Sleep-related Fatal Vehicle Accidents: Characteristics of Decisions Made by Multidisciplinary Investigation Teams

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Objectives: To analyze factors that explain the attribution of crash causes as sleep-related by accident investigators.
Design: Analysis of national database of fatal road accidents studied in depth. All nonprofessional nonintoxicated car drivers responsible for a fatal accident from 1991 to 2001 were included (N = 1464).
Setting: Finland, with approximately 5.1 million inhabitants and 2.3 million motor vehicles.
Participants: N/A.
Interventions: N/A.
Measurements: Comprehensive database recorded by multidisciplinary investigation teams, with specific emphasis on the availability of sleep-related driver variables and sleep-related causal decisions by teams.
Results: Injury severity, age, and marital status of the responsible car driver were related to the proportion of missing data in fatigue-related variables in the database (sleeping time, time awake, lifetime mileage). While there were differences between investigation teams and their activities, a series of logistic regression models showed that the lack of relevant variables in the database did not affect the proportion of accidents attributed to falling asleep (10% of cases) or as having fatigue-related causal factors (an additional 5% of the cases). The accident type (head-on and running-off versus other) and road conditions (dry or wet versus icy or snowy pavement) predicted the investigation teams' attribution of sleep-related causes in all models.
Conclusions: Multidisciplinary teams' attribution of sleep-related causal factors were rather stable, comprising 10% to 15% of the cases investigated, independent of the availability of specific sleep-related information.
Key Words: Sleepiness, fatigue, in-depth studies, motor-vehicle drivers, FIRAIS
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INTRODUCTION

THERE IS A BROAD CONSENSUS THAT FATIGUE REPRESENTS A MAJOR PROBLEM FOR ROAD SAFETY, AND SEVERAL RESEARCHERS SHARE THE OPINION THAT IT IS NOT SUFFICIENTLY RECOGNIZED AND REPORTED AS A CAUSAL FACTOR IN ROAD ACCIDENTS.[1,2] This is highly understandable considering how difficult a task police officers have in recognizing fatigue as a major or contributing cause of road accidents. Investigating officers don't have direct insight of a driver's preaccident condition and, at best, only discover information regarding it some time after the accident when the driver's arousal and emotional state have changed. There are also obvious difficulties in correctly identifying cases where a driver has fallen asleep. Some drivers are killed or seriously injured and therefore unavailable to provide information about such causal factors. Even uninjured participants may not have any recollection of falling asleep or, indeed, any clear recollection of the accident at all.[3] Finally, some drivers may not be willing to admit having fallen asleep because of concerns of possible legal and insurance consequences.[3,4] Consequently, the proportion of fatigue-related accidents in police reports and accident databases from different jurisdictions varies greatly, ranging from about 1% for all police-reported accidents in the United States[5] to about 20% in fatal accidents in New South Wales, Australia.[6]

Multidisciplinary in-depth analysis of road accidents provides extensive and very detailed data of accidents. With interviews of all the participants and the relatives of those deceased, among other things, such analyses should improve decision making on attributing causal factors to an accident, especially on the role of driver fatigue. However, such in-depth analyses also suffer from missing data, which makes the use of the database more complicated. This study first analyzed the factors that explain the prevalence of missing values in these in-depth studies. Second, in a series of logistic regression models, it analyzed factors that explain falling-asleep accidents and the role of fatigue-related background data in investigation teams' decisions in attributing causal factors.

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METHODS

Fatal-accident Data

This study used the Finnish in-depth road accident investigation system data (FIRAIS) of the Traffic Safety Committee of Insurance Companies (VALT), Finland, for the period 1991 to 2001. Fourteen multidisciplinary teams consisting of a police officer, a road engineer, a traffic engineer, a physician, and in certain cases a psychologist investigated each fatal accident in which at least 1 vehicle occupant had died. Team members were called to the accident scene just after the crash, where they analyzed vehicle positions, damage, road geometry, signage, and all other available information. In addition, they interviewed survivors and eyewitnesses and performed alcohol and drug testing. A preliminary reconstruction of the accident was outlined on the spot. Additional data were gathered afterward from national driver records and healthcare centers, and, in the case of deceased participants, their relatives were interviewed to provide background factors. All team members completed their own standardized data sheets. In the final meeting, based on all the collected data and an autopsy statement, the final statement for each accident was formulated with an explicit decision on the primary cause (the event that triggered the accident event and made the accident irrecoverable, for example, falling asleep). The team also listed risk factors that contributed to the accident (for example, fatigue). All original documents are stored in files available to researchers, and some 300 variables about participants, vehicles, traffic situation, and road and weather conditions, among others, were imported into the FIRAIS database.[7,8] Yearly reports on information in the database are published by VALT.[9] This is a unique worldwide database covering all vehicle-occupant fatalities in the country, since the early 1970s, and has now been extended to cover pedestrian and bicyclist fatalities. A similar countrywide in-depth study program was recently started in Sweden, and several other countries have expressed interest in this kind of activity.

Sample

There were 2978 fatal accidents studied in depth in the database from 1991 to 2001. We only included car drivers (n = 2275) because truck (and bus) drivers are quite different in terms of their driving task, fatigue coping skills, and fatigue-related problems, as reflected by their crashes.[10,11] Drivers with alcohol or drugs (n = 752) were excluded because of the strong interaction of fatigue and intoxication[11-13]; therefore, this sample focused on "pure" fatigue problems. Furthermore, certain small specific groups were excluded: drivers without a license (those who had never had a license, n = 16), professional drivers (taxi or delivery drivers, n = 25), and those few cases where a car's technical fault had a major or crucial role (n = 13). After these exclusion criteria, the sample consisted of 1469 drivers responsible for the accident in which they were involved.

Sleep-related and Fatigue-related Accidents

An accident was considered related to fatigue if the primary cause was falling asleep or the investigation team noted fatigue as a risk (contributing) factor. There were 224 of 1464 (15.3%) cases that were considered as fatigue-related accidents. (The investigation team was not able to attribute the primary cause in 5 cases.) In 148 cases (10.1%), falling asleep was the primary cause, and in an additional 76 cases (5.2%), fatigue was defined as a risk factor that contributed to the accident with another kind of primary cause. The latter primarily consisted of errors in perception (18 cases; for example: *did not notice the other participant*), anticipation (15 cases; for example: *faulty interpretation of the intention of others*), and vehicle handling (29 cases; for example: *too strong steering movement*). In the analysis of falling-asleep accidents and the teams' decisions on them, we included variables that have been earlier identified as contributing to or characteristic of sleep-related accidents, such as time of day,[1,11,14-16] type of accident,[12,17] age of driver,[11,12,16] sex,[17] road conditions,[16,17] driving time,[17] insufficient sleep (sleeping time before accident, time awake),[1,18] and precrash preventive action.[16]

RESULTS

Analysis of Missing Values

There was considerable variation in the proportion of missing values in different variables for drivers responsible for an accident, ranging from 0% to 44%. Variables about time and place of the accidents did not have any missing values. Variables about weather conditions, road type and conditions, and vehicle conditions were missing in only very a small proportion of cases, averaging about 1%. Driver-centered variables were missing much more often. Among those indicating driving experience, lifetime mileage was missing in 33.5%, current annual mileage in 33.1%, mileage with the present vehicle in 31.1%, and the extent of driving on the current road or in area where the accident happened in 14.9%. The driver-record data were lacking quite often: former traffic accidents in 23% of cases and traffic penalties in 13% of cases. Finally, the background characteristics and the current state of the driver, often relevant to fatigue, had high percentages of missing values: the main purpose of the trip in 11%, sleeping time last night in 44.1%, time awake in 39.5%, total driving time before impact in 20%, breaks during driving in 32%, driving since last break in 33.5%, the most important action to prevent the crash in 32%, insomnia in 39.1%, and whether the participant felt tired in 35.2%.

Quite expectedly, variables were not randomly missing. Logistic regression models were computed for the most important sleep-related background factors (sleeping time last night, time awake since sleep) and driving experience (lifetime mileage). The best predictor of the proportion of missing values was the driver's condition after the accident (see Table 1). Also, a few other less important predictors were identified: sex, age, and marital status such that data were more often available for female, younger, and married drivers. There were also some small differences between investigation teams that may indicate less activity and less emphasis on coding details into the database by certain teams, possibly because they focused more on the causes of the accident. The teams were also more active in inquiring about and noting background data into the database during 1991 just after the update of the accident-investigation procedure in 1990.

Explaining Fall-asleep Accidents

A series of logistic regression models were computed to explain falling asleep in these data or, rather, the investigating team's decision that the major causal factor was falling asleep. By gradually adding sleep-related variables, the sample size decreased due to missing values such that the third model included a subsample of 591 cases (40.4%), those with all values on major sleep-related variables (sleeping time last night, time awake, preaccident preventive action, and tiredness anamnesis, which refers to a physician's report of a driver's previous exhaustedness or frequent tiredness). This procedure was aimed at explaining the teams' decisions first by means of fairly objective (and complete) data and, second, to test whether specific (and less reliable) sleep-related information influenced the sleep-related attributions.

Model 1, in Table 2, uses the objective data as predictors and includes all cases except for 12 due to missing data. It can be seen that day of week, time of day, road type, accident type, road condition, and age of the responsible driver significantly explained falling-asleep accidents. The highest odds ratios were in the early-morning time of accident (7.36 times higher than in early afternoon), on main roads with reference to street (17.51), in head-on (12.46) and running-off crashes (12.4) with reference to other, and on dry (15.3) and wet road pavement (9.25) with reference to snowy, icy, and other difficult conditions. (The other conditions primarily refer to situations with bare driving tracks on a snowy, icy, or slushy road). Model specificity (correct prediction of non–sleep-related cases) was high (98.4%) but sensitivity (correct prediction of sleep-related cases) was low (30.4%).

Including sleeping time last night into the regression model (Model 2) had a strong effect for under 6 hours (10.37 times higher than for sleep duration of 7 to 8 hours), while time-of-day effect no longer reached significance. Including preaccident preventive action—the absence of which is one important indication of falling asleep—and time awake and tiredness anamnesis (Model 3), the model sensitivity increased to 55.7%. Driving time had no significant effect in this car-driver sample, possibly due to the fact that 85% of participants had been driving less than 3 hours. The study year did not have a significant effect in any of the models. Neither chronic illnesses in general nor sleep disorders specifically improved prediction of any model, probably because of a high percentage of missing values and a small number of positive cases in these data, especially concerning sleep disorders (less than 1% of drivers had insomnia, while sleep apnea was not classified separately at all).

Table 1—Percentage of missing values in fatigue-related variables by injury severity of driver responsible for accident.

	Not injured (*n* = 116)	Light injury (*n* = 183)	Serious injury (*n* = 105)	Died (*n* = 1060)	Total (*n* = 1464)
Time awake, %	4.3	11.5	21.9	50.0	39.5
Sleeping time, %	6.9	11.5	24.8	55.8	44.1
Lifetime mileage, %	8.6	11.5	19.0	41.5	33.5

Table 2—Logistic regression models for predicting falling-asleep accidents with increasing number of fatigue-related predictors (Models 1 to 3). Unidimensional distributions of cases in each variable are also given.

	MODEL 1 %	MODEL 1 Odds ratio (95% CI)	MODEL 2 %	MODEL 2 Odds ratio (95% CI)	MODEL 3 %	MODEL 3 Odds ratio (95 %CI)
Day of accident						
(ref. Thursday)	14.3	$P < .05$		$P > .05$		$P > .05$
Friday	16.7	3.17 (1.41-7.11)†				
Saturday	11.6	2.19 (0.92-5.25)				
Sunday	13.1	2.69 (1.19-6.11)*				
Monday	15.6	2.08 (0.91-4.75)				
Tuesday	14.5	1.85 (0.79-4.31)				
Wednesday	14.1	0.96 (0.38-2.44)				
Sex						
(ref. Female)	23.7	$P > .05$	26.5	$P > .05$	24.9	$P > .05$
Male	76.3	1.58 (0.93-2.67)	73.5		75.1	
Age, y						
(ref. ≤ 25)	23.9	$P < .05$	28.0	$P = .052$	27.4	$P > .05$
26-35	14.0	0.59 (0.30-1.17)	12.1	0.40 (0.13-1.20)	11.5	
36-45	15.2	0.86 (0.44-1.69)	16.3	0.98 (0.39-2.48)	17.1	
46-55	15.8	1.54 (0.84-2.81)	16.4	1.74 (0.75-4.04)	15.7	
56-65	10.5	1.26 (0.62-2.58)	9.9	2.18 (0.78-6.14)	10.3	
≥ 66	20.6	0.59 (0.29-1.23)	17.5	0.58 (0.19-1.72)	17.9	
Time of accident						
(ref. 11:01 AM - 2:00 PM)	18.5	$P < .001$	17.4	$P > .05$	18.1	$P > .05$
2:01 PM - 5:00 PM	24.0	2.58 (1.27-5.23) †	24.9	1.70 (0.67-4.31)	26.9	
5:01 PM - 8:00 PM	15.8	2.72 (1.27-5.78)*	16.4	1.38 (0.48-3.94)	16.1	
8:01 PM - 11:00 PM	9.4	0.64 (0.19-2.15)	8.7	0.24 (0.04-1.44)	8.8	
11:01 PM - 2:00 AM	4.4	3.51 (1.25-9.91)*	4.3	2.38 (0.57-10.04)	3.7	
2:01 AM - 5:00 AM	2.7	7.36 (2.62-20.63)‡	2.1	4.12 (0.72-23.73)	2.2	
5:01 AM - 8:00 AM	9.3	5.64 (2.43-13.06)‡	11.0	1.32 (0.39-4.43)	9.5	
8:01 AM - 11:00 AM	16.0	1.66 (0.71-3.90)	15.3	1.48 (0.48-4.58)	14.7	
Road Type						
(ref. Street)	9.4	$P < .001$	9.9	$P < .01$	10.5	$P > .05$
Main road	48.6	17.51 (2.29-133.96)†	45.3	8.75 (1.05-72.73)*	42.5	
Main connecting road	10.9	11.84 (1.44-97.30)*	10.8	5.70 (0.61-53.02)	11.0	
Other highway	19.8	7.67 (0.97-60.86)	20.8	2.18 (0.24-19.62)	21.7	
Other	11.4	3.15 (0.32-30.76)	13.2	0.60 (0.04-8.50)	14.4	
Accident Type						
(ref. Other)	15.7	$P < .001$	18.8	$P < .001$	19.6	$P < .05$
Head-on	43.5	12.46 (4.77-32.58)‡	42.0	8.25 (2.80-24.28)‡	38.1	6.84 (1.87-24.84)†
Intersection	19.0	0.005 (0.000-157633)	18.8	0.004 (0.00-2.6x10^7)	19.5	0.001 (0.000-7x10^9)
Running-off	21.8	12.43 (4.59-33.63)‡	20.3	11.43 (3.60-36.24)‡	22.8	5.50 (1.48-20.31)†
Road Condition						
(ref. Snow, Ice, Other)	35.4	$P < .001$	14.9	$P < .001$	15.6	$P < .01$
Dry	48.8	15.43 (7.41-32.09)‡	44.7	24.31 (8.63-68.46)‡	46.2	24.12 (4.57-127.25)‡
Wet	15.8	9.25 (4.06-21.10)‡	15.0	16.74 (5.24-53.53)‡	14.0	13.13 (2.14-80.66)‡
Sleeping Time						
(ref. 7-8 h)	. . .		22.3	$P < .001$	21.2	$P < .01$
< 6 h			8.4	10.37 (3.98-26.99)‡	8.0	4.11 (1.18-14.26)*
6-7 h			9.0	1.30 (0.49-3.58)	9.8	0.79 (0.22-2.83)
> 8 h			60.3	0.73 (0.34-1.57)	61.1	0.50 (0.18-1.40)
Preventive Action						
(ref. Yes)	. . .		. . .		48.7	$P < .001$
No					51.3	5.13 (2.02-13.04)
Time Awake						
(ref. < 8 h)	. . .		. . .		51.6	$P < .01$
8-16 h					43.7	2.21 (0.97-5.06)
> 16 h					4.7	8.05 (2.10-30.90)†
Tiredness Anamnesis						
(ref. not reported)	. . .		. . .		94.1	$P < .001$
Reported					5.9	25.78 (8.22-80.83)
Number of cases (%)	1452 (99.2)		812 (55.5)		591 (40.4)	
Number of falling asleep (%)	148 (10.2)		86 (10.6)		61 (10.3)	
Model Specificity, %	98.4		98.5		98.3	
Model Sensitivity, %	30.4		41.9		55.7	
Model overall prediction, %	91.5		92.5		93.9	

*$P < .05$, †$P < .01$, ‡$P < .001$
. . . Not included

It is important to note that in each model the percentage of falling-asleep cases remained approximately the same (about 10% of all cases). The similar models computed for all the fatigue-related cases (falling asleep plus fatigue as a contributing factor) also showed that the teams' decisions in terms of the proportion of fatigue-related cases was very similar (15%), independent of the availability of the background variables.

We identified 58 cases with missing values in all fatigue-related predictors. In 7 of them, the teams had marked *fatigue* as a contributing factor. It was of interest to check on what other information the investigation team had relied in that situation. A detailed examination of the original files of these cases revealed that all the relevant data in the original files were not coded into the database, especially if the data were based on the official police investigation for the juridical process that was not made by the police member of the team. In certain cases, it was implicit information or opinions from relatives that might have been used by the teams. In some other cases, the team members clearly had a possibility to interview a deceased driver's relatives who were occupants in the same car (eg, a surviving husband) and should have been able to give background information.

DISCUSSION

While in-depth accident investigations applied to all road fatalities offer an excellent detailed database for the analyses of the role of fatigue in road crashes, these results indicate many systematic sources of missing data that should be taken into account to avoid possible biases. However, missing data do not appear to influence the overall percentage of falling-asleep (or fatigue-related) cases in these data. The most plausible explanation is that, in their difficult task, the teams count on any indication of fatigue. In the case of no other obvious cause for the accident, short sleep duration during the previous night, a long time awake prior to the accident, and no indication of preventive action all suggest that the driver was drowsy and probably fell asleep. One such indication might have been sufficient for the investigator's decision to attribute fatigue as a causal factor, and even in the cases where no explicit information was available in the database, the teams obviously had some implicit knowledge.

These results show that investigation teams' decisions about sleep-related accidents could be explained by well-known factors identified in earlier experimental and accident studies such as time of the accident, sleeping time prior to the accident, time awake prior to the accident, and signs of no preventive action to avoid the accident.[1,14-18] However, 2 variables, accident type (head-on and running-off) and road condition (absence of ice or snow) were quite important predictors in all 3 models, which raises a question of possible circular reasoning. That is to say, in the absence of any obvious other causes, the fact that a crash was a head-on or running-off type and occurred on a road without ice or snow may predispose investigators to attribute the cause to sleep- or fatigue-related factors.

In cases where the driver's task is easy and monotonous and demands little effort, as in open-road driving in good weather and road conditions, there are reasons to assume that fatigue will be induced,[19,20] and, on the other hand, there are fewer competitive causal explanations for crashes that primarily consist of head-on and running-off-the-road types. If the task is more demanding, instead, such as entering a crossing or driving in bad road conditions, falling asleep is a much less probable explanation, and perceptual errors or loss of control are more often offered as a primary cause, although fatigue, a lapse in attention, or even falling asleep might trigger or substantially contribute to the cause. Quite surprisingly indeed, specific sleep-related information does not appear to have much impact on investigation teams' decisions when attributing causal factors.

We were not able to show any effect of sleep disorders in teams' decisions due to the high percentage of missing values and the small number of positive cases. Lack of a sleep apnea category and the less than 1 % proportion of insomnia in these data, given a prevalence of 11.7 % for any DSM IV insomnia and of 1.6 % for a diagnosis of primary insomnia in general population of Finland,[21] suggest that sleep disorders have not received sufficient attention in the teams' work. Therefore, sleep disorders may indeed contribute to accidents through sleepiness, and highly probably do so,[22-25] but the issue cannot be properly addressed with these data.

The percentage of fatigue-related cases was somewhat higher than in a similar analysis of the teams' decisions for the years 1984 to 1989.[11] In this former fatality sample of nonintoxicated car drivers, the percentage of cases involving falling asleep was 6.2% and of all fatigue-related cases was 8.2%. The higher rates (10.1% and 15.3 %, respectively) in the 1991-2001 data do not necessarily mean an increase in exposure to fatigue while driving, or even in the prevalence of fatigue in fatal crashes. The investigation teams probably are giving more attention to fatigue due to increased discussion and research in this area. It is to be remembered that even well-educated and highly experienced multidisciplinary teams cannot avoid a certain degree of subjectivity when assessing the role of the fatigue in accidents.

Although the present analysis gives a fairly consistent estimate of the fatigue-related crashes in these fatality data, this approach cannot be considered fully reliable or exhaustive. The teams possibly tend to focus on the critical nonperformance of falling-asleep drivers. The methods (and teams) seem to be not so sensitive in detecting the influence of fatigue on driver performance instead, since there were fairly few cases in these data where fatigue was marked as a risk factor when the primary cause was a perception or anticipation mistake. However, fatigue should result in inattention and late or no detection of hazards even before a driver falls asleep.[26,27] Quite obviously, more attention should be given to such effects of fatigue in road-accident investigation.

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REFERENCES

1. Åkerstedt T. Consensus statement: fatigue and accidents in transport operations. J Sleep Res 2000;9:395.
2. Brown ID. Driver fatigue. Hum Factors 1994;36:298-314.
3. Reyner LA, Horne JA. Falling asleep whilst driving: are drivers aware of prior sleepiness? Int J Legal Med 1998;111:120-3.
4. Corfitsen MT. 'Fatigue' among young male night-time car drivers: is there a risk-taking group? Safety Science 1999;33:47-57.
5. Knipling RR, Wang JS. Revised estimates of the U.S. drowsy driver crash problem size based on general estimates system case reviews. 39th Annual Proceedings from the Association for the Advancement of Automotive Medicine 1995;451-66.
6. Roads and Traffic Authority, NSW. Road traffic accidents in New South Wales 2000. Available from http://www.rta.nsw.gov.au/roadsafety/downloads/accidstati_dl3.html.
7. VALT. Fatal road accidents. Research plan for the accident investigation teams 1991 (In Finnish). Helsinki: Finnish Motor Insurers' Centre; 1990.
8. Hantula L. Development of a case study method of road accidents in Finland. J Traffic Med 1992;10:27-35.
9. VALT. Report of road accidents with killed occupants studied by road accident investigation teams in 2001 (In Finnish). Helsinki: Finnish Motor Insurers' Centre; 2002.
10. Häkkänen H, Summala H. Fatal traffic accidents among trailer truck drivers and accident causes as viewed by other truck drivers. Accid Anal Prev 2001;33:187-96.
11. Summala H, Mikkola T. Fatal accidents among car and truck drivers: effects of fatigue, age, and alcohol consumption. Hum Factors 1994;36:315-26.
12. Pack AI, Pack AM, Rodgman E, Cucchiara A, Dinges DF, Schwab CW. Characteristics of crashes attributed to the driver having fallen asleep. Accid Anal Prev 1995;27:769-75.
13. Philip P, Vervialle F, Le Breton P, Taillard J, Horne JA. Fatigue, alcohol, and serious road crashes in France: factorial study of national data. BMJ 2001;322:829-30.
14. Åkerstedt T, Kecklund G, Hörte LG. Night driving, season, and the risk of highway accidents. Sleep 2001;24:401-6.
15. Garbarino S, Nobili L, Beelke M, De Carli F, Ferrillo F. The contributing role of sleepiness in highway vehicle accidents. Sleep 2001;24:203-6.
16. Horne JA, Reyner LA. Sleep-related vehicle accidents. BMJ 1995;310:565-7.
17. Sagberg F. Road accidents caused by drivers falling asleep. Accid Anal Prev 1999;31:639-49.
18. Philip P, Sagaspe P, Taillard J, et al. Fatigue, sleep restriction, and performance in automobile drivers: a controlled study in a natural environment. Sleep 2003;26:277-80.
19. Wertheim AH. Highway hypnosis: a theoretical analysis. In Gale AG, Brown ID, Haslegrave CM, Moorhead I, Taylor S, eds. Vision in Vehicles - III. Amsterdam: North-Holland; 1991:467-72.
20. Summala H. Transportation and traffic in the information society—monotony and overload. In Rantanen J, Lehtinen S, Huuhtanen P, Härmä M, Laitinen H, Lehtelä J, eds. Work in the Information Society. Helsinki: Finnish Institute of Occupational Health; 1996:108-15.
21. Ohayon MM, Partinen M. Insomnia and global sleep dissatisfaction in Finland. J Sleep Res 2002;11:339-46.
22. Aldrich MS. Automobile accidents in patients with sleep disorders. Sleep 1989;12:487-94.
23. Findley LJ, Weiss JW, Jabour ER. Drivers with untreated sleep apnea. A cause of death and serious injury. Arch Intern Med 1991;151:1451-2.
24. George CFP, Smiley A. Sleep apnea and automobile crashes. Sleep 1999;22:790-5.
25. Teran-Santos J, Jimenez-Gomez A, Cordero-Guevara, J. The association between sleep apnea and the risk of traffic accidents. N Engl J Med 1999;340:847-51.
26. Lamond N, Dawson D. Quantifying the performance impairment associated with fatigue. J Sleep Res 1999;8:255-62.
27. Williamson AM, Feyer AM. Moderate sleep deprivation produces impairments in cognitive and motor performance equivalent to legally prescribed levels of alcohol intoxication. Occup Environ Med 2000;57:649-55.