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MURDOCH UNIVERSITY
PERTH, WESTERN AUSTRALIA

Directors
Dr. Laurence R Hartley, PhD
Pauline Arnold, M.App.Psych

South St., Western Australia 6150
Tel: +61 (0)8 9360 2398
Fax: +61 (0)8 9360 6492
email: hartley@socs.murdoch.edu.au
wwwsoc.murdoch.edu.au/irst/irst.htm

Meg Crooks
Secretary
Standing Committee on Communications, Transport and the Arts.
Parliament of Australia
17.5.1999

Dear Ms Crooks,

In addition to the evidence I have provided the committee in the shape of a report on the problems of 'prescriptive hours of service', I would like to make the following brief submission specifically addressing your terms of reference. I shall mainly address the impact of fatigue on land transport since this is the modality with which I am most familiar. However, I believe the issues can be easily generalised to other modalities.

A definition

It may be helpful to provide a definition of the state referred to as fatigue. The working definition I use is that 'It is a progressive loss of alertness ending in sleep'. This definition emphasises that:

- It is a progressive state unless something is done to prevent it, by taking a sleep.
- Alertness is impaired long before sleep intervenes, and this results in poor control of a vehicle.
- Drivers do not have to be soundly asleep to have a crash. Drowsiness will impair attention.
- Finally sleep intervenes, initially in very brief microsleeps of which the operator is usually unaware.
- The operator may wake spontaneously or from the sound of the vehicle running off the road.

The evidence for these assertions is abundant; see for example 1) Belenky, 1998; 2) Smiley, 1998 and 3) Mitler et al, 1998.

The Causes of Fatigue

It is now universally accepted that there are a number of causes including:

1. Driving at a time when people would normally be asleep at night, when the propensity to fall asleep is greatest, with considerable implications for safety.
2. Long hours of work, which result in increased crashes at the end of a long journey

3. Less than 6 hours of sleep, which results in increased hazardous incidents including crashes. Lost sleep accumulates over days to cause chronic 'sleep debt'.
4. Splitting the sleep period between day and night, as in having 3 hours sleep during the day and then taking some more sleep at night.

There is abundant evidence that these conditions cause crashes, see for example:
1) National Transportation Safety Board (1995); Schwing (1989-1990); Kecklund and Akerstedt (1995); Kaneko and Jovanis (1992); Horne and Reyner (1995).
2) Smiley (1998); Hamelin (1987); Jones and Stein (1987)
3) Arnold and Hartley (1998); National Transportation Safety Board (1995);
4) National Transportation Safety Board (1995); Hertz (1988).

Thus countermeasures for fatigue focus on preventing these conditions occurring by having sufficient sleep, timing the sleep appropriately and avoiding driving when drowsy at night.

Truck Crashes and the Diurnal Rhythm of Alertness

It is now well known that there is a 24 hour, or circadian, cycle of alertness and reciprocal sleepiness synchronised to the day-night cycle. This cycle is driven by both an internal biological clock and by external events such as day light. **The clock dictates that sleepiness is greatest in the pre dawn hours (Lavie, 1991). There is a secondary period of sleepiness in the afternoon.** The clock can be completely reset over many days if external events require it to be, such as when we change time zones. However, no study has ever observed complete adjustment of the body clock to a reversed cycle of work and sleep if external events remain unchanged in timing, such as occurs in shiftwork.

In the largest on-road study of driver fatigue, The Driver Fatigue and Alertness Study (DFAS) (Wylie et al, 1997) conducted for the US Department of Transportation, driver drowsiness and sleep was recorded by brain waves and video cameras. Continuous video recordings of the driver's face were sampled every half hour, and assessed for indications of drowsiness (eyelid closures, drooping eyelids, yawning, head nods etc.). In approximately 5% of all of these video samples, the driver was judged to be drowsy. **Of these drowsy episodes, 82% occurred during the hours of 1900 to 0700. Furthermore, most drivers were affected to some degree - about 2/3 were judged drowsy in at least one sample.**

Some of these drivers passed into Stage 1 sleep as determined from their brain waves (Mitler, et al. 1998). These are instances of micro-sleeps of which the driver would be unaware. It has been found that between 2-4 minutes of sleep must elapse before more than 50% of people will acknowledge that they had fallen asleep (Horne and Reyner, 1995). **It is now accepted that drivers can judge they are fatigued because they have to fight sleep. They will often do so in the belief they can complete the journey because they are bad judges of when they will fall asleep (Horne and Reyner, 1995).**

Of all the causes of fatigue, driving during the night has the greatest impact on fatigue. **Wylie (1998) has shown that driving at night is a greater cause of driver drowsiness and sleepiness than is the amount of prior sleep obtained.** Night driving (0000 - 0600) was associated with worse performance on each of four important criterion variables (drowsiness, lane tracking, code substitution, and sleep length).

Hamelin (1987) found that the risk of a truck crash is relatively low when drivers are on the road between 0800 and 1900, and have completed less than 11 hours of work. However, these same drivers show approximately twice the risk of an accident when driving between 2000 and 0700 hours.

Kaneko and Jovanis (1992) used 'statistical cluster analysis' to identify common patterns of driver's trip schedules; 9 patterns were identified. The crash rates of these 9 patterns were extracted. Drivers who began work around midnight and finished at 10 am faced a particularly increased risk of a crash if they had been working to this pattern for several days.

The classic study of the impact of hours of work on performance and accident rates of truck and bus drivers was carried out by Mackie and Miller in 1978. They analysed 406 dozing driver accidents and controlled for exposure by examining the ratios of percentage accidents to percentage trucks on the road by time of day. An accident involving a dozing driver was found to be 7 times more likely to occur during the hours of midnight to 8:00 a.m. than in the other hours of the day, with the highest risk occurring between 4:00 and 6:00 a.m. (88% of these dozing driver accidents were single vehicle accidents.)

Kecklund and Akerstedt (1995) have examined truck crashes at different times of day in which no other vehicle was involved over a recent four year period. These data were corrected for exposure; that is they were adjusted to take account of the number of vehicles on the road at different times of day. **For trucks the risk for single vehicle crashes increases during the night with a peak between 0300 and 0500 am. at 3.8 times greater than during the day. There is also a secondary peak in crashes during the early afternoon.**

The timing of the propensity to fall asleep at night matches the peak time for having a single vehicle crash during the night (Prokop and Prokop, 1955; Lavie, 1991).

Truck Crashes and Long Hours of Work

Long hours of work increase the risk of a crash in two ways. Long hours of work result in increased fatigue. Long hours of work curtail the opportunity to sleep and recover from fatigue. Jones and Stein (1987) found that driving in excess of eight hours, drivers who violate logbook regulations, drivers aged 30 and under, and interstate carrier operations were associated with an increased risk of crash involvement. **In particular, the relative risk of crash involvement for drivers who reported a driving time in excess of 8 hours was almost twice that for drivers who had driven fewer hours.**

Saccomanno et al (1996) found there was a higher proportion of truck crashes in which no other vehicle was involved on routes typified by long driving times. In remote Canada the nighttime single vehicle accident rates were particularly high - 13 times greater than for more populated areas in the daytime. For both daytime or nighttime conditions there were more single vehicle accidents at locations with high driving times. However, nighttime single vehicle accident rates were significantly higher than the daytime rates. **Thus it is clear that long hours, night time driving and driving in remote areas are associated with increased risk of single vehicle accidents due to fatigue.**

Truck Crashes and Hours of Sleep

Sleep is a restorative body function with a strong 24 hour circadian component. Sleep lasts longest and is of the most recuperative quality if taken starting around 9:00 p.m. If because of scheduling, sleep is taken during the daytime, it is significantly poorer in quality as measured by brain waves, and shorter in duration by at least 2 hours even if more time for sleep is available. **The most sleep is obtained when sleep is initiated in the evening around 9:00 p.m. and the least amount if sleep is initiated in the afternoon.**

Mackie and Miller (1978) measured behaviour of a total of 12 truck drivers and 6 bus drivers over a week long period of driving. Drivers in this study reported obtaining 6.5 to 7 hours on regular daytime schedules. However, drivers with start times of 3:00 a.m. averaged 5.5 hours sleep, and for 8:00 p.m. start times, only 4 hours sleep.

The U. S. National Transportation Safety Board (1995) studied 107 single-vehicle, nighttime accidents, where the driver survived and in which the previous 96 hours of work could be reconstructed. Fifty eight percent of the crashes had fatigue as a probable cause. The most important factors predicting crashes were length of sleep and splitting the sleep period. Truck drivers in fatigue-related accidents had an average of 5.5 hours sleep in the last sleep period prior to the accident. This was 2.5 hours less than the drivers involved in non-fatigue-related accidents (8.0 hours). Truck drivers with split sleep patterns obtained about 8 hours sleep in a 24-hour time period; however, they obtained it in small segments, on average of 4 hours at a time. **The Safety Board concluded that driving at night with a sleep deficit is far more critical in terms of predicting fatigue-related accidents than simply nighttime driving.**

Hertz (1988) examined the impact of splitting the sleep period on crashes. **Splitting sleep in to two shifts increased the risk of a fatal crash by a factor of 3.**

Given these findings it is not surprising that a study by Braver et al. (1992) suggests that sleepiness while driving is a widespread problem**. In a survey of truck drivers at truck inspection stations, 19% admitted to falling asleep one or more times while driving during the past month**.

The Characteristics of Fatigue Related Crashes.

Haworth and Rechnitzer (1993) found that in half of the crashes determined to be due to fatigue the vehicle drifted off a straight road (Off path, on straight) as compared to 14.8% of non fatigue related crashes attributable to this maneuver. A further 23.4% of fatigue related crashes involved the vehicle drifting of the road on a curve. **Thus close to 75% of fatigue crashes involve these two maneuvers, of drifting off the road**.

Horne and Reyner (1995) have conducted a study of 606 crashes in the UK, which Police suspected involved sleepiness. They had the following characteristics:

- No alcohol involvement
- Vehicle either ran off the road or into the back of another vehicle
- No signs of the brakes applied beforehand as demonstrated by the absence of skid marks prior to running off the road
- No vehicle defects, speeding and good weather
- For several seconds before the crash the driver could have seen the point of run-off and thus was inattentive for some time.

Horne and Reyner found a strong circadian pattern in the crashes. They calculate that the vehicle drivers were 50 times more likely to have a crash at 2 am as compared to 10 am.

The Size of the Truck Fatigue Crash Problem

The WA Road Injury Database contains 2544 casualty crashes involving rigid and articulated trucks between 1988 and 1992. This has been examined by Spittle and Ryan (1995) for fatigue related crashes as judged by evidence from Police comments and drivers, regarding tiredness and past sleep habits. **For single vehicle crashes 16.2% were fatigue implicated. For road train crashes 16.5% implicated fatigue**.

It is widely believed that these percentages considerably underestimate the impact of fatigue as the cause of a crash. This is because drivers are loath to admit to driving whilst impaired by fatigue, and Police are reluctant to attribute fatigue as a cause without clear evidence for it, and that is hard to find after a crash. The NSW Roads and Traffic Authority (RTA) have adopted a proxy measure for the involvement of fatigue in a crash based on the work of Haworth and Rechnitzer described above. According to this proxy measure, a crash is caused by fatigue if it involves drifting off the road or if there is a head on collision when the vehicle is on the wrong side of the road but is not over taking.

In Western Australia an analysis of Main Roads WA data base for truck crashes with these characteristics shows that 35% of fatal rural crashes are of these types. Twenty one percent of serious injury rural crashes are of these types. These percentages are closely similar to those published by the RTA in NSW.

In 1985 the American Automotive Association examined 221 truck crashes where the truck was towed away. Surviving drivers and families were interviewed and records tracked to determine working hours. Crashes were determined to be due to fatigue if the driver had worked more than 16 hours and if the characteristics of the crash were consistent with falling asleep such as running off the road or on to the wrong side of the road. **It was estimated that fatigue was the primary cause in 40% and a contributory cause in 60% of crashes.**

These figures show fatigue to be comparable to alcohol in its impact on safety. Alcohol is estimated to be involved in about 5% of all crashes, 20% of injury crashes and 40% of fatal crashes. A recent study demonstrated that 24 hours without sleep produces comparable impairment on tests to a blood alcohol concentration of 0.05% (Dawson, Lamond, Donkin and Reid, 1998). A blood alcohol level just in excess of 0.05% at least doubles the risk of a crash (Warren and Simpson, 1980). It is noteworthy that society prosecutes individuals who drive when their risk of a crash is doubled by alcohol but tolerates people driving when their risk of a crash is even greater because of their fatigue. This is undoubtedly due to past ignorance of the contribution of fatigue and the difficulties inherent in measuring and predicting fatigue. Nevertheless, we now know which circumstances cause a crash due to fatigue by analysis of what those are.

The Impact of Fatigue on the WA Road Transport Industry

Hartley et al (1995) reported the findings of an on-road survey of the transport industry in WA. Six hundred and thirty eight drivers were interviewed about their conditions of work. Thirty eight % of drivers on the road on any day exceeded 14 hours driving in any 24 hour period. If the other work they do is also taken into account this percentage increases by over 10% and that other work contributes measurably to driver fatigue. **Close to one third of WA drivers worked in excess of 72 hours per week, and 11 % worked for more than 90 hours a week.**

In the week preceding the survey about 5% of drivers reported having not slept on at least one working day. A further 7.5% had slept less than four hours on one or more days. Thus 12.5% of drivers obtained less than 4 hours sleep on one or more days of the week. **About 30% of WA drivers obtained less than 6 hours sleep on at least one day.**

When asked whether they had experienced any hazardous events 5% (32) of the 638 drivers reported a fatigue related event on the trip they were doing during the survey. The most common events were nodding off whilst driving or near misses, and together these totaled 56% of dangerous events reported. Whilst about 20% of drivers had slept for less than 6 hours before the trip they were doing during the survey, twice as many (40%) as would be expected of the dangerous events were reported by these drivers. Of the 32 drivers who had a crash, 12% (n=4) thought they were fatigue related. **About 2% of drivers reported nodding off very frequently in the past 9 months, 1% often nodded off whilst driving and a further 11% occasionally nodded off. A segmentation analysis of these data indicates drivers who have less than 6 hours sleep have a 3 fold increase in risk of a dangerous incident including crashing.**

Thirty seven % of WA drivers see fatigue is *often or always a problem* for the transport industry.

Summary and Conclusions

From the foregoing it must be apparent that fatigue as a cause of impairment and crashes is not an inconsiderable problem in Western Australia and other parts of the world. The causes of fatigue, the timing of work and the adequacy of rest, are established. The WA Road Safety Council now acknowledges that fatigue ranks equally with speeding, alcohol and lack of seat belts as one of the major causes of road trauma. This is no less true in the transport industry. Jurisdictions around the world are seeking better policies and regulations to reduce the impact of fatigue as a cause of trauma.

Although the percentage of crashes due to fatigue varies according to the precise methodology used to study the crash, a reasonable estimate is that 30% of fatalities are due to fatigue. As a result of the loss of alertness or micro-sleeps, the driver lost control of the vehicle and it ran off the road or onto the wrong side of the road and crashed. A fatigue related crash is typically severe because no, or inappropriate, avoidance maneuvers are made.

Drug use is a Consequence of Fatigue in the Transport Industry

Mabbott and Hartley (1998) conducted a survey on drug use among transport drivers. Twenty eight percent of drivers reported using at least one stimulant drug to counter the effects of fatigue while driving. Drivers were also asked how many of all drivers they knew used drugs; again, twenty eight percent of drivers they knew used drugs. The range of drugs used was as follows:

Over counter stimulants	Freq.	Prescription stimulants	Freq.	Illicit stimulants	Freq.
Not specified	13	Duramine	16	Speed	18
Sudafed	7	Not specified	13	Not specified	10
Guarana	5	Ephedrine	7	Cocaine	1
No-Doz	4	Tenuate Dospan	3	Marijuana	1
Codral	1				
Demazin	1				

Interstate drivers used prescription or illicit drugs more than WA intrastate drivers did. WA intrastate drivers used over the counter stimulants more than expected and a prescription or illicit drug less than expected**. A significant relationship was found between drug use and hours of sleep the drivers had before the trip during which they were interviewed. Those who only had between 2 and 6 hours sleep before the trip used significantly more than expected over the counter drugs.**

Drivers hauling general freight used prescription or illicit stimulant drugs more than expected and over counter drugs less than expected. Drivers were asked whether it was more responsible to use stimulant drugs to remain alert while driving rather than risk falling asleep at the wheel and having an accident. There were no significant differences in responses with 107 (45.3%) stating it was more responsible and 119 (50.4%) stating it wasn't. Drivers based in WA or those driving intrastate routes responded more than expected that it is not more responsible to use stimulants than risk falling asleep. Drivers based outside of WA and interstate drivers responded more than expected that it is more responsible to use drugs than risk falling asleep.

Those hauling general and express freight were more likely than expected to say that it is more responsible to use stimulants. Company management also had a significant influence on whether a driver would consider using a stimulant drug if it were available. Where the company was said to allow adequate rest, the drivers respond more than expected that there is no need to use stimulants. When drivers hauled for companies setting tight schedules, they were more than expected to consider or probably use the drug for the current trip.

Objective assessment of the prevalence of drugs used depends upon sensitive and reliable chromatography and spectrometry of drivers' saliva, urine or blood samples. Many studies are reviewed by Haworth (1989) and Drummer (1995). Studies have been conducted on live, volunteer, truck drivers (e.g. Lund, Preusser, Blomberg, and Williams, 1988; Starmer, Mascord, Tattam and Zeleny, 1994). Several other studies have been carried out at post mortem on drivers killed in road crashes. Sweedler (1992) and Crouch, Birky, Gust, Rollins and Walsh (1993) have examined tissue samples from deceased truck drivers. Studies of drug use using body samples from drivers report reasonably consistent findings. Samples from live, volunteer drivers (Lund, Preusser, Blomberg, and Williams, 1988; Starmer, Mascord, Tattam and Zeleny, 1994) report drug use among about 30% of drivers sometimes or more often. In Lund et al.'s US sample and Starmer et al.'s Australian sample about 30% of drivers tested positive for drugs. Lund et al found 15% took marijuana, 17% took prescription and non prescription stimulants and 5% took cocaine. Starmer et al. found 29% of drivers tested positive for prescription and non prescription stimulants. Non prescription stimulants included amphetamine and methamphetamine. Prescription stimulants included ephedrine, fenfluramine, methoxyophenamine, phentermine and phenylpropanolamine.

In studies of samples from US deceased drivers (Sweedler, 1992 and Crouch, Birky, Gust, Rollins and Walsh, 1993), Sweedler found 33% of drivers were positive for drugs of abuse including alcohol and marijuana (13% each), cocaine (9%), amphetamines and other stimulants (15%). Crouch et al. found 33% of deceased drivers were positive for psychostimulants or alcohol; alcohol and marijuana were each found in 13%, cocaine in 8% and prescription and non-prescription stimulants were found in 14% of drivers. All studies of bodily samples agree that poly drug use occurs in a large proportion of drivers testing positive for any drug.

Summary and Conclusions

Drug use is widespread in the transport industry as a way of managing fatigue. Stimulant drugs are the most commonly used although poly drug use occurs, probably as a way 'coming down' after stimulant use. Both self report and tissue sampling produce quite consistent data; around 30% of drivers use drugs.

In order to estimate whether drug use increases the risk of a crash we can compare the prevalence of drug use in live drivers and deceased drivers. The figures shown above reveal that the presence of drugs in deceased drivers is approximately the same as in live drivers. That is, deceased drivers are representative of the population of drivers and are no more likely to have taken drugs.

This conclusion must be qualified. It is possible there are complex interactions in the data. For example it is hard to draw conclusions about dose levels. Furthermore it may be that drivers who die in a crash do so because the drugs are wearing off and the full effect of fatigue is revealed, and they fall asleep at the wheel. **Thus, stimulant drugs per se do not increase crashes but when a drug wears off and the driver is fatigued there will be increased risk of a crash.**

Initiatives in transport addressing the causes and effects of fatigue

World wide prescriptive hours of service, enforced by log books or other devices recording hours of work, have been used to reduce the impact of fatigue on transportation. In my separate submission of evidence to the committee I argue why this approach is unsatisfactory. It only addresses part of the problem and it does not tackle the fundamental issue that fatigue is caused by the inappropriate timing, and the length, of periods of work and sleep. It is also difficult to enforce. A more satisfactory approach needs to comprehensively address all of these issues.

The community is beginning to recognise that fatigue is an issue for everybody. It has been a recognised risk for the transport industry for several decades. An appropriate legislative mechanism therefore for controlling fatigue for employees is the Occupational Safety and Health Act. This provides for a Duty of Care which includes avoiding fatigue as a risk, and that when driving as an employee the vehicle is a place of work.

Occupational Safety and Health Acts provide for the development of Codes of Practice for any industry. In Western Australia the transport industry, union and government have developed such a Code which seeks to comprehensively address all the factors causing fatigue known in the industry. Practically, the Code defines the condition of fatigue for the first time, what causes it and how it should be managed. It provides a basis for developing a company Fatigue Management System, which is a statement of how the company reduces the risk of fatigue in its own particular operations. The Code obliges all companies to develop such a system. The Code was gazetted in October 1998.

There are incentives to do so. Conformity with a satisfactory Fatigue Management System provides protection from prosecution on the grounds that a crash was caused by fatigue. It also provides a basis for negotiating lower insurance premiums. The Code has the potential to level the playing field for all operators and lead to realistic incomes without having to work excessively long hours. Unlike the Queensland Fatigue Management Program, the Western Australia approach applies industry wide, to both good and bad operators. It thus has the potential to catch the worst offenders who are exploiting employees in order to cut costs to gain business at any price. Offences under the Act are potentially more severely financially punished than are log book offences.

Enforcement is carried out by the Occupational Safety and Health Commission. At the present time Inspectors from the Commission are visiting companies suspected of unsafe practices which fall outside the Code of Practice. The Commission has imposed many work improvement and work prohibition notices on companies who have been found to operate unsafe practices. The Commission is also writing to all transport companies requesting to sight their Fatigue Management System, and requiring them to provide a System if one is not in existence.

Any occupation which obliges employees to drive as part of their work, which probably includes most of the workforce, fall within the jurisdiction of the Occupational Safety and Health Act. So there is an argument that all of these occupations need a Code of Practice to manage fatigue. It would be part of the company suite of risk management systems. In Western Australia steps are being taken to develop a general purpose Code for all employees who drive as part of their work.

Ways of achieving greater responsibility by individuals, companies and governments to reduce the problems related to fatigue in transport.

Individuals, companies and governments already have this responsibility under the Act for employees who drive as part of their work. What is lacking is recognition and guidance in this responsibility. The Western Australian Office of Road Safety has convened a conference of employers to outline their responsibility and demonstrate the value of managing fatigue. As noted industries are to be encouraged to develop their own Codes of Practice to manage fatigue.

The recognition of the impact of fatigue in a domain, such as at work, where there is a legislative mechanism for controlling its impact should flow through to the driver when not at work. Thus, managing fatigue at work should steadily improve its management in society at large.

At the present time we are consulting with Comcar, the Commonwealth car fleet, in order to assist them to develop a Code of Practice and Fatigue Management System for their operation. I believe the Taxi Board in Western Australia is requiring operators to develop Fatigue Management Systems and I think the same process is going to take place with bus operators here. Clearly the merits of the approach are receiving recognition.

As part of this process Western Australia has hosted 3 biennial international conferences on 'Managing Fatigue in Transportation' supported by government and industry. A fourth conference will be held in March 2000. The conference has been very successful in bringing researchers, government, policy makers, practitioners and private individuals from around the world together and raising awareness and the level of debate on fatigue.

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Yours Faithfully

Laurence Hartley, PhD.