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Summary:

Falling asleep at the wheel: Causes and consequences

Previous research

Previous research has clearly shown that falling asleep at the wheel is an important cause of car crashes. The incidence estimates found in the research literature vary between 8 and 29 per 100 drivers per year for falling asleep while driving. Also the estimates regarding the share of crashes that are caused by a sleepy or fatigued driver vary considerably. If all kinds of crashes (even those with property damage only) are included, between 1 and 6 % of the crashes have been found to be sleep or fatigue related. For more serious crashes the estimates are higher; e.g., it has been estimated that about 30 % of fatal crashes on rural roads and of head-on and running-off-the-road crashes on straight road sections are related to sleep or fatigue.

There are mainly three causes of sleepiness. First, there is the circadian rhythm, which implies that sleepiness reaches a maximum late at night or early in the morning. I addition there is a peak in sleepiness during the afternoon. Several studies have shown a correspondence between performance on various tasks and the diurnal variation in sleepiness. Second, sleepiness varies with the amount and quality of sleep. Research has shown that a sleep deprivation of less than an hour each night is sufficient to increase the probability of falling asleep during daytime. Third, the sleepiness is determined by the time that has elapsed since the last sleep period. For drivers this implies that time behind the wheel is an important determinant of sleepiness. It has been shown that all the three mentioned factors contribute to explaining the risk of car crashes.

In addition to those three factors, which are relevant to all drivers, there are certain sleep disorders and illnesses (e.g., sleep apnoea and narcolepsy) that increase the risk of falling asleep during daytime and are associated with increased crash risk.

Mapping the various indicators and early signs of sleepiness is a large area of investigation, and one possible implication of this research is the development of in-vehicle systems for warning sleepy drivers and possibly preventing sleep-related crashes. Sleepiness can be detected by changes in the electrical activity of the brain (EEG), and other physiological processes, in observable behaviour (such as characteristic movements of eyes and eyelids), and in driving behaviour (reduced steering precision, increased reaction time to traffic events).

Drivers are generally aware of the sleepiness signs, but it is difficult to prevent sleepiness by other means than sleeping. However, caffeine drinks seem to have a certain short-term effect. And the combination of coffee and a short nap (15 to 30 minutes) has proven effective for staying awake for a considerable period of time.

Sleepiness is a particular problem among professional drivers, who often drive continuously for several hours and may be exposed to time pressure that may imply insufficient rest and sleep during the work period. Although there are regulations regarding hours of service, it has been shown that violations of the regulations occur frequently. It may also be questioned to what extent the regulations are adequate for preventing driver drowsiness even if they are complied with. Several studies have shown that organisational measures in the companies are important in order to prevent sleep-related crashes among the professional drivers. Possible measures can be information and education regarding both causes and countermeasures for sleepiness, and appropriate trip scheduling and work organisation in general.

Questionnaire study among crash-involved drivers

A questionnaire study was carried out in order to investigate the following issues.

- Has the incidence of sleep-related crashes changed during the recent years?

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- What is the relationship between falling asleep at the wheel and the traffic environment (road conditions, speed limits, traffic volume, etc.)?
- To what extent do drivers experience signs of sleepiness before they fall asleep at the wheel?
- Is it possible to differentiate between falling asleep crashes and other crashes caused by the driver being fatigued but not actually falling asleep?
- To what extent can a driver fall asleep at the wheel without previous sleep deprivation? Is a monotonous environment sufficient to cause sleep?
- What proportion of falling asleep incidents happen to drivers with sleeping problems?
- Are there other characteristics of drivers, vehicles or the trip that are related to the probability of falling asleep at the wheel?

In June, 2003, a sample of 15000 car owners who had reported a crash to the insurance company Gjensidige NOR during the last 6 months, received a questionnaire, which was supposed to be filled in by the person who had been the driver during the reported crash. The drivers were questioned whether sleep or fatigue had contributed to the crash. In addition, the drivers were asked about any previous incidents of falling asleep while driving. Those who reported such an incident were asked a series of questions regarding that incident. A total of 4448 persons filled in the questionnaire.

Sleepiness-related crashes

Fatigue or sleep contributed to 1.3 % of the reported crashes. This is a somewhat lower proportion compared to a similar study in 1997. The difference may be partly related to methodological differences between the two studies, but if it reflects a real decrease the incidence of sleep-related crashes, it may be an effect of increased use of rumble-strips as edge-lines and centrelines during the recent years.

Sleep-related crashes can somewhat schematically be described by the following characteristics:

- More than 40 % of the involved drivers reported some kind of sleep problem.
- A relatively large share of sleep-related crashes are caused by running off the road.
- Sleep-related crashes make up a larger proportion of crashes during the night than during the day.
- They are generally more severe than other types of crashes.
- They are relatively more frequent in rural areas.
- They make up a larger proportion of crashes on dry and bare roads compared to roads with snow or ice.
- They happen relatively more often during long trips, and during the last part of the planned trip.
- They make up a larger proportion of crashes among inexperienced as compared to experienced drivers.
- They are relatively more frequent when the driver is alone in the car.

Falling asleep while driving is rather common

Six per cent of the drivers reported an incident of falling asleep at the wheel during the previous 12 months, and 22 % reported having ever fallen asleep while driving. Both these estimates are relatively low compared to previous studies. This is consistent with the decrease in sleep-related crashes mentioned above.

The relationship between falling asleep at the wheel and various background factors was investigated by a multiple logistic regression analysis, where the effect of each factor was assessed independently of the other factors.

The proportion of drivers having fallen asleep is about 2.5 times higher among men than among women; 29 % of the men reported such incidents, compared to 12 % of the women.

Young drivers are more likely than elderly drivers to fall asleep while driving. This is probably related to more night-time driving and possibly also a lifestyle implying less sleep (more sleep deprivation) among young people.

Relatively more obese drivers (as shown by the body-mass index) report incidents of falling asleep while driving. This seems partly explainable by a relationship of obesity to sleeping problems, which in turn affect the risk of falling asleep during daytime.

Most drivers who fall asleep at the wheel wake up again in time to avoid serious consequences. The most common consequence is that the driver wakes up when the car crosses the right-hand edge of the pavement, just in time to bring the car back on course without running off the road. Less common is deviating into the opposite lane. About 4 % of the incidents result in a crash (mostly running off the road or crashing into other vehicle). This corresponds to a risk of 0.15 sleep-related crashes per million km.

As a group, drivers who have experienced falling asleep at the wheel have a higher crash risk in general, even for crashes that are not directly caused by sleep or fatigue. A possible explanation is that falling asleep at the wheel may be related to certain risk-related personal characteristics, such as an increased tendency to take risks.

Drivers tend to fall asleep during good or monotonous driving conditions

Falling asleep typically occurs on a straight road section on an undivided rural road with low traffic, and during good weather and driving conditions. Although this may indicate that falling asleep is more likely during monotonous conditions, it is, however, not possible to make any definite conclusions regarding the risk associated with those various characteristics, without knowing how the exposure is distributed according to the same characteristics.

Most incidents of falling asleep at the wheel occur during daytime, because of the higher exposure. The *risk* of falling asleep (incidents per distance driven) is however highest during the night. Between midnight and 6 a.m. the risk of falling asleep at the wheel is about 17 times higher than between 6 a.m. and noon. There is also a slight risk increase during the afternoon, corresponding to the diurnal variation of the biological rhythms.

It was intended to assess a hypothesis implying that lowering the speed increases the risk of falling asleep, due to increased boredom or monotony. The risk of falling asleep is highest on roads with high speed limits, which is obviously related to good road conditions, and possibly also less traffic and a relatively higher share of night traffic on those roads. The speed limits on parts of the Norwegian road network have been reduced (from 90 to 80 or from 80 to 70 km/h) since the previous sleep study, and a relevant test of the hypothesis could be a comparison between the two studies regarding the proportion of sleep-related crashes on roads with different speed limits. However, the number of sleep-related crashes in the latest study was too small for a breakdown by speed limit, and therefore it is not possible to make any conclusion on this issue.

Concerning car characteristics, we do not find any indications that drivers who have fallen asleep have newer cars than the average for the car population in Norway, as would be expected from an assumption that more comfortable cars facilitate falling asleep. We do, however, not know whether car age is an adequate indicator of driving comfort, so we cannot exclude the possibility that car characteristics influence the probability of falling asleep.

Drivers fall asleep relatively more often on roads where they seldom drive, and when the trip purpose is going on holidays, leisure driving or visits, and when there are passengers in the car.

At first glance the latter finding may seem to be at variance with the result showing a relatively higher proportion of sleep-related crashes for drivers who drive alone. The explanation of this apparent discrepancy may be that the increased probability of falling asleep with passengers in the car is outweighed by the possibility of passengers to wake up the falling-asleep driver before serious consequences ensue.

Feeling tired, but go on driving

Most drivers who have fallen asleep at the wheel report that they felt tired before the incident, but they tried to defy the symptoms, believing they could keep awake by effort. A very few report that they fell asleep without being aware of tiredness in advance.

Those who have felt tired while driving tried various measures to stay awake (opening the window, putting on the fan, playing music, listening to the radio, etc.), but very many report falling asleep despite such measures.

A substantial proportion of the drivers fall asleep while driving after poor sleep the night before, or after a particularly long or strenuous day on the job, but most incidents seem to occur without any reported sleep deprivation or fatiguing precursors.

Knowledge gaps

Even though the present study has provided a better understanding of the phenomenon of falling asleep while driving, there is still a need for more knowledge in order to develop and implement efficient measures to prevent accidents related to sleep and fatigue.

There is a need for a clearer distinction between fatigue and sleep as risk factors, and more knowledge about how tiredness and the risk of falling asleep is influenced by road and vehicle characteristics, as well as the drivers' sleep habits.