to compensate the effects of medication by modifying driving style;
- There was a decreased performance in lateral stability;
- Performance on awareness tasks was poor.

2.2.3 Synthesis of results concerning alcohol, drugs and medicines (D-R 4.6)

Bernhoft (2005d) summarises the results from work-package R 4 concerning alcohol, drugs and medicines in traffic. This field of work also used diverse techniques to handle the issue of alcohol, drugs and medicines in traffic:

- Case control studies (prevalence of drug driving in The Netherlands, Norway and UK),
- Qualitative interviews (drug driving in Denmark) and
- Experiments were conducted (MDMA, alcohol, cold and cold medication).
- The starting point was a literature review (summary see chapter 2.2.1).

The following acute impairments were covered by the studies:

- In general: Prevalence of drug driving
- In particular: MDMA, MDMA and alcohol, cold and cold medication.

In the synopsis of the results of this area, the following outcomes have to be especially emphasised:

- In the prevalence studies, the numbers of detected drivers impaired by drugs vary considerably²⁹.
- The substances identified most frequently were cannabis, benzodiazepines, and alcohol. Combinations of drugs were also determined in all three studies.
- Serious road injuries were especially associated with: BAC $\geq 1,3\text{g/l}$; BAC $\geq 0,8\text{g/l}$ combined with drugs; and combinations of two or more illegal drugs.
- Significant odds ratios were computed also for BAC between 0.5 and 0.8g/l, BAC between 0.8 and 1.3g/l, and for BAC below 0.8g/l in combination with drugs, as well as for morphine/heroine alone.
- Benzodiazepine users (only) showed a slightly increased injury risk (it is assumed that the intake is based on doctor's prescription).
- No significantly increased injury risk was associated with the use of cannabis, amphetamine, ecstasy, cocaine, codeine or tricyclic antidepressants, when taken alone. Methadone alone was not found in the samples.
- Concerning the field trial of an observational detection method, this approach showed a low sensitivity (61%). Based on observed signs of impairment alone, it would have been 25%. As the drivers were willing to report use of psychoactive drugs, the sensitivity increased.
- Information on drugs and effects of drugs should be distributed in schools, driving lessons and by general practitioners.
- Single doses of MDMA affect spatial memory and recall of words, but enhance road tracking performance.³⁰
- Performance compensation after combined MDMA/alcohol administration was limited to a single driving parameter and was never sufficient to fully overcome alcohol impairment in all driver tasks.
- The study concerning driver performance and suffering from cold and having medication showed that compensation to some extent is possible (extra effort decreases performance in other driving aspects), but medication impairs road tracking control.

2.3 RESULTS OF IMMORTAL POLICY WORKPACKAGE

The last part of the IMMORTAL project covered aspects of impairment that were not part of the IMMORTAL research projects, but were of great interest for policy makers.

²⁹ Reasons for these serious differences include: varying experimental designs, high refusal rate, frameworks not sufficiently controlled or standardised in the different countries.

³⁰ But this does not automatically mean safer driving.

2.3.1 Cost-benefit analysis of potential impairment countermeasures

This study (Vlakfeld, Wesemann, Devillers, Elvik and Veisten 2005, Vlakveld 2005) dealt with measures that are promising against chronic and acute impairment of drivers. In order to decide on possible policy options, it is necessary to have an insight into the socio-economic effects of countermeasures, Vlakveld (2005) states. This was carried out by means of Cost-Benefit Analysis (CBA). Advantages and disadvantages of a measure are expressed in terms of costs and benefits (wherever in monetary terms). Even side effects are considered.

As Vlakfeld points out, the size of the relative risk associated with a certain impairment alone is not the only criterion for implementing a countermeasure. Additionally important are prevalence of impairment, effectiveness of measure, feasibility of the measure and public support for the measure.

The following measures were checked using the criteria mentioned above:

- Mandatory eyesight testing (three specific types of tests)
- Increased random roadside breath testing, combined with a zero BAC limit for young drivers
- Installation of alcohol lock for drivers with an alcohol problem.

4 countries were selected for CBA: Norway, the Netherlands, Spain and the Czech Republic.

And these are the results of CBA³¹:

- Mandatory eyesight testing (three specific types of tests): the socio-economic yield in general is negative (mainly because of small safety benefits and large loss of welfare due to withdrawal of driving licence)
- Increased random roadside breath testing, combined with a zero BAC limit for young drivers and installation of alcohol lock for drivers with an alcohol problem seem to be promising, because the countermeasures aim at prevention of drunk driving by means of deterrence.

2.3.2 Policy Workshop on Cost Benefit Analysis (D-P4.4)

Wesemann, Vlakveld and Devillers (2005) report about the workshop on CBA. The workshop intended to present and discuss the results of CBA, described in P2 (see section above, Vlakveld et al. 2005). The comments from this workshop were incorporated in P2.

2.3.3 Policy Workshop on Vision and Perception Deficit (D-P4.1)

Fjerdingen, Jenssen, Lervag, Rijn, Vaa, Kooijman, Bjerre and Arnljot (2004) covered in the workshop vision and perceptual deficiencies as a risk factor in traffic safety. Vision is the most important source of information while driving a car.

One finding of the workshop is that data on prevalence of contrast sensitivity problems, glare/straylight and Useful Field of View are scarce, also for the population in general. Until now, scientific research has failed to prove causal relationship between visual parameters and safe driving. The authors assume that persons with less severe visual defects use compensatory mechanisms, so there is no impact on accidents (see e.g. simulator studies, on

³¹ For critical considerations concerning input see Vlakveld et al. (2005).

road trials and interviews). Recently developed simulator tests and computer based tests seem to be promising as screening devices.

2.3.4 Policy Workshop on Fatigue (D-P4.2)

A second, very essential field is impairment by fatigue and sleepiness while driving. Sagberg, Jackson, Krüger, Muzet and Williams (2004) dealt with this issue also in an IMMORTAL Workshop.

Falling asleep at the wheel is one of the most important single causes of road crashes, as Sagberg (2005a) points out. More than 10% of drivers admit to having fallen asleep while driving. About 4 to 5% of these cases result in crashes including personal injury or property damage. Additionally, there is a unknown number of crashes due to drivers who are fatigued (but had not fallen asleep). Looking at this group of drivers, young males are over represented. Long distance truck drivers are also at high risk.

In summary: Between 5 and 15% of all crashes with personal injuries are related to fatigue. There is a high average severity of the crashes, and most of the crashes that are fatigue related occur during daytime.³² For daytime sleepiness, 3 general causative factors come into consideration: Too little sleep, too much wakefulness and circadian rhythm. Some drivers are excessively sleepy because of some sleep disorders. These are: Obstructive sleep apnoea/hypopnoea syndrome, narcolepsy³³, and sleep problems (difficulties to fall sleep, waking up early). Therefore, sleep disorders have potential implications for licensing procedures, Sagberg points out.

Most drivers feel tired before falling asleep, they think they can stay awake by effort and they do (wrong) things to stay awake. Sagberg et al. (2004) therefore think that countermeasures relying only on drivers' actions will have limited effects. The *only* effective countermeasure is sleep, preferably a nap between 15 and 30 minutes.

Several driver warning systems have been evaluated recently. These methods focus on raising driver's awareness of early signs of fatigue or sleepiness, or on warning systems to detect such signs. However, it should be noted that many such devices respond to the signs of falling asleep that occur too late in the process (e.g. head nodding, eyes closing), by which time the driver may already have had an accident. Studies dealing with environmental measures to decrease monotony showed that road lighting seemed to have little effect. Further research is needed in this aspect.

There is ongoing research in other EU projects, e.g. AWAKE (see www.awake-eu.org). Meaningful management of fatigue could involve:

- Educational programmes for companies;
- Including fatigue management in company policy (work organisation: Adequate shiftwork schedules, trip planning);
- Legislation concerning occupational health and safety and hours of service regulations;
- Public information campaigns.

³² Sagberg (2005a) points out that the risk at night is higher, but there is less traffic, nevertheless night time crashes are more severe.

³³ Obstructive sleep apnoea affects 4 to 5% of middle aged men (breathing stops during sleep, quality of sleep is poor and the result is daytime sleepiness).

Narcolepsy is less prevalent but more serious, this group is clearly over-involved in crashes (Sagberg 2005a).

2.3.5 Policy workshop on Licensing (D-P4.3)

The Licensing Policy Workshop in the EU dealt with the use and usability of CD 91/439/CEE on driving licensing (Alvarez, Gomez, Fierro 2005). In the Council directive, minimum standards of physical and mental fitness for driving are established. The aim of the workshop was to analyse medical aspects of fitness to drive and propose recommendations (see next chapter).

2.3.6 Policy Synthesis Report (D-P8)

Lervag, Jenssen and Fjerdingen (2005) summarize the results of the policy workshop package of IMMORTAL project. It is stated that in Europe diverse standards exist and thus harmonisation has to be the goal. For this purpose, the “Best Practise Model” for licensing is proposed, in which the processes of driver assessment and driver improvement are to be included. Other parts of the process to be considered are licence renewal, licence withdrawal and re-licensing after delinquency. If there is suspicion of impairment, administration should have the possibility to order medical and psychological assessment before licensing. It is further recommended that not every impairment should automatically lead to licence withdrawal.

Concerning driver fatigue, a package of measures should be implemented. Periodical standardised checks of fitness to drive for all drivers should be standardised. The authors also recommend that more and new research is needed concerning driver impairment in order to develop and evaluate the best methods for dealing with impairment. Measures to prevent drunk driving as assessed in CBA (random breath tests roadside, alcohol lock) also fall within this field.

The authors conclude that New Advanced Driver Assistance Systems (ADAS) and intelligent road infrastructure may facilitate safer driving for impaired drivers in the future.

3. RECOMMENDATIONS CONCERNING ACUTE AND CHRONIC IMPAIRMENT IN DRIVERS

The recommendations regarding main areas of application and delineation of possible further activities that result directly from the IMMORTAL research work can be divided into two areas:

- Recommendations concerning measures for legislation and/or policy makers;
- Recommendations that apply to further research and therefore allow for e.g. better comparability of data, further evaluations, and testing of more efficient methods.

Research of IMMORTAL should provide evidence to propose intervention methods for driver impairment. The results of research should support future development of European Policy governing driver impairment legislation and identify where research is still missing.

3.1 RECOMMENDATIONS FOR POLICY

The following recommendations are based on the recommendations of the individual tasks. The description follows at first the order of the deliverables and then gives a summary where the conclusions of the synthesis reports are incorporated.

Medical conditions and driving

Diseases included in the Annex III of the Council Directive on the Driving Licence (CD 91/439/EEC) show a relative risk of accident involvement of 1,33 (weighted average across all categories). On the basis of the results of the case control study on driver health and crash involvement, the following medical conditions require special attention: Sleep related problems, depression and other mental disorders, diabetes type 2, impaired vision (particularly myopia), history of myocardial infarction and stroke. In addition, a measure for practitioners is recommended: Guidelines should specify the importance of advising patients about possible risks associated with the conditions mentioned above.

The study on assessment of fitness to drive (Alvarez et al., 2004) clearly showed that such checks, conducted regularly, are reasonable, because 17% of the drivers is assessed as 'fit with restrictions'. Less than 1% were assessed as not fit. With older drivers (especially those aged 64 years or over), the percentage of persons assessed as fit with restrictions increased to 32%. In summary, it can be stated that mental disorders, depression, cardiac diseases, and diabetes have to be considered when assessing drivers.

The authors cite that in 2002 a beginning was made to edit guidelines for evaluating fitness to drive concerning medical conditions. Courses are held every year to update medical issues on driving. This constitutes a very vital step towards a harmonisation of the assessments (unambiguousness of the criteria, use of the same criteria at the assessment, integration of new findings, plausibility and homogeneity).

General decision criteria for all agencies conducting these assessments, namely both for health professionals and psychologists, are desirable not only at national, but also at international level. Harmonisation and plausibility of the decisions has to be the aim.

The screening instruments, their validation and the use of adequate standards both in the field of medicine and psychology play a vital part in this context. For validation, robust evidence should be used (e.g. official data concerning accidents, as a positive example, see the validation studies on Driver Improvement in Germany), because subjective statements clearly tend to be biased.

Spain has a unique position concerning the assessment of drivers: There is no other country in the EU, where regular examinations to determine the fitness to drive are obligatory. Therefore statistical data from Spain give detailed information about “fit”, “fit with restriction” and “not fit” drivers. The results from Spain cannot directly be copied to other European countries, therefore it would be desirable to determine the percentage of rejections and restrictions in the other EU countries.

Exchange of information between countries concerning assessment criteria, criteria for different regulations of restrictions, and experiences in this regard from different countries could give vital support to the development and harmonisation throughout Europe.

As the experience with medical-psychological assessment in Austria demonstrates, psychological variables like response rate, gaining of overview, or response certainty are of vital importance. Also, regarding personality, negative changes concerning the willingness to adapt to the traffic can occur (e.g. high willingness to take risks, lack of norm consciousness, lack of self-control). Therefore, greater importance should be given particularly to the psychological aspect of the assessment. In this area, substantial and confirmed empirical data are available and there are specific tests that make an economical survey of the individual situation possible (Alvarez et al., 2005, Session 2/8.3, p. 27 and Annex VIII, Bukasa et al. 2003, Bukasa and Piringer 2001, Bukasa 1999).

The assessment of cognitive and physical functioning of medically impaired drivers is also supported by the results of the study on older drivers and arthritis. Also the studies on diabetes and depression have shown that it is necessary to carry out an individual assessment of fitness to drive.

From the study on learning difficulties and driving performance, the following conclusions result: A general assessment of this group is on no account possible, rather, a decision should be based on individual medical-psychological assessment (multidisciplinary approach). The assessment should consider personal weaknesses and strengths, but also compensation abilities. In addition to the medical and neuropsychological evaluation a test on a driving simulator and an on-road assessment should be conducted. It is also vital to clarify the motivation for driving at an early stage.

Concerning ADHD patients, the following can be recommended:

- Individual licensing procedures to identify severe functional disorders. Because there is no indication that medication in prescribed doses has negative effects on driving performance, individual proof is the only procedure for a decision on licensing. In some cases medication might be a prerequisite for driving (see above).
- For ADHD patients who have developed drug abuse, severe criminal records, or psychiatric disorders, guidelines concerning licensing should be generated.
- Medical examination because of medication with CNS-active drugs should be discussed EU-wide – and harmonisation should be aimed at.

- In the case of medication, a specialist should be consulted every year (similar regulations as for epilepsy and narcolepsy).

Key issues regarding enforcement to combat drug driving

On the basis of the literature reviews, the following recommendations arise:

- Documentation of impairment is required (standardisation, check-list). Further development of psychometric roadside tests is necessary.
- Test devices should be very sensitive and easy to administer.
- Roadside tests remain preliminary tests and the results must be confirmed in order to be admissible evidence in court. Since a summary of pharmacologically and toxicologically justified threshold values is currently not possible because of the differences in breakdown of the various drugs and medicines, for the time being, one has to rely on exact statements of the police, on exact description of the subject's behaviour, and medical examinations as well as confirming chemical and toxicological analyses for criminal prosecutions.

For the improvement of methods, it is suggested to establish legal conditions that allow to secure 2 to 3 bodily fluids that are easily available (saliva, blood, or urine) to permit systematic pharmacological examinations and to gain the necessary experience.³⁴³⁵

- Exchange of methods and experiences in detection of police enforcement between countries should be encouraged.
- Police officers need training in personal contact with intoxicated motorists.
- Accreditation and homologisation on EU level is an important target.
- Concerning medical examinations, there is need for training of physicians in neurological and psychopathological examination for the detection of influence of drugs and medicines. Proceedings and documentation at the clinical and neurological examination need standardisation.
- The experiences in Germany and Austria with regard to the validation of traffic-psychological examinations suggest that case-specific assessment can lower the recidivism risk by up to 50%. These results suggest that a similar approach could be beneficial in other countries.

Key issues regarding legislation

Concerning prevalence of DUI, European policy should generally consider the following aspects:

- Allow random breath testing for alcohol in all member countries;
- Testing all killed drivers of motor vehicles for alcohol and drugs;
- Increased enforcement of drinking-and-driving rules;
- Promote alcohol ignition interlocks, e.g. in public transport or in heavy vehicles;
- Prosecution and rehabilitation of drivers with high alcohol concentrations and drivers having used alcohol/drug or drug/drug combinations.

On the basis of the Dutch case control study, it can be stated that in order to be effective, road safety policy should mainly target high BAC-levels (>1.3 g/l), alcohol/drug and drug/drug combinations. About 30% of serious injuries in the Tilburg police district were associated with these three categories of self-administered psychoactive substances.

³⁴ Bernhoft (2005c), however, also points out that screening kits can only detect a few different drugs. The used saliva screening device in the IMMORTAL study in Denmark seemed to result in many false positives. Improvement is urgently needed.

³⁵ The cost and time implications on the police service need to be considered here.

The effect of alcohol/drug and drug/drug combinations on road safety proved to be so detrimental that effective legislation and enforcement seem urgently needed. For most alcohol/drug and drug/drug combinations, a legal zero-tolerance limit for each of the substances involved seems to be appropriate.

For illegal drugs that are taken alone, and with the exception of heroin, zero-tolerance legislation would, seem to produce very high costs and few road safety benefits. This can be illustrated by taking cannabis use as an example: 87% of all cannabis users among the Tilburg control sample were positive for cannabis alone, which did not result in a significantly increased injury risk. In order to establish realistic, risk-related legal limits for single-used illegal drugs, case-control studies on an EU-wide scale are needed.

For most medicinal drugs, like antidepressants, benzodiazepines, codeine, barbiturates and even morphine, therapeutic levels may be adequate as legal limits, at least for the time being.

Information

Young people at school get already some information about drugs and addiction. But the link to driving is missing. Based on investigation of drugged driving and accidents in Denmark, it was identified that drivers need more information about drugs and driving. Generally, young people think that the effect of alcohol on driving constitutes a higher risk than drugs. But there should also be given more emphasis to inform young people about the consequences on road safety (and on health) of using cannabis or amphetamines or being addicted to them. This information should be given at school or during driving lessons. Also their medical practitioner may inform them, when they need prescribed medicines.

There exist already some road safety education measures dealing with this topic. Examples of such measures can be found in the EU Project ROSE 25: “Inventory and Compiling of a European Good Practice Guide on Road Safety Education targeted at Young people” (Weber et al., 2005).

Some older people are not familiar with the effects of mixed use of medicines and alcohol. The practitioner should identify possible alcohol addiction or abuse and find ways of starting rehabilitation.

Concerning chronic diseases, the practitioners should provide their patients with information about dosages, changes in health condition, and prevention of incorrect medication (provision of special medicine boxes).

Importance of information was also a consequence of the MDMA study. The authors recommend that users of MDMA should be informed on the drugs’ potential to selectively affect cognitive function and performance at relevant aspects of the driving task.

Results concerning cold and medication demonstrates that the addition of pseudoephedrine, present in common cold remedies to counteract drowsiness and somnolence, does not fully compensate for the sedative potential of diphenhydramine (even at the lowest therapeutic dose). Because drivers may feel better as a result of the medication, but are less aware of the impairing effect on their driving, driving should always be contraindicated in drivers taking diphenhydramine. Relevant information should be made available for practitioners so that they can inform their patients in a selective way.

Physical deficiencies and driving

In the context of licensing procedures, the survey of specific diseases linked with sleepiness is of special importance.

The Licensing Policy Workshop dealt with the use and usability of CD 91/439/EEC on driving licensing and led to the following recommendations:

- Greater standardisation among EU member states (and adoption for new members) concerning medical criteria, evaluation procedures and intervals of evaluation;
- Detailed research on effectiveness of driving restrictions;
- Definition of criteria for refusing and definition of criteria for re-granting driving licence;
- Updating and revising of Annex III of CD91/439/EEC as the new CD is written;
- Key priority for standardising assessment of older drivers;
- Development and improvement of a licence information system in EU member states;
- On national level: Evaluation of effectiveness of assessment system (for fitness to drive);
- Information exchange between countries concerning criteria and procedures.

Concerning vision and vision impairment, the consequences and recommendations are:

- Recent studies have shown that concerning some visual impairments compensation is possible, but people have to be informed and trained for it.
- The rules for vision related driving licensing requirements need to be harmonised. As research evidence is not sufficiently clear, specific recommendations cannot be warranted.

On the basis of research on fatigue and sleepiness, it is stated that:

- Countermeasures should address the fact that many drivers are not motivated to stop driving when fatigued;
- Drivers should be warned of the dangers of driving while tired;
- Further research on in-car systems is needed;
- The use of profiled edgelines and centrelines ("rumble strips") should be increased;
- Implementation of fatigue management in Occupational Health and Safety legislation is necessary;
- Serious consequences should be prevented by:
 - Forgiving road system;
 - Car occupant protection systems.

The recommendations of the Cost Benefit Analysis are:

- The withdrawing of driving licence due to poor eye sight leads to large negative socio-economic effects. Based on treatment, countermeasures will lead to a more positive socio-economic yield. Moreover, such a measure will not deter people from seeking medical treatment (to get better glasses to conform to the criteria of visual acuity).

3.1.1 Summary of policy recommendations

Licensing:

- Proper information and awareness regarding the increased risk of drivers with medical conditions listed in Annex III of CD 91/439 CEE should be made widely available.

- The increased risk shown by drivers with certain medical conditions should serve for a further and more strict licensing policy within the EU. A balance should be aimed at between road safety and mobility.
- Concerning implications for EU regulations, some group of diseases stand out as candidates for specific attention, because of having both a high prevalence and a significantly elevated risk:
 - Neurological disorders;
 - Psychiatric disorders;
 - Drug and alcohol related disorders;
 - Diabetes mellitus.
- Among specific disorders sleep apnoea stands out as a candidate for specific attention.
- The standards are different across European countries, efforts should be made to harmonise the (standard of the) process of licensing in Europe by proposing a “best practice model” for licensing. This should include the process of driver assessment and driver improvement, licence renewal , withdrawal and re-licensing after delinquency.
- Both cognitive and physical tests are necessary for an adequate assessment of fitness to drive.
- Reaching of a consensus on mental and physical prerequisites for safe driving. It is important to pursue consensus on cut off values regarding different performance parameters within different patient groups and consensus on patient groups with diagnosis incompatible with safe driving. This point leads as well to individual assessment and to an answer to the question to what extent compensation abilities are available.
- Preventing innocent road users from impaired drivers and lowering the accident rate should be an important motive to examine drivers before they get the licence to drive. So, fitness to drive should be assessed by especially trained and experienced psychologists using standardised and validated methods. Driver assessment is necessary especially before re-licensing after delinquency or for licence holders in case of acute or chronic impairment. Traffic-psychological examinations can determine the crucial deficits in the fields of performance, personality, and attitude and identify more appropriate rehabilitation programmes.
- Not all impairments should lead automatically to licence withdrawal. Drivers with certain impairments, e.g. vision and perceptual deficiencies, should be given the opportunity to pass a driver assessment to test their compensation abilities. Also, suffering from an illness or disease such as diabetes mellitus, depression, arthritis, ADHD, or LMR needs assessment on an individual basis to determine whether individual compensation abilities are available. Chronic impairment relevant for driving (list and definition are necessary) should lead to a mandatory examination of driver fitness. The examination has to use standards and validated methods. Dissemination of information by family doctors, hospital, etc.
- As the Spanish Model shows, periodical standardised checks of fitness to drive for all drivers are very useful. Restrictions on licence increase with age due to illnesses and medication.

Therefore, periodical standardised checks of fitness to drive for all drivers should be constituted and implemented.

- In case of suspicion of impairment, the administration should have the possibility to order medical and psychological assessment *before* licensing.
- Safe mobility is a key factor for cost benefit calculation, so in the case of licence withdrawal, driver rehabilitation or driver improvement measures should aim to re-establish driver fitness and safety awareness.
- The reliability of existing saliva tests is poor, so the final decision about fitness to drive has to be fulfilled by especially trained experts (e.g. especially trained psychologists, especially trained physicians). A saliva test is merely a screening device.

Legislation:

- The effect of alcohol/drug and drug/drug combinations on road safety proved to be so detrimental, that effective legislation and enforcement seem to be urgently needed. For most alcohol/drug and drug/drug combinations, a legal zero-tolerance limit for each of the substances involved seems to be appropriate. For illegal drugs that are taken alone, and with the exception of heroin, zero-tolerance legislation is expected to result in very high cost and hardly any road safety benefits.
- Both the prevalence and the relative risk are important parameters for assessing the traffic safety implications of preventing drivers with various medical conditions from driving. The effect on the number of crashes will be larger for regulation conditions with high prevalence, even if they are associated with low to moderate risk.
- Although road safety policy in general should focus on making any driving under the influence as being unacceptable, a special target should address high alcohol concentrations (above 1.3 g/l), alcohol/drug combinations and drug/drug combinations.
- For most medicinal drugs, like antidepressants, benzodiazepines, codeine, barbiturates and even morphine, therapeutical levels may be adequate as legal limits, at least for the time being. Because exact cut off scores for each individual person and for single substances and even for a mix of substances (e.g. alcohol plus medicines or illegal drugs) cannot be defined, a formal and standardised procedure for driving under influence is necessary. So, one possible countermeasure could be a general law that it is not allowed to drive a vehicle when not fit to drive (already exists in some member states). If the police find drivers suspected to be impaired, a standardised psychological and physiological check should take place. Only especially and well trained medical doctors and psychologists should be allowed to carry out these tests and should decide on fitness to drive. Drivers with prescribed impairing medicines should in any case undergo an examination or driver assessment procedure to decide if they are fit to drive. It should be the case that a psychological *and* medicinal assessment together examine if this fitness is given.
- Random road side tests and installation of alcohol ignition locks seem promising to prevent drunk driving. It is strongly recommended to allow random breath testing for alcohol in all member countries as well as evidential breathalysers to combat drink driving.

- It is strongly recommended to allow random drug tests of drivers in order to be able to collect data for scientific purposes.
- Procedures used by national forensic laboratories for assaying and reporting illegal drugs as well as prescribed medicines should be standardised across the European countries.

Countermeasures:***Information, education, training:***

- To raise the awareness of drivers of the different impairment possibilities and causation of road accidents, a campaign in all member states has to be launched. Target group is the whole population, dissemination via medical doctors, hospitals, pharmacies, schools and car driver associations.
- For persons who are daily in need of various medicines, more focus should be given to the possibility of providing these persons with appropriate information regarding the effect of the medicinal drug on the ability to drive safely. Further to provide them with medicine boxes including the right dosages for different times of the day in order to prevent an incorrect medication.
- Information on medicines that impair driving should stress that drivers may feel capable of driving, but in fact may be more dangerous and less aware than non-medicated drivers. E.g. information about impact of SSRI on driving behaviour is necessary for health professionals to provide appropriate counselling and follow up of the patients.
- Patients suffering from diabetes mellitus need psychological assistance and training to cope in a positive way with the changes entailed by a life with diabetes mellitus - especially with regard to a further active participation in motorised road traffic.
- Rehabilitation programmes give vital individual support to reach a long lasting effect on lowering recidivism. Rehabilitation programmes for diverse conditions should be implemented EU-wide through best practice-models. Here, sound experience is already available, an exchange between the countries should be systematically encouraged.

Enforcement:

- The enforcement of drink driving should be maintained or increased. Enforcement of drug driving must not result in losing focus on drink driving.
- Driver fatigue is among the most important causes of accidents, and only enough hours of sleep can help. Strict rules and more enforcement of this risky behaviour is necessary, new in-car devices and telematic-tools could provide support. Training for police to recognise sleep-related vehicle accidents, better enforcement by police on the road, better education for professional drivers - especially long distance drivers, are all components of an effective strategy to combat the problem. More responsibility and controlled legal measures for the employers.
- It is recommended not to drive under the influence of MDMA. Though MDMA can improve certain aspects of psychomotor function, it can also selectively impair cognitive function (memory). So effects on driving performance are different, previous published studies proved several negative effects of MDMA on driving style and behaviour.

- Combined use of MDMA and alcohol should always be avoided when driving a motor vehicle.
- Since a summary of pharmacologically and toxicologically justified threshold values for impairing substances does not yet exist, for criminal prosecutions, one has still to rely in the near future on police statements, an exact description of the subject's behaviour, and medical examinations as well as confirming chemical and toxicological analyses. Therefore, appropriate training of the police and the physicians should take place. Furthermore, training of police forces in detection of impaired drivers might result in a more effective use of drug tests.
- Exchange of methods and experiences in police detection of impaired drivers should be encouraged between countries.
- It should be recommended to combine drug detection of drivers by the police with confirmation analysis of body fluids from the suspected drivers. This would save both time and money and enhance likelihood of detection.
- New Advanced Driver Assistance systems (ADAS) and intelligent road infrastructure may, in the near future, facilitate safe driving for impaired drivers (groups of impaired drivers who are denied licensing today).

3.2 RECOMMENDATIONS FOR FURTHER RESEARCH

The following recommendations are based on the recommendations of the *individual* tasks. The description follows at first the order of the deliverables and then gives a summary where the conclusions of the synthesis reports are incorporated.

Medical conditions and driving

From the meta analysis concerning impairments, diseases, age and their relative risk of accident involvement, implications for further research arise: For several diseases for the assessment of the relative risk, a wider data basis is lacking: This is the case for e.g. hearing impairment, alcoholism, angina pectoris, depression, sleep apnoea/narcolepsy, use of cannabis, analgesics/opiates, and antidepressants.

The control of confounding factors turned out to be difficult: Mileage was controlled only in 24% of the studies³⁶. In the context of the studies, it was not known to what extent the impairment was treated. The reviewed studies seldom specify severity of condition. Use and abuse of drugs and medicines are seldom specified. Relative risks might be underestimated due to drivers refusing to participate or failing to provide accurate information regarding medical conditions.

For this reason, the following conclusion can be drawn: Aside from covering those diseases on which currently only very few studies are available further studies on relative risk should consider, for example, the following parameters when collecting data:

- Annual mileage;
- The extent to which an existing disease is currently treated;
- The manner of treatment and medication;

³⁶ According to Vaa (2003), in most of the studies the assumption is made that mileage is the same for drivers with condition X and for drivers without condition X.

- Abuse of additional substances;
- Severity of the disease;
- Co-morbidity;
- Refusal-rate.

The case control study of relative risk in Norway showed that, generally speaking, health problems among drivers don't appear to be a major safety problem. This might be due to the fact that most cases of high risk conditions (e.g. epilepsy and diabetes type 1) are detected early and treated adequately.

It should be noted here as a recommendation, that it should be checked whether it is possible to draw a similar picture for other countries, i.e. to what extent the Norwegian results can be generalised throughout the EU.

The results of the study concerning diabetes mellitus cannot be transferred to patients suffering from diabetes type 2. Another study must be designed to identify risks and impairments.

In the case of older drivers, it would be necessary to consider impacts of a concurrent cognitive and a physical deficit component on driving. Furthermore, in order to strengthen the results of the study dealing with elderly drivers and arthritis, it would be necessary to conduct studies using the same methodology but using a different road safety measure.

For further studies, the choice of a group of patients with a medical condition that inherently has a known cognitive and a known physical deficit would be beneficial to ascertain the ability to generalise current findings to medical groups of drivers.

Accident risk regarding drink and drug driving

On the basis of the literature review concerning acute impairment due to drugs and alcohol, the following recommendations can be made for further research:

- Studies of epidemiology need consistent standards to allow for comparison of data (see also the meta-analysis and studies concerning prevalence within IMMORTAL). In addition, data collection should consider the needs for scientific research.
- To improve risk assessment, it is important to know which doses of drugs and saliva are associated with acceptable and unacceptable driving quality. This is especially relevant for persons under therapy.
- Responsibility analysis/case control studies should be conducted for the most frequently used drugs.
- Comparison of fatal accident cases and matched random samples of non-accident cases and the driving population are needed.
- Risk studies including combinations of various drugs and combinations of drugs with alcohol are needed.
- A comparison of the effects of the diverse legislation approaches regarding DUI in the different countries should be undertaken.

From the IMMORTAL research, the following resulted: Concerning roadside surveys, using identical test methods would be vital. Only then would a comparison between countries be possible. The observational drug detection method needs further improvement.

Experiments on drug impairment

As to the studies on the risk of alcohol and drugs, IMMORTAL was able to shed further light on this issue.

The conclusion concerning MDMA and alcohol is that existing driving tests must be further developed in order to include the assessment of the cognitive domains relevant to stimulant drugs such as MDMA. Candidate concepts are objective measurements of estimated time to collision and prospective memory during actual driving.

An especially important result is that in case of MDMA, results are not definitely. There has to be drawn the conclusion that single dose up to 100 mg of MDMA are not likely to pose a great hazard in drivers due to its stimulating abilities. But this perspective may, however, change if MDMA users take higher doses or repeated doses of MDMA on one or successive nights, in hot environments at raves and dance parties. Subjective response may change during intoxication and withdrawal.

The detrimental effect of MDMA on verbal and spatial memory may be relevant to driver performance in case of reduction in situation awareness or spatial orientation while driving impaired. Therefore, more research is needed concerning

- Repeated doses;
- Environmental conditions;
- Sleep deprivation.

Overall, the authors hope for more research concerning the levels of drugs which cause impairment and that there are international standards for methods of collection and analysis. This is essential to allow true comparison between countries.

Cost benefit analyses

Regarding the assessment of measures in the context of CBA, it has to be noted that the qualitative input that is provided for the calculation of the individual components is essential for the result. In the case of the present study, the qualitative input was very diverse and it became therefore necessary to make assumptions. Hence the request for further research in this area: An improved, harmonised data basis.

Physical deficiencies and driving

Concerning UFOV testing (one measure that was assessed), it was stated that more research is needed to determine prevalence, relative risks ratios and effectiveness. Further stricter regulations for registrations of accidents are needed. One of the largest difficulties in this study was the lack of accurate and detailed information. The European Commission might provide a framework for registering accident data and perhaps even medical information.

Working on topics concerning vision and perceptual deficiencies as a risk factor in traffic safety, the following conclusions were drawn: More knowledge is needed to identify the importance of problems, e.g. studies show that visual field defects are not necessarily associated with high risk (see also meta analysis).

The most important research topics in this area for the near future are: Overview of impairment variations within each diagnosis, knowledge of available methods for testing visual diseases (also adequateness to specific problems), better identification of symptoms (especially for the concerned driver and his family), correlation of visual impairments and

medical problems, testing methods for impaired night vision³⁷, cost-benefit-analysis of various driver licensing requirements related to vision, and development of useful tests (e.g. for stray light, which glares).

Regarding fatigue, further research would be necessary concerning optimal work-rest schedules, as a basis for improved hours-of-service regulations, and information about sleep disorders and other risk factors.

Further research is needed to find out to what extent environmental measures can contribute to the prevention of fatigue-related accidents. Another important future research need is field trials of in car monitoring, warning and controlling systems.

3.2.1 Summary of recommendations for research

Knowledge of fitness to drive

- There is need for targeted research focusing on the mechanisms underlying the elevated risk for specific medical conditions, as well as for the development of procedures and methods for early identification of the presence of the risk factor.
- More research is needed concerning evaluation of fitness to drive across countries (concerning criteria, degree of impairment, effectiveness of licensing system, impact of assessment of driving behaviour).
- Further research should focus on the fatigue resulting from MDMA the day after consumption, and the interaction of cold medication with other risk factors such as fatigue.
- There are already many results available concerning detrimental effects of over-the-counter medicines and prescribed medicines. The effort in near future should be aimed at an effective dissemination.

Knowledge of the size of the problem

- Responsibility analyses and/or case control studies should be conducted for the most frequently used drugs alone or in various combinations as well as for drugs in combination with alcohol. Experimental studies and in-depth analyses are useful for providing an insight into the impairing mechanisms of alcohol/drug and drug/drug combinations.
- Collection of data in the field of epidemiological studies should primarily serve the needs of scientific research. There is a need for uniform surveys all across Europe in order to be able to estimate differences as well as similarities between countries. Blood samples of injured drivers – or as a minimum of fatally injured drivers – should be collected as a routine and examined for alcohol and other drugs that are interesting from a traffic safety point of view. The analysing institutions (forensic institutes or hospitals) should report annually. Co-operating partners of studies - e.g. hospital surveys – should be involved and get paid for their work. It has to be solved who will finance this research and ethical problems have to be taken into consideration. It should be possible to utilise the results on the prevalence of drugs in traffic together with data from hospital samples regularly

³⁷ Recent studies on night time vision and glare show that these impairments may imply greater risk in traffic as identified before (Jenssen 2005).

throughout Europe to be able to determine the relative risk of driving while impaired by drugs, including alcohol.

- There is a critical need for studies examining the consequences of changes in legislation.

Methods to identify impairment

- Drug detection methods need further improvement, since large scale random body fluid screenings are very expensive and time consuming.
- It would be counterproductive, if drug driving enforcement were to result in reduced drink driving enforcement.
- Drug screening tests should be sensitive enough to detect all the drivers who have taken drugs and they should be specific enough to detect only drivers who have taken drugs that impair driving. The most sensitive methods for the analyses of saliva have to be used.

4. EXPLOITATION AND DISSEMINATION

Each participating institute developed a plan for exploitation of the IMMORTAL outcome. The plans are collected in the deliverable A3.8 together with the collaboration agreement and the intellectual property rights.

Exploitation of scientific results within the IMMORTAL project means that

- The researcher has to be aware that his achieved results are useful for increasing traffic safety.
- The main target group for exploitation is represented by the user representation panel (URP).
- The exploitation process starts with approval of achieved results and should also be continued after the end of the IMMORTAL project.
- The appropriate legal situations within the IMMORTAL project are defined in the Intellectual Property Rights and in the collaboration agreement (see Deliverable A3.8 part 1 and 2).

The exploitation of the results of IMMORTAL will go in two directions.

Exploitation in voluntary context:

One goal is to enhance the awareness of the importance of impaired driving in general. Immortal will help people or involved professionals to assess the degree of impairment and the implications of this impairment for the individual driver. It is the intention to find the most relevant parties which can apply and disseminate the findings from IMMORTAL. Those parties are expected to use the know-how because of their own interest to avoid impaired participation in traffic.

Target groups for exploitation in voluntary context are:

Road Safety professionals (Local and Central Government) Mass media, journals for health care professionals, professionals in trauma rehabilitation, medical doctors, geriatric centres, addiction care institutes, automobile-clubs, pharmaceutical industry and distribution, developers of test methods, insurance companies...

Exploitation in legal (mandatory) context:

Even if a high awareness of impairing factors on driving can be established, legal measures will still remain necessary to prevent a relevant number of impaired subjects from participation in motorised road traffic. Therefore, another direction of the exploitation of IMMORTAL results will address legislation, enforcement and licensing issues.

Responsible groups for the exploitation in legal context:

Decision makers, politicians, administration, police, European Commission, lobbies, safety institutes.

User demands and general proposal for exploitation

The needs of the different user groups mentioned above have to be considered. Representatives of the User groups (URP) will have the opportunity (in workshops, meetings, on website) to announce their experiences and expectations for methods to identify impaired

driving. They should also present their aims and conditions for the application of IMMORTAL results. The aim of this feedback collection is to achieve a better match of the IMMORTAL developments with the current requirements of the different target groups and to develop target-group-specific marketing.

Table 7: Exploitation grid for the results of IMMORTAL - application in voluntary and mandatory context

scope of impairment/ exploitation target	acute impairment	chronic impairment
<i>Application in voluntary context</i>		
Awareness and increased knowledge of practitioners (MDs)		Articles in specific journals Online availability of catalogue of relevant diseases and relevant assessment criteria on impairment
Knowledge at trauma rehabilitation centres		Articles in specific journals Promotion of validated test procedures and devices to assess driving ability
Information for institutions focusing on older adults	Information about side effects of medication (older adults are more likely to be prescribed medication)	Articles in specific journals Enhance the information of people working with older adults about relevance of diseases and possibilities to judge driving capability.
Improved pharmaceutical information	Promotion of methods for testing the effects of medicines on driving performance. Achieve a (voluntary) code for minimum standards for impairment classification assessment. Better information for the patients.	
Exploitation of IMMORTAL findings in addiction care institutes and information exchange with them	Experience and strategies in preventing impaired clients from driving.	Articles in specific journals Information about long term effects of addiction, methods to treat long term effects, judgement criteria for driving aptitude (performance as well as willingness to conform)
Insurance issues	Inform car insurers about methods to judge if a responsible driver was acutely impaired	Inform the car insurers about methods how to judge if a driver's chronic impairment is relevant for his driving aptitude
Public, opinion leaders, automobile clubs	Achievement and promotion of a realistic perception of the relevance of acute impairment	Achievement and promotion of a realistic perception of the relevance of chronic impairment

<i>Application in Legal (mandatory) context</i>		
licensing	restrictions to issue licences to people dependent on alcohol or on psychotropic substances (CD 91/439/EEC)	Update of the categories of impairing conditions regular checks in certain intervals (CD 91/439/EEC does not specify but mentions "medical opinion". – specifications e.g. in Driver and Vehicle Licensing Agency (DVLA)- "At a glance" – in general and for specific diseases) obligation of licence holder to report changes – in DVLA notification of drivers about criteria for

		reporting changes in physical condition, definition of consequences for not reporting changes in physical condition (insurance issues, fines)
road surveillance, enforcement, screening methods	training of enforcement personal, driver monitoring systems, “impairment” resulting from automated driving, intelligent highway	methods to identify chronic impaired drivers and riders – restrictions in licences, electronic driving licence with access restrictions
proof of impairment, evidential impairment tests/ witness	definition of limits, decision criteria, approval of test devices, definition of education and qualification of experts	definition of limits, decision criteria, approval of test devices, definition of education and qualification of experts
legal consequences of impairment, punishment, licence restrictions, licence withdrawal	definition of decision grids concerning consequences of acute impaired driving, thresholds concerning degree of impairment and consequences, thresholds concerning repetition of impaired driving and consequences	definition of consequences for violation of driving restrictions connected to chronic impairment catalogue of criteria for licence restrictions related to chronic impairment issues
rehabilitation measures	definition and evaluation of rehabilitation measures for people caught driving or riding impaired, definition of education and qualification of experts conducting rehabilitation measures	catalogue of promising intervention and treatment methods for the mitigation of chronic impairment factors information of authorities and public health services on these possibilities
judgement on success of rehabilitation	decision criteria, definition of education and qualification of experts in charge for the judgement	definition of limits, decision criteria, approval of test devices, definition of education and qualification of experts
surveillance measures for rehabilitated drivers and riders	regular checks at authorities in certain intervals (based on expertise or based upon certain standardised criteria like medical indicators)	regular checks at authorities in certain intervals (based on expertise or standardised medical indicators), obligation of licence holder to report changes

The dissemination/exploitation of these studies will be primarily carried through by IMMORTAL documentation. The results from these experiments will be used to direct and formulate further research and may be presented at relevant meetings/seminars.

The individual deliverables are available on the homepage www.immortal.or.at, and may be viewed and downloaded.

Individual deliverables will be published as hard copy (by e.g. TOI, SWOV, KUSS, UVA etc.)

In addition, the results of IMMORTAL were presented to the public at international conferences:

- ICADTS World Conference T2002 Montreal, August 2002
- ICADTS World Conference T2004 Glasgow, August 2004
- TRB 2003 – Washington, January 2004, Presentation in the Committee meeting of Alcohol, Drugs and Traffic Safety
- Seminar of the Pompidou Group, Strasbourg, June 2003
- WHO World Conference on Safety 2004, Vienna, June 2004
- Expert Group on Alcohol, Drugs and Medicines, Brussels December 2004

- IMMORTAL Final Project Seminar, Vienna, March 2005
- Joint meeting “Fitness to drive” Brussels, April 2005
- TRB Committee on Alcohol, Other Drugs and Transportation, Woodshole MA June 2005

Articles were published in relevant journals:

Forensic Science International:

- Bernhoft IM et al. (2005). Drugs in injured drivers in Denmark. Vol. 150, Nos. 2-3, June 2005 (based on D-R4.3)
- Wylie FM et al. (2005). Drugs in oral fluid. Part 1. Validation of an analytical procedure for licit and illicit drugs in oral fluid. Vol. 150, Nos. 2-3, June 2005 (based on D-R4.2)
- Wylie FM et al. Drugs in oral fluid. Part 2. Investigation of drugs in drivers. Vol. 150, Nos. 2-3, June 2005 (based on D-R4.2).

Accident Analysis and Prevention:

- Sagberg F (2005). Driver health and crash involvement: A case-control study". In press (based on D-R1.2).

Journal of Psychopharmacology:

- Kuypers KPC, Ramaekers JG (2005) Transient memory impairment after a single dose of 3,4-methylenedioxymethamphetamine (MDMA). Accepted for publication (based on D-R4.4).

Neuropsychopharmacology:

- Ramaekers JG, Kuypers KPC (2005). Acute effects of 3,4-methylenedioxymethamphetamine (MDMA) on behavioural measures of impulsivity, alone and in combination with alcohol. Accepted for publication (based on D-R4.4).

Submitted for publication:

- Wingen M, Ramaekers JG, Schmitt JAJ (2005). Depression induced driving impairment is only partially ameliorated by chronic SSRI treatment. Submitted (based on D-R1.5).
- Kuypers KPC, Ramaekers JG (2005) Acute dose of MDMA impairs spatial memory for location but leaves contextual processing unaffected. Submitted (based on D-R4.4).

5. REFERENCES

- Alvarez, J.; del Rio, M.C., Fierro, I., Viccondoa, A. and Ozcoidi, M. (2004): Medical Conditions and fitness to drive. IMMORTAL EU research project Deliverable R1.4, www.immortal.or.at.
- Alvarez, J. (2005): Ageing, Mental Illness and medical Diseases: A synthesis of results. IMMORTAL EU research project Deliverable R1.9, www.immortal.or.at.
- Alvarez, J.; Gomez, T. and Fierro, I. (2005): The use and usability of CD 91/439 on driving licensing. IMMORTAL EU research project Deliverable P4.3, www.immortal.or.at.
- Bernhoft, I.M. (2005a): Introduction to IMMORTAL. Aims and Progress. Presentation held on the Final Programme Seminar in Vienna, 14 – 15 of March 2005. www.immortal.or.at.
- Bernhoft, I.M. (2005b): Drugs in traffic accidents. Presentation held on the Final Programme Seminar in Vienna, 14 – 15 of March 2005. www.immortal.or.at.
- Bernhoft, I.M. (2005c): Drugs in Accident involved drivers in Denmark. IMMORTAL EU research project Deliverable R4.3, www.immortal.or.at.
- Bernhoft, I.M. (2005d): Drugs, Alcohol and Traffic Safety: A Synthesis of results. IMMORTAL EU research Project, Deliverable R4.6, www.immortal.or.at.
- Bjorkli, C.; Flo, M.; Jenssen, G., Ryum, T. and Zeiner, P.(2004): Assessment of fitness to drive amongst patients with learning difficulties. IMMORTAL EU research project Deliverable R1.8, www.immortal.or.at.
- Braun, E. and Christ, R. (2002): Review of impairment and accident risk for alcohol, drugs and medicines. IMMORTAL EU research project Deliverable R4.1, www.immortal.or.at.
- Brookhuis KA, Riedel W, Mathijssen M, Tunbridge R, Clark A, Ward N, Dye L and Berghaus G (2000): Conception and Evaluation of Roadside Testing Instruments to Formalise Impairment Evidence in Drivers; Summary Report. CERTIFIED Deliverable DR4. School of Psychology, University of Leeds.
- Bukasa, B., Christ, R., Ponocny-Seliger, Smuc, M. & Wenninger, U. (2003): Validitätsüberprüfung verkehrspsychologischer Leistungstests für die Fahreignungsbegutachtung. Zeitschrift für Verkehrssicherheit 49, 4, 191-197.
- Bukasa, B. & Piringer, A. (2001) Validierungsstudien zur Überprüfung der Aussagekraft von Leistungstests für die Fahreignungsbegutachtung. Psychologie in Österreich, 21, 3, 187-194.
- Bukasa, B. (1999). ART2020 – Das neue Multimedia-Testgerät für die Fahreignungsbegutachtung. In F.Meyer-Gramcko (Hrsg), Verkehrspsychologie auf neuen Wegen: Herausforderungen von Strasse, Wasser, Luft und Schiene (I). Bonn: Deutscher Psychologen Verlag, 381-401

Fjerdingen, J.; Jenssen, G., Lervag, L.J. van Rijn, Vaa, T., Kooijman, Bjerre, B. And Arnljot, H.(2004): Vision and perceptual deficiencies as a risk factor in traffic safety. IMMORTAL EU research project Deliverable P4.1, www.immortal.or.at.

Immortal: www.immortal.or.at

Jenssen, G. (2005): Assessment of Fitness to drive amongst Patients with learning difficulties. Presentation held on the Final Programme Seminar in Vienna, 14 – 15 of March 2005. www.immortal.or.at.

Lervag, L.; Jenssen, G. and Fjerdingen, L. (2005): Policy synthesis report. IMMORTAL EU research project, Deliverable P8, www.immortal.or.at.

Ramaekers, J.G. (2005): Depression, antidepressants and driving ability. Presentation held on the Final Programme Seminar in Vienna, 14 – 15 of March 2005. www.immortal.or.at.

Ramaekers, J.G. and Kuypers, K.P.C. (2005): MDMA effects on actual driving and cognition. Presentation held on the Final Programme Seminar in Vienna, 14 – 15 of March 2005. www.immortal.or.at.

Ramaekers, J.G, Kuypers, K.P.C., Wood, C.M., Hockey, G.R.J., Jamson, S., Jamson, H. and Birch, E.(2004): Experimental studies on the effects of licit and illicit drugs on driving performance, psychomotor skills and cognitive function. IMMORTAL EU research project Deliverable R4.4, www.immortal.or.at.

Rehnova, V., Weinberger, J. and Kotal, R. (2005): Effect of diabetes Mellitus on Driving Performance and Relation to Fatigue and alcohol effect. IMMORTAL EU research project Deliverable R1.6, www.immortal.or.at.

Rehnova, V. and Kotal, R.(2005a): Diabetes Mellitus and ability to drive. Presentation held on the Final Programme Seminar in Vienna, 14 – 15 of March 2005. www.immortal.or.at.

Rosita: www.rosita.org.

Sagberg, F. (2003): Driver health and crash involvement: A case control study of relative risk. IMMORTAL EU research project Deliverable R1.2, www.immortal.or.at.

Sagberg, F. (2005): Driver Health and Crash Risk. Presentation held on the Final Programme Seminar in Vienna, 14 – 15 of March 2005. www.immortal.or.at.

Sagberg, F.; Jackson, P., Krüger, H.P., Muzet, A. and Williams, A. (2004): Fatigue, Sleepiness and reduced alertness as risk factors in driving. IMMORTAL EU research project Deliverable P4.2, www.immortal.or.at.

Sagberg, F. (2005a): Risk factor fatigue, sleepiness and reduced alertness. Presentation held on the Final Programme Seminar in Vienna, 14 – 15 of March 2005. www.immortal.or.at.

Schmitt, J.A.J.; Wingen, M., Riedel, W.J. and Ramaekers, J.G. (2005): Effects of Depression and antidepressant therapy on driving performance. IMMORTAL EU research project Deliverable R1.5, www.immortal.or.at.

Vaa, T (2003): Impairments, diseases, age and their relative risks of accident involvement: Results from a meta analysis., IMMORTAL EU research project Deliverable R1.1, www.immortal.or.at.

Vaa, T. (2005): Impairment diseases, age and their relative risks of accident involvement: Results from meta-analysis. Presentation held on the Final Programme Seminar in Vienna, 14 – 15 of March 2005, www.immortal.or.at.

Vlakveld, W. (2005): Cost Benefit Analysis of Potential countermeasures. Presentation held on the Final Programme Seminar in Vienna, 14 – 15 of March 2005, www.immortal.or.at.

Vlakveld, W.; Wesemann, P., Devillers, E.; Elvik, R. and Veisten, K. (2005): Detailed cost benefit analysis of potential impairment countermeasures. IMMORTAL EU research project Deliverable P2, www.immortal.or.at.

Weber, K. et al (2005): ROSE 25: Inventory and Compiling of a European Good Practice Guide on Road Safety Education targeted at Young people. Final report. EU research project, europa.eu.int/comm/transport/road/publications/projectfiles/rose-25_en.htm

Wesemann, P.; Vlakveld, W. and Devillers, E. (2005): Proceedings 4th workshop “Cost Benefit Analysis on impairment countermeasures. IMMORTAL EU research project Deliverable P 4.4, www.immortal.or.at.

Wood, C.M., Hockey, G.R.J., Jamson, S. Jamson, H. and Birch, E. (2005b): The effect of cold virus and cold virus medication on cognitive and driving performance. Presentation held on the Final Programme Seminar in Vienna, 14 – 15 of March 2005, www.immortal.or.at.

Wood, C.M., Read, N.L., Hockey, G.R.J; Pring, P. and Conway, G.(2005): Development of Licensing assessment protocols for elderly drivers with arthritis. IMMORTAL EU research project Deliverable R1.7, www.immortal.or.at.

ANNEX 1: EXECUTIVE SUMMARIES OF RESEARCH DELIVERABLES

D-R1.1 IMPAIRMENT, DISEASES, AGE AND THEIR RELATIVE RISKS OF ACCIDENT INVOLVEMENT: RESULTS FROM A META- ANALYSIS

T. Vaa, 2003

Deliverable R1.1 in EU-project IMMORTAL is a literature review of impairment and accident risk associated with ageing and disease. The deliverable gives an updated literature review and meta-analyses of health-related risk factors referring especially to the medical conditions addressed in Annex III of Council Directive on driving licences (CD 91/439/EEC). The deliverable also gives an overview of national practices regarding mandatory medical examination and self-report for drivers applying for a driver's licence and licence renewals in the countries participating in the IMMORTAL project. These countries are: Austria, the Czech Republic, Denmark, the Netherlands, Norway, Spain, and the UK.

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 statistically 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

*) 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'. 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.

D-R1.2

DRIVER HEALTH AND CRASH INVOLVEMENT: A CASE-CONTROL STUDY OF RELATIVE RISK

F. Sagberg, 2003

This study is a part of the project IMMORTAL, which is financed by the EC under the 5th Framework Programme for RTD. The study investigates the relative crash involvement risk associated with diagnosed medical conditions, self-reported symptoms and the use of some medicinal drugs. Data from crash-involved drivers in Norway were collected by means of a postal questionnaire. The questionnaire was distributed by an insurance company to about 15000 car-owners, who had recently reported a crash. The questionnaires were anonymous and were returned in prepaid postage envelopes to the Institute of Transport Economics. Completed and usable questionnaire data were returned from 4448 drivers, yielding a return rate of 30 percent.

In addition to information about the crash, the drivers responded to a list of diagnoses, indicating if they had the disease, and whether they were on medication for the condition in question. Some specific categories of medicinal drugs were listed, and the drivers were supposed to indicate drugs taken during the week before filling in the questionnaire. There was also a list of relatively common health complaints and symptoms, where the respondents indicated how frequently they experienced the various conditions.

Crash risk was estimated by a case-control approach, using the method of so-called “induced exposure”. In this approach, crash culpability is the basis for estimating relative risk. The drivers were asked in the questionnaire to state whom the insurance company considered to be at fault for the crash, the driver him-/herself or another road user. In this methodological approach, the prevalence of a potential risk factor among drivers not at fault is considered to be proportional to the exposure with that factor present. The relative risk (“relative accident involvement ratio”) is defined as the ratio of the prevalence of a given condition among drivers at fault to the prevalence among drivers not at fault.

There was a general tendency for drivers who reported medical conditions or symptoms to have an elevated crash risk. The following conditions were associated with statistically significant relative risks (RR, with 95% confidence intervals):

- . • History of cerebral hemorrhage or stroke: RR=2.47 (1.23 – 4.94)
- . • History of myocardial infarction: RR=1.71 (1.10 – 2.65)
- . • Mobility disorder: RR=1.52 (1.03 – 2.23)
- . • Sleep onset insomnia: RR=1.78 (1.21 – 2.62)
- . • Waking up too early: RR=1.41 (1.04 – 1.92)
- . • Having taken antidepressant drugs: RR=1.66 (1.09 – 2.54)
- . • Wearing glasses or lenses when driving: RR=1.17 (1.08 – 1.26)

Relative risk estimates in the same order of magnitude were found also for some additional conditions generally assumed to be incompatible with safe driving, as for example Parkinson’s disease and multiple sclerosis, but the prevalence of these diseases in the driver sample was too low for the estimates to reach statistical significance. Reliable risk estimates for such relatively rare conditions require special targeted studies.

For most conditions where comparison with previous results was possible, the present results tended to be in accord with previous research. This attests to the validity also of the results regarding other conditions not previously investigated.

Some findings in the present study, however, were clearly at variance with previous work. For example, for both diabetes and epilepsy low and non-significant relative risks were found. This may be due to efficient procedures for health examinations (which are mandatory for drivers with those conditions), resulting in persons at risk being selected away from the driver population. For epilepsy, the result may also be due to the low prevalence of this condition combined with a too small sample size.

The present results are considered to add significantly to the knowledge needed for scientifically founded health requirements for driver licensing. An important function of the present study is to provide input to cost-benefit analyses to be carried out in other parts of the IMMORTAL project, which in turn will provide conclusions to support EC regulations regarding driver impairments and licensing.

Concerning implications for EC regulations, some particular conditions stand out as candidates for specific attention, because of having both a high prevalence and a significantly elevated risk. The most notable among such conditions in the present study are:

- stroke and myocardial infarction, and underlying cardiovascular disease,
- affective or psychological disorders (including anxiety, depression and related conditions),
- sleep disturbances,
- mobility disorders,
- visual deficiencies (refraction errors and/or visual field defects).

D-R1.4

MEDICAL CONDITION AND FITNESS TO DRIVE PROSPECTIVE ANALYSIS OF THE MEDICAL - PSYCHOLOGICAL ASSESSMENT OF FITNESS TO DRIVE AND ACCIDENT RISK

F.J. Alvarez, M.C. del Rio, I. Fierro, A. Viccondoa and M. Ozcoidi, 2004

This study investigates the fitness to drive among Spanish drivers. Spanish regulations following EU rules (CD 91/439/CEE) establish that all drivers wishing to obtain or renew their driving licence must undergo a medical examination of their fitness to drive. The renewal of a driving licence is mandatory every ten years up to 45, every 5 years between 46 and 70, and every two years from 70 onwards for non-professional drivers; professional drivers renew every five years up to 45, every three years between 46 and 60 and every two years from 60 onwards). Following the medical examination (carried out by a team of a general practitioner, an ophthalmologist and a psychologist) drivers are considered fit, fit with restrictions (allowed to drive but with some sort of restriction) or unfit (not allowed to drive).

The study includes 5234 drivers who attended two Medical Driver Test Centres in Spain. The following figures are noteworthy.

1. One out of every 6 drivers (16.65%) was considered fit with restrictions, while only 0.65% was found not fit.
2. Among those wishing to obtain the driving licence for the first time, 4.7% were considered fit with restrictions and none unfit.
3. Regarding elderly people (over 64 years of age) 1 out 3 (31.5%) were considered fit with restrictions and 2.2% not fit.
4. As regards the kind of restriction imposed on these 871 drivers, in 647 cases there was a reduction of the duration of the validity of the licence, in 260 there was a speed restriction, in 233 a mechanical restriction and in 91 another kind of restriction.

These data show that a relevant part of the driver population have some restriction in their driving licence, and not only those who are elderly. It thus seems appropriate to evaluate the fitness to drive of the population.

5. Drivers were followed during one year after the medical examination of their fitness to drive regarding their involvement in traffic accidents and sanctions for traffic violations. No statistically significant differences were found among fit and fit with restriction drivers in their risk of involvement in accidents as drivers (RR 1.310, 95% CI: 0.934-1.837) or receiving sanctions for traffic violations (RR 0.966, 95% CI: 0.789-1.182). Only in the medical evaluation (in which ophthalmologic, hearing and psychological causes are not taken into consideration) were significant differences seen, there being a greater risk of involvement as a driver in accidents for those drivers who were found to be fit with respect to those found fit with restrictions (RR 2.740, 95% CI: 1.230-6.106).

6. Apart from the results of the medical evaluation of the fitness to drive, the medical examination shows that 1 out 3 suffers some kind of pathology (32.6%) and are taking some kind of medication (34.1%). Diseases and medication use increase with age. These data show that (like the general population) not all drivers are healthy, and that the use of medication is



linked to the diseases the driver suffers. Therefore, disease/medication should be analysed jointly from the point of view of fitness to drive

D-R1.5

EFFECTS OF DEPRESSION AND ANTIDEPRESSANT THERAPY ON DRIVING PERFORMANCE

J.A.J. Schmitt, M. Wingen, W.J. Riedel and J.G. Ramaekers, 2005

Depression is a common mental disorder with known cognitive deficits, but little is known about the relationship between depression and driving ability. Besides the influence of depression on driving ability, antidepressant treatment may also affect performance. Because of their therapeutic effects, antidepressants may counteract a possible negative influence of depression on driving ability. On the other hand, specifically in the first weeks of antidepressant treatment before the therapeutic effect is apparent, antidepressants may have no positive or even additional detrimental effects on driving ability. Negative effects may be caused by mild adverse cognitive side effects of SSRI (Specific Serotonin Reuptake Inhibitors) type antidepressants. The importance of the present study is to gain insight in the influence of depression, as well as the time course of the interaction between depression effects and those of pharmacological treatment, with regard to driving and cognition.

Actual driving performance and cognitive performance of 24 patients with unipolar depressive disorder (based on DSM-IV criteria(American Psychiatric Association, 1994)) without antidepressant treatment and 23 patients with unipolar depressive disorder who were treated with an SSRI type antidepressant for 6-52 weeks were compared to matched controls. A third patient group who receives SSRI treatment for less than 3 weeks is also being tested, but data collection is ongoing for this group. Effects of depression and treatment effects were assessed using cognitive tests assessing memory, attention and psychomotor speed, and two standardized on-the-road driving tests: the standard deviation of the lateral position (SDLP) and the car-following test. Depression severity was assessed using various depression rating scales, including the Hamilton Depression Rating Scale (HDRS).

The results show that, in accordance with the hypotheses, depression is associated with a significant and quite robust reduction of driving ability as was measured by the SDLP. Secondly, successful treatment of depression with a SSRI-type antidepressant seems to alleviate not only depressive symptoms but also improved driving ability. However, performance in this SSRI treated group was still significantly worse than that of their matched healthy controls, cognitive.

D-R1.6

EFFECT OF DIABETES MELLITUS ON DRIVING PERFORMANCE AND RELATION TO FATIGUE AND ALCOHOL EFFECT

V. Rehnova, J. Weinberger and R. Kotal, 2005

This study investigates effects of diabetes mellitus type 1 to driver performance and his/her ability to drive safely. Laboratory psychological assessment is used to evaluation of basic mental and personal capabilities which are known as risky aspects in the context of traffic human factor. The driver simulator test is used for evaluation of driver behaviour in various traffic conditions and situations. The same simulator test is applied for assessment of alcohol effect to driver behaviour. There is also comparison of diabetes, alcohol and fatigue effect arising from previous studies and reports.

The methodology of this study resources from requirements to describe more detail risky areas, conditions and possibilities of safety attendance of diabetes patients in the traffic as drivers and to discover other relevant circumstances including social context and education processes.

The test battery was build on the base of long time used methodologies of driver assessment which were developed step by step and evaluated on large number of drivers. These methods constitute complex of needing psychical capabilities and personal qualities in relation to safety driver behaviour and risky ranges of received values. All of tests have their driver norms therefore the control group of psychological assessment is not needed. Selection of particular tests was consulted with diabetes experts and education staff as well as special questionnaire focusing to driver practice, experience and opinion in context of driver attendance in traffic, level of adjustment with illness and other. Diabetes parameters of particular participants were collected in co-operation with diabetologies.

The driver simulator test was prepared and developed in close co-operation with diabetes experts and auto school instructors. It constitutes the basic driver tasks, risky traffic situations, various traffic and climatic conditions and also simulated drive behaviour of other drivers. Three groups of drivers were involved in this test – diabetic drivers (the same as of psychological assessment one), control group of healthy and alcohol non impaired drivers and group of drivers under affect of alcohol.

All participants were voluntaries, diabetic patients were only recommended by their doctors to attend. Difficulty problems were appeared with this system of requirement therefore the sample of diabetic drivers of this study is not so representative as authors supposed and intended to keep.

Results of psychological assessment and driver simulator test were processed by standard statistical method of significant deviations between norms and obtained values, or significant deviations between two independent samples. Meaningful correlations between diabetes parameters (duration of illness, doses of insulin and mode of application) were evaluated too.

Main results and findings of this study

There are no reasons for discrimination of diabetes drivers if they control self-monitoring operations, keep regime of diet, regular medicine checking and fundamentals of safety driver behaviour.

There are some restrictions of professional drivers in context of manifestations and risk events concerning diabetes mellitus type 1. They can not satisfy all of conditions because of dependence on work and employer demands. Risky of accidents with serious damages caused by them is so high.

The significant impairment by diabetes was founded in a quality of personality, especially in risky areas such as disintegration, higher emotionality. This is the goal for rehabilitation educative programs.

Individual and causally very bad psychic performance results were observed which indicated serious difficulties and disorders in psychic functions.

Definition of limits for ability/disability for attendance in traffic appears to be difficult and impossible. This problem has to be solute by individual and regular assessing, checking and training of diabetes drivers.

Main conclusions and recommendations of this study

It is beneficial to develop efficient system of medicine and psychological assessment and target education of diabetes patients, especially in the case of the first manifestation and diagnostic of this illness.

Recommendation of authors - to continue in the research activities according this theme. The sample of diabetic patient of this study could not contact other diabetes patients which refused participation or were not contact by their doctors and which could have more serious difficulties and problems.

Recommendation of medicine experts – diabetes type 2 can constitute more risky and difficulty driver practice because of lower responsibility concerning diet regime and hazard of decompensate states. Therefore it seems to be useful and important to solute also this question by similar research study.

D-R1.7

DEVELOPMENT OF LICENSING ASSESSMENT PROTOCOLS FOR ELDERLY DRIVERS WITH ARTHRITIS

C.M. Wood, N.L. Read, G.R.J. Hockey, P. Pring, G. Conway and A. Parkes, 2005

In the past decades, demographic studies have shown a steady and significant increase in the older citizen groups in developed countries. A significant proportion of the older population is affected by medical conditions, and most such conditions have a cognitive and a physical deficit component (each present to varying degrees). A mainly cognitive condition common in old age is the dementia syndrome. A largely physical condition common in older people is arthritis.

The study planned initially aimed to detect what is the best combination of known non-driving tests that predict driving ability in a simulator and on the road for two age-prevalent conditions: one mainly affecting physical abilities (arthritis) and one mainly cognitive functioning (dementia) medical groups above. Severe limitations and delays in securing ethical approval to conduct the on-road study, and in recruiting the dementia sample for the simulator study, lead to a substantial change in the study that could be carried out. The study that was conducted, and which is reported here, involved arthritic older drivers only, and only used driving in a simulator as outcome.

The term arthritis refers to a group of medical conditions that adversely affect the joints. Arthritic patients suffer from pain, joint stiffness, limitations of the range of movements for affected joints and the inability to mobilise joints fast. These symptoms can affect the ability to drive a car safely.

In the existing literature, a number of off road tests have been developed and applied to determine driving ability in arthritic and older drivers. This report reviews the evidence and points out the most promising tests for both physical and cognitive dysfunctions in older drivers. This review, carried out by TRL Ltd, suggests the off road tests to be included in the experimental part of this study. Although there is, sometimes scanty, evidence that these tests correlate with driving performance, it is not known, however, how reliable is the performance on these tests and how susceptible these tests are to practice effects, issues that are important if such tests are to be used in licensing decisions.

The experimental part of this study, carried out at the University of Leeds, employed a test-retest design in order to test the reliability of these measures. Thirty older arthritic drivers were tested on the battery of cognitive (for age-related cognitive effects) and physical tasks (for arthritis-related physical deficits) recommended by the TRL review, and also drove the Leeds driving simulator (to determine driver performance). The drivers were then recalled weeks later asked to performed the same tasks again. Correlation analysis was used to a) quantify the association between laboratory test performance and driving performance at each time of testing b) compare the results from the first testing session with the results from the second.

Significant correlations were found between performance on all physical tests on first and second administration, suggesting that they are robust measures of physical ability. Simulator

scores were correlated both within a single driving session (i.e. measurements from the first part of the drive were correlated with those from second part of the drive) and between testing sessions. Time headway was found to be the most robust measurement both within and between testing sessions. The traffic gap acceptance correlated significantly within each driving session, but not between sessions. This finding suggests that there may be a degree of learning for gap acceptance behaviour in the Leeds Advanced Driving Simulator, particularly since mean gap acceptance was smaller on the second session. This was also the case with the other simulator measurements that were analysed, again suggesting that while some simulator measurements remain stable while others are improve with practice..

Drivers were separated into two groups (safe/risky) based on their driving ability, determined by performance on several driving measures thought to relate to safety. The tests showing significant differences in performance between risky and safe drivers were used in a multiple linear regression analysis, in order to determine which test combination best predicts driving simulator ability. The Rapid Pace Walk and the Useful Field of View were the best combination of tests to use as a predictor of driving simulator ability.

The study conducted suffered from several limitations, including a small sample size for the test-retest reliability analysis and a restricted segment of the old driver group. Because of these limitations the results from the research are presented tentatively and further research is necessary to confirm the results.

The results highlighted several important issues that are relevant for the use of laboratory, and driving simulator tasks in the assessment of fitness to drive in older drivers, and in particular in older drivers with arthritis.

First, only some of the laboratory tasks used and only some driving simulator measures appear to give reliable performance measurements. The others are hence best avoided when making decisions since performance on those measures varies with the times when they are administered. The results showed that when arthritic older drivers are classified, based on their performance in a simulator, into safe and risky, both some of the physical performance measures (specific to their arthritis) and some of the cognitive measures (specific to their age-related cognitive deficits) appear to differentiate between the two groups. This further suggests that in older drivers, both the cognitive component of their condition (be it ageing or other medical state) contributes to the discrimination between safe and risky drivers.

D-R1.8

ASSESSMENT OF FITNESS-TO-DRIVE AMONGST PATIENTS WITH LEARNING DIFFICULTIES

C. Björkli, M. Flö, G.D. Jenssen, T. Ryum and P. Zeiner, 2004

The pros and cons of current methods to evaluate fitness to drive and accident risk associated with Learning Disabilities (LD) such as Attention Deficit Hyperactivity Disorder (ADHD) and Light Mental Retardation (LMR) is the main theme of this report. The report contains two studies one on ADHD and one on Light Mental Retardation.

ADHD Study

The principal characteristics of ADHD are inattention, hyperactivity, and impulsivity. The skills needed for safe driving are several; the ability to focus on the road, attention to detail, and sustained attention are many times the areas which all people with ADD/ADHD have difficulty. Becoming distracted by the passengers in the car or by the radio, for even just a moment, can cause an accident.

It is also a question whether it is the ADHD symptoms as such that represents elevated risk for traffic accidents. Some studies have indicated that it is the accompanying psychiatric problems, in particular aggressiveness and conduct problems, which explain the increased risk. This question is unanswered so far.

Learning Disabilities, such as ADHD, are often treated by medication to enhance concentration and facilitate learning (e.g. Ritalin, amphetamine). These substances may affect driving, and there is a need to understand how such medication affect driver performance.

The present study is the first Norwegian study on ADHD and car driving. On an international level there are few studies on ADHD and fitness to drive. In the present ADHD study, seventeen adults with ADHD participated and completed the tests without side effects. Stimulant medication was used in a double blinded design to ensure evaluation under both conditions.

The patient group is considered to be representative of ADHD groups in general. Symptom load on SCL-90 was significantly above score in the reference group. Diagnostic assessments showed a high proportion with comorbid disorders such as conduct disorder, tics, depression, and various forms of anxiety disorders. In the reference group there was no indication of any psychiatric disorders in the participants.

When data from the driving simulator were analysed, the most striking finding is the similarities between the ADHD group and the reference group. There are small differences with regard to distance to vehicle in front or shift in position in the lane. These differences indicate that persons in the ADHD group show better driving skills. However, the differences are small and not considered to be of practical significance.

The data in this study compared a reference group of drivers with patients in medicated or non-medicated condition during a navigation task in a high-end simulator. The results indicate

that there are not distinct and clear group differences, either between reference drivers and patients with active medication or compared to patients with placebo treatment.

However, patients with active medication had more variance in steering wheel movement, a characteristic often associated with the motoric disturbances seen in the hyperkinetic aspect of the ADHD disorder. The finding is then somewhat counter intuitive, in that one would expect the unmedicated condition to provoke this kind of motoric feature.

Separating the ADHD drivers into two groups, denoting them as fast or slow drivers, some interesting results on subgroups and effects of medication surfaced. A correlation analysis suggest that the cluster label follows the medical condition, that is, subjects tend to be e.g. fast drivers when medicated, then become labelled slow when the placebo treatment condition. A possible interpretation of this pattern can be that the subject compensates their medical condition in accordance to their driving. This may be the case for fast drivers when driving without medication: They slow down in the placebo treatment in order to get everything right. Concerning the slow drivers, there may be another mechanism at work. This change of driving performance (from slow to fast) may possibly be a more traditional ADHD pattern, in which placebo treatment suffers the impulse control and thus results in faster driving.

Future studies will certainly have to further explore the individual effects of medication on driving as exemplified by the results on time to complete task. This present study outlines findings that may have multiple explanations, and must be regarded as a first step towards better knowledge of this specific patient group, as well as an effort to clarify what licensing procedures and policies that should be applied when making judgements on who is to drive and not.

Light Mental Retardation Study

SINTEF has since 1992 performed assessments of fitness to drive based on simulator tests. Some of the patients referred to SINTEF for evaluations are patients with Learning Disabilities. Some of these patients have been given exemption from the requirements of the law regarding health for drivers. Drivers with Light Mental Retardation (LMR) have been allowed to drive based on results of the simulator evaluation, testing driving performance in a virtual driving environment. However, decisions with regard to fitness to drive for LD drivers are today often solely based on a medical and/or neuropsychological examination.

Many people with Learning Disabilities never get the opportunity to show driving abilities in on road tests. Hence, medical and neuropsychological requirements might be too strict since compensatory strategies are not taken into account. International reviews show there are few studies on the importance of Light Mental Retardation on driving performance in traffic. A literature review, Elvik, Mysen & Vaa (1997) summarise the relation between different diseases and accidents. According to Meta analysis estimates of accident risk for drivers with health impairments, drivers with Low Intelligence (IQ < 70 vs IQ >70) have a accident risk of 1.20 (uncertainty in risk = 1.16-1.25) when accident risk for healthy drivers equals =1.0.

The aim of the project on LMR was to develop an assessment method for considering whether people with light mental retardation are fit for driving or not. Assessment methods for candidates/patients with little or no prior driving experience.

The study was initiated by a College offering specially adjusted education, and all the candidates for the study were recruited from this school. The 8 candidates had no prior driving experience.

The study was set up as a double blind experiment. This implies neither the subjects nor the experimenters were aware of the diagnosis of the participants or the results of prior screening procedures before the separate evaluations were completed. This ensured independent and unbiased evaluations by independent screening procedures and independent experts.

The results stress the need and the importance of individual assessment, like the Norwegian regulation recommends today. The study has shown great differences in driving skills within the same medical diagnose category.

The study shows the importance of clarifying the motivation for driving at an early stage. The pupil has to be motivated if fitness and learning skills for driving is to be assessed. It is also important to clarify whether it is diffidence and not lack of motivation that causes the refusal of driving training.

There was consensus on fitness to drive between medical, neuropsychological, school, and driving expertise in 50% of the cases. In some cases medical conditions like epilepsy was unknown to all except the medical expertise. Such conditions may not be exposed during a short trial in a simulator or during a few hours of on road driver training. In other cases a lack of motivation, slow reaction time and severe attention problem was detected by driving expertise in the simulator and by the school, but not by medical and neuropsychological expertise.

From a clinical perspective it is recommended that evaluation of driving performance and rehabilitation of drivers with Light Mental Retardation must be based on teamwork of medical, neuropsychological, and driving expertise. A combination of methods specific to the domain of expertise should be utilized when assessing drivers with learning disabilities.

D-R4.1

REVIEW OF IMPAIRMENT AND ACCIDENT RISK FOR ALCOHOL DRUGS AND MEDICINES

E. Braun and R. Christ, 2002

First, this report describes various ways which aim to estimate the number of impaired drivers. It reports estimated figures and points out the problems in quantification of the size of the impaired driving problem. Risk classification then combines exposure data and impairment effects and results in a ranking – still to be seen as a preliminary attempt.

A separate chapter describes different legal approaches to define impairment and outlines the variety of legal implications of impaired driving in European countries concerning alcohol and drugs and medicines. Especially concerning drugs the impairment definition is essential on how suspicion of impaired driving is dealt with – how police controls and roadside testing are conducted and what consequences for driving and driving license the convicted has to expect.

To outline the basis for drug recognition and impairment assessment the pharmacokinetic and the acute effects of drugs and medicines are described in detail. If available studies focusing upon effects on driving are reported. Effects resulting from combinations of various substances are described and discussed.

Based on this background the current ways of impairment identification are described - police suspicion, psychometric tests, drug screening methods and medical screening. Advantages and shortcomings of these methods are described; needs and ways to achieve improvement are discussed.

Ways how European countries proceed in driving license issues once a driver is convicted for driving under the influence of alcohol or a drug are described in a separate chapter. The diversity concerning alcohol is listed. Concerning drugs the procedures established in some European countries are described in detail. This concerns especially the psychological and medical judgement of single cases with respect to recidivism risk and rehabilitation measures.

Main results

The main results of the literature study are described in D-R4.6, Chapter 4 as follows (Bernhoft, 2005d):

Epidemiological studies

A comparison of prevalence studies from different European countries was found to be difficult for various reasons, e.g. lack of representative samples, lack of uniformity in the reporting and missing information on refusal rates. Furthermore, data collection often takes place at night, which does not reflect the prevalence of drugs in the general driving population, but results in an overrepresentation of young people compared to older people.

Also the current practice in many countries, that drug screening is only used if the alcohol concentration of the suspected driver is below the limit and that drivers who are suspected for

combined use of drugs and alcohol are not included in the data for research purposes, form an important bias.

As for responsibility studies, they often use highly pre-selected groups of seriously and fatally injured drivers, and the results might therefore be biased.

Risk assessment

The literature review showed that regarding risk assessment of drugs in road traffic several interpretation problems are vital, among others the distinction between acute and residual effects, separation of intoxication effect and treatment effect, and the distinction between active ingredient and metabolite.

Currently, risk assessment can only be made as a first approach. A first ranking has been presented within the project CERTIFIED as to how substance groups should be observed more severely because of its danger for road traffic (Tunbridge et al., 2000), taking into account A: impairment effects, B: prevalence in population and C: association with accidents:

High risk:	alcohol, benzodiazepines, cannabis with alcohol
High-moderate risk:	cocaine
Moderate risk:	cannabis, amphetamines
Low-moderate risk:	opiates, methadone, antihistamines
Low risk:	antidepressants

However, it should be mentioned that although opiates produce a strong sedation, the risk has been ranked as “low-moderate” due to the fact that the prevalence in the general driving population is considered low.

The Pompidou group (De Gier 2000) has summarised the importance of determining which doses of drugs in blood or saliva are associated with acceptable and unacceptable driving quality. This knowledge is relevant, for example for persons under therapy (e.g. heroin substitution) and can be derived from responsibility analyses or case control studies. These types of studies should be conducted for the most frequently used drugs and should also include the issue of combinations of drugs and alcohol.

Furthermore, the Pompidou group mentions the importance of minimising the risks for the general driving population. This can be obtained by controlling by law the driving of substitution patients.

Legislation

The Pompidou group (De Gier, 2000) points out that the police should receive sufficient powers to conduct roadside screening. There are two principle options in favour by European countries:

1. To admit roadside screening only in case of substantial suspicion of driving under the influence of drugs, or
2. To admit such screening on a random basis.

Furthermore, it is recommended that a zero tolerance limit of any illicit psychoactive substance should be a permitted option under the laws of any European country. The other option is adapting the impairment approach to the special problems of drug driving. Also, national bodies should consider the possibility of establishing lower per se blood alcohol limits for drivers depending upon the presence of illicit and licit drugs in the same samples.

Regarding test devices (Möller et al., 1999), the project ROSITA concludes that there is a need for validation of existing devices (urine tests, but also saliva and sweat etc. devices) and investigation into the correlation between impairment and pharmacokinetics in easily accessible body fluids and development of optimal test devices that are able to identify even small amounts of specific substances (especially for drugs).

Identification of impairment

The literature review states that numerous international studies have examined the acute impairment of alcohol, various types of medicines (anxiolytic sedatives, antidepressants, neuroleptics analgesics and antihistamines) and various illegal drugs (cannabis, cocaine, amphetamines and hallucinogens). For all these substances it has been concluded that they influence the psychomotor skills, the cognitive functions, the driving behaviour or combinations of these functions.

Besides the abuse of a single drug or a single medicine, simultaneous consumption of one or several further substances occurs frequently, as found in the epidemiological studies. Especially with heavily drug- or medicine-addicted persons, multiple drug use is frequently found. In recent years, the effect of multi-drug consumption on driving performance and psychomotor functions has also been studied.

The following causes for multiple drug use were stated (Möller, 1998): Group pressure, curiosity, testing of combinations, enhanced effects, reduction of undesirable effects, economic benefit of prolonged or intensified effects and addiction to substance combinations.

As preferred combinations can be observed where the basic consumption is considered to be the drug that is mainly taken, respectively the drug that primarily accounts for the addiction:

Heroin	co-consumption: cocaine, codeine, dihydrocodeine, benzodiazepines
Methadone	co-consumption: cannabis, heroin, cocaine, benzodiazepines
Cocaine	co-consumption: alcohol, benzodiazepines
Cannabis	co-consumption: alcohol
Amphetamines	co-consumption: cannabis, cocaine, LSD, designer drugs
Designer drugs	co-consumption: cannabis, cocaine, LSD, amphetamines, and alcohol
Benzodiazepines	co-consumption: alcohol, other benzodiazepines.

Each drug develops its own characteristic effects, hence the observable symptoms of combined use is the combination of all single effects, including any miscellaneous interactions (Möller, 1998). The method of consumption also has an essential influence on the intoxication effects, as well as the location of the substance uptake (lungs, stomach, blood).

The combination of active substances may have an additive, magnifying, weakening or neutralizing effect on the organism, for example:

Alcohol and benzodiazepines: over-additive depressant -effect

Alcohol and opiates: additive depressant effect

Alcohol and cocaine: weakening or intensifying effect (depending on the effect phase)

Amphetamines and cocaine: additive inciting effect

Methods to assess impairment

Closely connected with the legal framework is the question of whether drug enforcement in traffic needs to be based on a behavioural assessment of impairment or can be based solely on a forensic analysis.

For the impairment approach it is important to consider the complexity of different drug effects. The kind of impairment of a single drug or a single medicine already varies depending on the substance and the user. But, simultaneous consumption of one or several further substances occurs frequently and results in a variety of interaction effects, which makes impairment identification even more difficult.

Most countries are willing to introduce legislation concerning drug impairment, but they are opposed to the use of any form of behavioural assessment either because of being afraid of additional subjectivity in the assessment or overtaxing the police on the roadside. This is the reason for demanding useful detection devices and tests.

A few countries have introduced clinical evaluation procedures, for which they use a variety of methods, whereas the Southern European concept (e.g. French) is oriented towards biological methods. Other countries, especially Scandinavia, have adopted an approach between these two extremes. This concept is based on a police intervention in case of a reasonable suspicion. If drivers seem to be clearly impaired and the results of an alcohol test turn out to be negative, police officers are enabled to request a clinical assessment and a biological sample.

1. Road side evaluation procedures

The implementation of drug recognition programmes should be included in the police practice (depending on the legal status). This leads to high requirements for police officers, especially when a general, easily detectable impairment of the driving fitness (symptoms similar to an impairment by alcohol) alone is not sufficient to set further investigation steps, or when they have to conclude on specific substance groups from certain indicators.

In the first step the impairment evaluation is the power of the traffic police, in the second step different approaches are used depending on legislation of the countries. The USA has developed a special training for the police in charge to perform a complete evaluation of the driver. The Scandinavian countries, Germany, and Belgium pursue different procedures. In a first step, the police officer has to identify if there is a suspicion of impairment, using simple behavioural tests (not always standardised). In the case of suspicion, a biological sample is collected. In countries like France, they have no obligation to perform a clinical evaluation of drivers and no obligation of reasonable suspicion. The detection is only focused on an alcohol test followed by a confirmation.

In some provinces in Germany police officers are instructed in drug recognition. The essential main focus is the training of observation for gaining suspicion; moreover the police officer should be able to formulate the suspicion of drug impairment orally and in writing as witness in court.

In The United Kingdom, several police officers have shared the DEC (Drug Evaluation and Classification) training of the United States of America and impairment testing at the roadside. They have developed the general principles and techniques of the DRE (Drug Recognition Expert) programme into a training package, suitable for use in the UK and the police officers have been trained in drug impairment recognition and also in the administration of a standardised Field Impairment Test (FIT).

Recently, computer based roadside tests in combination with physical task performance have been introduced. These psychometric roadside tests still need development before they can be

used as a proof for impairment. They also have to be supported by well-defined procedures for how to carry out the test as well as training of the personal.

Test procedures still in development, such as video recordings for assessment of attitude, saliva examinations and pupillometry or contact-free measurements all offer possibilities for future development in this area. Further studies concerning a state of the art method of electro-nystagmography show promising results.

2. Drug screening methods

A large number of pre-test possibilities exist that, however, operate mainly on the basis of urine samples. But it should be mentioned that drugs might be detected in urine long after the acute impairment phase.

However, it should also be mentioned that pre-tests can only serve as an initial examination of suspicious drivers. A positive screening result from a pre-test must always be confirmed explicitly by reliable physical and chemical analysis methods. For the probability to detect drug consumption, the sensitivity of the analysis, the frequency of consumption and the time period of detecting the drug after consumption are of importance. The initial screening analyses give - even with exact performance - only hints to drug consumption, the proof is supplied solely by chemical and toxicological confirmation analyses.

However, since a summary of pharmacologically and toxicologically justified threshold values is currently not possible because of the differences in breakdown of the various drugs and medicines, for the time being, one has to rely on the combination of an exact statement of the police, an exact description of the subject's behaviour, medical examinations as well as confirming chemical and toxicological analyses for criminal prosecutions.

The ROSITA project (2000) concluded that devices for urine tests are validated but they are not applicable under the respective legal systems or operational conditions of police forces in most countries; Saliva/sweat test devices fulfil most operational requirements, but are still in development and under validation.

The Pompidou-group demands (De Gier, 2000) that European harmonised proficiency testing programmes for drug analyses in blood should be implemented in each country. European proficiency testing survey should be elaborated.

3. Medical examination

The assessment of the general physical condition of a suspected driver is not a very meaningful method to judge drug impairment. Deficiencies due to malnutrition or signs of neglect are at the best unspecific hints toward drug addiction. Typical characteristics of consumption like injection marks are concrete clues to drug consumption.

Therefore, a psychiatric-neurological examination to observe changes in the way of conversation and behaviour in order to detect mental disorders is very helpful. Furthermore, because of their complexity, generally only a specially trained physician or a neurologist can detect neurological problems.

Rehabilitation

The experiences in Germany and Austria with regard to the validation of traffic-psychological examinations make clear that by this kind of case-specific assessment, the recidivism risk can

be lowered by up to 50%. With that, this measure should surely be pushed in other countries, too.

As emanates from earlier experiences in Norway, penalties and high probabilities of detection alone are not sufficient to prevent recidivism or repeat offences. Especially persons with serious behaviour of abuse and/or addiction problems are not sufficiently deterred from endangering road use by penalties alone.

D-R4.2

THE PREVALENCE OF DRUG DRIVING AND RELATIVE RISK ESTIMATIONS A STUDY CONDUCTED IN THE NETHERLANDS, NORWAY AND THE UNITED KINGDOM

T. Assum (Editor), S.C. Buttress, B. Sexton, R.J. Tunbridge, J. Oliver, M.P.M. Mathijssen and S. Houwing, 2005

In recent years, the number of drivers who drive while under the influence of drugs has been increasing. Previous studies of the presence of drugs in the samples obtained from road traffic accident fatalities have shown that a significant proportion of fatally injured drivers have drugs in their body. This present study of the prevalence of drugs in the driving population forms part of a larger, Europe-wide investigation of the impact of drugs, medications and medical conditions have on road safety. This research programme, known as the IMMORTAL project (Impaired Motorists, Methods of Roadside Testing and Assessment for Licensing) investigates the accident risk associated with different types of driver impairment and examines the implication for licensing assessment and roadside impairment testing (including drug screening).

The present study's intention was to examine, in three European countries, Netherlands, Norway and UK (Scotland), whether drivers using one or more of eight defined drug groups have a higher accident risk than drivers not using these drugs; and to as far as possible quantify this risk.

The study in the Netherlands included testing of an observational method for detecting drug-impaired drivers.

The Netherlands

The eight drug groups included in the Dutch study were: benzodiazepines, tricyclic antidepressants, methadone, opiates, amphetamines, cannabis, cocaine and alcohol. The methodology used in the Netherlands included a case-control study, where the prevalence of the substances among injured drivers (a hospital sample) was compared with the prevalence in the general driving population (a random roadside sample), and risk ratios were calculated.

Data on substance use by seriously injured drivers (in-patients) was collected in the St. Elisabeth Hospital in the city of Tilburg. Data on substance use by the general driving population was collected in the Tilburg police district, which is the hospital's catchment area. A random roadside survey was conducted in close cooperation with the Tilburg police force.

Among the general driving population, cannabis, benzodiazepines and alcohol were the prevailing substances. Out of the 3,799 stopped and tested drivers:

- 4.5% were positive for cannabis; 3.9% for cannabis alone and 0.6% for cannabis in combination with other drugs and/or alcohol.
- 2.1% were positive for benzodiazepines; 2.0% for benzodiazepines alone and 0.1% for benzodiazepines in combination with other drugs and/or alcohol.
- 2.1% were positive for alcohol (BAC ≥ 0.2 g/l); 1.8% for alcohol alone and 0.3% for alcohol in combination with other drugs.

Drugs of abuse were strongly concentrated in male drivers aged 18-24. No less than 17.5% were positive for illegal drugs. Psychoactive prescription drugs were strongly concentrated in female drivers aged 50 and older: 11.3% were positive.

Comparison of the road and hospital samples showed that approx. 35% of serious injuries among drivers in the Tilburg police district were associated with self-administered alcohol and/or illegal drugs, and especially with drug-free BAC-levels ≥ 1.3 g/l, with drug/alcohol combinations at BAC-levels ≥ 0.8 g/l, and with drug/drug combinations. These three categories accounted for 12.7%, 8.3% and 7.2%, respectively, of the 184 seriously injured drivers included in the hospital sample. The corresponding odds ratios were 87, 179 and 24, respectively.

Considering the fact that in part of the alcohol and/or drug-related serious-injury crashes a sober driver was seriously injured, it can be assumed that alcohol and/or illegal drug use accounted for even more than 35% of serious road injuries in the Tilburg police district.

In addition to the case-control study, and combined with the roadside survey, an observational method for detecting drug impaired drivers was tested. The method consisted of a checklist of signs of impairment supplemented with two questions about recent drug use. Specificity (98.6%) and negative predictive value (95.8%) of the method were satisfactory, whereas sensitivity (61.1%) and positive predictive value (82.9%) were rather low. It is recommended to try and improve the method in future trials, since large-scale random analytical drug-screening will probably not be feasible in the years to come.

Norway

The seven drug groups included in the Norwegian part of the study were alcohol, amphetamine, benzodiazepines, cannabis, cocaine, ecstasy, and opiates. The methodology used in Norway included a case-control study, where the prevalence of the selected substances among injured and killed drivers (hospital and forensic institute samples) was compared with the prevalence in the general driving population (a random roadside sample), and risk ratios were calculated.

The study met with severe practical problems in collecting data from the general driving population and especially from injured drivers. The Medical Ethical Committee demanded a written positive approval for the use of blood samples from injured drivers. Although no injured driver refused to participate, obtaining the written approval turned out to be so demanding for the hospital staff, that one co-operating hospital refused to continue after the pilot study, and the other hospital obtained approvals from only 19 admitted drivers of a total of 77 who met the criteria of the project. For this reason, data on fatally injured drivers selected for autopsy by the police were included to compensate for the small number of injured drivers included.

Data on substance use by seriously injured drivers (in-patients) were collected in the Ullevål University Hospital in Oslo and the University Hospital in Bergen. Data on substance use by fatally injured drivers were obtained from the forensic medicine institutes in the two cities.

Data on substance use by the general driving population were collected in the above hospitals' catchment areas by means of oral fluid specimens by officers of the national mobile police and the Hordaland police district. The results are weighted by traffic flow.

Of 410 tested general drivers 1 was positive for benzodiazepines, 2 for cannabis and 1 for opiates. In total four general drivers tested positive for drugs above the analytical cut-off limit set by Altrix healthcare. However, providing an oral fluid specimen to the police was voluntary, and there may be reason to believe that drivers having recently used illegal substances or high doses of medical drugs may have refused to provide a specimen. Of 438 drivers stopped by the police for the survey, oral fluid specimens are missing for 28. All stopped drivers had to take a breath test for alcohol, but no driver stopped was positive for alcohol above the legal limit in Norway, BAC 0.2 g/l.

Of the total of 87 killed or injured drivers in the cases sample, 59 were negative for all seven drugs tested. 13 drivers were positive for alcohol, 8 positive for amphetamine, 10 for benzodiazepines, 2 for cannabis, 1 for ecstasy and 7 for opiates. No case driver was positive for cocaine. 18 drivers were positive for one drug. Seven drivers were positive for two drugs and three were positive for three drugs.

Relative risk is calculated by two methods, using percentages and odds ratios. As the total number of cases and controls is small and the cases are a selected sample, it is difficult to compute case/control and odds ratios for all seven drugs. The relative risk of drivers, who have used one or more substances of the seven included in the study, is 32.1 and the odds ratio for the same drivers is 48.2. Even though samples are small, there is no doubt that the risk of a severe accident increases considerably for drivers using one or more of these substances, with the exception of drivers who have taken cannabis only. Their risk is not significantly different from drivers who have taken no drug. However, the relative risk or odds ratio of drivers who have taken amphetamine, ecstasy, cocaine or alcohol alone, cannot be computed, because there is no driver positive of these substances alone among the control drivers.

United Kingdom

The eight drug groups included were: benzodiazepines, codeine, other opiates, amphetamines, ecstasy, cannabis, cocaine and alcohol.

The intended methodology included a case/control study, where the prevalence of the substances among injured drivers (a Hospital Sample) could be compared with the prevalence in drivers in general (a Roadside Sample), and risk ratios calculated. However there was a problem with ethical issues in Scotland in obtaining body fluid samples from injured drivers. This meant that the case samples in the UK study could not be provided by hospitals. In practice the UK study had to resort to using a sample of fatally injured drivers and extracting data on drugs from their post-mortem records.

The roadside survey was, however, successfully accomplished as planned, and was used to estimate the prevalence of drug use amongst motorists. In the UK this involved a roadside survey of drivers in central Glasgow. Teams of Police and research staff stopped motorists, obtained an oral fluid sample and asked them to complete a questionnaire on drugs and driving. Over 1300 drivers were stopped and agreed to help in the survey.

The main outcomes from the UK part of the study are estimates of the prevalence of drugs in Glasgow drivers at or above concentration levels proposed by the Substance Abuse and Mental Health Services Administration (SAMHSA). This prevalence varied from 4.10% for ecstasy or similar drugs alone, to 0.02% for opiates alone (not including codeine). Ecstasy alone and cannabis alone (3.14%) were, by far, the drugs with the highest prevalence.

Information on drug presence at the minimum detectable level is also presented in the report. The study successfully developed and employed a methodology for the roadside collection of oral fluid samples enabling the detection of drugs. It also illustrated some of the difficulties in obtaining data on drug use from accident involved drivers in Scotland.

Discussion

Although much effort was given to harmonise the studies in the three countries, it was agreed upon in Annex I of the contract that either urine samples or oral fluid samples should be collected at the roadside. Therefore, due to the existing possibilities in the involved countries, it was decided to collect urine at the roadside in the Netherlands, whereas oral fluid samples should be collected in Norway and the UK.

Furthermore, the different studies used different detection methods and therefore different cut-off thresholds to calculate prevalence. Because of these differences, a comparison of results from the three studies is difficult. However, **table S1** shows a rough comparison between the three countries regarding psychoactive substance use among the general driving populations.

Table S1 shows that prevalences are low in general – compared to other violations like speeding or not wearing a seat belt. The prevalence of one or more drugs is of the same magnitude, around 10 per cent, in the Netherlands and the UK, whereas it is considerably lower in Norway, only 1 per cent. However, the Norwegian sample is very small, but the difference between the two former countries and the latter is likely to be significant. Norway has a long tradition of strict drinking-and-driving rules and enforcement, which may explain the low prevalence of alcohol as well as other drugs among Norwegian drivers. A larger sample would, however, be required to confirm the prevalence in Norway.

Table S1. Prevalence of drugs alone or in combinations with other drugs in the general driving population by country (weighted results). Per cent.

Drug alone or in combination	NL	Nor	UK
Alcohol > 0.2 g/l	2.1	0.0	-
Amphetamine	0.03	0.0	0.66
Benzodiazepines	2.1	0.2	-
Cannabis	4.5	0.5	3.26
Cocaine	0.7	0.0	1.34
Ecstasy	0.6	0.0	4.61
Opiates (excluding codeine)	0.06	0.2	0.08
Codeine	0.6	-	1.61
Tricyclic antidepressants	0.3	-	-
Methadone	0.04	-	-
Positive for one or more drugs	9.9	1.0	10.8
N (Unweighted number of controls)	3799	410	1312

The prevalence in the UK is slightly higher than the Dutch prevalence, in spite of the fact that the results from the Dutch study include four more substances (alcohol, benzodiazepines,

tricyclic antidepressants and methadone) than the results from the UK study. Alcohol was not included in the UK results because no validation studies exist on detection of alcohol in the collection device that was used in the UK. Benzodiazepines were not considered because no SAMHSA proposed cut-off limit exists for oral fluid.

If the prevalence of these four substances in the UK is about the same as in the Netherlands, the total prevalence in the UK would be about 15 per cent.

The estimated prevalence of ecstasy, alone or in combination with other substances, was 4.6 per cent in the UK study. This was high compared with the values obtained in the Netherlands and Norway. The UK value may reflect sampling variation and/or factors specific to the city of Glasgow, and should not be taken to indicate prevalence in the UK as a whole. A larger study covering all of the UK would be required to establish a UK estimate.

Unlike in Norway and the UK, the use of cannabis is not a criminal offence in the Netherlands. This fact may be the explanation of the rather high prevalence of cannabis among the Dutch drivers. However, the blood and urine analyses used in the Dutch study are more sensitive methods to detect cannabis and benzodiazepines than oral fluid analysis used in Norway and the UK.

Cannabis is a frequently used psychoactive substance in all three countries. To compare the prevalence of the various drugs among the general driving populations between countries, larger, nationally representative surveys will be needed. Moreover, it is important that identical test methods are used.

The injury risk of drug use was calculated in the Dutch and Norwegian studies. The Dutch study shows that severe road injuries were especially associated with drug free blood alcohol concentrations (BAC) above 1.3 g/l, with combined alcohol and drug use at BAC levels above 0.8 g/l, and with the combined use of two or more illegal drugs. Together, these three categories were present among only 0.8 per cent of the general driving population, but they accounted for 28 per cent of all serious injuries. No significantly increased injury risk was associated with the use of cannabis, amphetamine, ecstasy, cocaine or tricyclic antidepressants when taken alone.

The Norwegian data sets were too small to calculate the injury risk of use of single psychoactive substances, but drivers who were positive for one or more of the drugs in question had a risk of injury or death about 30 times higher than drivers without these drugs.

Conclusion

Although the prevalences in the general driving population of the drugs studied in this project are generally small, there is no doubt that they constitute important factors increasing the risk for road accidents.

The results of the epidemiological studies indicate that road safety policy should give priority to the detection, prosecution and rehabilitation of drivers with high alcohol concentrations and drivers having used alcohol/drug or drug/drug combinations.

Further research is necessary to describe in greater detail the accident risks associated with concentrations and combinations of drugs. The requirement of the medical/ethical committees of written consent from injured drivers is a severe problem for such research.

With regard to the observational drug detection method that was tested in the Netherlands, it is recommended to try and improve the method in future trials, since large-scale random analytical drug screening will probably not be feasible in the years to come.

D-R4.3

DRUGS IN ACCIDENT INVOLVED DRIVERS IN DENMARK

I.M. Bernhoft, 2005

As part of the IMMORTAL project of 5th Framework Programme, a study regarding drugs in accident involved drivers took place in Denmark. The main objectives of this study were

1. To give an indication whether drug use may contribute to traffic accidents
2. To get information on characteristics of the drug positive drivers and their drug use
3. To get information on drivers' knowledge about drugs and their attitudes to driving under the influence of drugs, alone or in combination with alcohol

Data collection

Injured drivers from traffic accidents who were treated in two selected hospitals were asked to give a saliva sample (the correct term is oral fluid), a blood sample or both. The samples were screened for the following six drug groups: Opiates, incl. morphine and codeine, amphetamines, methamphetamines, incl. ecstasy, cannabis (tetrahydrocannabinol and metabolites), cocaine (cocaine and metabolites) and benzodiazepines. Screenings were carried out by means of Cozart Microplate EIA kit. Positive screenings were confirmed by gas chromatography/mass spectrometry (GC/MS) or liquid chromatography/tandem mass spectrometry (LC/MS/MS).

333 patients took part in the survey. In total, the samples from 26 patients were confirmed positive for one or more of the six drug groups. However, three of the drug-positive patients were excluded from the survey: One did not know whether he had been the driver and two patients had the drugs after the accident but before the sample was taken as part of their treatment. In addition to the drug-positive drivers, another 26 patients had reported drug use less than 24 hours prior to the accident.

Results of the confirmation analyses

Of the remaining 23 drug-positive patients, 15 were found positive for one drug group, and in 5 of these cases alcohol was also present in a concentration over the legal limit in Denmark (.05%). The other 8 patients were found positive for two drug groups, and in 4 of these cases alcohol was also present in a concentration over the legal limit. Alcohol was found both in combination with medicinal drugs, with illegal drugs as well as in combination with both types of drugs. Illegal drugs were present, alone or in combination with medicinal drugs and/or alcohol in 16 of the 23 drug-positive patients.

In 7 of 11 cases with patients positive for cannabis, this was in combination with other drugs and/or alcohol: Benzodiazepines (4 cases), ecstasy (1 case) and alcohol (6 cases). Another 6 patients were positive for benzodiazepines, and in 4 of these cases this was in combination with other drugs and/or alcohol: Morphine (2 cases), benzoylecgonine (1 case) and alcohol (3 cases).

In 9 of 23 cases there was strong suspicion of impaired driving abilities and in another 6 cases it is likely that the driving abilities had been impaired.

The interviews

33 interviews were carried out with drivers who were either confirmed positive for drugs or had self-reported drug use. However, only 23 of these could be included in the analysis. The remaining 10 interviews revealed that the reported use of drugs was not assumed to impair driving, the drugs were given after the accident took place or the patient was not sure whether he had been the driver.

In 10 of the accidents where it was not possible to conduct an interview, police records were available, and they form the background for estimating accident factors.

Accident factors

Based on the interviews it may be estimated that 18 of the 23 drivers who were interviewed have contributed to the accident occurrence. In two accidents, the female drivers seem to have had a blackout, resulting in losing control of the vehicle. Other important and well-defined human factors comprise too high speeds, overtaking, lack of attention, misjudgement of the situation, bad state of mind, and finally alcohol and drugs.

12 interviews with drivers confirmed positive for one or more drugs, alone or in combination with alcohol were included in the accident analysis. In 6 of these 12 accidents, it is assumed that the impairment has contributed to the accident factors. Other human factors related to driving behaviour also contributed to the accident occurrence in all but one of these accidents.

However, in the 11 accidents where interviews were based on the driver's self-reported drug use, the concentrations of the reported drugs are not known, as they were not tested for or not detected in the analyses of the samples. Therefore, it is unknown whether the drugs might have been a contributory factor in these accidents.

Furthermore, from the police records it may be estimated that in 8 of 10 accidents where the driver was confirmed positive for one or more drugs, alone or in combination with alcohol, and in one accident where the driver was impaired by alcohol, it is assumed that the impairment has contributed to the accident occurrence. In 5 of these 9 accidents, it is likely that human factors related to driver behaviour have also contributed to the accident.

Characteristics of the interviewees

The interviews showed that there are three common types of drug-impaired drivers:

- Young, well-functioning men who use illegal drugs (mostly amphetamines or cannabis), either during weekends or in the evening. Those who use amphetamines know that they should stop using drugs, whereas this is not to the same extent the case for cannabis users. Generally, they do not mix drugs with alcohol and do not think that the drugs constitute a traffic safety risk. The young drivers have a valid driving license for car or moped. They have got their own car or are able to borrow that of their parents. Except for one driver who had just bought a motorcycle and was out on his first drive, the young interviewees were familiar with the vehicles that they drove on the accident trip.
- Middle aged men and women (35-54 years old) who have stopped working because of their alcohol and/or medicine dependency. They do not refrain from mixing their prescribed medicines with alcohol, and they are not aware of the risk this may constitute in traffic. The middle aged and older drivers either ride a moped of their own or their own car. Some of the moped riders have lost their driving licence or have never had one. Except for one moped, all vehicles seemed to fulfil legal requirements although some of the cars were fairly old and not equipped with airbags.

- Drivers aged 55 and above who are still working or who have passed the retirement age and whose drug use is restricted to over the counter medicines or prescriptions. They do not combine the medicines with alcohol. They drive their own car that they have had since long.

Most of the interviewees used seat belt or helmet, and thus undoubtedly their injuries have been reduced. Those who did not use seat belt or helmet state that they will do it in future. In the same way, most of the interviewees have changed their behaviour in traffic after the accident.

Attitudes to drugs

Generally, the young drivers do not think that illegal drugs will cause any traffic safety risks like they know is the case for alcohol. Neither are they aware of the additive risk when combining alcohol and drugs. However, most of the drivers in all ages know about the impairing effect of medicines, but they have got no knowledge about the additive effect of mixed use of medicines and alcohol.

Some of the young interviewees will try to stop using illegal drugs and the few of them who also drink before driving or riding will stop doing this. On the contrary, the middle-aged drivers will not change their medicine use and those who mix drugs and alcohol will not change their habit. The older drivers do not mix prescribed medicines and alcohol.

Future perspectives

The interviews have produced new information about accident-involved drivers who took drugs before the accident. The results are of a qualitative character. They cannot be generalized and can under no circumstances give rise to any statistical suggestions. Nevertheless, they show that the drivers need more information about drugs and driving.

The results also show that more emphasis should be given to inform young people of the consequences that may follow their abuse of cannabis and amphetamine. This information should be given in schools, during driving lessons and with their general practitioner in case of prescribed medicines. The doctor should also assess whether health problems that require prescribed medicines are caused by drug use.

Early-retired people still drive a car or a moped irrespective of use of various medicines, often combined with high concentration of alcohol. They do not consider their alcohol consumption to be a traffic safety problem, neither in combination with use of medicine. They are in need of their prescribed medicine that most of them have taken for years. In these cases, the general practitioners should go into a dialog regarding a possible alcohol dependency of the patient and if so find a way of starting rehabilitation. Focus should also be directed towards the problems when using analgesics in combination with prescribed medicines regarding chronic diseases.

The older drivers use prescribed medicines but alcohol is not a problem. In relation to chronically diseases, the general practitioners should be aware of the possibility of sudden changes in the patients' health condition and give information on how to prevent such changes. More focus should be given to provide dose administration of medicines to elderly people.

D-R4.4

EXPERIMENTAL STUDIES ON THE EFFECTS OF LICIT AND ILLICIT DRUGS ON DRIVING PERFORMANCE; PSYCHOMOTOR SKILLS AND COGNITIVE FUNCTION

J.G. Ramaekers (Editor), K.P.C. Kuypers, C.M. Wood, G.R.J. Hockey, S. Jamson, H. Jamson and E. Birch, 2004

The current deliverable D-R4.4 of the IMMORTAL project entails a series of experimental studies on the effects of licit and illicit drugs on cognition, psychomotor function and driving performance. The studies have been conducted by two research groups with strong backgrounds in Drugs and Driving research: i.e. the Experimental Psychopharmacology Unit, Brain & Behavior Institute at Maastricht University and the School of Psychology at Leeds University. The former group conducted 2 double-blind, placebo-controlled studies on the acute effects of 3,4-methylenedioxymethamphetamine (MDMA or ecstasy) alone or in combination with alcohol on actual driving performance as measured in on-the-road driving tests and in laboratory tests measuring psychological functions relevant to driving: i.e. impulsivity, risk taking, psychomotor speed, tracking, motion sensitivity and memory (Study A and B). The latter group performed a single-blind, placebo controlled study on the effect of a common over-the-counter cold remedy mixture of diphenhydramine hydrochloride 25mg, paracetamol 1000mg and pseudoephedrine 45mg, on simulated driving performance and psychomotor function (Study C).

Study A

A placebo controlled study on the effects of 3,4-methylene-dioxymethamphetamine (MDMA) 75mg and methylphenidate 20mg on actual driving performance, visuospatial attention and memory during intoxication and withdrawal.

3,4-methylenedioxymethamphetamine (MDMA) is currently one of the most popular drugs of abuse in Europe. Its increasing use over the last decade has led to concern regarding possible adverse effects on driving and cognition.

The primary aim of the present study was to investigate the acute effects of MDMA on actual driving performance and cognition (i.e. visuospatial attention and memory). The second aim of the present study was to assess the effects of MDMA on driving and cognition during the withdrawal phase.

Eighteen recreational MDMA-users (9 males, 9 females) aged 21-39 yrs participated in a double-blind, placebo-controlled, 3-way cross-over study. Drugs and placebo were administered on Day 1 of treatment (Intoxication phase). Cognitive and driving tests were conducted between 1,5-2,5 hrs and 3-5 hrs post drug respectively. Subjects returned the following day for a repetition of the cognitive and driving tests at the same times as on the day of treatment, i.e. 24 hrs later (Withdrawal phase). Actual on-the-road-driving tests consisted of a Road Tracking Test and a Car Following Test. Its main parameters were Standard Deviation of Lateral Position (SDLP), Time to Speed Adaptation (TSA), Brake Reaction Time (BRT) and Gain. Visuospatial processing and memory were assessed in a range of cognitive laboratory tests.

Results demonstrated that MDMA and methylphenidate significantly decreased SDLP in the Road Tracking Tests by about 2 cm relative to placebo on Day 1. SDLP was not affected by Treatment or Period during withdrawal on Day 2. In addition, MDMA intoxication decreased performance in the Car-Following test as indicated by a significant rise in the 'overshoot' of the subjects' response to speed decelerations of the leading vehicle. Cognitive tests furthermore demonstrated that a single dose of MDMA 75 mg impairs performance in spatial and verbal memory tasks. MDMA's detrimental effect on spatial memory may be of particular relevance to the driver as it indicates a reduction in situation awareness or spatial orientation while driving under the influence. Collectively, these data indicate that MDMA possesses activating or stimulating properties that may improve driving performance in certain aspects of the driving task (road tracking) but cause impairment in others (car-following task).

Study B

Interaction effects of 3,4-methylenedioxymethamphetamine (MDMA or ecstasy) and alcohol on actual driving, psychomotor performance and risk taking behavior.

MDMA is frequently taken in combination with other recreational drugs, such as alcohol. It is presently unclear whether and how concomitant use of alcohol will affect MDMA effects on performance. The present study was designed to assess the effects of MDMA and alcohol, alone and in combination, on actual driving performance and risk taking behaviour. Eighteen recreational users of MDMA entered a double-blind, placebo-controlled, 6-way cross-over study.

The treatments consisted of MDMA 0, 75 and 100 mg with and without alcohol. Alcohol dosing was designed to achieve a peak Blood Alcohol Concentration (BAC) of about 0.06 g/dl during laboratory testing and of about 0.05 g/dl during the actual driving tests. Laboratory tests of psychomotor function and risk taking behaviour were conducted between 1.5-2.25 hrs post MDMA. Actual driving test, i.e. a Road Tracking Test and a Car-Following Test, were conducted between 3-5 hrs post MDMA.

Both doses of MDMA significantly improved performance in the Road Tracking Test, as indicated by decrements in standard deviation of lateral position (SDLP) and standard deviation of speed. The stimulating effect of MDMA 100mg was more prominent when combined with alcohol whereas the stimulating effect of MDMA 75mg did not change in magnitude after alcohol co-administration. MDMA did not affect performance in the Car-Following test, or any other test measuring psychomotor function and risk taking behavior. Alcohol alone, significantly increased SDLP in the Road Tracking Test, brake reaction time in Car-Following and tracking performance in a Critical Tracking Task.

Alcohol furthermore decreased inhibitory control in a Stop-Signal task, but increased inhibitory control in a Gambling paradigm of impulsivity. Collectively these data indicate that MDMA is a stimulant drug that may facilitate certain aspect of the driving task, i.e. road tracking, even when combined with a low dose of alcohol. However performance compensation after combined MDMA/alcohol administration was limited to a single driving parameter and was never sufficient to fully overcome alcohol impairment in all driver related tasks.

Study C

The effect of cold virus and cold virus medication on cognitive and driving performance

Common cold infections are so widespread that there can be very few people who escape infection each year. Symptoms can last anywhere between 1 day and 2 weeks. Several studies have shown that the cold virus can impair attention and psychomotor performance related to driving. Many cold sufferers take some form of over the counter medication to relieve their symptoms. The present study was designed to assess the effect of cold virus and cold virus medication on driving performance and cognitive performance related to driving. Ninety-six participants took part in a single blind 2x2 between subjects study. Participants diagnosed with a common cold were compared, with and without medication, and to baseline conditions. The medication was typical of many over the counter cold remedies used in the UK and contained the following active ingredients; Diphenhydramine hydrochloride 25 mg, Paracetamol 1000 mg, and Pseudoephedrine hydrochloride 45 mg. Laboratory tests of psychomotor performance related to driving were conducted between 0.25 –1 hrs post ingestion of placebo or medication. Participants' performance was then tested using the Leeds driving simulator 1.25-2.5 hrs post ingestion of placebo or medication.

The results from the cognitive tests were similar to previous findings and showed that volunteers suffering with a cold virus had slower reaction times and impaired visual search abilities. Cold sufferers also reported increased subjective fatigue and depression scores. Medication did not affect performance on the cognitive tasks but medicated volunteers did report higher scores of subjective fatigue. The results from the simulator tasks were somewhat mixed. Generally it seemed that cold sufferers taking medication could perform well in longitudinal control. Indeed, some results suggested that cold sufferers performed better in longitudinal control. Secondary tasks and lateral control, however, were often impaired by medication and sometimes further impaired by taking medication whilst having a cold. It seems that drivers compensate for the effects of medication by modifying their driving style. The extra effort applied to some driving aspects results in decreased performance in other aspects of driving such as lateral stability. Cold sufferers taking medication also performed poorly on awareness tasks during the simulated run again suggesting that although driving ability may appear adequate there may be less cognitive resources for additional secondary tasks.

Discussion

What all studies have in common is their use of well controlled, experimental study designs. The studies employed representative subject samples, i.e. recreational users of MDMA and cold sufferers, who went through strict medical screening and selection procedures. They furthermore employed (mixed-model) cross-over designs which are generally preferred for their efficiency while providing maximal statistical power with relatively small sample sizes, and they proceeded from conventional laboratory testing of psychomotor skills and cognition to sophisticated driving simulators and actual driving tests for establishing the driving hazard potential of the respective drugs. A final similarity can be found in the potential scope of the problem that is addressed in these studies. Both MDMA and cold remedies are a widely used among recreational drug users and cold sufferers respectively. Many of these people will operate their vehicles while under the influence of their drug. Yet the effects of these drugs on driving ability have been poorly studied and were prior to the initiation of the IMMORTAL research projects, largely unknown.

The MDMA studies demonstrated that MDMA significantly improved tracking control in a Road Tracking Tests. In addition, MDMA intoxication decreased performance in a Car-Following test as indicated by a significant rise in the 'overshoot' of the subjects' response to speed decelerations of the leading vehicle. Cognitive tests furthermore demonstrated that a single dose of MDMA 75 mg impairs performance in spatial and verbal memory tasks.

MDMA's detrimental effect on spatial memory may be of particular relevance to the driver as it indicates a reduction in situation awareness or spatial orientation while driving under the influence. In general, MDMA mitigated the impairing effect of alcohol on one driving parameter, i.e. road tracking performance, but failed to affect alcohol induced impairment on a range of other parameters such as brake reaction time and risk taking. Collectively, these data indicate that MDMA possesses activating or stimulating properties that may improve driving performance in certain aspects of the driving task but cause impairment in others.

Potential problem areas in cognitive function that have been identified in the present MDMA studies thus include time estimation of moving objects, spatial orientation and memory. Most of these problem areas have been indicated by laboratory tests and to a lesser degree by actual driving tests. The reason for this discrepancy may be related to the fact that on-the-road driving tests have primarily focussed on modelling (psycho)motor functions and have paid relatively little attention to the role of executive cognitive functions during driving. Consequently, actual driving tests have been very successful for assessing the impairing potential of sedative drugs on psychomotor function. MDMA however is a stimulant drug that has been shown to improve performance in a range of psychomotor tasks but causes impairment in some cognitive functions. The consequence might be that existing driving test must be further developed in order to also include the assessment of the cognitive domains relevant to stimulant drugs such as MDMA. Candidate concepts are objective measurements of estimated time to collision and prospective memory during actual driving.

The study on the effect of cold and cold remedy on driving ability showed volunteers suffering with a cold virus had slower reaction times and impaired visual search abilities. Medication did not affect performance on the cognitive tasks but impaired road tracking control in a driving simulator task. The data also suggested that drivers compensate for the effects of medication by modifying their driving style. The extra effort applied to some driving aspects resulted in decreased performance in other aspects of driving such as lateral stability. Cold sufferers taking medication also performed poorly on awareness tasks during the simulated run again suggesting that although driving ability may appear adequate there may be less cognitive resources for additional secondary tasks.

The impairing effect of cold remedy medication on road tracking performance is particularly noteworthy. Although many experimental studies have previously shown that diphenhydramine can impair psychomotor skills and driving performance, one would not necessarily have expected the same to occur in the present study. The reasons are twofold: 1) the dose of diphenhydramine in the present cold remedy formulation was rather low, i.e. 25mg, as compared to the usual doses that have been tested in previous studies, i.e. 50-100mg, and 2) the addition of a stimulant drug, i.e. pseudoephedrine, to the cold remedy formulation. The reason why stimulant drugs are usually added to cold remedy formulations is clear: to counteract drowsiness and somnolence induced by diphenhydramine. This study demonstrates however that the addition of pseudoephedrine, present in common cold remedies, does not fully compensate for the sedative potential of diphenhydramine.

Conclusions on tolerance levels

The general recommendation coming from these studies is that users of MDMA and common cold remedies should be informed on these drugs' potential to selectively affect cognitive function and performance at relevant aspects of the driver task.

In the case of MDMA however one has to also draw the conclusion that single doses up to 100mg of MDMA are not likely to pose a great hazard in drivers due to its stimulating

activities of psychomotor abilities. This perspective may change however for MDMA users taking higher doses or repeated doses of MDMA on one or successive nights, in hot environments at rave's and dance-parties that may change a subjects response to MDMA during intoxication and withdrawal. MDMA's detrimental effect on verbal and spatial memory may also be of relevance to the driver as it indicates a reduction in situation awareness or spatial orientation while driving under the influence. More research is needed to understand the influence of high en repeated dosing, environmental conditions and sleep deprivation on the effects of MDMA on driving performance. Combinations of MDMA (75 and 100mg) with low doses of alcohol however consistently impaired performance in a range of measures of actual driving, psychomotor function and risk taking behaviour. The implication is that any combination of alcohol and MDMA should always be avoided when operating a motor vehicle.

In the case of diphenhydramine the study results are straightforward. Diphenhydramine produced driving impairment in subject suffering from flu, even though the drug was administered at the lowest dose available. The implication is that driving should always be contraindicated in drivers taking diphenhydramine.

ANNEX 2: EXECUTIVE SUMMARIES OF POLICY DELIVERABLES

D-P2 DETAILED COST - BENEFIT ANALYSIS OF POTENTIAL IMPAIRMENT COUNTERMEASURES

W. Vlakveld, P. Wesemann, E. Devillers, R. Elvik and K. Veisten, 2005

Introduction

Traffic accidents in Europe as in other parts of the world are an enormous problem. In general road safety can be improved by measures regarding infrastructure, vehicle, or behaviour. The behaviour of the driver is influenced by his competences and capabilities. These competences and capabilities are the basis for the IMMORTAL research programme in which impairments (chronic and acute) and their influence on traffic safety are determined.

In order to decide on possible policies for impairment countermeasures it is necessary to have an insight in the socio-economic effects of the policies. This is provided in this report by means of a cost-benefit analysis. A socio-economic cost-benefit analysis provides an unambiguous appraisal method, which takes into account all relevant social effects.

Efficiency assessment

In this report we use a *cost-benefit analysis* to assess the potential impairment countermeasures. Another method for efficiency assessment is the *cost-effectiveness analysis*. Both methods have a common point of departure, namely the project-effects matrix (the overview of costs and effects). In a cost-benefit analysis the advantages and disadvantages are expressed in terms of costs and benefits and are wherever possible expressed in monetary terms. All effects are taken into account, both intended effects and side effects, including effects for those not directly involved.

The main difference is that in the cost-effectiveness analysis, only the intended effects are included (in this case safety effects) and only the costs to obtain these effects are expressed in monetary terms. This type of analysis proves to be valuable for cases in which the effects have to be maximized within a given budget or the costs have to be minimized guaranteeing a certain level of effect. However in order to make policy decisions it is necessary to have insight in all relevant social effects, not just the intended ones.

Impairment factors

In deliverable R1.1 within the IMMORTAL program, a review of relevant epidemiological studies has been made in order to evaluate the effects of various impairments. In a meta-analysis the studies were summarized leading to estimates of the *relative risks* associated with various impairments. If the value of the relative risk ratio is larger than 1, the impairment leads to an increased risk of accident involvement. The higher the relative risk ratio is, the larger the contribution of a certain risk factor to accident involvement of the impaired drivers. Values below 1 indicate that the impairment leads to a reduction of the risk of accident involvement. This could be caused by *behavioural adaptation*. If for instance a driver is

aware of his eyesight deficiencies he might avoid difficult circumstances such as driving at night or with reduced headway distances.

The results from the meta-analysis show that most medical impairments only have a small effect on the accident involvement. The estimates of the relative risk ratios associated with the impairments are in most cases in the range between 0.8 and 2.0. The estimates are in no case greater than 6. Hence, the effect on accident involvement of the different impairments tends to be smaller than the difference in accident involvement normally found between an 18-year old driver and a middle-aged driver. However, there are some limitations to the use of epidemiological data. In this report, most of the epidemiological evidence is taken as a basis for doing the cost-benefit analysis, but evidence that is weak (from just a few studies or from studies without a rigorous design) is not included.

Policy options

A driver has to perform certain tasks in order to reach his destination safely. Whether he/she is able to meet the *task demand* depends on his *competences* and *capabilities*. These are influenced by respectively chronic and acute impairments. The directions for policy options to control impairments can be based on these three elements.

- *Lowering task demands*; by vehicle adaptations or driving licence restrictions (no driving in the dark etc);
- *Improvement of competences*; by medical treatment, psychological rehabilitation or training;
- *Withdrawing drivers with low competences*; selection based on tests or on self-selection;
- *Improvement of capabilities*; deter drivers not to impair themselves, use of warning systems (such as fatigue warning systems).

In order to perform a cost-benefit analysis a concrete countermeasure for specific impairments needs to be defined. From all possible policy measures for all possible impairments a selection is made. This selection is made based on 1) the increase in accident risk of the impairment, 2) the prevalence of the impairment, 3) the effectiveness of the countermeasure and 4) the political and public support for the countermeasure.

This has led to the following selection of countermeasures that have been assessed for four countries on the North, South, East, and West boundaries of Europe (Norway, the Netherlands, Spain and the Czech Republic);

- Mandatory eyesight testing (three specific types of tests)
- Increasing random road side breath tests (combined with a zero BAC limit for young drivers)
- Installation of alcohol lock for drivers with an alcohol problem

Because the cost-benefit analyses in this report are only carried out for the four mentioned countries, the results are not representative for Europe. In fact there is no 'European average' for a certain countermeasure. Even between neighbouring countries that have many political and cultural aspects in common, due to minor differences between the two legal systems in those countries, the outcome of a cost-benefit analysis for a particular countermeasure may differ considerably. The four countries were chosen for practical reasons (all within the IMMORTAL-consortium and therefore fast access to data sources) and heterogeneity (different parts of Europe).

Cost-benefit analysis

As mentioned, in a cost-benefit analysis the relevant impacts of the countermeasure must be identified and expressed in monetary terms. The impacts that are assessed in the cost-benefit analysis of impairment countermeasures are;

- *Changes in number of road accidents*; the change is determined by using the relative risk ratio to estimate the number of attributable accidents for a specific impairment. The reduction of these attributable accidents depends on the type of countermeasure (when a driving licence is withdrawn and compliance is 100% (which is off course questionable), all attributable risks are gone). In case of treatment we have assumed that the treatment is 100% successful, leading to a normal relative risk ratio of 1. The valuation of the safety effects is based on the social costs of accidents in a country divided by the annual traffic fatalities. This method is described by the European Commission and is sometimes called the 1 million Euro test.
- *Changes in amount and type of mobility*; when a driving licence is withdrawn, the car driver is forced to either stop travelling or use another mode of transport, assuming all drivers comply with the withdrawal of the driving licence. For both the loss of trips and the shift of trips to other modes of transport, the loss of benefits is valued. The cost-difference method is used for the generalized costs (time costs and variable vehicle costs), assuming a common demand function for all transport modes. The effects are different for private drivers and commercial drivers. This difference is taken into account. Also, a shift in use of transport modes may lead to an increase of accidents in those ‘new’ transport modes. This second order safety effect is also determined and is in some cases rather substantial.
- *Changes in environmental effects*; the change in amount and type of mobility also leads to environmental effects. The reduction in environmental effects due to the decrease of car driving (*first order effect*) has to be corrected for the change of environmental effects due to the increase of other modes after the modal shift (*second order effect*).
- *Costs of countermeasure*; all related project costs during the introduction period and operational period are taken into account, regardless of who is paying the costs.

Results of analyses for countermeasures

The results of the analyses are benefits and costs, expressed in million Euros. The socio-economic yield is expressed in terms of the benefit/cost-ratio. If this ratio is larger than 1 it means that the social benefits are larger than the costs. When the benefits are negative, this ratio will be negative as well (and therefore smaller than 1). The annual effects are expected to remain the same over the project period, thus mathematically the benefit-cost ratio will not be influenced by the chosen time period.

Table 0.1. Results of different measures for different countries (million Euro, annual effects)

	Netherlands			Norway			Czech Republic			Spain		
	B	C	B/C	B	C	B/C	B	C	B/C	B	C	B/C
Testing eye sight												
- Visual acuity	-210	-30	-7	-10	-5	-2,0	4	-1.1	4,0	-	-	-
- Standard eye test	-805	-40	-20	-29	-6	-4,8	n.p.	n.p.	n.p.	-	-	-
- Standard eye test incl. UFOV	-1047	-60	-17	-44	-20	-2,2	n.p.	n.p.	n.p.	81	-55	1,5
Alcohol – breath test												
- Increased breath test	314	-42	7.5	35	-17	2.1	25	-4	6.4	271	-102	2.7
- incl. 0 BAC limit young drivers	376	-42	9.0	36	-19	1.9	-	-	-	280	-116	2.4
Alcohol – lock	168	-41	4.1	32.5	-7.2	4.5	9	-6	1.6	69	-99	0.7

Note: (-) means not relevant; (n.p.) means not performed due to lack of data. In Spain mandatory eyesight testing (excl. UFOV) is already in place. In the Czech Republic the alcohol limit for all drivers is 0 BAC.

Eyesight testing

The socio-economic yield of mandatory eyesight testing is in general negative. This is mainly caused by the loss of welfare due to the withdrawal of the driving licence. Especially when the driving licence is withdrawn at a relatively young age, the mobility effects may have a large negative impact.

Besides the large negative mobility effects, the traffic safety benefits are small, due to the rather small relative risk ratios and the rather large negative second order safety effects. The negative second order safety effects depend on the modal shift to other modes of transport. Sometimes these new modes have an even higher risk ratio than the impaired car driving (for instance mopeds). The first order safety effect due to the decrease of impaired car drivers is thus partly undone by the second order safety effects due to the increase on other modes of transport.

The only eyesight test that might lead to positive results is the reduced field of view test. This eyesight impairment leads to considerable relative risk ratios, the car drivers that suffer from this impairment are older and therefore the mobility effects of withdrawing the driving licence will be less decisive. The disadvantage of the UFOV test is that the data regarding prevalence and effectiveness is not completely reliable. Most epidemiological studies stem from the same source, which is not completely independent. This makes the UFOV test, at this moment, less qualified as a decisive test for acquiring a driving licence. The sensitivity and selectivity of the test is, compared to other medical tests, acceptable but there is also a risk to include false positives and exclude false negatives.

In general, the withdrawing of driving licence leads to large negative socio-economic effects, especially when the driving licence is withdrawn at a young age. It seems thus more promising to focus on various treatments rather than on driving licence regulations.

Alcohol related measures

Three countermeasures for drunk driving have been assessed, namely increased roadside breath testing, a zero BAC limit for young drivers, and the installation of an alcohol lock. All measures seem promising. This is mainly due to the fact that the countermeasures aim at preventing drinking and driving by means of deterrence. In principle these countermeasures will not cause any mobility effects and thus also no second order safety effects. Although in principle the measures do not prevent driving (only drunk driving), it may be possible that drivers rather prefer to drink and not to drive than to drive and not to drink. This mobility effect is only accounted for in the Norwegian cost-benefit analysis on zero BAC limit for young drivers.

The Czech Republic already has a zero BAC limit for all drivers. In the Czech Republic the data regarding drunk driving and the accidents related to this drunk driving are rather poor. For instance, statistics show that the percentage of road fatalities caused by drunk drivers is 8% as opposed to about 30% in the Netherlands. Despite the fact that this country seems to suffer from underreporting (and the effects are thus underestimated), the effects seem promising. Only for Spain the costs for alcohol-lock are slightly higher than the benefits. It seems likely that this negative effect for Spain is caused by the assumptions that had to be made due to lack of input data.

General conclusions and recommendations

The title of the report is "DETAILED COST-BENEFIT ANALYSIS OF POTENTIAL IMPAIRMENT COUNTERMEASURES". The word 'detailed' in the title is somewhat misleading. The presented cost-benefit analyses are detailed in the sense that as much as possible all the effects of the measures are taken into account, but the word 'detailed' in this case doesn't imply preciseness. Cost-benefit analysis is a rather complex instrument and the results depend heavily on the quality of the input. Some input, especially regarding the different aspects of traffic safety, is missing or is rather speculative. Therefore it is necessary to make assumptions. The assumptions made in this study however will probably not change the general conclusion, namely that withdrawing driving licence (especially at a young age) based on mandatory eyesight testing will push towards a negative socio-economic yield. Preventing drunk driving through random road side tests and installing an alcohol lock all seem promising, although the prevalence of alcohol abuse and the contribution to the road fatalities seems to be underreported especially in the Czech Republic.

The cost-benefit analysis provides objective information for policy makers by presenting an overview of all relevant socio-economic effects in a structured manner. It has a normative foundation, based on aggregating individual/household preferences, but the choice for policy measures always remains a political choice that might be influenced by other factors than the socio-economic yield. However some policy recommendations are included;

- *Treatment of eyesight problems*; the withdrawing of driving licences leads to large negative socio-economic effects. The countermeasures for eyesight problems will lead to a more positive socio-economic yield if they are based on treatment rather than driving restrictions. An additional advantage is that this will not prevent people from seeking medical treatment. What has to be kept in mind is that the threat of losing one's driving license (due to driving restrictions) may lead to medical treatment if medical treatment is possible. In order to meet the criteria for visual acuity, drivers will buy (better) glasses before they do the eyesight test.
- *Research on UFOV testing*; despite the substantial safety gain for UFOV testing, it leads to a negative net benefit in Norway and the Netherlands. This is mainly caused by the high costs related to loss of mobility in Norway and the Netherlands. As these costs are lower in Spain, the net benefit is positive for this country. A small change in the valuation of mobility loss will probably lead to a positive net benefit on UFOV testing in Norway and the Netherlands as well. This makes UFOV-testing promising. However, the quality of the input data is (partly) questionable. This leads to the conclusion that the UFOV test is not ready to play a decisive role in the provision of driving licences and more research is needed to determine prevalence, relative risk ratios, and effectiveness.
- *Deregulation of license restrictions might be fruitful*: based on this analysis it is clear that permanent withdrawal of driving licences leads to large negative socio-economic impacts. Especially when the initial relative risk ratio of the impairment is not so high and the drivers are relatively young (under 65 years old). Therefore it might be fruitful, based on socio-economic principles, to review existing regulations.
- *More countermeasures assessed*; the number of possible countermeasures is infinite and although explicit criteria were used for the pre-selection, it is possible that more promising countermeasures will be 'invented' or even are already in place in a particular country.
- *Stricter regulations for registration of accidents*; one of the largest difficulties in this study was the lack of accurate and detailed information. The European Commission might provide a framework for registering accident data and perhaps even medical information.

D-P4.1

VISION AND PERCEPTUAL DEFICIENCIES AS A RISK FACTOR IN TRAFFIC SAFETY

L. Fjerdingen, G.D. Jenssen, L.E. Lervag, L.J. van Rijn, T. Vaa, A. Kooijman, B. Bjerre and H. Arnljot, 2004

The purpose of the workshop was to give a broad introduction to the state-of-the-art related to visual and perceptual problems in traffic and to focus on new research results on selected topics of interest for the research community and decision makers.

The different presentations gave a broad picture of the topics and the main conclusions from the workshop in Trondheim are:

- a) We need more knowledge to tell what the most important problems are.
- b) The rules for vision-related driving licensing requirements need to be harmonised, but at this stage, the research evidence is not sufficiently clear to warrant specific recommendations.

Research topics:

- It is necessary to make an overview of impairment variations, within the same diagnoses.
- There is also a need for knowledge on different kind of available methods for testing visual field diseases; 1) specific, and 2) general and global.
- This includes recommendations to which test is adequate to what kind of problem.
- To make this problem possible to solve for the actual driver and his/her nearest family, it is necessary to get more knowledge about the possibility to identify symptoms without being an expert.
- How do visual impairments correlate with other medical problems, specially related to age? And how do we deal with this as a legal problem?
- One study indicates that night vision problems increase the accident risk. With more elderly drivers it is important to verify if this is a problem or not. There is also a lack of test methods on this topic.
- What is the cost/benefit concerning various driver licensing requirements related to vision. Prevalence, relative risk, cost for society.
- A new test for measuring glare straylight is promising, but it needs to be further developed before it can become common practice.
- The problems with night vision and glare for people being operated for vision impairment (laser operation)? Pilot studies: surgery, cataract, diabetes. Copilots: wife giving directions.

D-P4.2

WORKSHOP: FATIGUE; SLEEPINESS AND REDUCED ALERTNESS AS RISK FACTORS IN DRIVING

F. Sagberg, P. Jackson, H.P. Krüger, A. Muzet and A.J. Williams, 2004

The present report summarises presentations and discussions from a workshop entitled “Fatigue, sleepiness, and reduced alertness as risk factors in driving”. The workshop was a part of the EU project IMMORTAL.

Driver fatigue or falling asleep is recognized to be among the most important causative factors in road crashes, next to alcohol, speeding and inattention. (Certainly fatigue-related hypovigilance is related to inattention, but for practical purposes it may be useful to distinguish fatigue and sleepiness from other factors leading to inattention.) The purpose of the IMMORTAL project is to assess both chronic and acute driver impairments, and fatigue and drowsiness belong primarily among the acute impairments, although chronic impairment is also involved, as far as sleep disorders are concerned. Some of the issues discussed in the IMMORTAL workshop on fatigue were:

- The scope of the problem
- Normal and clinical aspects of excessive daytime sleepiness
- Detection of drowsiness in drivers be detected – experiences from simulated driving
- Early signs of falling asleep while driving
- Efficiency of countermeasures to be used by drivers
- Driver alertness monitoring and warning systems
- Drivers with sleep disorders, and implications for licensing procedures

There are basically two types of data from drivers that are relevant as indicators of the scope of the problem. The first concerns the prevalence of sleepiness among drivers, and the incidence of actually falling asleep. The second concerns the contribution of fatigue and drowsiness to the number of road crashes; what is the proportion of crashes partially or totally caused by these factors? The prevalence of fatigue without actually falling asleep is extremely difficult to assess, and no good estimates can be found. Concerning drivers who have actually fallen asleep, the estimates for a 12-month period range from 8 to 29 % of drivers. A rather conservative estimate then is that about one in ten drivers fall asleep at least once in a year. Barring the possibility of multiple occurrences for each driver, this implies an incidence of about one such event per 100 000 km.

The second type of data relates directly to the role of fatigue and falling asleep as primary or contributing cause of accidents. Among those who report that they have fallen asleep, between 4 and 14 % (differing between studies) report that the incident resulted in a crash.

It has been estimated that between 7 and 30 % of all personal injury crashes are caused by fatigue or sleep. And the evidence is clear that sleep- and fatigue-related crashes are on the average more severe than other crashes.

The risk of sleep-related crashes seems to vary with time of day, mirroring roughly the biologically based circadian variations in sleepiness and vigilance. This means that the risk shows a peak late at night or early in the morning, and a smaller peak in the afternoon.

Although the *risk* of sleep and fatigue related crashes is larger during the night than during the day, the *absolute number* of such crashes is as high during the day as during the night, due to the larger exposure during daytime. Countermeasures should therefore address the problem of falling asleep during daytime as well as during the night.

The risk also tends to increase with prolonged driving, and the research evidence seems to give some support for current regulations of rest breaks during the drive as well as for total daily driving hours for professional drivers. More research is however needed to establish the optimal rest-work schedules.

Excessive sleepiness seems to be a widespread problem lying at the base of sleep and fatigue-related crashes. This is primarily caused by “too much wakefulness”, as well as the circadian rhythm of sleepiness. In addition to those influences on daytime sleepiness, which everyone is subject to, some drivers are excessively sleepy because of some sleep disorder. The most prevalent sleep disorder is the obstructive sleep apnoea syndrome, which is a result of stopped breathing during sleep, resulting in poor quality of sleep and consequently excessive daytime sleepiness. This disorder affects as many as 4-5% of middle-aged men, who are the group with the highest prevalence. And then there is narcolepsy, or “intrinsic sleepiness”; patients with this condition are prone to fall asleep at any time. The prevalence is about 1 in 2000, and this group is clearly over-involved in crashes.

Sleep disorders clearly have potential implications for licensing procedures. However, current methods are to a large extent dependent upon self-report instruments. This means that only individuals that present a sleep-related complaint to their doctor will be assessed with respect to implications for driving. And as long as the licensing requirements in several countries leave to the patients themselves to consider their suitability for driving in relation to sleepiness, there is no guarantee that even people with sleep disorders actually will refrain from driving. There are also objective methods for assessing sleepiness and the preconditions for falling asleep. By the use of such methods, important knowledge has been obtained regarding early signs, which may indicate a danger of falling asleep. Such knowledge can be used for information to drivers to pay attention to those signs, and stop driving when they occur.

There is a growing body of research on technical devices to record the drivers' vigilance states as well as their driving behaviour, with the purpose of giving a warning and/or interfere with the driving when the state of the driver is not compatible with the requirements from the traffic environment. An important future research need is field trials of such systems in order to assess their effect on driver behaviour and crash risk.

A possible negative effect of in-car warning systems may be that driver's use them to stay awake and drive for longer periods rather than stopping and have a nap; i.e. risk compensation by relying too much on the safety system. Further research is needed to investigate how drivers adapt their driving to such systems, and what operational precautions should be taken to avoid risky behavioural adaptation.

Drivers are often not motivated to take a break and have a nap when becoming fatigued or tired, but rather tend to engage in several activities in order to keep awake. Research has shown that most such activities (opening the window, increasing the volume of the radio, etc.) at best can postpone sleep for only a few minutes. The only effective countermeasure against sleepiness is sleep, preferably combined with a caffeine drink. A nap of at least 15 minutes is very effective and enables a driver to continue driving in an alert and vigilant condition for a

considerable period. The nap should not exceed 30 minutes, because longer sleep may produce sleep inertia, from which the driver needs a certain time to recover.

It is important to increase drivers' awareness of the risks associated with driving when fatigued or sleepy, and about the effects of various countermeasures. The management of companies employing drivers have a special responsibility to take care that their employees are rested and fit and sufficiently aware of the risks, and also that their working schedules (especially for shift-workers) are compatible with the needs for rest and sleep. Educational programmes have been developed for helping both companies and individuals to manage fatigue in an adequate way.

Concerning warning systems an important message should be that these systems don't reduce sleepiness, but they are only backup systems in case the driver is not sufficiently aware of the fatigue symptoms. Safe use as well as adequate training and information regarding new technical systems is part of the joint responsibility of employers and employees under the Occupational Safety and Health legislation regarding duty of care for a safe working place, including the vehicles used in employment.

It has been assumed that a monotonous road and vehicle environment may facilitate sleepiness. It is, however, somewhat controversial whether this can occur in rested drivers. It may be that monotony and boredom *permit* sleep in a driver who has insufficient sleep, but that it does not *cause* sleepiness. Some preliminary simulator studies of night driving have shown that road lighting has little effect on the development of sleepiness in general, but further research is needed on this issue, to find out to what extent environmental measures can contribute to the prevention of fatigue-related accidents. The idea that monotony and boredom permit sleep also implies on the other hand that stimulation may *mask* sleepiness. Even if one is very sleepy it is not difficult to stay awake while walking around, but once seated comfortably in the car one may fall asleep very quickly.

Countermeasures against fatigue and sleep-related accidents are of two types. They can either prevent drivers from falling asleep or developing fatigue while driving, or they can alert a driver or intervene with driving once a driver's vigilance is not adequate. Thus, there is both primary and secondary prevention of such accidents. Examples of primary prevention are information to raise driver's awareness of early signs of fatigue or sleepiness, or warning systems detecting such signs. Rumble lines along the edge or centre of the road (profiled edgelines/centrelines) is an example of a secondary prevention that has proven very effective. Other examples are the in-car systems to wake up a driver who has fallen asleep.

For professional drivers an additional countermeasure is the hours-of-service regulations. Although the research evidence gives some support to current regulations, a pertinent question is whether the regulations are optimal from the point of view of fatigue management.

D-P4.3

THE USE AND USABILITY OF CD 91/439 ON DRIVING LICENSING

F.J. Alvarez, T. Gomez and I. Fierro, 2005

The workshop was held in Valladolid on June 21st-22nd, 2004. The meeting was attended by 42 people from 10 countries and there were 22 speakers, distributed over four sessions. The key element of each contribution was the Powerpoint presentation, which have been reproduced here along with pertinent comments.

The recommendations derived from the presentations and the discussions that followed them are:

1. Although there is already common EU legislation (CD 91/439/CEE), a greater standardisation among EU member states with respect to the medical criteria and procedures for evaluating fitness to drive and the periodicity of the evaluation is desirable.
2. Current EU legislation on driving licences needs to be adopted by new member states (EU – 25 member states) at the earliest opportunity.
3. Licensing and driving restrictions should also be standardised. Detailed research into the effectiveness of such restrictions should be carried out. Information on this is currently very limited.
4. We also have, at present, inadequate information on the criteria for refusing or revoking a driving licence in the EU member states, and on the opportunities and procedures for re-granting licences when drivers' medical circumstances change.
5. It would be useful if many aspects of Annex III of CD 91/439/CEE, currently being rewritten, were revised and updated (and this includes all the epigraphs). In particular, decisions on the ideal periodicity of medical checks for all drivers should be made and then applied across the EU. A decision on the necessity for age-related medical check-ups in each EU state should also be revisited, and we suggest that a good cut off may be, if not before, then at the age of 65.
6. Another key priority for the next few years is to standardise the assessment of fitness to drive for the "elderly".
7. There is a need to improve and develop driving licence information systems in the EU member states.
8. There is a clear need for greater and more in-depth EU-wide research monitoring the effectiveness of any current and forthcoming measures that cover the aspects discussed above.
9. On a national level, each EU member state needs to conduct close monitoring of the effectiveness of their national systems for evaluating fitness to drive.
10. Information on the national criteria and procedures, the research monitoring its effectiveness and the recent and planned changes should be more readily available and exchanged with other member states. A system of systematic data collection, and yearly updating of this information, carried out at EU level would be ideal.

D-P4.4**PROCEEDINGS 4th WORKSHOP
COST BENEFIT ANALYSIS ON IMPAIRMENT COUNTERMEASURES****P. Wesemann, W. Vlakveld and E. Devillers, 2004**

Within the IMMORTAL research programme the risk of accidents associated with different driver impairments and the identification of 'tolerance levels' applied to licensing assessment and roadside impairment testing are analysed.

The Policy Workpackage within the IMMORTAL programme identifies relevant information to support policy makers in the area of driver impairment. One of the results of this workpackage is a detailed cost-benefit analysis of potential impairment countermeasures (deliverable P2). The draft report on the cost-benefit analysis is presented at a workshop, called 'Cost-benefit analysis of impairment countermeasures'. In this workshop the impairment factors, methodology and results are presented and discussed. The workshop was held on 15 September 2004 in Brussels.

In this report the presentations, discussions and results of the workshop are presented. In the annex you will find a list of participants and the programme of the workshop.

ANNEX 3: EXECUTIVE SUMMARIES OF SYNTHESIS REPORTS

D-R1.9 AGEING, MENTAL ILLNESS AND MEDICAL DISEASES A SYNTHESIS OF RESULTS

F.J. Alvarez, 2005

IMMORTAL is a research programme on the accident risk associated with different forms of driver impairment and the specification of 'tolerance levels' applicable to various medical conditions for the assessment of fitness to drive. This assessment is part of licensing procedures and roadside impairment testing (including drug screening).

Task R1.9 includes both the co-ordination of the whole work package (WP) and the formulation of a synthesis based on the outcome of the research Tasks. Thus, the aim of this Task and the present paper is to link the results of the various Tasks in work package R1 (WP R1) "Ageing, mental illness and medical diseases" and to provide recommendations for further action. The paper focuses on requirements for acquiring a driving licence and the assessment of chronic impairment of fitness to drive.

The following recommendations are given based on the outcome of the studies in WP R1.

RECOMMENDATIONS REGARDING MEDICAL CONDITION AND ACCIDENT RISK

Recommendation 1: Both prevalence and relative risk are important parameters for assessing the traffic safety implications of preventing drivers with various medical conditions from driving. From a societal point of view, there is little benefit in preventing people with rare disorders from driving, even if there is a high relative risk associated with those disorders. The effect on the number of crashes will be larger for regulating conditions with a high prevalence, even if they are associated with low to moderate risk.

Recommendation 2: The increased risk for drivers with certain medical conditions, while also taking into account the right to mobility, would seem to call for a stricter licensing policy within the EU. A balance should ideally be reached between road safety and mobility.

Recommendation 3: With respect to implications for European Union regulations, certain conditions stand out as candidates that would merit specific attention:

- For having both a high prevalence and a significantly elevated risk (Relative Risk from 1.5 to 2) are:
 - Neurological disorders
 - Psychiatric disorders
 - Drug and alcohol related problems (abuse, dependence, induced disorders)
 - Diabetes mellitus

- For having a high prevalence but a significantly lower risk are:
 - Visual deficiencies
 - Mobility disorders
 - Cardiovascular deficiencies
- Among specific disorders, sleep apnoea has the highest observed relative risk ratio (3.71).

Recommendation 4: Balanced information for awareness of the increased risk to drivers with medical conditions listed in Annex III of CD 91/439/EEC should be made widely available, especially to policy-makers, health professionals and the general driving population.

Recommendation 5: Much more research is needed:

- Regarding the road traffic risk associated with the various medical conditions. For some disorders there is very limited information. Alcoholism is associated with one of the highest risk factors (RR 2.0), but this figure is derived from only three results. As alcohol-related problems (abuse, dependence, and induced disorders) are frequent in the population, much more research into driving and accident risk in these patients should be carried out, as well as on the effect of treatment.
- Regarding the effect of pharmacological treatment on the risk to drivers suffering from various diseases: that is, to compare the risk when driving for patients undergoing well controlled treatment with the risk for those not being treated or without due control.
- There is a need for both targeted research on the mechanisms underlying the high risk for these conditions, as well as on the development of procedures and methods for the early identification of the presence of risk factors.

RECOMMENDATIONS REGARDING MEDICAL CONDITION AND FITNESS TO DRIVE ASSESSMENT

Recommendation 6: The medical-ophthalmological-psychological evaluation of a driver's fitness to drive in a country with mandatory regular check-ups shows that, quite frequently, a medical condition only imposes a restriction on the driver, yet infrequently makes him/her unfit to drive. This is particularly relevant for senior drivers. In addition to the information on the above-mentioned increased risk (recommendation 4), much more information should be provided to the driver regarding medical conditions and fitness to drive.

Information to be addressed to the driver should include:

- Why medical conditions and fitness to drive are assessed
- How their fitness to drive is assessed
- What the implications of the assessment are
- What the benefits of the assessment are

Recommendation 7: A consensus on all the physical and mental pre-requisites for safe driving should be promoted.

Recommendation 8: A consensus on cut-off values regarding different performance parameters within different patient groups, as well as consensus on patient groups or diagnoses incompatible with safe driving, should be promoted.

Recommendation 9: There is a need for clear clinical criteria to assess fitness to drive among driver patients regarding the various disorders/diseases listed in Annex III of CD 91/439/EEC.

Recommendation 10: The assessment of fitness to drive should be individualized, though strict clinical criteria, taking into account the existence of compensation strategies, are strongly recommended. The existence of a disease in a particular driver does not directly imply his/her incapacity to drive (need for a driving licence restriction or unfit to drive).

Recommendation 11: Multidisciplinary assessment of fitness to drive should be promoted.

Recommendation 12: At present, DG TREN has committed several working groups (diabetes, epilepsy, vision) to the categories of medical disorders listed in Annex III, CD 91/439/EEC. It is strongly recommended that all the medical categories of Annex III should undergo an in depth review, providing evidence (effect on driving ability, risk involvement, etc) and criteria for fitness to drive assessment.

We would strongly advise the inclusion of the following categories:

- Neurological disorders
- Psychiatric disorders
- Alcohol/illicit drugs/medicinal drugs related disorders (abuse, dependence, induced disorders).

Recommendation 13: Health professionals should be encouraged to play a key role in providing the right information, selecting appropriate pharmacological treatments and providing adequate counselling and follow-up of patients with respect to driving.

Recommendation 14: Policy makers, from both the areas of road safety and pharmaceutical care, should provide appropriate information to the general public and consumers (of medicinal drugs) about the effect of the disease/illness and the medicinal treatment on the ability to drive. This could be generalized to the various disorders affecting EU fitness to drive legislation (Annex III, CD 91/439/EEC).

Recommendation 15: Policy makers should be aware of the relevance of key questions in fitness to drive implementation and evaluation:

- Driving licence renewal requirements represent one of the few public policies with the potential to have a direct effect on senior traffic safety.
- Licensing agencies also have a goal of promoting driver competence and safety, and also the challenge of how best to preserve both road system safety and people's independence and mobility.
- It is essential that driver-licensing authorities have a valid and reliable system for evaluating senior drivers' continuing competence.

Recommendation 16: Much more research is needed:

- Regarding how fitness to drive is assessed across countries, and on the criteria used in the assessment.
- Regarding the various categories and sub-categories of the diseases/disorders listed in Annex III, CD 91/439/EEC. In particular, regarding their prevalence among drivers, the prevalence and criteria for restrictions imposed and the prevalence and criteria for the refusal of a driver licence, as well as their relationship with clinical status (well controlled or not, etc).

- Regarding the relation of the disorders listed in Annex III of CD 91/439/EEC with fitness to drive and the effect of medicinal treatment on this relation.
- Regarding how fitness to drive is assessed across medical categories (for example, are we requesting the same degree of impairment and/or accident risk for drivers suffering from different diseases, such as diabetes, Parkinson's or psychotic patients?).
- Regarding the effectiveness of the licensing system in terms of road safety and people's mobility, as well as their cost-benefit analysis.
- Regarding the perception that drivers to be evaluated have of fitness to drive and how this modifies their quality of life (mobility) and driving patterns.
- Regarding the impact fitness to drive assessment has on the doctor-patient relationship.
- Regarding the psychomotor test to be used (laboratory, simulator, on-road tests), their reliability and predictable value as concerns fitness to drive assessment.
- Regarding the development of possible compensatory mechanisms, including education and special training.

D-R4.6

DRUGS, ALCOHOL AND TRAFFIC SAFETY A SYNTHESIS OF RESULTS

I.M. Bernhoft, 2005

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

Task R4.6 of the work package R4 "Alcohol, drugs and medicines" formulates a synthesis based on the outcome of the research tasks by linking the results of the various studies in work package R4 "Alcohol, drugs and medicines" and gives recommendations for further action.

Based on the outcome of the studies in R4, the following recommendations have been specified.

Regarding EPIDEMIOLOGY:

- Collection of data in the field of epidemiological studies should serve exclusively scientific research purposes. There is a need for uniform surveys all around Europe in order to be able to estimate differences as well as similarities between countries.
- Blood samples of injured drivers – or as a minimum of fatally injured drivers – should be collected as a routine and examined for alcohol and other drugs that are interesting from a traffic safety point of view. The analysing institutions (forensic institutes or hospitals) should report annually.
- It should be possible to utilise roadside surveys regularly throughout Europe to be able to determine the prevalence of illegal as well as medicinal drugs.
- It should be possible to utilise the results on the prevalence of drugs in traffic together with data from hospital samples regularly throughout Europe to be able to determine the relative risk of driving while impaired by drugs, including alcohol.

Regarding RISK ASSESSMENT:

- Responsibility analyses and/or case control studies should be conducted for the most frequently used drugs alone or in various combinations as well as for drugs in combination with alcohol.
- The prevalence of drugs as contributory accident factors should be studied further in the member states.

Regarding LEGISLATION:

- The effect of alcohol/drug and drug/drug combinations on road safety proved to be so detrimental, that effective legislation and enforcement seem urgently needed.

- Although road safety policy in general should focus on making any driving under the influence as being unacceptable, a special target should address high alcohol concentrations (above 0.13%), alcohol/drug combinations and drug/drug combinations.
- For most medicinal drugs, like antidepressants, benzodiazepines, codeine, barbiturates and even morphine, generally, therapeutic levels may be adequate as legal limits, at least for the time being.
- For most alcohol/drug and drug/drug combinations, a legal zero-tolerance limit for each of the substances involved might be appropriate.
- For illegal drugs that are taken alone, and with the exception of heroin, zero-tolerance legislation is expected to result in very high cost and hardly any road safety benefits.
- It is strongly recommended to allow random breath testing for alcohol in all member states as well as evidential breathalysers to combat drink driving.
- It is strongly recommended to allow random drug tests of drivers in order to be able to collect data for scientific purposes.
- There is a critical need for studies examining the consequences of changes in legislation, for example the impact of the zero-tolerance that has been implemented in some member states.

Regarding IDENTIFICATION OF IMPAIRMENT:

- It is recommended to not drive under the influence of MDMA. Though MDMA can improve certain aspects of psychomotor function it can also selectively impair cognitive function (memory).
- Combined use of MDMA and alcohol should always be avoided when driving a motor vehicle.
- Among others, further research should focus on the interaction between sleep deprivation and MDMA use in the morning following a rave party and the interaction of cold medication with other risk factors such as fatigue.
- Over-the-counter medicine might give drivers a feeling of being more capable of driving when they in reality are more dangerous and less aware than they would have been without medicine.
- Studies on the detrimental effect on driving performance of over-the-counter medicine and prescribed medicines should be carried out.
- Experimental studies and in-depth analyses are useful for providing an insight into the impairing mechanisms of alcohol/drug and drug/drug combinations.
- Experimental studies should be harmonized in order to be able to carry out a uniform interpretation of the test results.

Regarding METHODS TO ASSESS IMPAIRMENT:

- Since a summary of pharmacologically and toxicologically justified threshold values for impairing substances does not yet exist, for criminal prosecutions one has to rely in the near future always on exact statements of the police, an exact description of the subject's behaviour, and medical examinations as well as confirming chemical and toxicological analyses.
- Exchange of methods and experiences in police detection of impaired drivers should be encouraged between countries.
- Training of police forces in detection of impaired drivers might result in a more effective use of drug tests.
- It should be recommended to combine drug detection of drivers by the police with confirmation analysis of body fluids from the suspected drivers. This would save both time and money and enhance the detection risk.
- Drug screening tests should be sensitive enough to detect all the drivers who have taken drugs and they should be specific enough to detect only drivers who have taken drugs that impair driving.
- It should also be recommended to use more sensitive methods for the analyses of saliva.
- National forensic laboratories should be encouraged to introduce new methods to confirmation analysis of a large number of substances in one single analysis.
- Procedures used by national forensic laboratories for assaying and reporting illegal drugs as well as prescribed medicines should be standardised across the European countries.

Regarding REHABILITATION:

- The enforcement of drink driving should be maintained or increased. Enforcement of drug driving must not result in losing focus on drink driving.
- Traffic-psychological examinations can determine the crucial deficits in the fields of performance, personality, and attitude and identify more appropriate rehabilitation programmes.
- Rehabilitation programmes give vital individual support in permanently lowering the risk of recidivism.
- The implementation of alcohol ignition interlocks should be encouraged as a means of reducing drink driving and drink driving combined with drug use.
- More emphasis should be given to inform young people in schools and during driving lessons of the consequences that may follow their use of or addiction to illegal drugs.
- For persons who daily are in need of various medicines, more focus should be given to the possibility of providing these persons with medicine boxes including the right dosages for different times of the day in order to prevent an incorrect medication in connection to driving.

- Information on medicines that impair driving should stress that drivers may feel capable of driving, but in fact be more dangerous and less aware than non-medicated drivers.
- Prescribing doctors and pharmacists should play an important educational role, especially during the inception period.
- Prescribing doctors should assess whether an illness that requires prescribed medicines is caused by drug use or whether a patient is dependent on alcohol, and if so go into a dialogue regarding a possible rehabilitation.

D-P8

POLICY SYNTHESIS REPORT

L. Lervag, G.D. Jenssen and L. Fjerdings, 2005

The aim of IMMORTAL is to provide evidence to propose intervention methods for driver impairment, and support the future development of European policy governing driver impairment legislation. The technical and scientific objectives of IMMORTAL are to investigate the influence of chronic and acute impairment factors on driving performance and accident risk, recommend criteria for high risk categories of impairment, and provide key information to support formulation of European policy on licensing assessment and roadside testing.

The work plan for the research programme of IMMORTAL is structured in terms of work packages, separated into *administration*, *research* and *policy* functions. This report presents an executive summary of all issues and recommendations emerging from the work package relevant to future policy development.

Recommendations

- The standards are different in the European countries, harmonisation of the standard of the process of licensing in Europe by proposing a “best practice model” for licensing (including the process of driver assessment and driver improvement), renewing the license, withdrawal and re-licensing after delinquency
- Not each impairment should automatically lead to license withdrawal. Giving the possibility to drivers with vision and perceptual deficiencies to pass a driver assessment to test their compensation abilities
- Driver fatigue is among the most important causes of accidents, and only enough hours of sleep can help.
 - strict rules and more enforcement of this risky behaviour are necessary
 - new in-car devices and telematic-tools could support
 - enforcement by police on the road
 - better education for professional drivers, especially long distance drivers
 - more responsibility and controlled legal measures for the employers
- Periodical standardised checks of fitness to drive for all drivers are an ethical discussion that needs to be taken.
- More and new research regarding driver impairment to develop and evaluate the best methods how to deal with impairment
- Random road side tests and installation of alcohol lock seem promising to prevent drunk driving
- In case of suspect of impairment the administration should have the possibility to order medical and psychological assessment before licensing
- Safe mobility is a key factor for cost benefit calculation, so in case of license withdrawal driver rehabilitation or driver improvement measures should lead to re-establish driver fitness and safety consciousness
- New Advanced Driver Assistance systems (ADAS) and intelligent road infrastructure may in the near future facilitate safe driving for impaired drivers. Groups of impaired drivers who are denied licensing today.

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