Project No. TREN-05-FP6TR-S07.61320-518404-DRUID

DRUID

Driving under the Influence of Drugs, Alcohol and Medicines

Integrated Project
1.6. Sustainable Development, Global Change and Ecosystem
1.6.2: Sustainable Surface Transport

6th Framework Programme
D 2.3.3

Relative risk of impaired drivers who were killed in motor vehicle accidents in Finland

Due date of deliverable: 14.07.2009
Actual submission date: (10.09.2009)

Start date of project: 15.10.2006
Duration: 48 months
Organisation name of lead contractor for this deliverable: (U.Turku)
Revision 1.0

Dissemination Level		
PU	Public	X
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
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RELATIVE RISK OF IMPAIRED DRIVERS WHO WERE KILLED IN MOTOR VEHICLE ACCIDENTS IN FINLAND

Abstract

This study is a part of an integrated European Union (EU) project DRUID (Driving Under the Influence of Drugs, Alcohol and Medicines). The present study described killed drivers impaired by alcohol (n=211) or legal (prescribed) medicines (n=46) and compared their accidents with those of non-impaired killed drivers (n=689). The main aim of the study was to estimate the relative risk of crash responsibility in motor vehicle accidents of impaired and matched non-impaired killed drivers. Relative risk for crash responsibility was studied in four different exposed groups compared to their matched non-exposed groups. The exposures were: alcohol in collision accidents in which a driver was killed (41 exposed and 41 non-exposed killed drivers), alcohol in all accidents in which a driver was killed (75 exposed and 75 non-exposed killed drivers), medicine in collision accidents in which a driver was killed (23 exposed and 23 non-exposed killed drivers), and medicine in all accidents in which a driver was killed (28 exposed and 28 non-exposed killed drivers). The study utilized the database of Traffic Accident Investigation Teams in Finland from the period of 2002 to 2006 (1,108 killed drivers).

About 29 percent of all killed drivers had alcohol and 9 percent had some legal medicine in their blood at the time of the accident. Most alcohol-impaired drivers were heavily drunk: 77 percent of them had a blood alcohol content [BAC] of 1.2 ‰ or more. Drink-drivers were more often male, and younger, than sober drivers. Drink-drivers had single-vehicle accidents more often than sober drivers, and their accidents more often occurred during the evening and at night. Vehicle handling errors, anticipating errors, and suicides, were more typical risk factors for drink-drivers' accidents than for sober drivers' accidents. 93 percent of drink-drivers were the most responsible party compared to 68 percent of sober drivers in collision accidents (OR 6.6, 95% CI 1.8 – 31.7). Considering all accidents, the figures were 97 percent compared to 72 percent (OR 16.7, 95% CI 4.4 – 110.8), and drivers under 36 years were the most responsible party more often than drivers 36 years and older.

Compared to killed drivers with no medicine in their blood, those with medicine were typically middle-aged, were more often suffering from some chronic disease, and were more often tired at the time of the accident. 87 percent of drivers with medicine in their blood were recorded as the most responsible party in collision accidents compared to 52 percent of non-medicine drivers (OR 9.5, 95% CI 2.0 – 72.5). Considering all accidents, the figures were 89 percent compared to 50 percent (OR 10.4, 95% CI 2.2 – 75.4). The present results concerning the effect of medicine on crash responsibility should be treated with caution for several reasons. Firstly, the number of studied drivers was low. Secondly the recorded medicines included a variety of medicines at a variety of concentration levels. Further, it was not possible to differentiate the role of background diseases from the role of medicine in the analysis of crash responsibility.

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ABBREVIATIONS:

BAC = Blood alcohol concentration 0.05 % is equivalent to 0.5 ‰. In Finland the legal limit for BAC is 0.5 ‰.

MV = Motor vehicle

D-A = Description Alcohol, study group
D-NA = Description Non-Alcohol, control group

D-M = Description Medicine, study group
D-NM = Description Non-Medicine, control group

MEDALCO = Group of drivers who had both medicine and alcohol in blood

Ex-Ac = Alcohol-exposed drivers in collision accidents, study group
NEx-Ac = Matched alcohol-non-exposed drivers in collision accidents, control group

Ex-Aall = Alcohol-exposed drivers in all accidents, study group
NEx-Aall = Matched alcohol-non-exposed drivers in all accidents, control group

Ex-Mc = Medicine-exposed drivers in collision accidents, study group
NEx-Mc = Matched medicine-non-exposed drivers in collision accidents, control group

Ex-Mall = Medicine-exposed drivers drivers in all accidents, study group
NEx-Mall = Matched medicine-non-exposed drivers in all accidents, control group

Note: The word “medicine” refers in this paper to legal drugs and the word “drug” refers to illegal drugs

Introduction

The present study is a part of the EU 6th framework programme DRUID (Driving Under the Influence of Drugs, Alcohol and Medicines). Over 40 000 people were killed, and about 1.7 million injured, on the EU Member States' roads (15) in the year 2000. Drink-driving continues to be one of the biggest background factors for traffic accidents and drivers' use of drugs and some legal psychoactive medicines are emerging problems for traffic safety. DRUID aims to combat the scourge of drink-driving and find answers to the question of the use of drugs or medicines that affect people's ability to drive safely (DRUID, Annex 1 – "Description of Work", 2006; www.druid-project.eu).

Aims of the study

The main aim of the present study was to compare relative risk of crash responsibility of non-impaired killed drivers versus killed drivers impaired[1] by alcohol or some legal psychoactive medicine in motor vehicle (MV) accidents in Finland.

To gain a larger picture of the accidents of impaired drivers, the present study started with the description of all accidents of killed drivers who were impaired with alcohol or some legal psychoactive medicine (PART I). Further, comparisons were done between impaired and non-impaired drivers.

The relative risk analysis was to be conducted according to DRUID Annex 1 - "Description of Work" (2006); comparing groups of about 50 drivers who were under the influence of some psychoactive substance to matched non-influenced drivers. Although, 50 drivers is a low number of drivers to study relative risk, the number of accidents in Finland in which a driver is killed *and* impaired set the limits for the study design. We employed a matching procedure to control confounding factors and thus to reduce the need for large samples. The number of drivers impaired by illegal drugs in the database of Finnish fatal MV accidents was insufficient to allow relative risk analysis for drug drivers (PART II).

Each of the relative risk analyses was conducted first for collision accidents, and then all accidents (i.e. including single vehicle accidents). Thus, four exposure conditions were considered: alcohol in collision accidents, alcohol in all accidents, medicine in collision accidents, and medicine in all accidents.

[1] Note: "impairment" in this report implies a driver had some psychoactive substance in his/her blood which might have impaired his/her driving.

Method

Data material

In Finland all fatal motor vehicle accidents are investigated in detail by Traffic Accident Investigation Teams (for a description of these teams, see VALT Method 2003, 2002). A fatal motor vehicle accident in Finland is defined as an accident in which somebody involved dies within 30 days as a result of the accident. The aim of the investigation is to find ways to prevent similar accidents from occurring in the future. The investigation teams are multi-professional and consist of a police officer, a traffic safety engineer, a car inspection engineer, a medical expert and a psychologist. The team members produce reports which include, for example, information on the driver, the type and course of the accident, time and place, weather and road conditions, lighting conditions, speed of all parties concerned, and a description of the traffic environment. A record of a post mortem examination is available for all killed drivers. The team members produce a joint final statement for each accident. This statement includes their conclusion as to the course of the accident and its probable causes, and suggests means to prevent similar accidents in the future. The accident investigation team defines, according to the course of the accident and the risk analysis, which party of a collision accident was the most responsible for the accident. This party is not necessarily the legally culpable party of an accident. This means that the work of the accident investigation teams is separate from the work of police and courts that defines the legal responsibility of drivers in accidents.

From each fatal motor vehicle accident a crash report is compiled and the information from the crash report is encoded into a database. From each crash about 500 variables are encoded (see more VALT Method 2003, 2002). Although the material encoded from fatal accidents (crash files) is extensive, much information is available only in the crash reports. Both the crash files and crash reports are available for researchers.

Information on alcohol, drug and medicine use of drivers involved in fatal accidents

Alcohol use is tested by blood test or evidential breath-analyzer (in Finland the device is Dräger Alcotest 7110 MkIII FIN) for nearly all drivers involved in fatal accidents. However, there might be some cases in which alcohol is not tested; for example, in the cases where a driver has escaped from the accident site, or has been burned or mutilated so badly that a blood specimen could not have been taken.

For the years prior to 2002 information about medicine and drugs (other than alcohol)

used by the driver is available only in cases where the police suspected the effect of some psychoactive drug and requested blood analysis for drugs and medicine. In February 2003 the zero-level law for drugs in traffic was introduced in Finland and for 2002 and after information on medicines and drugs, as well as alcohol, is available for every driver killed in a traffic accident. Whenever possible, blood and urine specimens are taken in post mortem examination of killed drivers in Finland. Specimens are analysed for alcohol and the most usual psychoactive medicines and drugs at the Department of Forensic Medicine of the University of Helsinki (accredited by the national accreditation body in Finland).

The following groups of substances are usually analysed for all drivers involved in fatal accidents:

Alcohol
- ethanol, methanol, isopropyl alcohol, acetone, methyl ethyl ketone

Medication
- antipsychotics
- antidepressants
- hypnotics and anxiolytics (benzodiatzepine, zopiclone, zolpidem, barbiturate)
- opioids (during the study period "low-dose" fentanyl was not seen routinely)
- medicines for neurological diseases (some)
- medicines for allergic diseases (some)
- local anaesthetics and venous anaesthetics
- medicines for cardiovascular diseases (beta blockers, medicines for arrhythmia, calcium channel blockers, digoxsin)

Insulin (if requested)

Illegal drugs
- amphetamine
- cannabis
- cocaine
- heroin
- buprenorfin
- GHB (if requested)

Carbon monoxide (if requested)

Cyanide (if requested)

The present study used the accident database from the years 2002-2006. The study period commenced from 2002 because of a dramatic change in the proportion of fatal-accident-involved drivers who had used medicines (Figure 1). This change was linked with the introduction of the zero-level law for drugs in traffic in Finland at the beginning of 2003. This law increased the testing of legal medicines and drugs from blood specimens, and made such testing systematic rather than based on police suspicion of drug use. A similar sharply increasing trend from 2002 onwards was found in suspected DUID (driving under the influence of drugs) cases in Finland (Ojaniemi, Lintonen, Impinen, Lillsunde &

Ostamo, 2009).

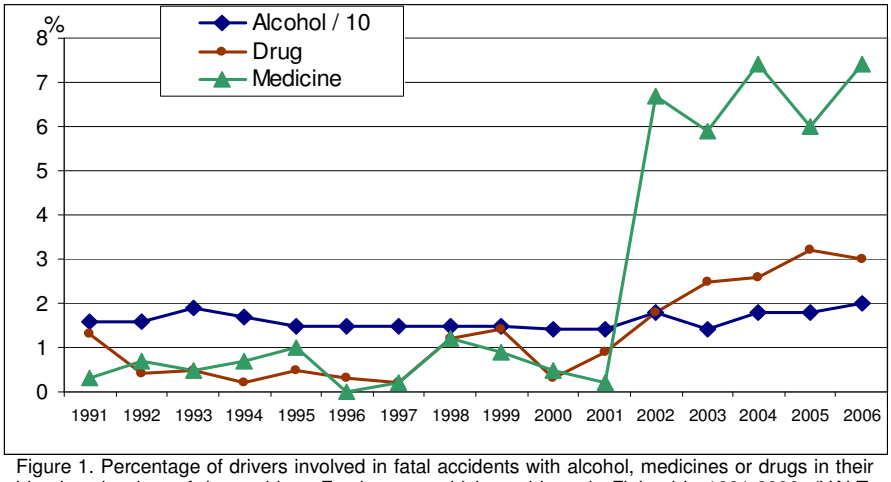

Figure 1. Percentage of drivers involved in fatal accidents with alcohol, medicines or drugs in their blood at the time of the accident. Fatal motor vehicle accidents in Finland in 1991-2006. (VALT, 1991-2006). Note: the different scale of percentage for alcohol.

The number of all fatal motor vehicle accidents during 2002-2006 was 1,335. The number of drivers involved in these accidents was 2,134 including the most responsible party and the less responsible parties (one or several parties) in each collision, and all drivers in single-vehicle accidents. In two vehicle collisions the “less responsible” driver is also “the least responsible”. Most of the collisions included only two parties. However, there might have been several parties in some collisions. In our analysis the most responsible party was a driver who had the biggest effect on accident causation and the “less responsible party included a driver or drivers who had less effect on accident causation. In an investigation of an accident of several vehicles it is difficult or even impossible to decide who was the “least responsible” driver. Therefore in the present study both “less responsible” and “least responsible” drivers are grouped under the name “less responsible”.

Figure 2 illustrates the distribution of drivers into the main categories employed in this study.

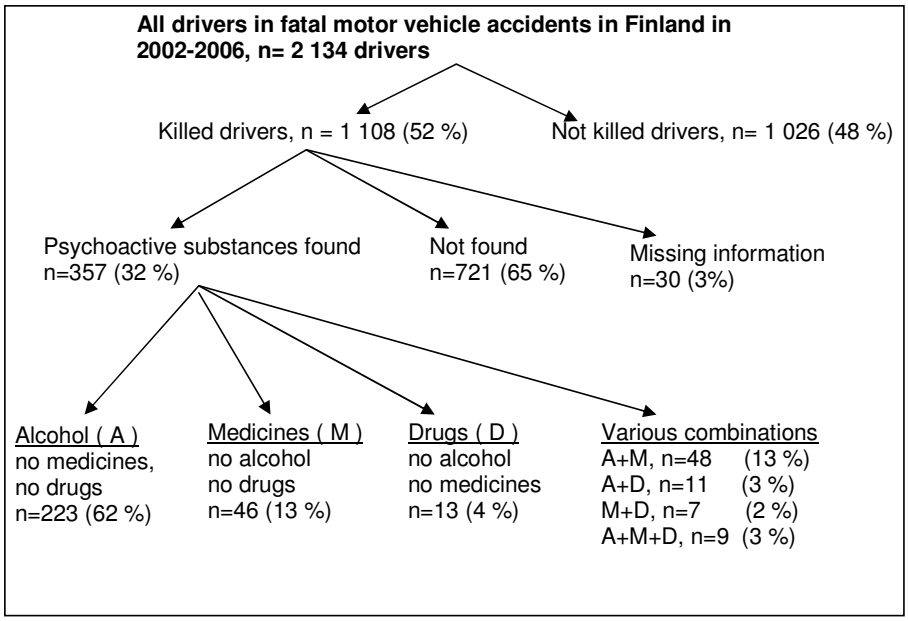

Figure 2. Distribution of killed drivers in fatal motor vehicle accidents in Finland 2002-2006 according to the presence of various psychoactive substances.

The present study utilized both the crash files and crash reports of the fatal accidents included. For example, although the crash file included the information from the alcohol blood test and about the presence of medicine and drugs, more precise information regarding the type of medicine or drug, and its concentration in the blood, was available only in the post mortem examination reports. The post mortem examination reports are included in the crash reports but the content of them is not coded into crash files. The original intention was to study only psychoactive medicine, but because only a low number of drivers were impaired by medicine, all reported medicine types were included (see table 18). As mentioned previously, no analysis of drivers impaired by illegal drugs was conducted due to the low number of these cases.

Study design

The present study has two parts: Description and comparison of impaired drivers and non-impaired drivers who were killed in road traffic accidents (PART I), and Relative risk estimations for impaired drivers who were killed in road traffic accidents (PART II). The detailed study design for each of the two separate parts is described in chapters PART I and PART II.

PART I

Description and comparison of impaired drivers and non-impaired drivers who were killed in road traffic accidents

Study design

The study described and compared impaired and non-impaired drivers killed in MV accidents during the period of 2002 to 2006 in Finland. The analysis was conducted separately for alcohol-impaired drivers and medicine-impaired drivers. Further, drivers who were impaired by both alcohol and medicine were compared with drivers who were impaired only by medicine.

Compared groups in the study on alcohol in fatal motor vehicle accidents

D-A (Description Alcohol, study group). The study group consisted of all killed drivers who had a BAC above the legal level (BAC > 0.50 ‰) at the time of the accident. The years between 2002 and 2006 were included in the study. Only those drivers who had alcohol but no medicine or drugs in their blood (n=211) were selected into the exposed group and were compared to sober drivers (D-NA-drivers, see below) (Figure 3).

D-NA (Description Non-Alcohol, control group). The control group consisted of all killed drivers who had no psychoactive medicine, drugs or alcohol in their blood at the time of the accident. The years between 2002 and 2006 were included in the study. There were 689 D-NA drivers.

Compared groups in the study on medicines in fatal motor vehicle accidents

D-M (Description Medicine, study group). The study group consisted of all killed drivers who had some medicine in their blood at the time of the accident. The years between 2002 and 2006 were included in the study. There were 110 D-M drivers. Forty-six of these drivers (42 %) had some medicine but no alcohol or drugs in their blood (D-M). Forty-eight drivers (44 %) had some medicine and alcohol in their blood (MEDALCO). D-M drivers were compared with MEDALCO and D-NM drivers (see below) separately.

D-NM (Description Non-Medicine, control group). The control group consisted of all killed drivers who had no medicine, drugs or alcohol in their blood at the time of the accident. The years between 2002 and 2006 were included in the study. There were 721 D-NM drivers.

PART I: DESCRIPTION

STUDY GROUPS	CONTROL GROUPS
D-A (n=211): Killed drivers with BAC-level ≥ 0.50 ‰, but no medicines and no drugs.	**D-NA (n=689)*:** Killed drivers, who had no alcohol (BAC=0.00 ‰), no medicines and no drugs in their blood.
D-M (n=46): Killed drivers with some legal medicine in their blood, but no alcohol and no drugs.	**D-NM (n=721)*:** Killed drivers, who had no alcohol, no medicines and no drugs in their blood.
MEDALCO (n=48): Killed drivers who had both some legal medicine and alcohol in their blood.	

* D-NA and D-NM groups are basically the same, except that 32 drivers are missing from the D-NA group because of a different group forming procedure. The exact BAC level of the driver was used in forming the D-NA group. The D-NM group was formed by using the variable that indicates whether or not the driver had alcohol in their blood (yes/no).

Figure 3. Description of the study and the control groups in PART I. Study years 2002 – 2006.

Results

Description of killed drivers who were impaired by alcohol and comparison with non-impaired killed drivers

During the study period from 2002 to 2006 there were 305 killed drivers who had alcohol in their blood. Thirty-two of these (10 %) had a BAC lower than 0.5. Most drink-drivers were heavily drunk (Table 1).

Table 1. Distribution of BAC-levels of killed drivers and presence of medicines and drugs in the blood.

BAC-level	Number of drivers		Number of drivers with medicines and/or drugs	
	N	%	N	%
0	753	71.2	64	48.1
0.01-0.49	32	3.0	7	5.3
0.5-1.19	38	3.6	16	12.0
1.2-	235	22.2	46	34.6
Total	1058	100.0	133	100.0

There were 50 drivers whose BAC-level was not known, one of whom had some medicine in their blood.
Note: in Finland the legal BAC-level is 0.5 ‰. BAC-levels from 0.5 ‰ to less than 1.2 ‰ are punished as drink-driving and BAC-levels 1.2 ‰ and higher are punished as severe drink-driving.

There were 211 D-A drivers [according to table 1: (38-16) + (235-46)]. Notably, 16 (42 %) of the 38 drivers whose BAC was between 0.5 and 1.19 had some medicine and/or drugs in their blood. Amongst the drivers whose BAC was 1.2 or more, the proportion of drivers who also had medicine and/or drugs was lower (46 out of 235 drivers, 20%). Amongst the group of 753 sober drivers, 64 (8 %) had some medicine and/or drugs in their blood.

There were 689 D-NA drivers (according to table 1: 753-64).

There were fewer females in the D-A –group (8 %) than in the D-NA –group (17 %) (df=1, χ^2=10.42, p<.01). Drivers were younger in the D-A –group (33.9 years) than in the D-NA-group (45.2 years) (df=452, t=-8.01, p<.001). Drivers in the D-A – group more often had single-vehicle accidents while drivers in the D-NA –group more often had collision accidents (df=2, χ^2=120.59, p<.001; Tables 2 and 3). Seventy-two percent of drivers in the D-A –group were involved in single-vehicle accidents compared to 30 percent of drivers in the D-NA –group.

Table 2. Number of drivers in D-A and D-NA –groups according to the type of accident.

	D-A		D-NA	
	N	%	N	%
Collision accident	60	28.4	463	67.2
(most responsible driver)	(57)		(318)	
(less responsible driver	(3)		(145)	
Single vehicle accident	151	71.6	204	29.6
Animal accident	0	-	22	3.2
Total	211	100.0	689	100.0

Table 3. Accident type in D-A and D-NA –groups.

	D-A		D-NA	
	N	%	N	%
Same driving direction (no turning)	3	1.4	19	2.8
Same driving direction, somebody was turning	1	0.5	21	3.1
Opposite driving direction	46	21.8	289	41.9
Opposite driving direction, somebody was turning	2	0.9	23	3.3
Crossing driving direction	4	1.9	54	7.8
Crossing driving direction, somebody was turning	2	0.9	45	6.5
Off road accident	140	66.4	189	27.4
Other type	13	6.2	49	7.1
Total	211	100.0	689	100.0

In their statement regarding an accident the motor vehicle accident investigation teams draw a conclusion about which was the immediate risk factor of the accident. Immediate risk factors are coded for every party involved in the accident. In the D-A –group vehicle handling errors, anticipating errors, and suicides, were more typical immediate risk factors than in the D-NA-group (df=8, χ^2=115.70, p<.001; Table 4)

Table 4. Immediate risk factor of the accidents in D-A and D-NA –groups.

	D-A		D-NA	
	N	%	N	%
Vehicle handling error	81	38.4	116	16.9
Anticipation error	52	24.6	104	15.1
Suicide	26	12.3	58	8.4
Observation error	16	7.6	99	14.4
Falling asleep	16	7.6	59	8.6
Sudden attack of illness	4	1.9	96	13.9
Other type	12	5.7	14	2.0
Vehicle or environmental factor	3	1.4	30	4.4
Could not avoid the accident	1	0.5	112	16.3
Total	211	100.0	688	100.0

Time of day clearly differentiated the accidents of the D-A and D-NA –groups (df=3, χ^2=166.13, p<.001; Table 5). Drink-driving accidents typically took place during the evening and at night: 71 percent of drivers in the D-A-group were involved in the accident during the evening and at night compared to 28 percent of drivers in the D-NA –group.

Table 5. Time of day in the accidents of DA and DNA –groups.

	DA		DNA	
	N	%	N	%
Morning (6 am. to 11.59 am)	23	10.9	190	27.6
Daytime (12 pm to 5.59 pm)	38	18.0	308	44.7
Evening (6 pm to 11.59 pm)	65	30.8	136	19.7
Night (00 am to 5.59 am)	85	40.3	55	8.0
Total	211	100.0	689	100.0

Description of killed drivers who were impaired by medicine

During the study period 110 drivers who died in motor vehicle accidents had used some medicine. Of these drivers 64 (58 %) had also used alcohol and/or drugs (Table 6).

Table 6. The use of psychoactive substances of those drivers who had used some medicine.

	N	%
Only some medicines	46	41.8
Medicines + alcohol	48	43.6
Medicines + drugs	7	6.4
Medicines + alcohol + drugs	9	8.2
Total	110	100.0

Comparison of drivers who had used some medicine (D-M –group) with drivers who had used both medicine and alcohol (MEDALCO - group)

The drivers who had used only medicine (D-M) were compared with drivers who had used both medicine and alcohol (MEDALCO -group). There were more females in the D-M –group (26 %) than in the MEDALCO –group (10 %) (df=1, χ^2=3.89, p<.05). Drivers were older in the D-M –group (47.6 years) than in the MEDALCO-group (37.4 years) (df=92, t=-3.23, p<.001). Drivers in the D-M – group had collision accidents more often than drivers in the MEDALCO –group. Drivers in the MEDALCO –group more often had single vehicle accidents (Tables 7 and 8).

Table 7. Number of drivers in different types of accidents in D-M and MEDALCO –groups.

	D-M		MEDALCO	
	N	%	N	%
Collision accident	33	71.7	21	43.8
(most responsible driver)	(30)		(20)	
(less responsible driver)	(3)		(1)	
Single vehicle accident	12	26.1	27	56.2
Animal accident	1	2.2	0	-
Total	46	100.0	48	100.0

The Traffic Accident Investigation Teams gather information about drivers' possible chronic diseases routinely together with other background information about a driver, regardless of any suspected role in the accident. There was no difference between the groups in terms of whether the driver had suffered from some chronic disease. 67 percent of drivers in the MEDALCO, and 74 percent of drivers in the DM , –group suffered from some chronic disease. Depression was more typical in the MEDALCO group (22 drivers out of 38 suffered from depression) than in the D-M - group (13 drivers out of 37). Heart disease was more typical in the D-M - group (12 drivers out of 37 suffered from heart

disease). No MEDALCO – group drivers suffered from heart disease.

Table 8. Accident type in D-M and MEDALCO –groups.

	D-M		MEDALCO	
	N	%	N	%
Rear-end collision	1	2.2	0	-
Head-on collision	23	50.0	16	33.3
Crossing accident	8	17.4	4	8.3
Off road accident	11	23.9	26	54.2
Other type	3	6.5	2	4.2
Total	46	100.0	48	100.0

In their statement regarding an accident the motor vehicle accident investigation teams draw a conclusion about which was the immediate risk factor of the accident. Immediate risk factors are coded for every party involved in the accident. In the D-M –group observation errors, sudden attack of illness, suicides, and falling asleep, were more typical immediate risk factors than in the MEDALCO-group. In the MEDALCO group vehicle handling errors and anticipation errors were the most typical immediate risk factors (df=6, χ^2=17.96, p<.01; Table 9).

Table 9. Immediate risk factor of an accident in D-M and MEDALCO –groups. (Note: one missing information in D-M group).

	D-M		MEDALCO	
	N	%	N	%
Observation error	12	26.7	6	12.5
Suicide	11	24.5	10	20.8
Vehicle handling error	10	22.2	16	33.3
Sudden attack of illness	6	13.3	1	2.1
Falling asleep	4	8.9	1	2.1
Anticipation error	2	4.4	11	22.9
Other type	0	-	3	6.3
Total	45	100.0	48	100.0

Time of day differentiated the accidents of D-M and MEDALCO –groups. Accidents of the DM –group took place during the morning or daytime more often than accidents of the MEDALCO –group (df=3, χ^2=16.68, p<.001; Table 10).

Table 10. Time of day in the accidents of D-M and MEDALCO –groups.

	D-M		MEDALCO	
	N	%	N	%
Morning (6 am. to 11.59 am)	13	28.3	4	8.5
Daytime (12 pm to 5.59 pm)	15	32.6	10	21.3
Evening (6 pm to 11.59 pm)	16	34.8	17	36.2
Night (00 am to 5.59 am)	2	4.3	16	34.0
Total	46	100.0	47	100.0

Comparison of drivers who had used some medicine (D-M –group) with drivers who had not used any medicine, alcohol or drugs (D-NM-group)

The drivers who had used some medicine but no alcohol or drugs (D-M–group) were compared with drivers who had not used any medicine, alcohol or drugs (D-NM-group).

In the D-NM –group 18 percent of drivers was female and in the D-M group 26 percent of drivers were females. The difference was not, however, statistically significant. The drivers' mean age was 47.6 years in the D-M group and 46.8 in the D-NM group (difference not statistically significant). 61 percent of all D-M drivers belonged to the 26-59 years age group compared to 48 percent for the D-NM drivers (difference not statistically difference; Table 11).

Table 11. Distribution of age of the drivers in D-M and D-NM –groups.

	D-M		D-NM	
	N	%	N	%
17-25 years	7	15.2	159	22.1
26-59 years	28	60.9	349	48.4
> 59 years	11	23.9	213	29.5
Total	46	100.0	721	100.0

The MV accident investigation teams also investigate some of the drivers' personal background factors that might influence accident causation; for example tiredness or illness of the driver at the time of the accident. D-M drivers were tired more often than D-NM drivers (24 % vs. 11 %, df=2, χ^2=8.23, p<.05). Fifteen percent of D-M drivers had some psychiatric disorder compared to one percent of D-NM drivers (df=2, χ^2=38.91, p<.001). Twenty-eight percent of D-M drivers suffered from depression compared to 5 percent of D-NM drivers (df=2, χ^2=44.46, p<.001). Overall, D-M drivers suffered some chronic psychiatric disease more often than D-NM drivers. Nonetheless, information

regarding drivers' personal background factors was quite often missing, and therefore the results are only suggestive.

Drivers in the D-M –group were deemed the most responsible driver in collision accidents more often than drivers in the D-NM –group (df=3, χ^2=8.57, p<.05; Table 12). Accident type was most typically head-on collision in both the D-M and D-NM –groups (Table 13).

Table 12. Distribution of accidents in D-M and D-NM –groups.

	D-M		D-NM	
	N	%	N	%
Collision accident, most responsible	30	65.2	327	45.4
Collision accident, less responsible	3	6.5	151	20.9
Single vehicle accident	12	26.1	220	30.5
Animal accident	1	2.2	23	3.2
Total	46	100.0	721	100.0

Table 13. Accident type in D-M and D-NM –groups.

	D-M		D-NM	
	N	%	N	%
Same driving direction: (rear-end collision or other type)	1	2.2	43	6.0
Head-on collision	23	50.0	299	41.5
Crossing accident	8	17.4	123	17.0
Off road accident	11	23.9	203	28.2
Other type	3	6.5	53	7.3
Total	46	100.0	721	100.0

The immediate risk factor for an accident was errors in observation, suicide, or errors in vehicle maneuvering, more often in the D-M group than in the D-NM group (df=9, χ^2=28.76, p<.001; Table 14)

Table 14. Immediate risk factor of an accident in D-M and D-NM –groups. Risks ordered in the table from the most typical risk to the least typical risk in the D-M -group.

	D-M		D-NM	
	N	%	N	%
Observation error	12	26.1	105	14.6
Suicide	11	23.9	57	7.9
Vehicle handling error	10	21.7	121	16.8
Sudden attack of illness	6	13.0	104	14.4
Falling asleep	4	8.7	63	8.8
Anticipation error	2	4.4	104	14.4
Did not have possibilities to avoid accident	1	2.2	117	16.3
Other type of error	0	-	18	2.5
Vehicle fault	0	-	4	0.6
Environmental fault	0	-	27	3.7
Total	46	100.0	720	100.0

Accidents of the D-M –group most often occurred during the evening and accidents of the D-NM –group most often occurred during the daytime. There was no statistically significant difference in the distribution of accidents according to time of day (Table 15).

Table 25. Time of day in the accidents of D-M and D-NM –groups.

	D-M		D-NM	
	N	%	N	%
Morning (6 am. to 11.59 am)	13	28.3	201	27.9
Daytime (12 pm to 5.59 pm)	15	32.6	317	44.0
Evening (6 pm to 11.59 pm)	16	34.8	144	20.0
Night (00 am to 5.59 am)	2	4.3	59	8.1
Total	46	100.0	721	100.0

PART II

Relative risk estimations for impaired drivers who were killed in road traffic accidents

Introduction

The number of impaired drivers killed in accidents during the study period in Finland set the limits for the study design of relative risk estimations. By employing a matching procedure we controlled confounding factors in order to reduce the need for large samples.

The methodology of Robertson and Drummer (1994) has been used widely in responsibility analysis when the effects of drugs on driving are studied. In their methodology factors which might mitigate drivers' responsibility are identified and scored. Factors considered include condition of road, condition of vehicle, driving conditions, road law obedience, difficulty of task and level of fatigue. The present study did not use the methodology of Robertson and Drummer (1994) because it used the data of Traffic Accident Investigation Teams in Finland and these teams have already assessed responsibility based on the investigations of a police member, a vehicle specialist, a road specialist, a physician and a psychologist. Each member of the team conducts his/her own investigation and risk analysis of possible causal factors. In a joint meeting the team defines which of the accident parties had the biggest responsibility for accident causation, according to the course of the accident and the risk analysis.

Relative risk of crash responsibility was studied for alcohol-exposure and for medicine-exposure, separately for collision accidents and for all accidents. Alcohol-exposed killed drivers, and medicine-exposed killed drivers, were each compared to matched non-exposed killed drivers. Relative risk for crash responsibility was thus studied in four different exposure conditions (see Figure 4):

1. Alcohol in fatal collision accidents
2. Alcohol in all fatal accidents
3. Medicine in fatal collision accidents
4. Medicine in all fatal accidents

Detailed study designs and the matching procedure are described below.

Study design for alcohol groups

During the time period from 2002 to 2006 there were 211 accidents in which a killed driver had a BAC ≥0.50 ‰ but had no medicine or drugs in their blood. Of these 60 were

collision accidents and 151 were single-vehicle accidents (Table 2).

Collision accidents were quite rare among drink-drivers, and in order to reach the target number of 50 drivers for analysis of relative risk of responsibility the whole study period 2002 to 2006 was utilized (see chapter “Aims of the study”). Among 60 drink-drivers who had a collision accident, 17 had intentionally driven into another car (mostly lorries) and these suicide cases were excluded from the analysis. For two drivers the cause of death was illness rather than the accident and these two cases were also excluded from the analysis. The final number of killed drink-drivers in collision accidents was 41 (Figure 4).

In the analysis of relative risk of responsibility for all accidents the whole time period of 2002 to 2006 was not utilized because the target number of 50 drivers was reached (and exceeded) by using the accidents of the two years in the middle of the time period (see chapter Aims of the study). The two years (2004-2005) in the middle of the study period were used instead of the latest years (2005-2006) because of the matching procedure. If the “case” accident would have been taken place for example the last day of December, 2006, it would have been impossible to find a control case, because that accident should have been taken place later in time (see the matching criteria below).

In 2004 and 2005 there were 91 accidents in which a killed driver had a BAC ≥0.50 ‰ but had no medicine or drugs in their blood. Among these, 14 drivers had intentionally driven into another car or object and these suicide cases were excluded from the analysis. Two drivers were excluded from the analysis because their immediate cause of death was illness and not the accident. The final number of killed drink-drivers in all types of accidents was 75 (Figure 4).

Group 1: Alcohol in fatal collision accidents

The analysis of collision accidents estimated the probability (odds ratio) of being the most responsible party in an accident in the study group of alcohol-exposed (Ex-Ac) compared to the control group of non-exposed (NEx-Ac) killed drivers.

Ex-Ac (Alcohol-exposed drivers in collision accidents). The study group for responsibility analysis for collision accidents included killed drivers who had a BAC above the legal level (≥0.5 ‰) but had no other psychoactive substances (i.e. medicine or drugs) in their blood. Drivers who committed suicide by intentionally driving into an oncoming vehicle were excluded, as were drivers whose cause of death was illness and not the accident. There were 41 drivers remaining for the relative risk analysis for collision accidents (Figure 4).

NEx-Ac (Matched alcohol-non-exposed drivers in collision accidents). A matched control group of alcohol-non-exposed drivers was formed by finding a matched alcohol-non-exposed driver for each of the drivers in the Ex-Ac group. The matched non-exposed

driver was taken from the next collision accident chronologically in which a driver was killed with no alcohol (BAC 0.00 ‰) or any other psychoactive substance in their blood, provided that the collision occurred in the same geographical area of Finland as the matching Ex-Ac collision, and the driver in the collision accident belonged to the same age and sex group as the matching Ex-Ac driver. There were 41 drivers in the matched non-exposed control group (Table 16).

The geographical areas of accidents were: Southern Finland, Middle Finland and Northern Finland (see appendix 1). Geographical area was employed as a selection criterion because the weather and road conditions, as well as traffic density, vary a lot from the north to the south of Finland. Therefore the background factors for accidents may also vary according to geographical area. Finland is a long country; the distance from the southernmost part to the northernmost part of Finland is about 1,100 kilometres. Traffic density is highest in the southern part of Finland. Southern Finland includes cities like Helsinki (the capital of Finland), Espoo, Vantaa, Tampere and Turku and over half of all Finns live in Southern Finland.

Age groups of the drivers were defined as 16 to 25 years, 26 to 35 years, 36 to 45 years, 46 to 55 years, 56 to 65 years, 66 to 75 years and 76-85 years.

Drivers who suffered a sudden attack of illness and drivers who committed suicide by intentionally driving into an oncoming motor vehicle were excluded.

If the selection procedure for the NEx-Ac matched non-exposed control group did not produce a driver of same sex and age who crashed the same geographical area of Finland in the same year as the driver in Ex-Ac study group, the selection criteria was enlarged in the following order: year, geographical area and age group.

Table 16. Description of Ex-Ac study group and NEx-Ac control group. Collision accidents from years 2002-2006. Number of males and females, age of the driver, year of the accident and geographical location of the accident.

	Ex-Ac (n=41)	NEx-Ac (n=41)
Males	35	35
Females	6	6
Age group		
16-25	12	12
26-35	3	3
36-45	9	8
46-55	8	12
56-65	6	3
66-75	2	2
76-85	1	1
Mean age (continuous variable)	41.2	40.3
Year of the accident		
2002	9	6
2003	6	7
2004	10	11
2005	8	10
2006	8	7
Geographical location		
Southern Finland	26	26
Middle Finland	12	13
Northern Finland	3	2

Group 2: Alcohol in all fatal accidents

Ex-Aall (Alcohol-exposed drivers in all accidents). The study group for the responsibility analysis for all accidents included killed drivers who had a BAC above the legal level (≥0.5 ‰) and had no other psychoactive substances (i.e. medicine or drugs) in their blood. The database was all fatal MV accidents in Finland during the period 2004-2005. The whole study period of 2002 to 2006 was not utilized in this analysis because the target number of 50 drivers was reached (and exceeded) by using the accidents from the two middle years. If the immediate risk factor of an accident was a suicide or sudden attack of illness, the driver was excluded from the Ex-Aall group. The number of Ex-Aall drivers was 75 (Table 17).

NEx-Aall (Matched alcohol-non-exposed drivers in all accidents). A matched control group of drivers in all accidents was formed in the same way as the control group for collision accidents, but with single vehicle accidents included.
The number of NEx-Aall drivers was 75 (Table 17).

Table 17. Description of the Ex-Aall study group and the NEx-Aall control group. All fatal accidents from years 2004-05. Number of males and females, age of the driver, year of the accident and geographical location of the accident.

	Ex-Aall (n=75)	NEx-Aall (n=75)
Males	70	70
Females	5	5
Age group		
16-25	22	22
26-35	15	15
36-45	13	13
46-55	10	10
56-65	9	9
66-75	2	2
76-85	4	4
Mean age (continuous variable)	38.8	38.8
Year of the accident		
2004	38	29
2005	37	34
2006	-	12
Geographical location		
Southern Finland	44	49
Middle Finland	30	25
Northern Finland	1	1

Study design for medicine groups

During the time period from 2002 to 2006 there were 46 accidents in which a killed driver had used some medicine but was not influenced by alcohol or drugs. All toxicological analysis was done at the Department of Forensic Medicine at the University of Helsinki (see more in the chapter “Method”). The present researchers read the results of the toxicological analysis. Precise concentration of medicine were not ascertained from the toxicological reports, but rather the information whether the concentration of medicine was within treatment level or above treatment level (see table 18).

Eleven drivers had intentionally driven into another car (mostly lorries) and these suicide cases were excluded from the analysis. Six drivers had a sudden attack of illness and were excluded from the analysis. Five drivers were not killed immediately in the accident, and were administered medical treatment (first aid) in the hours before they died. It was clear that four of these drivers already had some medicine in their blood at the time of the accident. For the remaining driver it was not clear whether the medicine found in post mortem blood analysis first entered the bloodstream after the accident. Therefore this

driver was excluded from the analysis. The final number of drivers who had used some medicine (but no alcohol or drugs) was 23 in collision accidents and 5 in single vehicle accidents, (28 in all vehicle accidents) (Table 18).

Table 18. Sex and age of the driver, types of medicines found, (> indicates a concentration above treatment level), hours after the accident until the death, and whether the Accident Investigation Team concluded the medicine may have had an effect on accident causation (+ indicates possible effect). Medicines in brackets are due to medical treatment after the accident.

	Sex	Age	Medicine	Hours	Effect
Collision accidents:					
Driver1	M	68	temazepam, diazepam, (lidocaine, thiopental)	20 h	+
2	F	56	temazepam	0	
3	M	20	ibuprofen	0	
4	F	54	diazepam, nordiazepam	0	+
5	M	53	zopiclone, (lidocaine)	1	+
6	M	49	diazepam, desmethyldiazepam, tramadol >, tramadol 0-demethyl	0	+
7	M	20	phenylpropanolamine	0	+/-
8	M	53	carbamazepine, tramadol, lidocaine	0	+
9	M	65	desmethyldiazepam, oxazepam, temazepam	0	+
10	M	63	temazepam, quinine, oxazepam, meprobamate, metoprolol	0	+
11	M	51	sertraline	0	
12	M	55	temazepam	0	
13	M	70	digoxin>, carvedilol	0	+
14	M	64	metoprolol>, (paracetamol, diazepam, lidocaine)	4	
15	M	51	zopiclone, mianserin, zolpidem, chlorpromazine, valproate	0	+
16	F	45	venlafaxine>, fluoxetine, diazepam, desmethyldiazepam	0	+
17	M	50	citalopram>, metoprolol	0	+
18	M	78	codeine	0	
19	M	56	melperone>, risperidone>, chlorprothixene	0	+
20	F	42	sertraline>	0	+
21	M	52	fluoxetine>, metoprolol	0	+
22	M	60	citalopram, methamphetamine	0	
23	F	69	desmethyldiazepam, diazepam, propanol	0	+
Single vehicle accidents:					
24	F	29	mirtazapine, temazepam, diazepam, desmethyldiazepam, carbamazepine, oxazepam, buprenorphine, norbuprenorphine (the driver was under treatment for drug addiction)	0	+
25	M	90	digoxin >, (lidocaine)	7	+
26	M	19	pseudoefedrine, ibuprofen	0	+
27	M	31	alpratzolam	0	+
28	M	23	diazepam, temazepam, oxazepam, desmethyldiazepam, buprenorphine (the driver was under treatment for drug addiction)	0	+

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Group 3: Medicine in fatal collision accidents

Ex-Mc (Medicine-exposed drivers in collision accidents). The study group for the responsibility analysis for collision accidents included killed drivers who had some medicine in their blood but had no other psychoactive substances (i.e. alcohol or drugs) in blood. Exclusion criteria were described earlier. There were 23 Ex-Mc drivers.

NEx-Mc (Matched medicine-non-exposed drivers in collision accidents). A matched control group of drivers in collision accidents was formed in the same way as the control group for collision accidents for alcohol cases (see earlier). For each of the drivers in the Ex-Mc group the matched non-exposed driver was taken from the next collision accident chronologically in which a driver was killed with no medicine, no alcohol (BAC 0.00 ‰) and no drug in their blood, provided that the collision occurred in the same geographical area of Finland as the matching collision, and the driver in the collision accident belonged to the same age and sex group as the matching Ex-Mc driver. The number of NEx-Mc drivers was 23 (Table 19).

Table 19. Description of Ex-Mc and NEx-Mc groups. Number of males and females, age of the driver, year of the accident and geographical location of the accident. Collision accidents from years 2002-2006.

	Ex-Mc(n=23)	NEx-Mc (n=23)
Males	18	18
Females	5	5
Age group		
16-25	2	2
26-35	0	0
36-45	2	2
46-55	9	9
56-65	6	6
66-75	3	3
76-85	1	1
Mean age	54.1	53.4
Year of the accident		
2002	8	4
2003	1	5
2004	7	6
2005	5	6
2006	2	2
Geographical location		
Southern Finland	12	12
Middle Finland	9	9
Northern Finland	2	2

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Group 4: Medicines in all fatal accidents

Ex-Mall (Medicine-exposed drivers in all accidents). The study group of Ex-Mall was otherwise equal to the study group of Ex-Mc, but with killed drivers of single-vehicle accidents included. The number of Ex-Mall drivers was 28 (Table 20).

NEx-Mall (Matched non-medicine non-exposed drivers in all accidents). A matched control group of drivers in all accidents was formed in the same way as the matched control group for collision accidents, but with killed drivers of single vehicle accidents included. For each of the drivers in the Ex-Mall group the matched non-exposed driver was taken from the next accident chronologically in which a driver was killed with no medicine, no alcohol (BAC 0.00 ‰) and no drug in their blood, provided that the collision occurred in the same geographical area of Finland as the matching collision, and the driver in the collision accident belonged to the same age and sex group as the matching Ex-Mall driver. The number of NEx-Mall drivers was 28 (Table 20).

Table 20. Description of Ex-Mall and NEx-Mall groups. Number of males and females, age of the driver, year of the accident and geographical location of the accident. All fatal accidents in 2002-06.

	Ex-Mall (n=28)	NEx-Mall (n=28)
Males	22	22
Females	6	6
Age group		
18-25	4	4
26-35	2	2
36-45	2	2
46-55	9	9
56-65	6	6
66-75	3	3
76-85	1	1
86-95	1	1
Mean age	51.3 years	50.9 years
Year of the accident		
2002	8	4
2003	3	6
2004	8	7
2005	5	7
2006	4	4
Geographical location		
Southern Finland	16	16
Middle Finland	10	10
Northern Finland	2	2

PART II: RELATIVE RISK ESTIMATIONS.

EXPOSED GROUPS (Ex)	MATCHED NON-EXPOSED GROUPS (NEx)
Ac (n=41): collision accidents, killed driver had BAC ≥.50 ‰ but no medicine, no drugs. Years: 2002-2006. Sudden attack of illness and suicide cases excluded.	**NAc (n=41):** collision accidents, chronologically the next (after Ac case) killed driver who had no alcohol, no medicines and no drugs. The accident took place in the same geographical area of Finland and the driver belonged to the same sex and age group as the driver in Ac case. Exclusion criteria the same as in Ac.
Aall (n=75): all accidents, killed driver had BAC ≥ .50 ‰, but no medicine, no drugs. Years: 2004-2005. Exclusion criteria same as in Ac.	**NAall (n=75):** all accidents, chronologically the next (after Aall case) killed driver who had no alcohol, no medicines, no drugs. Inclusion and exclusion criteria the same as in NAc.
Mc (n=23): collision accidents, killed driver had some legal medicine, no alcohol, no drugs. Years: 2002-2006. Exclusion criteria the same as in Ac.	**NMc (n=23):** collision accidents, chronologically the next (after Mc case) killed driver who had no alcohol, no medicines, no drugs. Inclusion and exclusion criteria the same as in NAc.
Mall (n=28): all accidents, killed driver had some legal medicine, no alcohol, no drugs. Years: 2002-2006. Exclusion criteria the same as in Ac.	**NMall (n=28):** all accidents, chronologically the next (after Mall case) killed driver who had no alcohol, no medicines, no drugs. Inclusion and exclusion criteria the same as in NAc.

Figure 4. Overview of the exposed and non-exposed groups in PART II.

Results

Group 1: Relative risk for alcohol-exposed killed drivers in collision accidents

Thirty eight drivers out of 41 drivers (93 %) in the Ex-Ac were the most responsible party in the collision accidents. In the matched non-exposed group (NEx-Ac), 28 drivers out of 41 (68 %) were the most responsible party. According to the results of logistic regression analysis (SAS statistical program) the drivers in the Ex-Ac group were the most responsible party in the accidents 6.6 times more often than the drivers in the NEx-Ac group (Table 21). Alcohol use was the only variable that was statistically significantly associated with culpability for collision accidents. Age and sex of the driver, time of year and time of day (daytime, evening, or night), type of vehicle, speeding, earlier traffic violations and road conditions (slippery or not) were not significantly associated with culpability.

Table 21. Odds ratio estimates (adjusted) for being the most responsible party in collision accidents: most responsible parties n=66, the less responsible parties n=16.

	Wald Chi Square	p<	Odds ratio	95% confidence limits
Group (Ex-Ac vs. NEx-Ac)	7.07	0.01	6.55	1.83 – 31.75
Vehicle type (two-wheeler vs.car)	2.67	0.10	0.23	0.04 – 1.32
Age	1.43	0.49		
16-35 vs. over 65 years			1.91	0.08 – 24.38
36-65 vs. over 65 years			0.75	0.04 – 6.37

For model the likelihood ratio Chi^2=11.37, df=4, p<.05
R-Square=.1294, Max-rescaled R-Square=.2063
Hosmer & Lemeshow Test, p=.5217

Group 2: Relative risk for alcohol-exposed killed drivers in all accidents

Seventy three drivers out of 75 drivers (97 %) in the Ex-Aall were the most responsible party in all accidents. In the matched non-exposed group (NEx-Aall), 54 drivers out of 75 (72 %) were the most responsible party. According to the results of logistic analysis the drivers of Ex-Aall group were the most responsible party in the accidents 16.7 times more often than the drivers in the NEx-Aall group (Table 22). Young drivers (drivers under 36 years) were the most responsible party in accidents 4.2 times more often than middle-

aged or older drivers (drivers over 35 years).

Table 22. Odds ratio estimates for being the most responsible party in all accidents: most responsible parties n=127, the less responsible parties n=23.

	Wald Chi Square	p<	Odds ratio	95% confidence limits
Group (Ex-Aall vs. NEx-Aall)	12.94	0.001	16.72	4.44 – 110.85
Age (16-35 vs. over 35 years)	6.72	0.01	4.23	1.50 – 13.66
Sex (male vs. female)	2.60	0.107	4.22	0.68 – 24.72

For model the likelihood ratio Chi^2=30.54, df=3, p<.001
R-Square=.1842, Max-rescaled R-Square=.3200
Hosmer & Lemeshow Test, p=.7303

Group 3: Relative risk for medicine-exposed killed drivers in collision accidents

Typically drivers in Ex-Mc group had several medicines in blood serum analysis (Table 18).

For 15 out of 23 drivers, the accident investigation team had concluded that at least one medicine or combination of medicines, might have contributed to accident causation. In two of these reports the accident investigation team concluded that not the medicine itself but the basic illnesses suffered by the drivers might have contributed to accident causation (driver numbers 13 and 23 in the table 18). One driver suffered from bipolar disorder and probably had too low a concentration of medicine in his blood and the other driver suffered from Parkinson disease.

Eight out of 23 drivers had an overdose of some medicine (Table 18). The accident investigation team concluded in seven out of these eight cases that the medicine (and its overdose) might have had some effect on accident causation.

Twenty of the 23 drivers in the Ex-Mc were the most responsible party in the collision accident (87 %). In the matched non-exposed group (NEx-Mc), 11 out of 23 drivers were the most responsible party (48 %). According to the results of logistic analysis the drivers of Ex-Mc group were the most responsible parties in the accidents 9.5 times more often than the drivers in the NEx-Mc group (Table 23).

Table 23. Odds ratio estimates for being the most responsible party in collision accidents: most responsible parties n=32, the less responsible parties n=14.

	Wald Chi Square	p<	Odds ratio	95% confidence limits
Group (Ex-Mc vs. NEx-Mc)	6.63	0.01	9.54	2.03 – 72.52
Time of day (evening/night vs. daytime)	2.52	ns. (.11)	0.23	0.03 – 1.29
Age (15-65 vs. over 65 years)	1.09	ns. (.30)	0.29	0.01 – 2.22

For model the likelihood ratio Chi^2=11.58, df=3, p<.01
R-Square=.2225, Max-rescaled R-Square=.3145
Hosmer & Lemeshow Test, p=.6188

Group 4: Relative risk for medicine-exposed killed drivers in all accidents

Twenty-five of the 28 drivers in the Ex-Mall were the most responsible party in the accidents (89 %). In the non-exposed group (NEx-Mall), 15 out of 28 drivers were the most responsible party (54 %). According to the results of logistic analysis the drivers of EX-Mall group were the most responsible parties in the accidents 10.4 times more often than the drivers in the NEx-Mall group (Table 24).

Table 24. Odds ratio estimates for being the most responsible party in all accidents: most responsible parties n=40, the less responsible parties n=16.

	Wald Chi Square	p<	Odds ratio	95% confidence intervals
Group (EX-Mall vs. NEx-Mall)	7.27	0.01	10.42	2.23 – 75.36
Time of year (summer vs. other)	3.27	0.10	0.23	0.04 – 1.09
Time of day (evening/night vs. daytime)	3.16	0.10	0.20	0.03 – 1.08
Age	3.06	ns. (.22)		
(16-35 vs. over 65 years)			0.77	0.03 – 11.99
(36-65 vs. over 65 years)			0.20	0.01 – 1.58

For model the likelihood ratio Chi^2=18.94, df=5, p<.01
R-Square=.2869, Max-rescaled R-Square=.4112
Hosmer & Lemeshow Test, p=.9495

Extra results of relative risk for alcohol-exposed killed drivers based on the whole database 2002-06

The “case – matched control” study design used in the present study is not a typical one when relative risk of crash responsibility is estimated. For comparison purposes the relative risk of crash responsibility of killed alcohol-exposed drivers was also analysed without using any matching procedure. The two extra analyses (logistic regressions), one for collision accidents and one for all accidents, were run on the whole accident database from 2002-06.

Using the whole database made it possible to estimate odds ratios in different BAC levels for all accidents. This was not possible for collision accidents due to the lower number of collision accidents among the group of drink-drivers. The number of killed drivers was 1108 during the years of 2002 to 2006 (see Figure 2).

Relative risk for alcohol-exposed killed drivers in collision accidents in the database 2002 - 06

There were 635 drivers who were killed in collision accidents during the years 2002 to 2006 in Finland. Drivers who had committed suicide by intentionally driving into another motor vehicle (84 drivers, 13 %), who had sudden attack of illness (23 drivers, 4%), whose blood alcohol level was not measured (34 drivers, 5 %) and who were younger than 16 years (14 drivers, 2 %) were excluded from the analysis. Furthermore, drivers were excluded if they had legal or illegal drugs in their blood, or if the information on drugs was missing (80 drivers, 13 %). Drivers with a BAC under the legal limit (BAC of 0.01 to 0.49) were also excluded (15 drivers, 2 %) to make this analysis more comparable with the analysis of the “exposed - matched non-exposed” study design (analysis of exposure condition 1, Group 1; see pages 20 and 21). Due to some overlapping of exclusion criteria, the final number of drivers in the analysis was 430.

Drivers with a BAC of 0.5 ‰ or more were the most responsible parties in collision accidents 7.8 times more often than sober drivers. Further, young drivers were culpable parties more often than middle-aged drivers, and drivers of motor vehicles besides busses and lorries were culpable parties more often than drivers of such vehicles (Tables 25 and 26).

The crude odds ratio (unadjusted odds ratio) for being the most responsible driver in collisions was 6.98 (95 % CI: 2.12 – 23.06) for a BAC of ≥0.50 ‰ compared to sober drivers (BAC=0 ‰).

Table 25. Drivers' age, BAC level and type of motor vehicle* in relation to responsibility of a collision accident. Killed drivers.

	The most responsible		The less responsible		Total
Age	N	%	N	%	N
16-25 years	78	82.1	17	17.9	95
26 -45 years	70	59.8	47	40.2	117
46 - 65 years	68	52.7	61	47.3	129
> 65 years	70	78.7	19	21.4	89
Alcohol					
BAC = 0 ‰	249	63.9	141	36.1	390
BAC 0.50 – 4.00 ‰	37	92.5	3	7.5	40
Type of motor vehicle					
Two-wheeler (moped, motorcycle)	40	59.7	27	40.3	67
Car, van, tractor	239	69.5	105	30.5	344
Lorry, bus	7	36.8	12	63.2	19

*Note: Drivers of trains (n=6) were excluded from the analysis.

Table 26. Odds ratio estimates for killed drivers being the most responsible party in MV collision accidents: most responsible parties n=286, the less responsible parties n=144.

	Wald Chi square	p<	Odds ratio	95% Wald confidence limits
Alcohol	11.03	0.001		
BAC 0.50 – 4.00 ‰ vs. no alcohol			7.80	2.69– 33.10
Age	28.47	0.001		
26 to 45 years vs. < 26 years			0.33	0.17 – 0.63
46 to 65 years vs. < 26 years			0.22	0.11 – 0.42
> 65 years vs. < 26 years			0.79	0.37 – 1.66
Type of vehicle	6.92	0.05		
Car, van vs. lorry, bus			2.74	1.02 – 8.01
Two-wheeler vs. lorry, bus			1.52	0.50 – 4.90

For model the likelihood ratio Chi^2=56.73, df=6, p<.001
R-Square=.1236, Max-rescaled R-Square=.1715
Hosmer & Lemeshow Test, p=.9808

Relative risk for alcohol-exposed killed drivers in all accidents in the database of 2002 - 06

There were 1,108 drivers who were killed in all MV accidents during the year period of 2002 to 2006 (Figure 2). The following drivers were excluded from the responsibility analysis of all accidents: drivers who had a sudden attack of illness (118 drivers, 11%), who had committed suicide (110 drivers, 10 %), whose BAC was not measured (50 drivers, 6 %), and who were younger than 16 years (18 drivers, 2 %). Collisions with animals (e.g. moose) were also excluded (26 accidents, 2%). Furthermore, drivers were excluded if they had some legal or illegal drugs in their blood, or if the information on drugs was missing (168 drivers, 15 %). The final number of drivers in the analysis was 642.

Age of the driver, drivers' BAC level and speeding were significantly associated with the responsibility for an accident (tables 27 and 28). Young drivers and drivers with high levels of BAC were the most responsible drivers in accidents more often than older drivers and sober drivers (BAC <0.21 ‰). Drivers who had been speeding at the time of the accident were the most responsible drivers more often than non-speeding drivers. Responsibility for an accident was not significantly associated with drivers' sex, type of vehicle, or time of day.

Crude odds ratios (unadjusted odds ratios) for being the most responsible driver when all accidents were considered were:
7.16 (95 % CI: 2.15 – 44.41) for BAC 0.21-1.20 ‰,
31.0 (95 % CI: 4.28 – 224.73) for BAC 1.21-2.00 ‰ and
30.20 (95 % CI: 4.16 – 219.10) for BAC > 2.01 ‰
compared to BAC < 0.21 ‰.
The crude odds ratio for being the most responsible driver when all accidents were considered was 23.23 (95 % CI: 7.30 – 73.93) for BAC ≥0.50 ‰ compared to sober drivers (BAC=0 ‰).

Table 27. Drivers' age and BAC level and speeding in relation to being responsible for an accident. The most responsible party includes the most responsible drivers in collision accidents and all drivers in single vehicle accidents.

	The most responsible		The less responsible		Total
Age	f	%	f	%	f
16-25 years	161	93.1	12	6.9	173
26 -45 years	147	76.6	45	23.4	192
46 - 65 years	114	67.1	56	32.9	170
> 65 years	88	82.2	19	17.8	107
Alcohol					
BAC < 0.21 ‰	332	72.2	128	27.8	460
BAC 0.21-1.20 ‰	35	94.6	2	5.41	37
BAC 1.21-2.00 ‰	72	98.6	1	1.4	73
BAC > 2.01 ‰	71	98.6	1	1.4	72
Speeding					
No speeding	290	72.7	109	27.3	399
Speeding 1 to 30 km/h	46	79.3	12	20.7	58
Speeding > 30 km/h	94	96.9	3	3.1	97

Table 28. Odds ratio estimates for killed drivers being the most responsible party in MV-accidents: most responsible parties (all single vehicle accident drivers + the most responsible parties in the collisions) n=430, the less responsible parties n=124.

	Wald Chi square	p<	Odds ratio	95% Wald confidence limits
Alcohol	18.38	0.001		
BAC 0.21-1.20 ‰ vs. no alco (<0.21 ‰)			3.37	0.75 – 15.17
BAC 1.21-2.00 ‰ vs. no alco (<0.21 ‰)			14.96	2.00 – 111.89
BAC > 2.00 ‰ vs. no alco (<0.21 ‰)			23.49	3.17 – 174.31
Age	25.04	0.001		
26 to 45 years vs. < 25 years			0.27	0.13 – 0.58
46 to 65 years vs. < 25 years			0.25	0.12 – 0.51
> 65 years vs. < 25 years			0.77	0.34 – 1.76
Speeding	8.26	0.05		
Speeding 1 to 30 km/h vs. no speeding			1.47	0.72 – 3.03
Speeding > 30 km/h vs. no speeding			5.66	1.65 – 19.34

For model the likelihood ratio Chi^2=99.21, df=8, p<.0.001
R-Square=.1640, Max-rescaled R-Square=.2504
Hosmer & Lemeshow Test, p=.8354

Summary and conclusions

The study started with comparison of killed drivers impaired by alcohol or legal medicine with killed drivers not impaired by alcohol or any medicines. About 29 percent of killed drivers were positive for alcohol and about 9 percent of killed drivers were positive for various legal medicines in their blood at the time the accident took place.

Description of alcohol and medicine impairment in fatal accidents

Alcohol found in killed motor vehicle drivers

In Finland the legal BAC level is 0.50 ‰. According to roadside surveys in Finland about 0.71 percent of drivers in traffic flow have a BAC below the legal limit (but above 0 ‰) and 0.16 percent of drivers have a BAC over 0.50 ‰ (Niemi, 2006; Rajalin, 2004). The present study found that 29 percent of drivers killed in MV accidents had some alcohol in their blood. Twenty-six percent of killed drivers had a BAC over 0.5 ‰. Gonzalez-Wilhelm (2007) reviewed studies concerning the prevalence of alcohol in blood specimens from killed drivers. There was a large variation in the prevalence of alcohol in blood specimens between the studies (and countries): the prevalence of alcohol ranged from 13 percent to 57 percent.

A typical feature of Finnish drink-drivers in fatal accidents is a particularly high BAC. The present study found that 77 percent of drink-drivers had a BAC of 1.2 ‰ or more. Twenty three percent of drink-drivers also had some medicine or drugs in their blood. The mixed usage (alcohol + some other psychoactive substance) was more typical among drivers with low BAC levels (42 % of drivers with BAC 0.50 ‰ to 1.19 ‰) than among drivers with high BAC levels (20 % of drivers with BAC 1.20 ‰ or more).

Compared to sober drivers, drink-drivers were more often male and younger. 71 percent of the accidents of drink-drivers took place during the evening and at night, compared to 28 percent of sober drivers' accidents. Drink-drivers often had single vehicle accidents. 72 percent of drink-drivers' accidents were single vehicle accidents, compared to 30 percent of sober drivers' accidents. Among drink-drivers, the immediate risk factor for an accident was typically error in vehicle handling or anticipation. The results of the present study support earlier findings concerning drink-driving accidents (Laapotti & Keskinen, 2008; Mayhew, Donelson, Beirness & Simpson, 1986; NHTSA, 2007; Öström & Erikson, 1993; Rajalin, 2004)

Medicines found in killed motor vehicle drivers

During the study period 110 killed drivers had some legal medicine in their blood. Of

these 58 percent were mixed users, i.e. they had alcohol and/or drugs in their blood as well. The study compared drivers of mixed usage (medicine and alcohol) with drivers who had only medicine in their blood. The mixed users were more often male and younger than medicine-only drivers. Both groups were equally likely to have suffered from some chronic disease but mixed users appeared more likely to have suffered depression than medicine-only drivers. Medicine-only drivers typically suffered from heart disease. Information of possible long-time diseases is gathered routinely in the method of traffic accident investigation teams, regardless of any suspected role in the accident. The fact that a driver is diagnosed with a psychiatric disorder, for example, does not necessarily imply use of anti-psychotic drugs, or that the condition had an effect on accident causation.

Suicides were more typical in both medicine groups compared to non-medicine drivers. Nearly one fourth of all accidents of drivers with some medicine in their blood were suicides, compared to 8 percent of non-medicine drivers. Drivers with medicine in their blood were more often tired and affected by some psychiatric disorder than non-medicine drivers.

Accident responsibility of exposed killed drivers compared to non-exposed killed drivers

About the study design

The present study used the data of Traffic Accident Investigation Teams in Finland. The teams examine risk factors for crashes based on the investigations of a police member, a vehicle specialist, a road specialist, a physician and a psychologist. Focus is therefore not only on what happened in an actual crash situation, but most importantly on what factors e.g. related to the vehicle, the road and infrastructure, the driver's decision making and driving state etc., contributed to the outcome. Even matters related to the traffic system on the whole are considered, e.g. legislation and driver training. Each member of the team conducts his/her own investigation and risk analysis of possible causal factors. In a joint meeting the team defines which of the accident parties had the biggest responsibility for accident causation, and what factors related to the car, the road, the driver, or the system contributed according to the course of an accident and the risk analysis. The investigation teams aim to find risk factors of fatal accidents and suggest means to prevent such accidents in the future, but do not aim to find legally guilty parties. Although the processes of traffic accident investigation and police investigation are separated in Finland it is difficult to avoid that information about the use of alcohol or some other substance influence the judgement of the investigation teams regarding responsibility for an accident. However, substance use is never regarded as the sole cause of an accident, but as one possibly contributing risk factor among several factors.

Most important when judging crash responsibility is to look at the total course of an

accident. The immediate investigation done at an accident site is of utmost importance. The Finnish Traffic Accident Investigation Teams do their work immediately at the site of the crash and each accident is investigated in detail by the team of several traffic safety experts. But it is equally important to look at what happened before the accident, i.e. what the driver did, and what influenced his decision making. By including the drivers' decision making and its effect on accident causation provides, in our view a more complete picture of accidents than methods which assess responsibility for crashes with a delay after the crash e.g. by using information from police reports. The methodology of Robertson and Drummer (1994) has been used widely in responsibility analysis when the effects of drugs in driving are studied (e.g. Drummer, Gerostamoulos, Batziris, Chu, Caplehorn, Robertson & Swann, 2004; Laumon, Gadegbeku, Martin & Biecheler, 2005; Longo, Hunter, Lokan, White & White, 2000). In that methodology the factors which might mitigate drivers' responsibility are identified and scored. Eight factors are considered: condition of road, condition of vehicle, driving conditions, type of accident, witness observations, road law obedience, difficulty of task involved, and level of fatigue. The method of Robertson and Drummer (1994) does not take into account the fact that driver behaviour is self-paced (see e.g. Näätänen and Summala, 1976; Brown, 1982, Hatakka, et al., 2002). For example, why should a winding road or rain automatically be a factor that mitigates driver's responsibility for a crash? Should the drivers not lower their speed when the road is curvy or when it is raining? Further, there may be some mitigating factor (e.g. fog) at the accident site but it doesn't have anything to do with the accident causation. Normally drivers adjust their driving according to the difficulty of the task, but this adjusting process may deteriorate when a driver is impaired by some psychoactive substance. Thus we argue that methodologies which try to score drivers' responsibility according to task difficulty fail to take account of the self-paced nature of driver behaviour.

The original idea of our study was to take about 50 killed drivers who were exposed to alcohol and 50 killed drivers who were exposed to some legal (prescribed) medicine and form matching non-exposed control groups for the both exposed groups. The matching procedure was designed to control several confounding factors and therefore to reduce the need for large samples. However, due to changes in data collection methods in accident investigation in 2002 (see chapter "Method") we could not reach the target number of 50 drivers for all comparison groups. Especially the number of medicine-exposed drivers turned out to be very small although all killed drivers in Finland during the years 2002 to 2006 were considered. Therefore, the odds ratios for responsibility should be interpreted with caution. Nonetheless, the present study showed clearly that being exposed to alcohol or medicines is associated with crash responsibility.

To study relative risk of crash responsibility by using a "case - matched control group" design is not a typical method. Usually all factors that may be associated with crash responsibility are studied using a logistic regression model without any prior matching between exposed and non-exposed groups. In the present study we used drivers' age

and sex and geographical location of accidents as matching criteria. By matching drivers' age and sex we simultaneously match a range of other variables because age and sex are associated with many factors that contribute to driving safety. For example, young drivers are more inexperienced as drivers than older drivers; male and younger drivers typically travel at higher speeds and have more traffic violations than female and older drivers; male drivers and younger drivers use safety-belts more seldom than female and older drivers; males ride motorcycles more than females etc (Begg & Langley, 2001; Laapotti, 2003; Parker, Manstead, Stradling, & Reason, 1992; Simon & Corbett, 1997; Şimşekoğlu, 2009; Waylen & McKenna, 2002). Thus by matching exposed and non-exposed drivers according to drivers' sex and age we control many confounding factors simultaneously. The disadvantage of the matching procedure is that it is labour intensive (particularly because we performed it manually) and therefore sample sizes cannot be very high. For comparison purposes we also conducted a multivariate logistic regression analysis without any prior matching to estimate odds ratios for being the most responsible drivers within the groups of alcohol-exposed and non-exposed drivers. According to the results responsibility was significantly associated with variables such as age of driver, speeding, and type of vehicle, in addition to alcohol. According to the case-matched control design only alcohol and age of a driver were significantly associated with crash responsibility, probably because the effects of speeding and type of vehicle were already controlled by matching drivers' age and sex. Odds ratios for being the most responsible party were quite comparable between the different methods (for collisions in the matched-control design: 6.6 with confidence limits of 1.8 to 31.8 and in the non-matched design: 7.8 with confidence limits of 2.7 to 33.1). Odds ratio estimates were not very reliable in either method (large confidence intervals) due to the small number of non-responsible alcohol-exposed drivers in the whole database.

Relative risk of crash responsibility

Relative risk of crash responsibility was studied separately for collision accidents and for all accidents.

Alcohol-exposed drivers were the most responsible parties in collision accidents 6.6 times more often than non-exposed drivers. However, over 70 percent of drink-drivers' accidents were single-vehicle accidents. When culpability for all accidents (i.e. being responsible for collisions and single-vehicle accidents) was studied, the alcohol-exposed drivers were the most responsible parties 16.7 times more often than the non-exposed drivers. Drivers' age was also associated with culpability. Drivers under 36 years were the most responsible party in accidents 4.2 times more often than older drivers.

Odds ratios for different BAC levels were estimated for all accidents in the whole database. It was found that drivers with BAC levels of 0.21 ‰ to 1.20 ‰ were the most responsible drivers 3.4 times more often than sober drivers. The figures for BAC levels 1.21 ‰ to 2.00 ‰ and BAC over 2.0 ‰ were 15 and 23.5, respectively. Young age of the driver and speeding (exceeding the speed limit by more than 30 km/h) were also

associated with crash responsibility. These results are consistent with earlier results regarding culpability of drivers impaired by psychoactive substances (Drummer, Gerostamoulos, Batziris, Chu, Caplehorn, Robertson & Swann, 2004; Longo, Hunter, Lokan, White & White, 2000). These studies found that drivers with higher BAC-levels were more often culpable, as were younger drivers.

In the whole database there were only 4 killed drink-drivers who were non-responsible for the accident out of 237 killed drink-drivers (2 %). The low number of non-responsible parties among drink-drivers may reflect the fact that in Finland drink-drivers who are involved in fatal accidents are typically heavily drunk. It may also reflect the fact that in Finnish traffic flow there are very few drivers who are exposed to alcohol which means that the probability of colliding by chance (as the most responsible party) with a car driven by drink-driver is minimal.

The medicine-exposed drivers were the most responsible drivers 9.5 times more often than the non-exposed drivers in collision accidents, and 10.4 times more often than the non-exposed drivers in all accidents. The present study on crash responsibility included a variety of medicines at a variety of concentration levels. Although it would be preferable to estimate odds ratios separately for different kind of medicines and for different concentrations (at the treatment level or overdose) this was not possible in the present study due to the low number of exposed drivers.

The present results concerning the effect of medicine on crash responsibility should be treated with caution for several reasons. Firstly, the study included all kinds of legal medicine, and not only those known as impairing. Secondly, the study included various concentrations of medicines, without differentiating low or high doses. Thirdly, the study included both single and multi-drug users. Fourthly, the number of available cases was very low. Further, it was not possible to differentiate the role of background diseases and medicine use on increasing crash responsibility.

The study found that suicides were more common among alcohol- or medicine-exposed killed drivers than among non-exposed killed drivers. 24 percent of killed drivers with medicine in their blood had committed suicide by intentionally driving into an oncoming vehicle or other object. For alcohol-exposed drivers the figure was 12 percent, and for non-exposed drivers 8 percent. In studying the relative risk for crash responsibility it is extremely important that suicides be excluded from the analysis.

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APPENDIX 1: Geographical areas of investigation teams. In the present study the investigation teams of numbers 01 to 10, 13 and 22 comprised the area of Southern Finland. The investigation teams of numbers 11, 12, 14 to 18 and 23 comprised the area of Middle-Finland and the investigation team of 19 comprised the area of Northern Finland.