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Executive summary:

Fatigue, sleepiness and reduced alertness as risk factors in driving

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

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

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

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

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

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

The risk of sleep-related crashes seems to vary with time of day, mirroring roughly the biologically based circadian variations in sleepiness and vigilance. This means that the risk shows a peak late at night or early in the morning, and a smaller peak in the afternoon. Although the *risk* of sleep and fatigue related crashes is larger during the night than during the day, the *absolute number* of such crashes is as high during the day as during the night, due to the larger exposure during daytime. Countermeasures should therefore address the problem of falling asleep during daytime as well as during the night.

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

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

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

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

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

Drivers are often not motivated to take a break and have a nap when becoming fatigued or tired, but rather tend to engage in several activities in order to keep awake. Research has shown that most such activities (opening the window, increasing the volume of the radio, etc.) at best can postpone sleep for only a few minutes. The only effective countermeasure against sleepiness is sleep, preferably combined with a caffeine drink. A nap of at least 15 minutes is very effective and enables a driver to continue driving in an alert and vigilant condition for a considerable period. The nap should not exceed 30 minutes, because longer sleep may produce sleep inertia, from which the driver needs a certain time to recover.

It is important to increase drivers' awareness of the risks associated with driving when fatigued or sleepy, and about the effects of various countermeasures. The management of companies employing drivers have a special responsibility to take care that their employees are rested and fit and sufficiently aware of the risks, and also that their working schedules (especially for shift-workers) are compatible with the needs for rest and sleep. Educational programmes have been developed for helping both companies and individuals to manage fatigue in an adequate way. Concerning warning systems an important message should be that these systems do not reduce sleepiness, but they are only backup systems in case the driver is not sufficiently aware of the fatigue symptoms. Safe use as well as adequate training and information regarding new technical systems is part of the joint responsibility of employers and employees under the Occupational Safety and Health legislation regarding duty of care for a safe working place, including the vehicles used in employment.

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

Countermeasures against fatigue and sleep-related accidents are of two types. They can either prevent drivers from falling asleep or developing fatigue while driving, or they can alert a driver or intervene with driving once a driver's performance is impaired. Thus, there is both primary and secondary prevention of such accidents. Examples of primary prevention are information to raise driver's awareness of early signs of fatigue or sleepiness, or warning systems detecting such signs. For professional drivers an additional countermeasure is the hours-of-service regulations. Rumble lines along the edge or centre of the road (profiled edgelines/centrelines) is an example of a secondary prevention that has proven very effective. Other examples are the in-car systems to wake up a driver who has fallen asleep.