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HEAVY VEHICLE DRIVER HEALTH AND SLEEP DISORDERS

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Austroads Incorporated

Austroads is the association of Australian and New Zealand road transport and traffic authorities whose mission is to contribute to development and delivery of the Australasian transport vision by:

- supporting safe and effective management and use of the road system
- developing and promoting national practices
- providing professional advice to member organisations and national and international bodies.

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- Roads and Traffic Authority New South Wales
- Roads Corporation Victoria
- Department of Main Roads Queensland
- Main Roads Western Australia
- Transport South Australia
- Department of Infrastructure, Energy and Resources Tasmania
- Department of Transport and Works Northern Territory
- Department of Urban Services Australian Capital Territory
- Commonwealth Department of Transport and Regional Services
- Australian Local Government Association
- Transit New Zealand

Executive Summary

In 1992 the Austroads report *Management of Heavy Vehicle Driver Safety* identified sleep disorders as a key factor in heavy vehicle driver health and recommended that an investigation into this problem be carried out. This report presents the results of that investigation.

Over the last decade it has been established that there is an important relationship between accident risk and the impairment due to sleep-related fatigue for heavy vehicle drivers. Some of the most respected overseas authorities, have identified countermeasures based on scientific studies of sleep as an important approach to reducing fatigue-related accidents.

The physiological need to sleep can be as powerful as the need to breathe – and when the drive is intense, sleep can overtake the brain in seconds. Sleep attacks can occur without warning in drivers suffering chronic excessive sleepiness. It has been established that chronic excessive sleepiness significantly increases accident risk.

This report presents the results of the measurement of chronic excessive sleepiness in a large sample of heavy vehicle drivers in Australia and the results of a concurrent medical examination by doctors. This report has shown that on the basis of Epworth Sleepiness Scale (ESS) methodology chronic excessive sleepiness was a major issue for Australian heavy vehicle drivers. Whereas normal individuals do not suffer from this problem, 16% of the Australian heavy vehicle drivers surveyed suffered from this sleep complaint, which is directly related to accident risk. In 11.1% of these drivers there were indications of some degree of sleep apnoea.

In terms of road safety issues there were also those drivers who had an increased accident risk because on occasions they also suffered short term excessive sleepiness due to shiftwork, stress or lifestyle factors.

These survey results were accompanied by medical examinations of drivers, which showed that medically detectable fatigue symptoms were present in 33% of drivers, with 20% of drivers having fatigue levels, which were considered by the examining doctors to be of medical concern. Overall 6.4% of all drivers were referred to sleep disorder clinics for further investigation.

This report concludes that the results from scientific studies of sleep should be used in the development of road safety fatigue countermeasures. Both the American and Canadian Expert Panels have used the findings of such studies to identify actions which can be taken to reduce fatigue-related accidents. Unlike many other road safety accident factors, sleepiness is identifiable, predictable, and preventable. The adverse effects of some of the major medical sleep disorders, such as sleep apnoea can be reversed by appropriate treatment and countermeasures such as "napping strategies" have been shown to be successful in both the aviation and railroad industries. Similar actions should be taken within the Australian heavy vehicle transport industry.

Managing fatigue in transportation industries requires a comprehensive approach covering education and training, hours of service regulations, scheduling practices, countermeasures, design and technology, and research. The countermeasures that have been developed within Victoria by the Transport Industry Safety Group, based on education programs for napping strategies, should be supported by the industry for implementation on a national basis. Future research such as the major study of the "Prevalence of Sleep Disordered Breathing in Australian Transport Drivers" which is being done by three Hospital sleep clinics should also be supported by the heavy vehicle transport industry.

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1. Background

In 1992 the Austroads report *Management of Heavy Vehicle Driver Safety* (Austroads 1992) identified sleep disorders as a key factor in heavy vehicle driver health and as a potentially important factor in heavy vehicle fatigue crashes and recommended that;

- Research into the impact of sleep disorders on road safety is continued and Austroads should initiate a project "Heavy Vehicle Driver Health and Sleep Disorders”. (Recommendation 8)
- Medical general practitioners be advised on sleep disorders in relation to heavy vehicle driving. (Recommendation 9)
- Information about sleep disorders, the health risks of lifestyle factors such as smoking, poor diet and lack of exercise, and techniques to reduce stress be disseminated to all heavy vehicle drivers and operators. (Recommendation 10).

In 1993 and 1994 a project team consisting of representatives from the State Road Authorities, the National Road Transport Commission and the Road Transport Forum implemented some of the actions recommended in the above 1992 Austroads report. The project team investigated options for promoting research into heavy vehicle driver sleep disorders, provided information to a number of medical practitioners on sleep disorders, provided information to a number of heavy vehicle drivers on sleep disorders and co-operated with the Road Transport Forum's investigations with heavy vehicle drivers. The results from the fatigue section of the data obtained on heavy vehicle drivers are presented in this report.

2. Discussion

For more than 60 years Governments throughout the world have attempted to reduce fatigue accidents in transportation by implementing regulatory countermeasures (Vespa, Rhodes et al. 1998:1). The Canadian Expert Panel stated

> "Driver fatigue has long been recognised as a major risk factor for commercial drivers. Estimates of the percentage of crashes that are partially or completely attributable to fatigue range from 1 to 56 percent, depending on the database examined, the level of detail gathered from crash investigations, and the study methodology employed." (op.cit).

However it is only in the last decade that countermeasures based on scientific studies of sleep have been identified as one of the most valuable approaches to reducing fatigue related accidents in the transport industry.

Managing fatigue in transportation industries requires a comprehensive approach covering education and training, hours of service regulations, scheduling practices, countermeasures, design and technology, and research

(i) Sleep and impairment

The National Highway Traffic Safety Administration Expert Panel on Driver Fatigue and Sleepiness carried out an extensive review of the literature in 1996 and concluded that

> "Sleepiness causes auto crashes because it impairs performance and can ultimately lead to the inability to resist falling asleep at the wheel. Critical aspects of driving impairment associated with sleepiness are reaction time, vigilance, attention, and information processing" (National Highway Traffic Safety Administration 1996:4).

In April 1997, Transport Canada (TC) established an expert panel (Vespa, Rhodes et al. 1998) to advise on options for improving fatigue hours of service (HOS) regulations. The panel comprised experts in shiftwork, sleep and human performance who found that

> "sleep loss and circadian variations in alertness and performance are of primary concern in driving safety from a fatigue perspective" (Vespa, Rhodes et al. 1998:5).

The conclusion that scientific studies of sleep are one of the most valuable approaches was documented by the NCSDR/NHTSA Expert Panel on Driver Fatigue and Sleepiness, which concluded that

> "the data on fatigue and inattention provide less support for defining risk factors and high-risk groups than the data on sleepiness or drowsiness. In addition, sleepiness is identifiable, predictable, and preventable" (National Highway Traffic Safety Administration 1996:8).

This group of 14 acknowledged experts reviewed more than 119 current scientific publications on fatigue, sleep and accidents and they stated that

> "Sleepiness leads to crashes because it impairs elements of human performance that are critical to safe driving (Dinges and Kribbes 1991, cited op cit)".

The issue of sleepiness is of special interest to heavy vehicle drivers as the American National Transportation Safety Board (Sweeney, Ellingstad et al 1996) found that excessive sleepiness was the most frequently cited probable cause of mass transportation accidents, accounting for nearly one-third of all fatal-to-the-driver heavy trucking accidents.

The National Commission on Sleep Disorders Research (1992) also highlighted the importance of sleep as a major factor in heavy vehicle fatal accidents. The report identified truck drivers as being at risk particularly in terms of the sleep disorder sleep apnoea. Sleep apnoea[1] causes excessive daytime sleepiness and increases the risk of a road accident.

(ii) Sleep and accident risk

The key factor of interest for road safety is the accident risk associated with the interactive continuum of mental and physical fatigue. Significant accident risk is associated with sleep-related fatigue (Horne and Reyner, 1995a) (Horne and Reyner, 1995b), compared to physical fatigue, which has minimal accident risk.

The consequences of sleep disorders and sleep deprivation are diverse, some sleep disorders are potentially fatal, others are little more than an annoyance (National Commission on Sleep Disorders Research 1992). The physiological need to sleep can be as powerful as the need to breathe (Kryger, Roth et al. 1994) and when the drive is intense, sleep can overtake the brain in seconds. Dement describes this as “like a seizure taking over the brain” (Dement, Sullivan et al. 1993). The mechanism that puts an individual to sleep is operating 24 hours a day, it never shuts off, and its level of operation varies from weak to extremely powerful (op cit).

A body of literature exists on the mechanisms of human sleep and sleepiness that affect driving risks (National Highway Traffic Safety Administration 1996:8). The sleep-wake cycle is governed by both homeostatic and circadian factors. Homeostasis relates to the neurobiological need to sleep; the longer the period of wakefulness, the more pressure builds for sleep and the more difficult it is to resist (Dinges, 1995). The circadian pacemaker is an internal body clock that completes a cycle approximately every 24 hours. Homeostatic factors govern circadian factors to regulate the timing of sleepiness and wakefulness (National Highway Traffic Safety Administration 1996:8).

One expert panel stated that

> " the sleep-wake cycle is intrinsic and inevitable, not a pattern to which people voluntarily adhere or can decide to ignore. Despite the tendency of society today to give sleep less priority than other activities, sleepiness and performance impairment are neurobiological responses of the human brain to sleep deprivation. Training, occupation, education, motivation, skill level, and intelligence exert no influence on reducing the need for sleep. Micro-sleeps, or involuntary intrusions of sleep or near sleep, can overcome the best intentions to remain awake."(National Highway Traffic Safety Administration 1996:8).

Horne and Reyner (1995a) describe “the processes of falling asleep at the wheel”, state that the classical signs of sleepiness or of sleep onset are not easy to detect and describe the condition of drivers being neither alert nor asleep, that is, “driving in a protracted state of quasi-sleep”. Brown (1994) presents other sleep impairment conditions such as "attentional impairment " including "driving without awareness".

Other authors (Dement and Mitler 1993; Kryger, Roth et al. 1994:56) refer to microsleeps The spectrum of "sleep related fatigue" impairment has at one extreme the driver being asleep and it is clear that this state is associated with a very high accident risk. Extremely sleep deprived individuals appear to be in a trance-like stupor similar to a coma and their driving impairment is exceptional and their accident risk very high.

At lower sleepiness levels, microsleeps occur and can last for seconds or even more than 10 seconds and during this period the driver is again effectively asleep and does not respond to dangerous situations.

These sleep attacks can occur without warning and in a long microsleep the vehicle can leave the road or cross into oncoming traffic. This is a lower level of sleepiness than actually falling into a deep sleep whilst driving, and thus has a lower accident risk, but this accident risk level is still dangerously high.

At even lower levels of sleepiness drivers have a significant withdrawal of attention from road and traffic demands which can be both general, impairing vehicle control and collision avoidance ability, and can also be selective, impairing collision avoidance ability but leaving vehicle control intact. At these impaired levels of information processing drivers may not detect critical events, such as stop signs and red lights and may fail to appreciate high accident risk situations. Brain activity can still be high, and the driver is not aware of his dangerous condition, because the focus of the eyes is fixated too close to the front of the vehicle.

This condition can be referred to as "empty field myopia", often described as a trance like condition. Again whilst the sleepiness level in this state is lower than that for drivers suffering frequent microsleeps, at this level of impairment the accident risk is still of serious concern.

At the lowest levels of sleepiness, drivers are simply slow to react, and can daydream, not concentrate or be easily distracted. This can increase the risk of an accident, but it is arguable how much of a road safety issue this degree of sleepiness creates.

In 1998 an extensive review of the published literature on fatigue and car crashes (Connor, Norton et al. 1998) identified the sleep clinic study of Wu and Yan-Go as having the best internal validity of those performed to that time. Wu and Yan-Go (1996) found that sleep apnoea increased the risk of having a crash by 2.6 times and excessive daytime sleepiness increased the risk of having a crash to 5.7 times. The 95% confidence limits for this study showed that excessive daytime sleepiness increased the odds of having a crash by between 2.4 times and 9.2 times.

Estimates of the prevalence of excessive daytime sleepiness and sleep apnoea amongst Australian heavy vehicle drivers are presented in Section 3.

Performance decrements due to sleep loss have been equated with those associated with alcohol consumption. This approach can assist in conceptualizing the importance of sleep loss, as BAC levels have been closely linked to accident risk and have been used as a basis for legislative road safety initiatives. Dawson and Reid (1997) found that 17 hours without sleep was equal to the level of impairment that is associated with a BAC of 0.05%, and 24 hours of sleep loss produces the same degree of performance decrement as a BAC of 0.10%. These preliminary results, reported in a letter to *"Nature"*, deserve further research.

Another approach to quantifying the road safety risks associated with sleep-related fatigue has been to use the Epworth Sleepiness Scale, which is also used in this Austroads report[2]. The Epworth Sleepiness Scale (for a detailed explanation see Appendix 1) has been used in Section 3 as a means of quantifying road safety risks associated with sleep-related fatigue. Briefly, as sleepiness increases then so does a driver's score on the Epworth Sleepiness Scale. The Epworth Sleepiness Scale can be used to measure the prevalence of the sleep disorder "Chronic Excessive Daytime Sleepiness", which is when the driver has an Epworth score greater than 10.

Maycock (1995, 1996), examined British truck and car drivers and found that drivers with an Epworth score of 12 or above had a crash risk 3.05 times higher than drivers with an Epworth score of zero.

Sleep science investigations have shown that the accident risk associated with sleepiness varies over a daily period with key factors being the time of day and the number of hours worked. The Canadian Expert Group listed 6 studies which showed increased crash risk associated with increased hours of driving (Vespa, Rhodes et al. 1998:3), and also that hours worked and time of day interact so that time-of-day effects are greater as the number of hours worked increases. They present evidence from 8 earlier studies that show night driving to be particularly risky and quote 7- to 50-fold risk increases for night driving compared to daytime driving.

(iii) Accident factors

The American Expert Panel (National Highway Traffic Safety Administration 1996) concluded that the key factors associated with sleep related accidents were:

- that the accident occurs during late night/early morning or mid afternoon;
- the crash is likely to be serious;
- a single vehicle leaves the roadway;
- the crash occurs on a high-speed road;
- the driver does not attempt to avoid a crash; and
- the driver is alone in the vehicle.

For heavy vehicle drivers, the key factors which increase accident risk are sleep loss, job-related sleep restriction, sleep fragmentation, circadian factors, driving patterns and sleep disorders (National Highway Traffic Safety Administration 1996:10).

In a study specifically of heavy vehicle crashes in America the National Transportation Safety Board (1995) concluded that the critical factors in predicting heavy truck crashes were:

- the duration of the most recent sleep period;
- the amount of sleep in the previous 24 hours; and
- fragmented sleep patterns.

For most drivers, who do not have sleep disorders, the primary causes of sleepiness and drowsy driving are sleep restriction and sleep fragmentation (National Highway Traffic Safety Administration 1996:10). Both sleep restriction and sleep fragmentation can have internal and external causes (op cit).

The issue of "sleep debt" is of particular concern for heavy vehicle drivers because the effects of sleep loss are cumulative (Carskadon and Dement 1981). Drivers working shifts who regularly lose 1 to 2 hours of sleep a night can create a "sleep debt" which in turn can lead to chronic sleepiness over time. Only sleep can reduce sleep debt.

The impact of sleep loss depends on the following factors (Kryger, Roth et al. 1994:55):

Sleep-circadian factors —

* Prior sleep, amount and distribution;
* Length of time awake;
* Circadian time[3.]

Environmental situation —

* Noise;
* Exercise;
* Temperature;
* Drugs

Personal factors —

* Interest level;
* Motivation;
* Sleep debt history;
* Age;
* Personal sleep requirements;
* Good/poor sleepers;
* Personality and psychopathology

Whilst both temporary and chronic excessive sleepiness are associated with accident risk, the present report is concerned with general or chronic excessive sleepiness, rather than with the temporary or one-off, easily reversible condition.

There are 3 major sleep symptoms associated with the 84 sleep disorders. These 3 major symptoms are excessive sleepiness, insomnia and an abnormal event during sleep. Over the last decade the term Excessive Daytime Sleepiness has been used in epidemiological studies (D'Alessandro, Rinaldi et al. 1995; Johns 1997; Kryger, Roth et al. 1994:443) to describe the condition referred to as general or chronic excessive sleepiness.

3. Investigations

(i) Background

The Road Transport Forum (RTF) published its report on the "Self Regulation Pilot Project" in June 1993 (Road Transport Forum 1993) and eight volumes of published papers supported the report. The "Driver Health Paper" stated that “drivers were very concerned about their fatigue levels” (Stewart 1993) and that “…their greatest concerns were: falling asleep and having an accident involving another party”. The recommendation of the RTF report was that “A larger trial encompassing 200 operators should be run for 12 months”. This recommendation was implemented as the RTF “Team 200” project.

The Team 200 project provided a major opportunity to conduct a sleep awareness education and information program with both heavy vehicle drivers and their medical practitioners. This was done by providing medical practitioners with information on sleep disorders and providing drivers with information on the importance of sleep (posters and brochures) and also using a driver sleep questionnaire.

The background, rationale, strategies, results, discussion and conclusions for the Team 200 project have been fully reported in the RTF publication (Road Transport Forum 1995) and other publications (Parliamentary Road Safety Committee 1995). The project involved over 3,500 drivers in a 10-step driver health program with Step 7 the driver medical process.

The medical process consisted of a driver health survey, a medical examination and a counseling session. The present project reports only on the fatigue section of the driver health survey and the fatigue section of the medical examination. The full results of the driver health survey, the medical examination and the counseling session are presented in the RTF publication *Raising the Standard: Project Team Report on the Industry Accreditation Health Research Project conducted for the Road Transport Forum Team 200* (Road Transport Forum 1995) along with a discussion and conclusions.

(ii) Driver health survey

The survey was a questionnaire that the driver completed prior to the medical examination. It included questions on personal details, driver safety issues, personal and family health issues, occupational health issues, diet, lifestyle and fatigue. The present project was concerned with measuring the driver's general or chronic sleepiness. This was done by incorporating the Epworth Sleepiness Scale as the last section of the driver survey.

The Epworth Sleepiness Scale (ESS), was selected as the best and most appropriate measure because in 1993, when this decision was made, the ESS was the only validated survey technique which had been applied to drivers. The ESS score gives an indication of sleepiness and sleep disorders. Other researchers around the world have also used the ESS test to measure daytime sleepiness and its relationship to accidents.

It is beyond the scope of this report to discuss in detail the other measurements of sleepiness which have been comprehensively surveyed in the report of the American Expert Panel *Drowsy Driving and Automobile Crashes* (National Highway Traffic Safety Administration 1996:11). This report stated that:

> "An ideal measure of sleepiness would be a physiologically based screening tool that is rapid and suitable for repeated administration".

Unfortunately no such tool currently exists and the Panel stated

> "The current tools for the assessment of sleepiness are based on questionnaires and electrophysiological measures of sleep, and there is interest in vehicle-based monitors".

The Panel's report presents a discussion of some of the key tools for the assessment of sleepiness, which illustrate the different subjective and objective measures of chronic and situational (acute) sleepiness and the vehicle-based technology to sense sleepiness.

(a) Epworth Sleepiness Scale (ESS)

Appendix 1 presents detailed information on the ESS and only a summary of this appendix is presented below.

In 1991 a method of measuring chronic or general excessive daytime sleepiness (Johns 1991) was published and validated. Excessive daytime sleepiness (EDS) was defined as having an ESS score of greater than 10. Johns used the traditional medically accepted "gold standard" of the Multiple Sleep Latency Test (MSLT) to validate the ESS process. A significant correlation was established between the ESS Score and the sleep latency measured during the day with MSLT and at night with polysomnography.

In the laboratory the best method of measuring chronic daytime sleepiness is the MSLT, however this test is very cumbersome, time consuming and expensive to perform. It takes all day both for the subject and the polysomnographer and is not easily justified as a routine test for all people, nor even for the more than 3500 drivers in the Team 200 project.

It was important that the test selected for this driver survey actually measured chronic or general sleepiness, not simply sleepiness at the time when the driver was doing the survey. A driver's sleepiness at any particular time on a specific day when filling in the survey would be influenced by many factors. Some of these factors being the quality and duration of prior sleep or of sleep deprivation, the time of day, the presence of various sleep disorders, drug and alcohol effects and the level of interest and motivation when doing the survey.

By selecting the ESS, rather than a subjective test, which measures tiredness only at the time of test, this Austroads' study was measuring general or chronic sleepiness.

The ESS is a brief self-administered questionnaire that asks the subject to rate on a scale of 0-3 the chances that, over "recent times", they would have dozed in eight specific situations that are commonly met in daily life (0 = would never doze; 3 = high chance of dozing). Thus, the subjects are asked to characterize retrospectively part of their usual behaviour in a variety of situations that are more or less soporific. Subjects are asked to distinguish dozing behaviour from feelings of tiredness. The ESS score can range from 0 to 24.

Excessive daytime sleepiness was defined as having an ESS score of greater than 10. Normal sleepers do not suffer from excessive daytime sleepiness.

As the ESS approach has been increasingly used in sleep investigations throughout the world, significantly more data on both normal and abnormal sleep patterns has been accumulated.

The sleep disorder "Obstructive Sleep Apnoea Syndrome (OSAS)" and the condition of "Chronic or Excessive Daytime Sleepiness (EDS)" are both indicated by the Epworth Sleepiness Scale and both are directly related to accident risk.

(b) Epworth Sleepiness Scale results for excessive daytime sleepiness

The results from the Team 200 project survey are that 16% of heavy vehicle drivers scored greater than 10 and thus these individuals are at increased risk of an accident (see Table 1).

In addition to this group which are chronically sleepy there are also those drivers who on occasions, due to lifestyle or work related reasons, are temporarily impaired due to lack of quality sleep.

(c) Epworth Sleepiness Scale results for sleep apnoea

The ESS score is related to the severity of sleep apnoea and increases linearly with its severity (Johns 1993).

On this basis 8.2% of truck drivers surveyed (see Table 1) have ESS scores of 13 or more which is indicative of moderate sleep apnoea and 2.9% of truck drivers have ESS scores of 16 or more, which is indicative of severe sleep apnoea.

(iii) Driver medical examination

The Team 200 project medical examination lasted between 30 and 40 minutes and covered a review of the drivers' health plus specific investigation for the drivers' throat, chest, cardiovascular indicators, abdomen, vision, hearing, neurological/locomotor indicators, urinalysis, chronic fatigue indicators and drug abuse indicators. The doctor was also encouraged to provide comments on the medical report forms.

The doctor filled in two separate medical reports, which were Medical Screening Form and a form titled "To Be Completed By Doctor" . This study only considers the sections of each of these two reports, which address the issues of fatigue and sleep.

(a) Driver medical examination results from "The Medical Screening Form"

On the Medical Screening Form the doctors were required to assess the driver with respect to a range of issues, which were driver and safety issues, fatigue, ESS, physical activity, family history, medical history, current symptoms, smoking, OH&S, and diet. For each of these issues the doctors were encouraged to write specific comments. As part of the medical examination the doctor was requested to record and assess the drivers' chest, cardiovascular system, abdomen, vision, hearing, neurological/locomotion system, urinalysis, drug abuse, and record both issues for counseling, fitness to drive and date for future medical review.

The doctor had the completed Driver Health Survey Form to assist in the examination and in making a judgement for each issue. This form had questions on working hours, kilometres travelled and sleep issues. For driver and safety issues, fatigue and diet the doctor's judgement options were whether the driver was "Acceptable", "Borderline" or "Of Concern".

It is notable that the doctors rarely wrote comments on the Medical Screening form, even when the doctor had judged the driver as being in the most severe category for a specific issue. The exception to this pattern was for the issue of ESS where the comment made most often referred to the driver's insomnia.

The Team 200 project was concerned with the doctor’s assessment of drivers’ fatigue status. All the results were calculated as percentages for the total pool of drivers. The results showed that the doctor’s assessments identified 67% of the drivers examined as having “Acceptable” fatigue, while 13% of drivers had “Borderline” fatigue and 20% of drivers had fatigue which was “Of Concern”.

For the 20% of drivers given the most severe fatigue rating, almost one third (32%) were referred to sleep disorder clinics for treatment.

Thus medically detectable fatigue symptoms were present in 33% of drivers with 20% of drivers having fatigue levels which were of medical concern. Overall 6.4% of all drivers were referred to sleep disorder clinics for treatment.

(b) Driver medical examination results from “To Be Completed by Doctor” form

The doctors were also required to complete the form titled “To Be Completed by Doctor”. On this form the doctor was required to make a judgement on the following issues:

- Body Mass Index of concern,
- Medical history of concern,
- Current symptoms of concern,
- Driver smokes,
- Diet of concern,
- Diastolic BP above 95 mmbg,
- Visual problems of concern,
- Spinal problems of concern,
- Abnormal urinalysis,
- Neurological concerns,
- Signs of drug abuse,
- Major fatigue problems,
- Needs further investigation.

It is notable that the doctors appeared to view this form as a multichoice question, with only one answer being correct. Thus the majority of doctors tended to tick only one of the above choices.

The results were that 6% of drivers were identified as having “major fatigue problems” as their primary major health issue.

(iv) Comments on results

The above results indicate that fatigue is a major factor in the Australian heavy vehicle industry. Maycock (1995) did a survey of British drivers using the Epworth Sleepiness Scale.

Table 2 presents both Maycock's results and the results calculated in the present Austroads report, using the Team 200 project survey data.

Table 2 – Epworth Sleepiness Scale scores for Australian and UK Truck Drivers

	Normal Drivers	Australian Truck Drivers	UK Truck Drivers
Average ESS score	4.6	6.7	5.7
% ESS > 10 (Indicative of excessive daytime sleepiness)	0.0	16.0	8.1
% ESS > 12 (Indicative of sleep apnoea)	0.0	8.2	2.4
% ESS > 15 (Indicative of severe sleep apnoea)	0.0	2.9	0.5

The ESS scores for the United Kingdom truck drivers are in all cases notably less than the Australian truck drivers. This may, however, reflect the methodology used by Maycock in his study.

The United Kingdom truck drivers were volunteers who agreed to provide the time to co-operate in the survey. These drivers had been approached at service stations used by truck drivers during normal daytime working hours. These drivers are thus a self-selected sample of drivers who were prepared to provide enough time to do the survey and were in truck service stations during normal daytime working hours.

The Australian drivers were randomly selected from a group of 3500 drivers whose employers had agreed to participate in the Team 200 study.

In terms of road safety issues, there are 16% of drivers who suffer chronic excessive sleepiness and are at increased risk of road crashes, and within this group there are 11.1% of drivers who have indications, or worse, of a sleep apnoea problem. In addition, there are also those drivers who have an increased accident risk because, on occasions, they also suffer short-term excessive sleepiness because of shiftwork, stress or lifestyle factors.

Sleep factors, which contribute to accidents, should be the focus of future road safety fatigue preventative programs because, unlike many other road safety accident factors, "sleepiness is identifiable, predictable, and preventable" (National Highway Traffic Safety Administration 1996:8)

(v) Countermeasures for sleepiness

It is beyond the scope of this report to discuss in detail the full range of sleep-related fatigue countermeasures. Two recent major reports on this topic are available which need not be duplicated here (Vespa, Rhodes et al. 1998) and (National Highway Traffic Safety Administration 1996). Managing fatigue in transportation industries requires a comprehensive approach covering education and training, hours of service regulations, scheduling practices, countermeasures, design and technology and research. It remains the case, however, that the only treatment for sleep deprivation is sleeping (Kryger, Roth et al. 1994:61) and "napping strategies" are potentially one of the most powerful countermeasures for Australian heavy vehicle drivers.

Napping has been one of the most carefully studied behavioural strategies (National Transportation Safety Board (NTSB) and National Aeronautics and Space Administration (NASA) Ames Research Centre, 1995:47)

> "During the past 15 years, there has been extensive scientific documentation in both academic and field settings of the benefits of naps in persons undergoing prolonged, irregular, and/or sustained work schedules".

Keynote publications on napping are listed in the proceedings of this Symposium.(op.cit)

Naps are defined as any sleep that is less than four hours in duration. Most naps have duration of between 20 minutes and two hours. Napping is a normal part of the human sleep-wake cycle and is the most important countermeasure for drivers driving at night particularly between midnight and dawn.

Restoration of performance over time is a logarithmic relationship rather than a linear one, and therefore the greatest benefits are derived early in the nap. The benefits, in terms of accident risk reduction, are also greater for drivers with increased fatigue impairment (op.cit).

The aviation (Rosekind, Graeber et al. 1994; Mann 1999) and railroad (Union Pacific Railroad 1999) industries have shown the benefits of sleep science countermeasures and napping strategies, which are being progressively implemented.

Drivers who suffer short-term excessive sleepiness due to factors other than sleep disorders can also improve performance by napping strategies and proper sleep. Drivers who suffer sleep disorders will benefit by napping strategies, but they also need treatment for their sleep disorder.
Sleep science countermeasures are starting to be introduced into the Australian heavy vehicle industry. An example of this is the video for heavy vehicle drivers on napping called "How the Hell do You Take a Break". This video was produced by the Victorian branch of the Transport Workers Union in conjunction with the Victorian Transport Industry Safety Group (Transport Industry Safety Group 1998) and has been supported by both drivers and employers.

(vi) Future work

Three of Australia's leading sleep clinics are co-operating in a major study of the "Prevalence of Sleep Disordered Breathing in Australian Transport Drivers" (Howard, Worsnop et al. 1999). The study’s objectives are to determine the prevalence of sleep disordered breathing (SDB) and excessive daytime sleepiness in Australian transport drivers, to identify factors which can predict which drivers are most likely to have SDB, and to assess the relationship between SDB, sleepiness and driving performance in these drivers. The study will use randomly selected drivers for both its questionnaire components and its overnight laboratory studies and will also investigate the relationship between lifestyle factors, daytime sleepiness and sleep quality in Australian transport drivers.

Importantly, the section of this study that uses the Epworth Sleepiness Scale will be repeated in 1999 and these results will provide information on the current sleep status of the industry.

The Victorian Transport Industry Safety Group, which consists of representatives from VicRoads, Workcover, Police, Transport Workers Union, Victorian Road Transport Association and the Bus Proprietors Association, has developed road safety countermeasures based on sleep science. These countermeasures consist of workshops with drivers and workplace education programs, with videos, promoting napping strategies. These countermeasures have been positively received by both drivers and employers and should be supported by the heavy vehicle sector of the transport industry on a national basis.

4. Conclusions

This report has documented some of the major scientific studies that show there is an important relationship between impairment due to sleep-related fatigue and accident risk for heavy vehicle drivers. Important overseas transport authorities such as the National Transportation Safety Board, the National Aeronautics and Space Administration the National Highway Traffic Safety Administration and Transport Canada have identified countermeasures based on sleep science as a major approach to reducing fatigue-related accidents.

The physiological need to sleep can be as powerful as the need to breathe and when the drive is intense sleep can overtake the brain in seconds. Sleep attacks can occur without warning in drivers suffering chronic excessive sleepiness and it has been established by scientific studies that chronic excessive sleepiness significantly increases accident risk.

This report presents the results of the measurement of chronic excessive sleepiness in a large sample of heavy vehicle drivers and the results of a concurrent medical examination. This report has shown that chronic excessive sleepiness was a major issue for Australian heavy vehicle drivers. Whereas normal individuals do not suffer from this problem, 16% of the Australian heavy vehicle drivers surveyed suffered from this sleep complaint, which is directly related to accident risk. Furthermore 11.1% of these drivers showed some degree of sleep apnoea which is also related to accident risk.

In terms of road safety issues, in addition to the 16% of drivers who suffered chronic excessive sleepiness, there were also those drivers who had an increased accident risk because on occasions they also suffered short term excessive sleepiness because of shiftwork, stress or lifestyle factors.

These survey results were accompanied by medical examinations of drivers, which showed that medically detectable fatigue symptoms were present in 33% of drivers, with 20% of drivers having fatigue levels, which were considered by the examining doctors to be of medical concern. Overall 6.4% of all drivers were referred to sleep disorder clinics for further investigation.

It is concluded that sleep science should be used in the development of road safety fatigue countermeasures. Both the American and Canadian Expert Panels have used sleep science to identify actions which can be taken to reduce fatigue accidents. Unlike many other road safety accident factors, sleepiness is identifiable, predictable, and preventable. The adverse effects of major medical sleep disorders, such as sleep apnoea can be reversed by appropriate treatment, and countermeasures such as "napping strategies" have been introduced into both the aviation and railroad industries. Similar actions should be taken within the Australian heavy vehicle transport industry.

The countermeasures that have been developed within Victoria by the Transport Industry Safety Group based on implementing education programs for napping strategies should be supported by the industry on a national basis. Future research such as the major study "Prevalence of Sleep Disordered Breathing in Australian Transport Drivers" (see section 3(vi) above) should also be supported by the heavy vehicle transport industry.

Appendix 1. The Epworth Sleepiness Scale (ESS)

In 1991 a method of measuring chronic or general excessive daytime sleepiness (Johns 1991) was published and validated. Johns used the traditional medically accepted "gold" standard of the Multiple Sleep Latency Test (MSLT) to validate the ESS process. A significant correlation was established between the ESS score and the sleep latency measured during the day with MSLT and at night with polysomnography.

Over the last 7 years Johns has published many more papers (Johns 1991, 1992, 1993, 1994, 1997) on the ESS and he and other researchers (Maycock 1995) have accumulated significantly more data on ESS scores in both normal individuals and individuals with sleep disorders.

The Epworth Sleepiness Scale is a questionnaire measuring the general level of daytime sleepiness. The developer Murray Johns consistently calls this general level of daytime sleepiness the average sleep propensity and is expressed in terms of the tendency to fall asleep in a variety of situations.

The conceptual basis of the ESS involves a four-process model of sleep and wakefulness. The sleep propensity at any particular time is a function of the ratio of the total sleep drive to the total wake drive with which it competes.

Sleepiness is a physiological drive resulting from many causes one of which is sleep deprivation and can be measured by the time taken to fall asleep in the Multiple Sleep Latency Test (MSLT). The MSLT is widely used (Johns 1991) and is generally believed to provide a valid measurement of sleepiness on the particular day of the test (Carskadon and Dement 1985).

In the laboratory the MSLT is the best method of measuring chronic daytime sleepiness, however this test is very cumbersome, time consuming and expensive to perform. It takes all day both for the subject and the polysomnographer and is not easily justified as a routine test for all people.

Mild sleepiness is most apparent during passive environments such as reading and watching television. Severe sleepiness results in falling asleep during meals and conversations.

Excessive sleepiness results in falling asleep at inappropriate times, such as during work and driving and can be an indicator of a sleep disorder. Excessive sleepiness that is not relieved by increasing the amount of sleep at night is usually a sign of a sleep disorder (Kryger, Roth et al. 1994).

Excessive sleepiness can be temporary or chronic and is accompanied by lapses of attention and impaired motor and cognitive abilities. Individuals fall asleep without warning ("sleep attacks"). In severe sleep apnoea excessive sleepiness may even progress to stupor.

Medical sleep scientists use the term sleep propensity (SP) to describe excessive sleepiness and SP is defined as a measure of a subject’s tendency at a particular time to doze or fall asleep, at least briefly. This means entering Stage 1 sleep, whether or not it progresses to Stage 2 and other stages. SP is the probability of falling asleep at a particular time, more precisely it is the probability of a state of change from wakefulness to non-REM sleep.

Although SP will inevitably vary during the day and from day to day, different subjects will have a mean SP over prolonged periods about which a fluctuation will occur. This long-term characteristic is called by Johns “the Average Sleep Propensity” (ASP) (Johns 1993). Johns has stated that this ASP is affected by a chronic sleep disorder such as sleep apnoea by increasing the total sleep drive over a long term but not the awake drive.

The ESS is a brief self-administered questionnaire that asks the subject to rate on a scale of 0-3 the chances that, over "recent times", he would have dozed in eight specific situations that are commonly met in daily life 0 = would never doze; 3 = high chance of dozing). Thus, the subject is asked to characterise, retrospectively part of his usual behaviour in a variety of situations that are more or less soporific. Subjects are asked to distinguish dozing behaviour from feelings of tiredness. The situations are specially chosen to vary in their soporific nature from highly soporific to less soporific. The ESS score is the sum of the eight item scores and can range from 0 to 24.

ESS scores are statistically significantly correlated with sleep latency measured in Multiple Sleep Latency Tests. Item and factor analyses have shown that the ESS is a unitary scale with high internal consistency and high test/re-test reliability over a period of 5 months in normal subjects. High initial scores of subjects with OSAS return to normal after treatment with CPAP treatment (Johns 1993).

The ESS is conceptually unique in its ability to measure ASP over its whole range from very low levels in insomniacs to very high levels in patients with severe OSAS and narcolepsy.

Each ESS item gives an estimate of SP in one of eight specific situations whereas the total ESS score gives a measure of the more general parameter, ASP, relating to a range of situations that are commonly met in daily life.

As with any questionnaire-based method, the ESS is limited by the subject's ability to read and comprehend the questions and to answer the questions honestly.

Sleepiness is often confused with feelings of fatigue or weariness that are not related in any simple or constant way to one’s SP. Fatigue and a low level of alertness may signal the need for sleep but they do not provide a useful measure of the likelihood of falling asleep (Monk 1987). Many insomniacs are very tired at night but cannot fall asleep readily whereas narcoleptics often fall asleep during the day without feeling tired (Johns 1993).

The factors that affect excessive sleepiness are fully described by Bonnet (Kryger, Roth et al. 1994:51) and are given in the body of this report.

Comparisons with other measures of sleepiness

Other measures of sleepiness or vigilance have been proposed, such as the "Maintenance of Wakefulness Test (MWT) (Mitler, Gujavarty et al. 1982) where the person sits in a dimly light quiet room trying to stay awake rather than fall asleep. Other tests based on eye closing or cerebral evoked potentials are also cumbersome and expensive.

The Stanford Sleepiness Scale (SSS) is quick and simple and involves the person's own reports of symptoms and feelings, however this test, and others like it, measure feelings of tiredness and fatigue at a particular time - they do not measure the general level of daytime sleepiness. The ESS measures general or chronic sleepiness and has been shown to be relatively independent of time over periods of several months (Johns 1992). In subjects who maintain the same lifestyle and are not treated for medical sleep disorders the ESS score does not change significantly over many months..

It was important that a driver survey actually measured chronic or general sleepiness not simply sleepiness at the time when the driver was doing the survey. As shown above a person's sleepiness at any particular time on a specific day when filling in the survey would be influenced by many factors. Some of these factors being the quality and duration of prior sleep or of sleep deprivation, the time of day, the presence of various sleep disorders, drug and alcohol effects and the level of interest and motivation when doing the survey.

By selecting the ESS test, rather than the Stanford Sleepiness Scale (SSS) which measures tiredness at only the time of test, a measure of general or chronic sleepiness can be obtained, which is much more relevant to the accident risk of drivers in the heavy vehicle industry**.**

Other researchers around the world have now used the ESS test to measure daytime sleepiness and its relationship to accidents.

Table A1 shows the mean ESS scores and their standard deviation with the ranges that were found in John's original study (Johns 1991).

Table A1 – ESS scores in mild, moderate and severe OSAS

	Mean	SD	Range
Mild OSAS	9.3	3.3	4-16
Moderate OSAS	11.5	4.2	5-20
Severe OSAS	16	4.4	8-23
Normal individuals	4.6	2.8	0-10
Primary snoring	6.5	3	0-11
OSAS	11.7	4.6	4-23
Narcolepsy	17.5	3.5	13-23

The relatively wide range of scores in normal people (0-10) (Johns 1997) is consistent with evidence that some healthy adults, without recognisable sleep disorders, remain sleepier than others during the day.

The normal range of ESS scores are from 0 to 10 and thus scores in excess of 10 indicate excessive daytime sleepiness, which in turn is directly related to accident risk (Wu and Yan-Go 1996).

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Appendix 3. Endnotes

[1.] Obstructive sleep apneoa is a medical condition involving obstruction of the airways during sleep, with a consequent cessation of breathing. This can be life threatening, but is more commonly associated with a disruption of the normal sleep cycle, causing sufferers to awaken from what they believe to have been uninterupted sleep still feeling sleepy and fatigued

[2.] The Epworth Sleepiness Scale (ESS) is a questionnaire measuring the general level of daytime sleepiness. This general level of daytime sleepiness is referred to as the average sleep propensity and is a measure of the probability of falling asleep in a variety of situations. The conceptual basis of the ESS involves a four-process model of sleep and wakefulness and the sleep propensity at any particular time is a function of the ratio of the total sleep drive to the total wake drive with which it competes. This, and other methods of evaluating sleepiness, are discussed in detail in Appendix 2

[3.] Circadian time refers to the natural biological rhythms of approximately 24hours in the activities of plants and animals. These rhymns are generated internally and have a periodicity, which is the time for one complete cycle of approximately 24 hours and thus have been called circadian (about a day).

INFORMATION RETRIEVAL

Austroads (2000), **Heavy Vehicle Driver Health and Sleep Disorders**, Sydney, A4, 31pp, AP-148/00

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ABSTRACT:

Chronic excessive sleepiness and accidents caused by sleep-related fatigue are major issues for Australian heavy vehicle drivers. This report examines the importance of sleep-related fatigue and its role in heavy vehicle accidents.

Unlike many other road safety accident factors, sleepiness is identifiable, predictable, and preventable.

This report presents the results of the measurement of chronic excessive sleepiness in a large sample of heavy vehicle drivers in Australia and the results of a concurrent medical examination by doctors.

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