

That Sleep of Death



The hidden factor behind the road toll

HUMAN BEINGS need to sleep. Sleep is not a matter of choice; it is essential and inevitable. The longer someone remains awake, the greater the need to sleep and the more difficult it is to resist falling asleep.

Sleep will eventually overpower the strongest intentions and efforts to stay awake³. The need for sleep varies between individuals, but sleeping for 8 out of 24 hours is common, and 7 to 9 hours sleep is required to optimise performance.

Sleep patterns are governed by the circadian rhythm (the body clock) that completes a full cycle approximately once every 24 hours. Humans are usually awake during daylight and asleep during darkness. There are two peaks of sleepiness: the early hours of the morning and the middle of the afternoon⁴.

The loss or disruption of sleep results in sleepiness during periods when the person would usually be fully awake. The loss of even one

night's sleep can lead to extreme short-term sleepiness, and continual disrupted sleep can lead to chronic sleepiness. The only effective way to reduce sleepiness is to sleep. Sleeping less than four hours per night impairs performance. The effects of sleep loss are cumulative, and regularly losing one or two hours of sleep a night can lead to chronic sleepiness over time^{5,6}.

Sleep loss and sleep disruption can be caused by a wide range of factors, some of which are beyond the indi-





vidual's control, but some of which are personal choices:

- hours of work, including long hours and shift work
- family responsibilities
- social activities
- illness, including sleep disorders
- medication
- stress.

Today's '24 hour society' seems to pressurise many people to sacrifice sleep in favour of other activities, without realising the negative effects this has on their health and ability to perform a wide range of tasks, including driving.

Sleepiness reduces reaction time (a critical element of safe driving). It also reduces vigilance, alertness and concentration so that the ability to perform attention-based activities (such as driving) is impaired. The speed at which information is processed is also reduced by sleepiness. The quality of decision-making may also be affected³.

DRIVER FATIGUE AND ROAD ACCIDENTS

There are difficulties in determining the level of sleep-related accidents because there is no simple, reliable way for an investigating police officer to determine whether fatigue was a factor in an accident, and if it was, what level of fatigue the driver was suffering. This results in varying estimates of the level of sleep-related accidents, and in particular, evidence based on accident reports usually produces lower estimated levels than research based on in-depth studies.

A recent study by the Sleep Research Centre¹ indicates that driver fatigue causes up to 20% of accidents on monotonous roads. This suggests that there are several thousand casualties each year in accidents caused by drivers falling asleep at the wheel.

Young males have a strong need to prove themselves and are generally prone to high risk behaviour, so the consequences of falling asleep at the wheel are likely to be more serious than for older, more cautious drivers. Thus, young males will show up in the statistics more often

A study of road accidents on two of America's busiest roads indicated that 50% of fatal accidents on those roads were fatigue related¹². Another study claimed that 30% - 40% of accidents involving heavy trucks are caused by driver sleepiness¹³. An analysis of road accidents between 1990 and 1992 in North Carolina found 5,104 accidents in which the driver was judged to have fallen asleep¹⁴.

A survey of 205 drivers in another State found that 31% admitted having dozed off at least once while driving during the preceding twelve months¹⁵.

VicRoads, an Australian road safety organisation, estimates that 25% - 35% (and possibly up to 50%) of road crashes are sleep related. A 1994 study estimated that driver sleepiness accounts for 6% of road accidents, 15% of fatal accidents and 30% of fatal crashes on rural roads.

However, it seems highly likely that there are many accidents which are attributed to other factors that have a strong element of fatigue, even if fatigue was not the only cause. For example, a man who has been drinking beer all night may doze off on his way home and lurch into the path of an oncoming truck. This type of accident is quite likely to be classified as being caused by drink-driving, even though the actual cause of the crash was arguably alcohol-enhanced fatigue. *

WHO'S AT RISK?

American studies³ have identified three main risk groups among drivers:

- male drivers aged 16 - 29 years
- shift workers
- people with sleep problems.

Another American study¹⁵ found that 55% of sleep-related crashes involved drivers aged 25 years or younger, with the peak age being 20 years.

* Although this article is generally faithful to the original RoSPA report upon which it is based, some repetitive information has been excluded and paragraphs marked with an asterisk* were added by the editor



Aside from unknown biological factors, young males' high likelihood of sleep-related crashes may be the combination of four dangerous traits:*

- A tendency to overestimate their endurance and ability to drive while tired. This problem is the result of, or exacerbated by, a combination of lack of experience and general poor judgement associated with this time of life. *

- Cultural conditioning that encourages male children to ignore their bodies' warning signals (e.g., pain, discomfort, fatigue) and to 'be a man' and continue regardless. Therefore the young man may simply be ignorant of how tired he really is. *

- Young males suffer badly from a modern syndrome that regards sleep as an interruption to a busy life. Thus, instead of the simple and obvious step of taking a nap or going to bed when tired, they will tend instead to drink strong coffee, an energy drink or take an illegal stimulant such as 'speed' or 'ecstasy'. This extreme behaviour is likely to impair judgement much more than simple tiredness – when stimulant-users are 'up' they are just as tired as before, but this fatigue is being masked by a drug that is forcing their bodies to work overtime. Fatigue combined with stimulants means that the body chemistry becomes unstable. Unstable body chemistry means that unstable judgement is almost inevitable. Further, when the stimulant is wearing off users are both deathly tired, quite probably depressed (possibly suicidally) and highly likely to make extremely poor decisions based on the combined effects of the above.*

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than for older, more cautious drivers. Thus young males will show up in the statistics more often.*

Researchers Maycock *et al* identified company car drivers as having a high probability of falling asleep at the wheel because they tend to drive high mileages on monotonous roads, and have tight schedules.

Untreated sleep apnea (brief interruptions of air flow and loss of oxygen while sleeping, resulting in poor and fragmented sleep) and narcolepsy (a disorder of the sleep-wake mechanism which can cause excessive daytime sleepiness) increase the risk of sleep-related driving accidents. Many people with these conditions are undiagnosed and untreated, and are unaware of their increased risk.

Time of Day

Sleep-related accidents peak in the early hours of the morning, between 2:00 and 6:00 am, and in the mid afternoon, between 3:00 and 4:00 pm, due mainly to the body's natural rhythms.

Horne calculated that drivers are 50 times more likely to fall asleep at the wheel at 2:00 am than at 10:00 am. The risk is three times as great between 3:00 - 4:00 pm as it is at 10:00 am.

There appears to be a link between the age of the driver and the peak fatigue time.²⁵ Younger drivers are more prone to fatigue in the early hours of the morning, whereas older drivers are more likely to fall asleep at the wheel during the afternoon sleep period. For drivers aged 70 years or more, the peak time period was between 10:00 and 11:00 am.

Type of Journey

Journeys involving long periods of driving on monotonous roads, such as motorways, are more likely to result in a driver falling asleep at the wheel.

Journeys for work purposes, especially ones involving truck drivers or company car drivers, are also a high risk type of journey.

Boredom

People who are under-stimulated tend to feel drowsy and are more likely to fall asleep.

Type of Road

As noted above, roads which involve sustained, monotonous driving, with little visual stimulus for the driver, and where drivers are not required to attend to either the vehicle's controls or respond to multiple road users and junctions, are more likely to have sleep-related accidents. Urban roads are less prone to fatigue crashes because the level of activity is so much greater, and helps to keep drivers active and alert.

Other Impairment Factors

Lack of sleep is not the only cause of sleepiness. Poor general health, alcohol, drugs, medicines and illness also cause tiredness, in addition to their other impairment effects. Most studies about driver fatigue exclude accidents where other impairment factors have been identified in order to isolate the effects of fatigue. However, sleepiness caused by alcohol or other drugs is still influenced by the circadian rhythm, so that the effects of the alcohol or drug are likely to be greater during peak periods of sleepiness (the early hours and mid afternoon).³

Research at Loughborough University shows that drinking alcohol in the early afternoon is about twice as likely to make a driver sleepy than the same amount drunk in the early evening.

Recent research in Australia and New Zealand suggests that staying awake for 17 - 19 hours results in the same level of impairment as drinking around 50 mg of alcohol, and produces much slower response speeds.²⁷



Type of Accident

Sleep-related accidents tend to be more severe, possibly because of the higher speeds involved and because the driver is unable to take any avoiding action, or even brake, prior to the collision. Horne⁷ describes typical sleep-related accidents as ones where the driver runs off the road or collides with another vehicle or an object, without any sign of hard braking before the impact. Horne⁷

also suggests that the risk of death or serious injury to drivers may be greater in sleep-related accidents than in other types of accident. A study of accidents in North Carolina also concluded that sleep-related accidents tended to have more severe consequences.

Bear in mind, however, that the accidents which make it onto the researcher's computer are only going to be the ones that get noticed. In Auckland, New Zealand, for example, the police frequently decline to investigate accidents where no one is killed or known to be injured. Therefore the police (and the researchers who rely on their data) probably won't have records of sleep-related accidents where people were *not* hurt or killed.*

WORK RELATED FATIGUE ACCIDENTS

Truck driver fatigue may be a contributing factor in as many as 30% to 40% of all heavy truck accidents.³⁰ Truck driver fatigue is a particular problem in single-vehicle fatal crashes, but in crashes involving other vehicles, it is often the other driver that appears to have to been fatigued, not the truck driver.

In another study, 593 truck drivers were interviewed at rest areas on New York's interstate highways. Nearly two-thirds reported episodes of drowsy driving within the previous month, and almost 5% said that they drove when drowsy on most, if not all, days. Nearly half had fallen asleep at the wheel at some point in their

driving career, and about one-quarter reported doing so at least once during the previous year²⁹.

For a two year period large truck crashes on the interstate system in Washington State were investigated using a case-control method. For each large truck involved in a crash, three trucks were randomly selected for inspection at the same time and place as the crash. This research indicated that driving in excess of eight hours increased the risk of crash involvement by a factor of two and also that drivers with log book violations, young drivers, and interstate drivers had increased crash risks.

Drivers' Hours

In most countries, commercial drivers are subject to regulations that set limits on the amount of time they can drive without a break, the amount of time they can drive in a day, the amount of time they can be on-duty and for minimum rest periods. These regulations are designed to prevent drivers from driving for unreasonably long periods and consequently falling asleep at the wheel. However, they still allow drivers to drive for very long periods

Even the limits set by Drivers' Hours Regulations are often flouted by operators and drivers. And many classes of drivers are not covered by these regulations. Van, taxi and company car drivers do not have legal limits on their driving time. An Australian survey showed that about 38% of truck drivers exceeded 14 hours of driving in a work day, and another 5% exceeded 14 hours of work (including non-driving work). About 5% of drivers reported having not slept and 7.5% reported less than four hours of sleep on at least one work day of the preceding seven days. Overall, about one third of drivers obtained less than six hours of sleep on at least one working day³⁴.

The Australian study found that 67% of truck drivers with irregular schedules had been involved in fatigue-related accidents, compared to 38% of drivers with regular schedules. 82% of the drivers who admitted to having exceeded the number of permissible driving hours had had a fatigue-related accident. The most important measures in predicting a fatigue-related accident in the sample were the duration of the last sleep period, the total hours of sleep obtained during the 24 hours prior to the accident, and the split sleep patterns.

There appears to be a strong link between business pressures and truckers' hours. Trucks are very expensive and both owner-drivers and trucking companies that hire drivers want a maximum return on their investment. Given the proven link between fatigue and accidents, you'd think that governments would act quickly to limit the hours that any driver could work. And you'd often be wrong. Governments are often either strongly influenced by business interests, or do not wish to be seen to be hostile to efficient business operation. Either way, governments often simply look the other way when it comes to regulating drivers' hours. In a recent example, the American Insurance Institute for Highway Safety petitioned the Federal government for tighter controls. The end result came up woefully short, allowing truckers to drive for up to 88 hours in 8 days.*

A study of schedules of 498 long-distance drivers found that, assuming average legal speed limits of 88km/h, 26% of the drivers had schedules that required them to exceed speed limits in order to meet the schedule³². Assuming average travelling speeds of 80km/h, the vast majority of long distance drivers would have to work more than 40 hours a week, half would work more than 65 hours and a quarter over 81 hours a week.



An informal truck driver 'pooling' system is known to operate in the UK, in which (usually self-employed) drivers are 'called-off' by large operators as and when required. It is understood that this enables individual drivers to work far longer than would be legally possible if they were employed by a single employer. Such practice, while obviously attractive to commercial operators because it enables them to pay only for the hours or trips they need, leaves much to be desired in safety terms, since the drivers may well have already worked a full quota of hours for other companies before they start the next job.

Shift Work

Shift workers are more likely to have less sleep and more sleep disturbances than non shift workers. A USA survey of rotating shift and straight day workers at a manufacturing plant found an increased incidence of motor vehicle accidents or 'near misses' in which sleepiness was cited as a cause³⁹: 22% of rotating shift workers compared to 7% of day-only workers. Complaints of poor sleep and increased sleepiness during hours of wakefulness were also significantly more common in shift workers than day workers. Shift workers reported higher caffeine and alcohol consumption, and were more likely to use alcohol as a sleep aid.

DRIVER AWARENESS

Drivers are normally aware when they are feeling sleepy, and therefore make a conscious decision about whether to stop and rest or to continue driving while trying to fight off sleepiness and stay awake.

Horne has demonstrated that most drivers involved in sleep-related accidents deny having fallen asleep. This may be due to embarrassment, fear of prosecution or loss of insurance indemnity, or to a genuine belief that they did not fall asleep. Laboratory studies have shown that if people are woken within a few minutes of falling

asleep, they will have no knowledge of having fallen asleep²⁴. However, even if drivers are genuinely unaware of having fallen asleep, they are fully aware of feeling sleepy beforehand. Horne used a driving simulator on which subjects whose sleep had been restricted to five hours the night before, drove for two hours in the afternoon on a monotonous road, to assess awareness of sleepiness while driving, awareness of the likelihood of falling asleep during the drive and the level of incidents due to sleepiness while driving. The study showed that drivers were well aware when they were feeling sleepy, and generally were aware that this meant they might fall asleep. The number of incidents increased as drivers grew more sleepy, and all the major incidents (where the car drifted out of the lane completely) occurred after a lengthy period in which the driver was aware of increasing sleepiness, and usually after a period of fighting sleepiness. Some drivers did not seem to realise that feeling very sleepy meant that they were likely to actually fall asleep. Another study²⁵ by Horne suggested that people often fall asleep more quickly than they realise or expect⁷.

DRIVERS' TACTICS TO AVOID FALLING ASLEEP

Given that drivers are usually aware that they are feeling sleepy, many employ a range of strategies to help themselves fight sleep and to stay awake. Maycock⁸ asked drivers to list the tactics they used:

- Open windows/turn up air conditioning 68%
- Stop and go for a walk 57%
- Listen to radio/cassette 30%
- Talk to a passenger 25%
- Drink coffee 14%
- Other 15%

A series of studies at the Loughborough University Sleep Research Centre assessed the effectiveness of these measures: subjects who had been

restricted to five hours sleep the night before drove on a driving simulator for 2.5 hours on monotonous roads.

Loughborough researchers found that the only strategies that had any effect (beyond a very short term 10 - 15 minutes) were an intake of caffeine of at least 150 mg and a nap of around 15 minutes.

Listening to the radio had no significant effect in reducing sleepiness or in reducing 'incidents' (i.e. drifting out of lane), other than for an initial, very short, 10 to 15 minutes. Air conditioning also found no significant benefit.

A study examining whether exercise can help to reduce sleepiness compared the effects of 10 minutes light, 10 minutes moderate and 10 minutes heavy exercise. Light and moderate exercise made some of the subjects feel less sleepy, but only for about 10 minutes. Heavy exercise produced better results, and the effects lasted for about 30 minutes. However, it does not seem feasible for people to take heavy exercise during breaks from journeys, nor indeed as preparation for a journey. Therefore, exercise is not a practical way of avoiding or reducing driver sleepiness.

The effects of caffeine appear to differ depending on the tiredness of the subject.

A trilogy of studies⁴⁵⁻⁴⁷ assessed the effects of caffeine intake on driver sleepiness using a driving simulator. The first found that it takes around 30 minutes for caffeine to take effect but that taking 150mg of caffeine in the early afternoon was effective in reducing sleepiness, and sleep-related 'incidents', for up to one hour.

A second study found that combining 150 mg of caffeine with a nap of around 15 minutes significantly reduced sleep-related incidents for up to two hours, compared to subjects



who had taken a placebo (decaffeinated coffee).^{7,8} The third study examined the effects of taking 200 mg of caffeine on a group of drivers who had only slept five hours the night before, and on a group who had no sleep the previous night. Again, for the group who had restricted sleep, the caffeine took around 30 minutes to take effect, but then significantly reduced sleep-related incidents for the next two hours. However, there was no such effect for the group who had no sleep. In fact, the driving of this group was so impaired that they were unable to continue driving on the simulator for more than one hour. The caffeine had some effect for the first 30 minutes, but this deteriorated markedly thereafter.

Horne⁴⁶ reports that various studies have shown that taking a nap can reduce impairment caused by sleepiness, and that the minimum nap time required to gain any benefit is 4 minutes, but naps of 20 minutes or more tend to be counterproductive. The optimum nap period is 15 minutes.

The bottom line is: most of the things that drivers do to fight off sleepiness when driving are ineffective for more than around 10 minutes. They are only useful in an emergency to provide time for the driver to find somewhere safe to stop and rest. The only measures that have an effect in reducing sleepiness when driving are taking a nap of around 15 minutes and taking at least 150 mg of caffeine. However, even these measures are no substitute for sleep. And there is some concern that drivers may use these tactics to enable themselves to continue driving when they should really stop.

It is clear that while drivers are aware that they are becoming sleepy, and that this increases their risk of having an accident, many will persevere with their driving, and employ a number of measures to fight off sleepiness.

Road safety education has a poor track record (see our separate article, *A Comedy of Errors*)*

However the Royal Society for the Prevention of Accidents believes that education and publicity measures are required to raise awareness amongst drivers of the dangers of driver fatigue. Such measures could focus on:

- the dangers of driving when tired and the consequences of falling asleep
- the signs that a driver is becoming too tired to continue driving
- the ineffectiveness of common tactics (such as listening to the radio)
- the relative effectiveness of caffeine and naps
- the need to plan journeys
- the need to rest well before long journeys
- the increased risk that illness, alcohol, drugs and medicines generate
- the types of journeys that carry the highest risk

As we stated above, road safety education has a poor track record, but given the woeful ignorance of the role of fatigue in accidents, no harm is likely to come from letting the public know of the dangers of driving when tired. *

The problem with education is that the people most likely to be driving while tired are least likely to respond to it.*

HIGHWAY ENGINEERING

Much of the research into driver fatigue has identified that dull, monotonous roads increase the risk of sleep-related accidents. Unfortunately, it is not feasible to design roads, such as motorways, that are stimulating to drive along. However, there are some highway design and engineering measures that can be used successfully. As sleep-related accidents often involve a vehicle drifting out of lane, it is thought that rumble strips along the

edge of a road, and particularly along the hard shoulder of motorways, may wake up a drowsy driver and so avoid an accident.

In the USA, an innovative rumble strip called the Sonic Nap Alert Pattern (SNAP) was developed and installed on the highway shoulder of the Pennsylvania Turnpike⁴⁸. A distinct warning sound and vibration are produced when drowsy or inattentive drivers' vehicles drift to the right and their tyres roll on the strips. After installation of SNAP, drift-off-road accidents per month decreased by 60% - 70%.

A 1994 study of continuous shoulder rumble strips (CSRS) in 34 states that used CSRS along at least parts of their freeway systems, and some other roads, concluded that CSRS can reduce run-off-road accidents by 20% to 50%¹⁵.

Concern in Japan about accidents, particularly involving truck drivers, caused by the driver falling asleep resulted in the development of a striped road surface design to help keep drivers awake at the wheel. This was used at locations where accidents probably caused by drowsy drivers were frequent. Accidents in these locations were reduced to zero where previously there had been two or three per month⁴⁹.

Devices to detect when drivers are falling asleep and to provide warnings to alert them of the risk, or even to control the vehicle's movement, have been the subject of much research and development. Some are designed to monitor the driver and detect changes in, for example, blink rates or head position. Others detect changes in vehicle movement, such as drifting out-of-lane. However, there are concerns about the reliability of such devices and that drivers may rely on them to warn them when the situation becomes particularly dangerous rather



than consider and plan when they should take rest breaks. It has been shown that drivers are normally well aware that they are sleepy, so why is a device necessary to tell them so?

An analysis of collision warning devices found that a system which only alerted a driver to a potential accident due to an unintentional lane change or roadway departure was not likely to be cost effective⁵¹. However, a system which could also warn of potentially hazardous situations when other manoeuvres were being made could be very beneficial.

Various studies of devices to monitor driver fatigue and modify his/her behaviour have produced lukewarm results. However it seems likely that future automotive technology will be able to monitor driver fatigue and take steps to cope with it.*

A system that monitors train drivers' behaviour and stops the train when the driver does not appear to be responding appropriately has had some success.*

However, while you can reduce the risk of a train crash by simply slowing the train if the driver appears to be asleep. Such a system cannot be directly transferred over to cars & trucks.*

Enforcement

Employers have a vital role to play in managing the risks involving their employees who drive for work purposes. As part of their health and safety policies and practices, employers should adopt and implement the principles of managing occupational road risk, with particular reference to reducing the risk of their employees being involved in a sleep-related driving accident.

However, given the track record of both self-employed transport operators and transport companies, it seems highly unlikely that fatigue-related

driving practises will be solved by anything less than a forced reduction in the number of hours drivers spent behind the wheel.*

Even drivers and operators who are governed by government regulations sometimes find ways of circumventing them. However, in the longer term, technological advancements would enable motor vehicles (with a few exemptions) to have some form of system that records and maintains a record of an individual's driving hours, no matter what vehicle they are driving. Whether this would be publicly or politically acceptable is another issue.

It's also arguable that such a system would miss the point. It's not a lack of monitoring technology that is causing road deaths on the US roads, it's the American regulations allowing truckers to legally drive for up to 88 hours in 8 days even though there is clear evidence that this a very unsafe practice.*

Commercial drivers crash because they choose to, or are forced to, work long hours. Given the high cost of motor accidents, governments should err on the side of caution when it comes to setting limits on how long drivers can sit behind the wheel. Perhaps the old concept of the eight hour day needs to be revisited.*

It can be difficult for the Police to detect a fatigue-impaired driver. However, some police forces are currently trialing general impairment roadside tests, which may prove effective in detecting sleepy drivers, as well as drivers affected by alcohol, drugs or medicines.

In the meantime, there are several major steps that need to be taken to reduce the incidence of fatigue-related accidents.*

First, if public attitudes towards driving while fatigued are to be

changed, then the logical first step is to organise discussion among the educated middle classes. There seems to be a pattern that the educated middle classes start to discuss topical social issues like driving while fatigued and opinions within this group are subsequently modified reasonably quickly. However, it often takes a full generation or more before the rest of society catches up. For example, for much of the twentieth century, women were effectively excluded from large sections of the workforce such as management. Feminists first challenged these practises in the mid 1970s but it was a full generation later before women began to appear *en masse* in many positions that had previously been effectively reserved for men.*

While organising discussion among the educated middle classes is unlikely to have any immediate effects among the high-risk sections of the population, over time there is likely to be a marked reduction in the acceptance of driving while fatigued.*

Second, there needs to be a strong regime regulation and enforcement of commercial drivers' hours, because self-regulation has been a proven failure.*

Third, the medical profession needs to be vigilant regarding sleep-related disorders and to help patients deal with these disorders in a way that minimises driving risks.

Fourth, there needs to be an overall road safety strategy that protects the public from the sleepy driver.*

* Although this article is generally faithful to the original reports upon which it is based, some repetitive information has been excluded and paragraphs marked with an asterisk* were added by the editor.



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