THE PERCEPTIONS AND EFFECTS OF SLEEP DEPRIVATION IN ANAESTHETISTS

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DECLARATION

I, Megan Adel Sanders, declare that this research report is my own work. It is being submitted for the degree of Master of Medicine in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at this or any other university.

Signed

On this day of 2016

ABSTRACT

Background: Sleep deprivation is known to have multiple pathophysiological, psychological and cognitive effects. The effects of sleep deprivation on anaesthetists have been recognised both within and outside of the workplace. Guidelines and strategies have been proposed to counteract some of the effects of sleep deprivation. This study investigated the perceived effects of sleep deprivation amongst anaesthetists.

Method: A prospective, contextual, descriptive research design was followed for the study. Anaesthetists completed a questionnaire regarding perceptions and effects of sleep deprivation and the Epworth Sleepiness Scale (ESS).

Results: A mean longest time spent without sleep due to work schedule of 31 (SD 9.1) hours. The mean score from the ESS was 11.5 (SD 4.4), indicating mild sleepiness. Sixty-one (57%) anaesthetists reported insufficient sleep due to work schedule 1 to 2 nights per week and the majority reported perceptions of the effects of sleep deprivation at work in the 1 to 2 times per week category. Sixty-two (57.9%) anaesthetists have dozed off in theatre during the day and 85 (79.4%) have dozed off in theatre on a night call with varying degrees of regularity.

Fifty-two (48.6%) anaesthetists perceived making mistakes related to sleepiness and 74 (69.2%) making mistakes unrelated to sleepiness. Due to sleepiness, 44 (41.1%) anaesthetists reported a percutaneous injury, 101 (94.4%) anaesthetists admitted to feeling at risk of a motor vehicle accident and 99 (92.5%) anaesthetists missed social or family activities because of sleepiness. Strategies to reduce sleepiness were assessed. Eighty-seven (81.3%) anaesthetists consumed at least one caffeinated beverage per day.

Conclusion: Anaesthetists reported perceptions of inadequate sleep and the subsequent effects. The mean score from the ESS indicated a mild sleepiness level. Few anaesthetists used strategies to reduce the effects of sleep deprivation.

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LIST OF ABBREVIATIONS

ECG	Electro-cardiogram
EEG	Electro-encephalogram
EMG	Electro-oculgram
EOG	Electro-oculogram
ESS	Epworth Sleepiness Scale
M-SD	Moderately sleep deprived
MSLT	Multiple Sleep Latency Test
NON-SD	Non sleep deprived
NREM	Non-rapid Eye Movement
POMS	Profile of Mood Status
PVT	Psychomotor Vigilance Task
REM	Rapid Eye Movement
SASA	South African Society of Anaesthesiologists
S-SD	Severely sleep deprived
WITS	University of the Witwatersrand

CHAPTER ONE
OVERVIEW OF THE STUDY

1.1 Introduction

In this chapter a brief overview of the background to the study; the problem statement; the aims and objectives of the study; research assumptions; demarcation of the study field; ethical considerations; a summary of the research methodology and the significance of the study of the study is presented.

1.2 Background

Sleep and its importance have long been speculated upon and studied. Neurophysiologists have researched sleep stages, patterns and control centres through the use of polysomnography. Through this research it has been established that the average adult has 6.8 to 7.4 hours of sleep a night (1). In today's society many shift-workers do not achieve this. Sleep deprivation may be chronic, with less than normal sleep achieved on consecutive nights, or may comprise a period of complete sleep loss (1). This has led to subsequent studies on the effects of sleep deprivation (1-4).

Sleep deprivation has effects on many physiological systems (5), as well as having a wide range of other effects. Acute and chronic sleep deprivation lead to symptoms of "daytime sleepiness", as well as psychological and emotional consequences (4, 6). Sleep deprivation also has an influence on neurocognitive functioning and can result in short lapses of attention which is often termed "microsleep" (4, 7). It has been stated that after 17 hours of sleep deprivation the decline in cognitive psychomotor ability is equivalent to alcohol intoxication (8, 9). Although it is difficult to test, executive functioning has also been shown to be effected by sleep loss. This has been described through studies on decision-making and simulated tasks (4, 10-12).

The aviation industry has provided many participants for research into sleep deprivation, due to the likelihood that pilots and airline staff are subjected to long, irregular working hours. In addition the type of cognitive functioning that seems to be affected by sleep loss, is important in this industry (11, 13). The link between the aviation industry and medicine, and anaesthesia in particular, has been made in the literature (14, 15). It provides for additional research and application of research studies from the aviation industry to that of the medical environment. The study of sleep deprivation is no different.

Within the medical environment sleep deprivation has been shown to increase the risk of medical errors and have an impact on academic development of training doctors (16-18). There are also increased risks of percutaneous injuries amongst doctors who are fatigued (19). Various studies on sleep deprivation in doctors have shown an impact on results of neurocognitive testing, as well as, effects on clinical performance through the use of questionnaires and simulations (7, 9, 16, 18, 20, 21).

Sleep deprivation has demonstrated an influence on the social lives and daily activities of doctors and has also been linked with a negative impact on mood changes and personal relationships (18). An increased risk of motor vehicle accidents has been demonstrated in sleep deprived doctors (22). These risks are concerning when considering the general well-being of training and specialist doctors.

In addition to research in the general medical community, the working hours and effects of sleep deprivation on anaesthetists have also been studied. Similar results in these two groups concerning cognitive function and clinical performance have been found (7, 23-25). Shift work and the resultant sleep deprivation are inevitable for those in the medical fraternity. Studies investigating the use of caffeine and stimulants, such as modafinil have emerged (26-28). However, opinions of various authorities regarding the use of modafinil and caffeine differ (20, 29).

Other strategies to promote wakefulness have been suggested (30). There are various international guidelines pertaining to work hour stipulation for training doctors and specialist programs, with the aim of preventing adverse events as a result of sleep deprivation (31-33). According to the South African Society of Anaesthesiologists (SASA): “continuous on call duty of less than 12.5 hours is suggested, more than 17 hours is to be discouraged, and excess of 24 hours to be condemned” (20).

1.3 Problem statement

It is known that sleep loss has negative sequelae on physical and psychological wellbeing, as well as, neurocognitive function (3-5). The detrimental effects of both chronic sleep deprivation and the direct influence of total sleep loss during night calls on doctors are also evident in the literature (18, 21, 34-36).

Within the Department of Anaesthesiology at the University of the Witwatersrand (Wits), anaesthetists are exposed to prolonged working hours and night calls. It is acknowledged that night calls are inevitable, with the average shift duration of 17 hours. With this knowledge and the potential harmful effects on both doctors and patients, the perceptions and effects of sleep deprivation needed to be assessed within this department.

1.4 Aim and objectives

1.4.1 Aim

The aim of this study was to describe the perceptions and effects of sleep deprivation in anaesthetists in the Department of Anaesthesiology at Wits.

1.4.2 Objectives

The objectives of this study were to:

- document longest time spent without sleep due to work schedule
- describe the perceptions of sleep insufficiency in anaesthetists

- describe the perceptions of the effects of sleep deprivation on the work and social life of anaesthetists
- describe the degree of sleepiness and daytime fatigue symptoms through the use of the Epworth Sleepiness Scale (ESS)
- describe measures taken by anaesthetists to overcome sleepiness.

1.5 Research assumptions

The following definitions were used in the study.

Anaesthetist: in this study will be interns, medical officers and registrars working in the Department of Anaesthesiology.

Night call: is a defined time period specific to after hour work in the Department of Anaesthesiology. Duration of night calls at the affiliated hospitals are:

Hospital	ICU	Theatre
Charlotte Maxeke Johannesburg Academic Hospital	Weekdays: 20 hours Weekends: 27 hours	15.5 hours
Chris Hani Baragwanath Academic Hospital	Weekdays: 17.5 hours Weekends: 14 hours	16 hours
Rahima Moosa Mother and Child Hospital	No ICU calls	15.5 hours
Helen Joseph Hospital	28 hours	15.5 hours
Wits Donald Gordon Medical Centre	12 hours	No theatre calls

ESS: this scale is used to describe daytime sleepiness. It is a validated scale developed and published by Dr M Johns in 1994.

Normal and Score ranges for ESS: The ESS website (37) states that "normal adults … have a mean score of 4.6 with a standard deviation of 2.8 and a range from 0-10." According to the Division of Sleep Medicine at Harvard Medical School (38), a score of 0-10 is normal; 11-14 indicates mild sleepiness; 15-17 moderate sleepiness and a score of 18 or higher indicates severe sleepiness.

Sleep deprivation: reduced sleep duration. It may be complete or partial. Complete or total sleep deprivation involves a prolonged time of wakefulness. Partial sleep deprivation involves shortened periods of sleep where the sleep period may be fragmented. (1)

Sleep insufficiency: less than six to eight hours of sleep per night (1, 31).

1.6 Demarcation of study field

The study was conducted in the Department of Anaesthesiology, affiliated to the Faculty of Health Sciences at Wits. The staff complement of the department is 112 registrars and 22 medical officers and approximately 30 interns. The following hospitals are affiliated to the department: Charlotte Maxeke Johannesburg Academic Hospital; Chris Hani Baragwanath Academic Hospital; Rahima Moosa Mother and Child Hospital; Helen Joseph Hospital and Wits Donald Gordon Medical Centre.

1.7 Ethical considerations

Approval to conduct this study was obtained from the relevant authorities. An anonymous self-administered questionnaire was used in the study, and consent was implied on completion of the questionnaire. The study was conducted in accordance with the Declaration of Helsinki (39) and the South African Good Clinical Practice Guidelines (40).

1.8 Methodology

1.8.1 Research design

A prospective, contextual, descriptive research design was followed in this study.

1.8.2 Study population

The study population consisted of anaesthetists working in the Department of Anaesthesiology.

1.8.3 Study sample

In this study a convenience sampling method was used. Eighty percent of the eligible population was targeted. The inclusion and exclusion criteria for this study were defined.

1.8.4 Collection of data

Development of questionnaire

A sleep questionnaire published by Kim et al (9) and a validated questionnaire, the ESS (37) were deemed the most appropriate in addressing the aims of this study. A draft questionnaire was drawn up and adapted using questions from Kim et al (9), together with additional questions. The ESS (37) was used in the questionnaire unchanged.

Data collection process

Data was collected at departmental academic meetings. The anaesthetists had 15 minutes during the meeting to complete the questionnaire, which was then placed into a sealed collection box. Measures were taken to ensure the validity and reliability of the study.

1.8.5 Data analysis

Using Microsoft Excel 2011®**,** data was captured onto spreadsheets. Descriptive statistics were used to analyse the data.

1.9 Significance of the study

Sleep deprivation has been shown to have adverse physiological effects (1, 5, 41). This is accompanied by other detrimental effects, including various psychological consequences (41, 42). Sleep deprivation is also responsible for decreased performance in neurocognitive and psychomotor testing, with an increase in sleepiness (1, 4, 43).

Research has investigated the effects of sleep deprivation on doctors in general. Within the context of South Africa, anaesthetists are exposed to prolonged work hours and therefore sleep deprivation (20). Perceptions regarding sleep deprivation in anaesthetists in South Africa could not be identified. For this reason, it was important to describe the perceptions and effects of sleep deprivation on anaesthetists. The results from this study may influence working hours in the department and thereby contribute to the improvement of general well-being of anaesthetists working in the department.

1.10 Study outline

The following chapters are presented in this study.

Chapter One	Overview of the study
Chapter Two	Literature review
Chapter Three	Research methodology
Chapter Four	Results and discussion
Chapter Five	Summary, limitations, recommendations and conclusion

1.11 Summary

In this chapter a brief overview of the study was given. Chapter Two comprises of a review of the literature.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

This chapter provides a review of the literature with regards to sleep physiology, pathophysiological effects of sleep deprivation, tests and assessment tools for sleep studies, sleep deprivation in the aviation industry, doctors, and anaesthetists. Strategies to reduce the effects of sleep deprivation and guidelines are discussed.

2.2 Background

Within the context of health care provision, long and irregular working hours are accepted. This has lead to investigative research into the effects of night shifts and sleep deprivation. First it is important to achieve a basic understanding of the physiological process involved with sleep. This then allows for an understanding of the effects of sleep deprivation. Studies have investigated effects of sleep deprivation from physiological, to psychological and neurocognitive functioning. The aviation industry has provided research into the field of sleep deprivation and fatigue studies. The link between the aviation industry and the medical world, specifically that of anaesthesia, with regards to safety practises and checklists has been noted. (14, 15, 44). The link with regards to prolonged working hours and sleep deprivation can be assumed between the aviation industry and anaesthesia (45). The effects of sleep deprivation on health care workers have been extensively researched (16, 18, 46, 47). Consequences both in and out of the workplace have also been demonstrated. Anaesthetists are vulnerable to the neurocognitive effects of sleep deprivation, due to the nature of the work. Vigilance, and response time are imperative when monitoring patients under anaesthesia (48).

2.3 Sleep physiology

Sleep is defined as: “a state of reversible unconsciousness in which the brain is less responsive to external stimuli” (2). The National Sleep Foundation Gallop Poll in the United States of America in 2005, suggested that the average sleep duration on weekdays was 6.8 hours and 7.4 hours on weekends (1).

2.3.1 Sleep stages

The study of sleep is a complex and continuously evolving subject. It has been established that throughout the duration of sleep there are a series of cycles of non rapid eye movement (NREM) sleep and rapid eye movement (REM) sleep. Each sleep cycle lasts approximately 90 minutes (42, 49-51).
Through the analysis of polysomnography, it has been possible to distinguish between NREM and REM sleep, as well as illustrate the transition from wakefulness to sleep. Polysomnography involves the analysis of electroencephalogram (EEG), electro-oculogram (EOG) and electromyogram (EMG) waveforms (2, 42).

The state of wakefulness is characterised by beta and gamma waves on EEG and high muscle tone on EMG. Alpha waves are typically noted when a human is at rest with eyes closed. Sleep is then initiated with the NREM pattern (2, 49, 52).

NREM sleep is comprised of four stages. Typically it involves almost no eye movement, no dreaming and no muscle paralysis. At the onset of NREM sleep, large amplitude mixed frequency waves are noticed on EEG. This is followed by stage one, which displays alpha waves and theta waves on EEG. Slow-rolling eye movements are noted, and moderate to low activity is seen on EMG, with occasional jerky movements. Stage two of NREM sleep shows delta waves and specific waves, which are called sleep spindles and k complexes. It has been thought that sleep spindles are specifically associated with memory formation. Eye movements rarely occur on EOG and low to moderate activity occur on EMG. Stages three and four sleep are often indistinguishable and may be classified together as slow wave sleep. In this period there are delta waves on EEG, with no eye movements and low activity on EMG (2, 49, 51-53).

REM sleep typically has theta and saw tooth, ponto-geniculo-occipital waves. REM sleep shows two different stages. The first is a tonic stage and involves muscle paralysis. It should be noted that the diaphragm and upper airway muscles are not affected. The second is the phasic stage, during which movements occur and heart rate and respiratory rate become irregular. It is thought that REM sleep is important for memory formation, the processing of emotional thought and brain development (2, 41, 50, 52, 53).

2.3.2 Physiological control of sleep

There are two specific processes regarding the control of sleep and wakefulness: the homeostatic process, otherwise known as process S, and the circadian process, or process C (2, 41, 53).

The homeostatic process is the fundamental drive for sleep, which increases with the duration of wakefulness experienced. Sleep is usually initiated voluntarily, and wakefulness maintained by suppressing the homeostatic drive. However, with prolonged wakefulness the onset of sleep can be an involuntary process (2, 41, 53).

The circadian pacemaker is located in the suprachaismatic nucleus in the hypothalamus and follows a 24-hour oscillatory cycle. Sleepiness peaks at 02:00 and 14:00 while wakefulness peaks at 06:00 and 18:00. The circadian process is influenced by genetic factors and external factors such as light, lifestyle and meals (2, 41, 53).

A state of wakefulness during the night disturbs the circadian rhythm, and daytime sleepiness is experienced. If a person stays awake during the night sleepiness will be experienced in the early hours of the morning, but this will improve at the start of the day. Daytime sleepiness is influenced by genetic circadian factors, external factors and time since the last sleep (2).

Neurophysiological research has found that the primary centre for the regulation for the state of wakefulness is the reticular activating system. From this system there are two neurological projections, with cholinergic, monaminergic, serotinergic, dopaminergic and histaminergic neurotransmitters. The first is to the thalamus, while the second has fibres to the lateral hypothalamus, cortex and forebrain. The main centre for onset of sleep is initiated by the ventrolateral pre-optic nuclei, which link to the hypothalamus and brainstem. Neurotransmitters involved in the initiation and onset of sleep include serotonin and GABA (41, 52, 53). The balance between these two sleep-control centres for sleep and wakefulness is known as the "flip-flop" system (53).

Other neurological pathways and neurotransmitters have been identified with regards to the control and regulation of the sleep-wake cycle. Orexin or hypocretin, is a neurotransmitter that helps to regulate sleep and the switching from wakefulness to sleep and vice versa. Adenosine also has been found to play a role in the homeostatic process of the sleep cycle (52, 53).

The neurohormonal interaction with regards to sleep regulation has been well established. Melatonin is a sleep hormone secreted by the pineal gland, every four hours. The regulatory effect on the circadian rhythm is important. The release is stimulated by the supra-chiasmatic nuclei, which are influenced by the perception of light and dark perceived by the retinohypothalamic fibres (2, 4, 49).

2.3.3 Physiological changes during sleep

Sleep plays a role in almost all other physiological systems and processes. It had initially been hypothesised that sleep was used for cellular repair in general. However there is a decreased metabolic rate between 10 and 30 % during sleep, which is accompanied by a decrease in core temperature. This disproves the suggestion that sleep is involved with repair and restitution. Despite this, there are various changes noted in many physiological systems during sleep (2, 42).

During NREM sleep there is a decreased respiratory drive, decrease in muscle tone of the upper airway, decreases minute ventilation, and a regular breathing pattern. This is accompanied by suppression of the cough reflex. During REM sleep there is irregular breathing and decreased muscle tone of the intercostal muscles, which is specific to the tonic stage (2, 41).

Changes within the cardiovascular system are also seen. This includes a decrease in systemic vascular resistance and heart rate, together with a decrease in cardiac output seen in NREM and tonic REM sleep, while the opposite is seen in phasic REM sleep (2, 41).

With regards to the central nervous system, there is an increase in cerebral blood flow and cerebral metabolic rate during REM sleep. Cerebral metabolic rate is decreased in NREM sleep. In general there is a decrease in sympathetic tone and increase in parasympathetic tone during sleep, while the opposite occurs during phasic REM sleep (2, 41, 42).

The genitourinary system is also influenced by sleep. During sleep there is a decrease in glomerular filtration rate, filtration fraction, with reduced excretion of electrolytes and an increase in secretion of vasopressin. Penile erection may occur during phasic REM sleep (2, 41).

The endocrine system plays an integral role in sleep physiology. As stated previously, melatonin is secreted by the pineal gland, and plays a role in the regulation of the sleep-wake cycle. Growth hormone is released during slow wave sleep as well as prolactin (2, 41, 49, 52). Cortisol levels are influenced by sleep, with trough levels seen before waking and peak levels after waking (2).

2.4 Pathophysiological effects of sleep deprivation

The importance of sleep is undeniable. Ganong (49) states that: “experimental animals completely deprived of REM sleep for long periods lose weight in spite of increased caloric intake and eventually die…deprivation of slow-wave sleep produces similar changes…” (49).

Sleep deprivation may be complete or partial. Complete or total sleep deprivation involves a prolonged time of wakefulness. Partial sleep deprivation involves shortened periods of sleep where the sleep period may be fragmented. This could result in changes of the normal process and cycles and in some instances complete loss of specific stages. Alternatively the sleep cycles may be retained within a restricted period of sleep. When partial sleep deprivation occurs over a series of nights, chronic partial sleep deprivation ensues (1). According to the Association of Anaesthetists of Great Britain & Ireland eight hours of sleep per night are necessary, and less than six hours of sleep per night for 14 days is equivalent to one whole night of wakefulness (31).

The severity of the effects (and in particular cognitive effects) of sleep deprivation differs significantly amongst individuals (4). This is thought to be due to genetic factors (1). There is also speculation that individuals may be able to adapt differently to sleep deprivation to a certain extent (43).

The concept of fatigue is linked to sleep deprivation. Fatigue has been defined as: “ a subjective feeling of the need to sleep, an increased physiological drive to fall asleep and a state of decreased alertness.” Sleep deprivation is one of the major factors responsible for fatigue (31).

2.4.1 General physiological effects of sleep deprivation

Sleep deprivation has numerous adverse physiological effects. Knuttson (5) speculated that various processes are responsible for the pathophysiological changes seen. First the direct cause of sleep deprivation and disruption of the circadian rhythm has influences on the health of participants or shift workers.

Secondly, because of the nature of shift work, participants are more inclined to have poor lifestyle habits, such as an unhealthy diet and smoking. Thirdly, shift work involves disrupted social activities, which can lead to stress.

There is an association between sleep deprivation and diseases of lifestyle such as obesity. Obesity is a multifactorial endocrine process. According to Knuttson, "…concentrations of uric acid, glucose and cholesterol are increased during night work." (5) It has been shown that sleep deprivation influences the timing of release of certain hormones such as cortisol, growth hormone, and melatonin, as well as decreasing glucose tolerance. This together with the reduction in leptin levels and increase in grehlin levels and their effect on appetite control can lead to the development of obesity in sleep deprived individuals (1, 5). An increased incidence of cardiovascular events has been shown to be associated with decreased sleep (1, 41).

Other physiological effects of sleep deprivation include impaired immune function. Sleep loss has been shown to influence antibody levels, activity of leucocytes and cytokine levels. Gastrointestinal effects such as changes in bowel habits, and abdominal pain, as well as an increase in incidence of peptic ulcers have also been reported. There have also been reports on negative outcomes with regards to reproductive health amongst shift workers. This includes increased incidence of miscarriage, preterm labour and low birth weight deliveries. (1, 5, 48, 54)

2.4.2 Psychological effects

Psychological consequences also result from sleep loss. Gruber and Cassof (55) suggest that emotion regulation is influenced by disruptions in the processes of sleep regulation. More specifically they suggest that disruption in the homeostatic process can lead to decreased communication between the prefrontal cortex and the amygdala. This then influences executive functioning and control of emotions. Interruptions to the circadian rhythm have a more direct effect on mood. The authors have defined mood as a temporary affective state that has influence on emotional regulation.

Common problems include mood changes, anxiety and sleep disorders which can lead to substance use (41). According to Guyton and Hall (42): “a person can become irritable or even psychotic after forced wakefulness.” Durmer and Dinges (4) state that “Virtually all forms of sleep deprivation result in increased negative mood states…”

A study by Kaida and Niki (56) analysed data from 16 male participants and compared what was termed a “flow experience” as well as profile of mood status (POMS) between participants in a rested group and a sleep deprived group. Flow was defined as “ a positive emotional state that typically occurs when a person perceives a balance between challenges associated with the situation and his or her capabilities to accomplish or meet the demands of this situation” (56). Their findings included a statistically significant decrease in flow experience in those who were sleep deprived as well as decrease in some factors from the POMS. The study, however, showed no statistically significant differences in the moods of anxiety and sadness between the two groups.

2.4.3 Neurocognitive effects

It has been established that acute total sleep deprivation has neurocognitive effects. Imaging studies as well as EEG tests, have shown that the prefrontal cortex, and thus neurocognitive functioning is affected by loss of sleep. In the case of acute total sleep loss, negative neurocognitive effects can be reversed by a night’s sleep. It has also been found that chronic sleep loss, results in impaired neurocognitive functioning, with a cumulative pattern. However the recovery time is delayed in those with chronic sleep loss, and more recuperative sleep may be needed (3, 4).

When analysing neurocognitive effects, specific dimensions have been examined in the literature. Sleep deprivation has a detrimental effect on alertness and can result in what is termed “microsleeps” (1, 31) in which the subject has a complete lapse in response to stimulation for a time period of seconds up to minutes (1, 48, 57). This is evident on EEG with the presence of theta and delta waves (6).

According to Durmer and Dinges (4) there are two types of cognitive errors made by the sleep deprived individual. Subjects make “errors of commission” in which inappropriate responses are made with or without a stimulus, or “errors of omission” in which there is no response to a stimulus. Sleep deprived individuals may also dream whilst performing cognitive tasks.

Other cognitive functions affected by sleep loss include, reduced memory and learning ability and slower response times. Sleep deprived individuals also try to compensate for the reduced level of functioning and prolong the duration to completion of a task (4). Van Dongen et al (43) compared cognitive functioning over 14 days between participants randomised into four groups. Three of the groups were allocated a certain amount of hours of sleep per night (eight, six and four) and the fourth group kept awake continuously for 88 hours. This study showed that participants subjected to four to six hours sleep per night had reduced alertness and memory equivalent to that of a group subjected to continuous sleep deprivation. The same study also showed statistically significant reduced neurocognitive performance in psychomotor vigilance task (PVT), a digit symbol substitution task and addition and subtraction tasks in the participants with four hours of sleep per night. They found that participants who had eight hours of sleep a night for 14 days had normal performance in the tasks (43).

On a more complex level, it has been found that sleep deprivation has a negative influence on decision-making, situational awareness, executive and lateral thinking. This is shown with a decreased ability to multi-task, make judgements, update strategy and show insight. This is more difficult to assess and more complex tools or neuropsychological tests are needed. Imaging studies have helped to link the effects of sleep deprivation on various parts of the brain. Positron Emission Tomography and Magnetic Resonance Imaging scans have shown reduced total glucose metabolism. Glucose metabolism is reduced in the prefrontal cortex; thalamus and posterior parietal cortices in sleep deprived participants, with demonstrated reduced ability on cognitive testing. EEG waveforms are shown to have tonic decreases in participants performing cognitive tasks while sleep deprived (4, 10, 58).

Different studies have reported effects on oculomotor and visual function in sleep deprived participants. It has been reported that there is a detrimental effect in oculomotor function and visual neglect of both peripheral and central vision in study participants (1, 58). Rogé et al (59) conducted a study with 19 participants using a driving simulator, and found participants had a typical tunnel vision pattern when sleep deprived.

It is known that control of pupil responses and saccadic eye movement are involuntary actions (60, 61). A study by Russo et al (60) assessed saccadic velocity and pupil diameter movements, together with sleepiness testing and driving performance, in 66 commercial drivers who were randomised into groups assigned to different "allowed sleep schedules". Their statistically significant findings included slowing of saccadic velocity and increased latency to pupil constriction in the sleep deprived groups. In addition to these findings the three-hour sleep group also demonstrated an increased risk of driving accidents on a simulator, and when correlated to saccadic movement a strong negative correlation was found.

This was supported by a subsequent study by Rowland et al (61) on 12 participants who were exposed to initial partial sleep deprivation with four hours of sleep for a night and then continuous wakefulness for 64 hours. They showed a positive correlation between latency to pupil constriction and subjective sleepiness and driving accidents and a negative correlation between saccadic velocity and subjective sleepiness and driving accidents.

A complex study by Previc et al (13) on 10 pilots also looked at eye movement. They however concentrated on scanning of instruments and dwell time, during flight in a simulator. This measured non-basic eye movement and voluntary function. Their findings showed no significant differences between initial flights and flights after a period of continued wakefulness (13). These findings can be translated to the potential effects of sleep deprivation of scanning of monitors in anaesthesia, in that while anaesthetists are aware of the effects of involuntary oculomotor function and vision, purposeful eye movements may not be affected.

The effect of prolonged wakefulness on psychomotor function has also been demonstrated. Dawson and Reid (62) in 1997 linked performance of sleep deprived participants to participants with alcohol intoxication. A group of 40 participants were divided into two groups, either exposed to 28 hours of wakefulness, or alcohol intoxication to blood alcohol levels of 0.10%. Statistically significant regression of performance was noted in both the sleep deprived and intoxicated groups. The researchers then continued to link these results and calculated that " for each hour of wakefulness between 10 and 26 hours was equivalent to the performance decrement observed with a 0.004% rise in blood alcohol concentration." (62)

According to Banks et al (1) there is an increase in the incidence of motor vehicle accidents if a subject has had less than seven hours of sleep. The US Federal Highway Administration (12) state that during a five year period in the 1990s, 56 000 motor vehicle accidents were linked to sleep deprivation. A subsequent report by Intelligent Transportation Systems (63) conducted a study with 20 drivers who were tested on a simulator at different times of day and night. Steering ability deteriorated during the drive after being sleep deprived and the average driving speed was faster for the drives after participants were sleep deprived. The application of this information to those working night shift is important. Åkerstedt at al (64) placed 10 participants in a simulator after working a night shift. They reported two accidents in the non-sleep deprived group and 18 accidents in the night work group.

Age plays a role in the capability of adapting to sleep deprivation. Older participants cope less well with sleep deprivation, and also tolerate night work less well than younger participants. It has also been found that with increasing age the incidence of disrupted sleep patterns occurs (31, 41, 48).

2.4.4 Daytime sleepiness

It has been stated that sleep deprived individuals often underestimate their limited cognitive functioning and sleepiness, secondary to sleep deprivation (1, 3, 8, 43). However, through sleepiness scales, the effect of sleep deprivation has been more objectively assessed. Van Dongen et al (43) showed that with chronic sleep deprivation, subjective sleepiness was increased on the Stanford Sleepiness Scale and Karolinska Sleepiness Scale, despite participant's beliefs that they had adapted to sleep loss. The same study did show that the increase in sleep loss demonstrated a plateau in the sleepiness results. This may suggest that participants had, to a certain degree, adapted to sleep deprivation, just not as well as they had thought.

2.5 Tests and assessment tools for sleep studies

Sleep researchers have developed many different tools for the assessment of sleep quality and effects of sleep deprivation. These range from basic subjective surveys completed by participants to complex performance tests.

2.5.1 Sleep diaries, polysomnography and the Actiwatch

Within a sleep laboratory, participants are generally required to complete a sleep diary. This involves a few questions based on the duration, quality of sleep and other habits pertaining to fatigue (65). Polysomnography is used as the gold standard for sleep testing and involves the use of EEG, EMG, EOG and electrocardiogram (ECG), as well as pulse oximetry and airflow monitors (66). The Actiwatch is a wrist device worn by participants, and monitors activity and rest patterns (67).

2.5.2 Sleepiness testing

The Multiple Sleep Latency Test (MSLT) is a common test used by sleep researchers. It is a test used for assessing sleepiness and involves asking a subject of a study to try to fall asleep at various intervals. The time it takes to fall asleep is recorded using EEG, EOG and EMG monitoring. The Maintenance of Wakefulness Test (MWT) is the exact opposite of the MSLT in that the subject is asked to remain awake. (1, 3)

2.5.3 Sleepiness scales

Three well known scales are used in the literature to assess sleepiness: The Stanford Sleepiness Scale, in which the subject selects a statement that represents their current state of sleepiness; the Karolinska Sleepiness Scale, which applies a Likert scale to subjective levels of sleepiness; and the ESS. (3, 37, 68) The ESS was one of the first subjective sleepiness scales to be implemented in sleep research and has been quoted repeatedly in the literature since its development. It is short and easy to complete. It is unique in that is assesses sleepiness in general at any given time.

The ESS was developed by Johns and published in 1991 as a unique tool to measure general sleepiness. The scale was then validated using the MSLT on 180 participants, some with sleep disorders and some without sleep disorders. In this initial test the mean score on the ESS for control participants was 5.9 +/- 2.2 and a value above 16 was noted in participants with narcolepsy and other sleep disorders. Subsequent to this validation the ESS has been used repeatedly in the literature and is freely available on the Internet. Currently, according to the ESS website (37) Australian data demonstrate a mean score of normal adults is 4.6 (SD 2.8).

Since its inception the ESS has been used as one of many tests when assessing sleepiness and effects of sleep deprivation, in multiple studies. The ESS provides the subjects with eight different scenarios ranging from "… sitting and reading in a car, while stopped for a few minutes in the traffic..." (68) It asks participants to state how easily they would fall asleep in each scenario using four point Likert scale.

2.5.4 Neurocognitive testing

There is a wide range of neurocognitive testing available. However it should be noted that confounding factors occur, such as the influence of practice and learning (69). The PVT is used to measure reaction time, through the use of random visual stimuli and a device that records response. The time lapse in response time to the stimulus acts as a marker of alertness. Basic arithmetic tasks can also be used, depending on the study population. This task is commonly used in the literature as it is largely unaffected by education and training. (3, 4, 43, 70)

Memory tests used include the Wechsler Memory Scale and the Auditory Verbal Learning Test, in which a participant is asked to recall 15 words that had previously been recited to the participant. (71)

Tests to measure executive function prove to be challenging, as there are many confounding factors. It is difficult to extrapolate results from simple vigilance and memory tests to complex cognitive performance. A review by Harrison and Horne (10) assessed simulations and tests to assess decision making, with specific applications to the military and medical sector. Simulations allow for more detailed effects of sleep deprivation on cognitive functioning.

The Stroop Colour Word Test is used to assess the speed at which visual information is processed. The accuracy of the response and the time taken to complete the task are recorded. (47, 71)

2.6 Sleep deprivation in the aviation industry

Literature has identified links between the aviation industry and anaesthesia more specifically with regard to safety practises and checklists (14, 15, 44). A link between the two industries with regard to the effects of sleep deprivation can be extrapolated (45). Within the aviation industry, fatigue plays a causative role in mistakes and near-misses despite the fact that “flight time” criteria are strictly enforced and adhered to. Pilots are not only subjected to long working hours over long haul flights, but also chronic sleep loss due to unusual working hours and flight times, and it is thought that pilots lose a significant amount of sleep if an early flight is planned. This is compounded by jet lag due to different time zones. This has consequences on the regulation of sleep and circadian rhythm (58). A study by Previc et al (13) suggested that “… flight performance was affected not only by sleep deprivation but perhaps by the circadian cycle as well.”

The concern is that sleep deprivation has negative effects on vigilance and reasoning ability during flight. Pilots also experience “microsleeps”, and demonstrate risky behaviour and make poor decisions when sleep deprived. Not only is decision-making affected by chronic sleep loss and a period of complete sleep loss, but psychomotor skills in flight performance also suffer. In addition to this sleep deprived pilots may also underestimate the effects of the sleep deprivation. (58)

Lopez et al (11) conducted a study with 10 active duty pilots and used both cognitive testing in the form of PVT and simulated flight tasks on the rested state and sleep deprived state. They found PVT reaction times were affected by sleep deprivation. A negative correlation between the PVT results and flight performance was also noted. They suggested that flight performance could be predicted by simple cognitive testing. This suggestion could be extrapolated to the medical world, in that it may be possible to perform a simple task before starting surgery or even driving home after a shift in order to predict performance.

Potential solutions to fatigue in the aviation industry include the use of stimulants such as caffeine. More recently strategic napping has been suggested as it has been noted that napping, either prophylactically or therapeutically, has shown cognitive benefit. As a result large aircraft are equipped with sleeping facilities and various aviation authorities and companies stipulate working hours and nap times. (58, 72)

2.7 Sleep deprivation amongst doctors

Doctors are not only exposed to acute loss of sleep during shift work and nights calls, but also suffer from chronic sleep deprivation. It is not only pure sleep loss that is a concern, but also the disruption of the circadian rhythm (73).

Kim et al (9) conducted a survey on various effects of sleep deprivation on residents and interns. Participants were divided into three groups according to the number of hours they slept. These authors then used a questionnaire, neurocognitive tests and sleepiness scales to assess effects of sleep deprivation.

They reported physical effects such as gastrointestinal symptoms, eye strain and muscle pains in all three groups. They also reported on impaired cognitive ability due to sleep deprivation through the use of the questionnaire. However they were unable to objectively demonstrate effects on cognition through the use of testing in any group. Results from their questionnaire showed the severely sleep deprived group had difficulty in learning and concentration, admitted to sleepiness related mistakes and often missed family or social activities.

A qualitative study by Papp et al (18) developed a conceptual model illustrating the effects of sleep deprivation on resident physicians from the use of focus groups as displayed in Figure 2.1. This demonstrates the broad range of effects, which are also addressed individually by other studies.

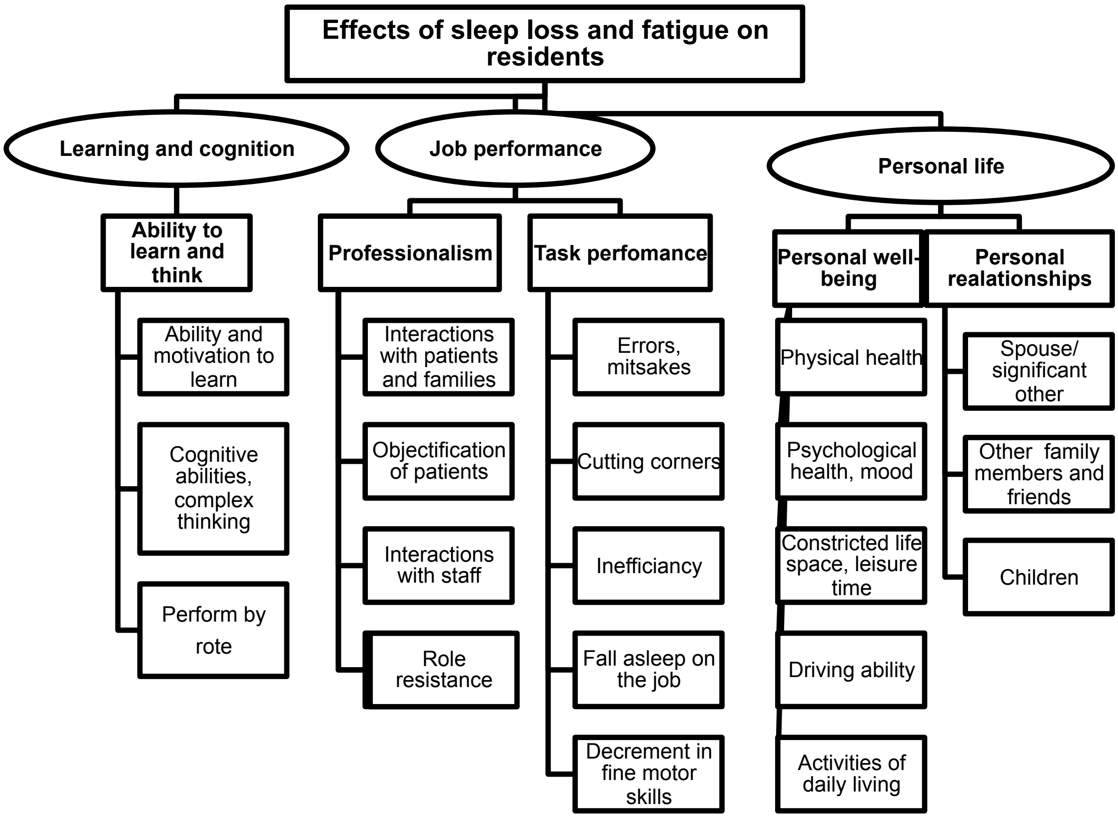


Figure 2.1 Conceptual Model by Papp et al (18)

2.7.1 Neurocognitive testing

A 1989 study by Orton and Gruzelier (34) looked at functioning of 20 house officers after a night call. They found a statistically significant reduction in processing-time of 5.15 seconds in the Haptic Scoring Test in the sleep deprived group. There was also a 0.04 millisecond difference between the sleep deprived and control group in the reaction time of the Vigilance Reaction Time test (34). It should be noted that this was not clinically significant.

Memory retention has also been tested on sleep deprived doctors. O'Brien et al (21) conducted a comprehensive study with 32 orthopaedic surgeons and found that there was a 1.83 times chance of making an error on the Running Memory test if the participant had had less than four hours sleep on a call. A later study on emergency physicians by Machi et al (47) with 13 emergency physicians and found that short term memory was affected at the end of a work shift regardless of whether that shift was during the day or night. This poses the suggestion that memory is influenced by hours at work and chronic fatigue as opposed to the direct influence of total sleep loss. (47)

As stated previously participants often underestimate the effects of sleep loss on their own sleepiness and cognitive abilities. Not only are practitioners at risk of making errors but are also at risk of being unaware of those errors. (1, 3, 8, 43)

2.7.2 Psychomotor performance

The detrimental effects of sleep deprivation on psychomotor function and surgical ability has been discussed in the literature. O'Brien et al (21) assessed psychomotor performance, as well as cognitive functioning. There were no statistically significant results with respect to psychomotor performance. However the sample size was small with only 32 participants, which may not necessarily represent the orthopaedic surgeon population in general, and the link between the testing and clinical performance can be questioned.

Yi et al (74) also assessed psychomotor skills in nine participants. Comparisons were made after a 24-hour call and participants only on night duty with no daytime duties. No significant differences were found on hand-eye co-ordination tasks with the exception of one finding, which noted faster movement in the 24-hour call group. Once again no link was made between the sleep deprived group and psychomotor performance.

A more clinically relevant study by Taffinder et al (35) on six surgeons found statistically significant data showing an increase in errors of 20% together with a 14% increase in length of time taken to complete the assigned task in a laparoscopic simulator. This contradicts the findings of the study on orthopaedic surgeons, and, more importantly, it analysed a specific surgical skill. However due to the size of the sample group, it can be argued that this demonstrates very little representation of surgeons in general. (35)

2.7.3 Clinical performance and patient and practitioner safety at work

Although it has been established that cognitive function is adversely affected by sleep deprivation, it has proven difficult to link this to clinical practice and patient care. However a review by Philbert (36) found that sleep loss over 24 hours correlated to reduced clinical functioning. According to Weinger and Ancoli-Israel (73) “Physician’s ability to provide high quality care can be adversely affected by many factors, including sleep deprivation.”

Landrigan et al (75) conducted a large prospective randomised study in Intensive Care Unit and Coronary Care Unit, over 2203 patient days, and compared medical errors made by interns and residents following a traditional work program to an intervention work program, which excluded a 24 hour call and reduced total working hours per week. Their results included a statistically significant 35.9 higher chance of serious medical errors in the group following the traditional work program.

In order to consolidate the theory that sleep deprivation has had an impact on clinical practice, a survey by Barger et al (16), on 2737 first year residents in the

United States of America was conducted. They reported increased fatigue related errors with the presence of five or more extended duration of work shifts with an odds ratio of 7.5.

Rothschild et al (17) conducted a retrospective study for one month on surgical complication rate in daytime surgical cases performed by surgeons who had worked the previous night. Their data only showed a significant increase in complication rate in cases when the surgeon had received less than six hours of sleep compared to when there were more than six hours sleep. This supports the concept of rest time on call in improving clinical performance.

However, Govindarajan et al (46) recently published a large multicentre study that contradicts the assumption that patient care is affected by sleep deprivation. This study involved 38 978 patients and 1448 attending physicians. The results showed no difference in patient outcome (death, complications or readmissions within 30 days post procedure) between procedures performed by physicians who had worked after midnight and those who had not worked after midnight.

It is not just the safety of patients that should be considered when looking at the effects of sleep deprivation in medical practitioners. The risk of injury on duty such as a needle stick injury is higher when sleep deprived. This is supported by a survey by Ayas et al (19) on the risks of percutaneous injuries in interns, which found a significantly greater rate of percutaneous injuries with extended work duration. It was also noted that the average time at which the injury occurred was at 12 pm after working a long shift (average of 29 hours). Another retrospective review of reported blood-borne pathogen exposures, found a relative risk for exposure during night-time work to be 1.5 times higher than during a day shift (76).

2.7.4 Motor vehicle accidents

Another threat to safety of doctors is the risk of motor vehicle accidents after night calls. The negative consequences (more specifically on decision-making and psychomotor effects) of fatigue on doctors in the workplace have been acknowledged. A link between fatigue and the occurrence of motor vehicle accidents after a night call is expected and has been suggested through tests on driving simulators. (77)

The cognitive and driving performance effects of fatigue in doctors after night calls have been linked to alcohol intoxication, by Arnedt et al (77). They conducted a study on 34 participants using the sleepiness testing cognitive tests and then a simulated driving task. Some participants were tested after a heavy call rotation, which consisted of 90-hour work-week and 34-hour call every fourth or fifth night. Other participants were tested after a light call rotation consisting of a 44-hour work-week and no night calls. The light call rotation participants then were either given alcohol to a blood level of 0.05% or, if in the control group, given no substance. Results of PVT in the light call with alcohol and heavy call participants showed slow reaction times. On the simulator-driving task, lane variability was higher in the light call with alcohol group and the heavy call group. Speed variability was also higher in heavy call participants and light call with alcohol participants. Although no correlation between sleep deprived participants and intoxicated participants were made, it was noted that the performance in the tasks were affected in both groups. This supported the findings by Dawson and Reid (62).

These findings are also supported by an annual survey by Barger et al (22) which found an increased rate of motor vehicle accidents as well as an increase in near-miss incidents, after an extended shift compared to a non-extended shift. The statistics showed ”… every extended work shift that was scheduled in a month increased the monthly risk of a motor vehicle crash by 9.1% ... and increased the monthly risk of a crash during the commute from work by 16.2%...” (22)

2.7.5 Effects on personal life and general well-being

There are psychological sequelae to sleep deprivation. A study by Orton and Gruzelier (34) with 20 house officers found, through the use of a POMS questionnaire, that there were significant changes in mood after a night call. Significant increases in score were noted with the following moods: anger-hostility, vigour-activity, fatigue-inertia and confusion-bewilderment and significant increases in mood score for tension-anxiety and depression-dejection. It was noted that there was a possibility that the results could be attributed to long working hours and not to loss of sleep alone.

The qualitative study by Papp et al (18) using focus groups analysed the effects of sleep loss. They looked specifically at personal well-being and relationships. Results showed that 20 out of 22 focus groups "… described a range of adverse effects on emotional wellbeing and on their psychological health…" Effects on relationships and children were also discussed by 16 out of 22 focus groups, and 14 of the groups commented on how working hours had affected their roles as parents.

Night calls have an impact on sleep patterns outside of work. According to Smith-Coggins et al (78) sleep at home was negatively affected by night shifts in 35% of the participants in the survey (78). This is due to a disruption of the normal circadian cycle (31). This could possibly perpetuate the cycle and negative effects of sleep deprivation.

Other physiological effects have also been mentioned in the literature and in the aforementioned studies physicians stated that fatigue had a negative influence on their physical health (18, 78).

2.8 Effects of sleep deprivation on anaesthetists

When assessing the effects of sleep deprivation on anaesthetists specifically, there are some pertinent points. Vigilance or sustained attention is an important skill for the anaesthetist when compared to other skills affected by sleep deprivation (48). “Anaesthetists are by no means exempt form the effects of fatigue, and by the nature of their work (vigilance-based), may in fact be more susceptible.” (79)

As noted in the literature, it has been found that speed of performance deteriorates with fatigue. This is termed the “”speed-accuracy trade-off” (20). The argument is that delayed responses to changes in monitors and alarms could potentially harm patients (48).

2.8.1 Neurocognitive tests

As in other medical specialities, various cognitive testing has been conducted with sleep deprived anaesthetists. Bartel et al (80) used reaction time testing in 33 anaesthetists. Four types of reaction time tasks were used. Baseline tests were conducted before the start of a call. These results were compared to those from tests conducted at the end of a 24-hour call. Statistically significant results showed reaction time was prolonged in all four tests and accuracy was affected in the two more complex tests. (80)

A study by Griffiths et al (24) looked at influences of chronic sleep deprivation and investigated cognitive functioning using a CogState program in participants exposed to seven consecutive night shifts compared to participants exposed to seven consecutive day shifts. Significant results included reduced performance in the night shift group and at the end of the seven days speed of reaction time had dropped. Some data was not significant because of near-perfect results, but it was noted that in tasks requiring speed of performance of tasks such as detection time, and identification time performance was affected. (24)

A larger study with 48 participants (trainees and specialists) in New Zealand found similar results using specific PVT, with performance being worse post night shift when compared to post day shift in 28 anaesthetic trainees. It was noted that performance was also dependent on circadian rhythm. (25)

Saadat et al (81) recently conducted a study with 22 paediatric anaesthesiologists and assessed the effects of sleep deprivation on mood and simple cognition. Participants were tested between 07:00 and 08:00 on a normal working day and after a 17-hour night call. When comparing results from cognitive tests and mood scores results demonstrated significantly higher scores in the fatigue, anger, jittery, irritable and sleepy categories and significantly lower scores in the vigour, total mood, energetic, confident and talkative scores. They then suggested the link between the negative affect on mood and simple cognitive scores with decreased work ability.

2.8.2 Psychomotor performance

Only one study on psychomotor performance on sleep deprived anaesthetists could be identified. This study by Hayter et al (82) assessed the performance of 29 sleep deprived anaesthetists with respect to epidural catheter placement and found no significant difference between the participants when they were sleep deprived and when rested.

2.8.3 Clinical performance

A ten-year Australian survey by Morris and Morris (79) analysed fatigue related anaesthetic incidents. They found common fatigue related errors to involve machine checking and pharmacological errors. It should be noted, however, that similar types of errors were reported to be unrelated to fatigue. It can be concluded that it was difficult to prove that errors in the workplace were directly related to fatigue and only a 2.7% contributory link was made. It should also be noted that errors reported as fatigue negative may not have been truly unrelated to fatigue. Confounding factors such as underreporting could have occurred. The study did serve to highlight the possible influence of fatigue on the anaesthetist.

In the same year Gander et al (83) published a New Zealand survey that found that 86% of respondents reported fatigue related errors in their careers. Yet again it is important to remember that this result is dependent on reporting by participants and many confounders were possible.

Howard et al (7) used a simulated anaesthetic case to compare participants after a period of 25 hours complete sleep deprivation to when they were rested. This data was collected together with other tests. Findings showed significance. The memory testing and PVT showed worse results in the sleep deprived group. In the sleep deprived group, one third fell asleep during the simulation, however no significant impact on clinical tasks was noted. The authors stated "… anaesthesiologist who is asleep and perceptually unaware of the environment only rarely cause a negative patient outcome…" It should be noted that the study only had11 participants in the sample group.

2.8.4 Motor vehicle accidents

The Association of Anaesthetists of Great Britain and Ireland state the concern for doctors driving when fatigued, as it is a cause for motor vehicle accidents (32).

Although there has been no equivalent survey amongst anaesthetists to Barger et al (22), a pilot study conducted by Murray and Dodds (23) on 11 consultant and training anaesthetists assessed steering error on a simulated task. Participants were divided into groups who had disturbed and undisturbed sleep. Comparisons between pre and post call performance were made. The timing of the testing coincided with circadian patterns. In the undisturbed group there were decreased steering errors in the post-call testing. The authors rationalised this result through the influence of circadian rhythm, which would lead to improved performance after a call, in the early hours of the morning. In the sleep disturbed group there was no difference between the pre and post call results. The speculated reasoning for this was that the participants had been sleep deprived to the extent whereby performance would not be influenced by circadian patterns.

2.8.5 Effects on personal life and general well-being

In the simulator study by Howard et al (7) a POMS was included. Results were statistically significant and showed an increase in total scores in the sleep deprived group. Specific mood changes included tension, confusion and anger.

As previously stated Saadat et al (81) found an increase in tension, anger, irritability, and a total mood disturbance score in sleep deprived paediatric anaesthetists.

2.9 Strategies to reduce the influence of sleep deprivation

With the acknowledgement of the effect of sleep deprivation on clinical performance, studies have subsequently investigated the influence of pharmacologic stimulants. Caffeine is a stimulating substance which reduces sleep time, improves attention, reaction time and memory (84). A report by Rodseth and Biccard (85) recommend the use of 150 mg of caffeine and a 15 minute nap at the end of a shift to reduce driving incidents.

Modafinil has been investigated and is used in patients with sleep disorders to support wakefulness. It has been shown to improve attention, reduce the effects of sleepiness and more importantly reduced the risk of motor-vehicle accidents in people with shift-work sleep disorder. The potential use of this drug has yet to be explored thoroughly within the medical field. It can be assumed that various ethical and other questions would need to be addressed. (26-28)

Basic strategies to reduce effects of sleep loss include maintaining hydration and eating regularly to avoid hunger and hypoglycaemia and avoiding alcohol before a shift. The provision of good lighting at work and light therapy has an influence on wakefulness and manipulating the control of the circadian rhythm. (31, 32)

In addition, the benefit of naps, as in the aviation industry, cannot be disregarded. Day sleeps before a call are recommended and naps of at least 40 minutes are recommended if fatigued at work, and before driving home. (20, 31, 32, 85)

A document giving advice to junior doctors on how to manage the effects of working night shift was published in Clinical Medicine in 2006 (30), following the implementation of the European Working Time Directive in the UK. The authors discuss preparation for a night shift focussing on sleep and the concept of sleep debt as well as the effects of the circadian rhythm. They continue to suggest strategies for maintaining wakefulness during the night shift and further strategies on sleep after the night shift.

2.10 Guidelines

The Joint Commission on Accreditation of Healthcare Organisations (86) acknowledges the link between fatigue and adverse events and makes various recommendations including the assessment of risks due to fatigue, reviews of working hours, known strategies such as caffeine use and regular work breaks in appropriate facilities.

Specific guidelines have been drawn up with respect to anaesthetists. The Association of Anaesthetists of Great Britain and Ireland (32) acknowledges the effects of sleep deprivation and quotes the European Commission's Working Time Directive which stipulates:

- " 11 hours rest in every 24 hours
- minimum 24 hours rest in every 7 days or minimum 48 hours rest in every 14 days
- maximum of 58 hours per week"

The association then makes some recommendations to minimise effects of sleep deprivation in the workplace. These include: education on sleep hygiene; work routines and regular checks; nap taking; consumption of caffeine and snacks; bright lights; physical activity and social interactions. They do not recommend the use of pharmaceutical substances to promote wakefulness.

The Australian and New Zealand College of Anaesthetists (29) stipulate responsibilities of the anaesthetist to ensure fatigue has a minimal impact on clinical practise. They do not recommend the use of caffeine and stimulants, but rather organisation of work schedules, rest periods and leave to counteract effects of fatigue.

The SASA (20) acknowledges the effects of fatigue in the work place. These include "…reduced attention and vigilance… decision making… prolonged reaction time… errors of omission, compromised problem solving…" with increased risk of critical incidents. They also acknowledge the psychological influences of sleep deprivation on the practitioner as well as the risks of driving a motor vehicle when sleep deprived.

It is noted that financial compensation is made for the additional hours worked by anaesthetists, within the employment contract. However this cannot compensate for the risks to patient and practitioner. SASA recommends additional personnel and reduced work hours to the individual. These, together with aforementioned strategies to prevent fatigue, are assumed to reduce the risks associated with sleep deprivation. (20)

2.11 Summary

In this chapter the literature review was presented. The following topics were discussed: sleep physiology and the various physiological effects of sleep deprivation; effects of sleep deprivation on the general population, workers in the aviation industry, doctors and specifically anaesthetists; modalities used in the literature to reduce the effects of sleep deprivation and international and South African guidelines on work hours. The next chapter will cover research design and methodology.

CHAPTER THREE
RESEARCH METHODLOGY

3.1 Introduction

This chapter will discuss the problem statement, aim and objectives of the study, ethical considerations, research methodology as well as the validity and reliability of the study.

3.2 Problem statement

It is known that sleep loss has negative sequelae on physical and psychological wellbeing, as well as, neurocognitive function (3-5). The detrimental effects of both chronic sleep deprivation and the direct influence of total sleep loss during night calls on doctors are also evident in the literature (18, 21, 34-36).

Within the Department of Anaesthesiology at the University of the Witwatersrand (Wits), anaesthetists are exposed to prolonged working hours and night calls. It is acknowledged that night calls are inevitable, with the average shift duration of 17 hours. With this knowledge and the potential harmful effects on both doctors and patients, the perceptions and effects of sleep deprivation needed to be assessed within this department.

3.3 Aim and objectives

3.3.1 Aim

The aim of this study was to describe the perceptions and effects of sleep deprivation in anaesthetists in the Department of Anaesthesiology at Wits.

3.3.2 Objectives

The objectives of this study were to:

- document longest time spent without sleep due to work schedule
- describe the perceptions of sleep insufficiency in anaesthetists

- describe the perceptions of the effects of sleep deprivation on the work and social life of anaesthetists
- describe the degree of sleepiness and daytime fatigue symptoms through the use of the ESS
- describe measures taken by anaesthetists to overcome sleepiness.

3.4 Ethical considerations

Approval to conduct this study was obtained from the Post Graduate Committee of Wits. (Appendix One) and the Human Research Ethics Committee (Medical). (Appendix Two)

An anonymous self-administered questionnaire was used in the study. The researcher invited anaesthetists to take part in the study, and then an information sheet (Appendix Three) was provided to those who were interested. The questionnaire was voluntary and consent was implied by completion of the questionnaire.

Confidentiality was ensured, as only the researcher and supervisors had access to the raw data. There was no identifying information on the questionnaire thereby ensuring anonymity.

Sleep deprivation may be detrimental to patient care and the safely and wellbeing of anaesthetists. The results were communicated to the Head of Department and the Wellness Committee. Data will be stored securely for six years after completion of the study.

The study was conducted in accordance with the Declaration of Helsinki (39) and the South African Good Clinical Practice Guidelines (40).

3.5 Methodology

3.5.1 Research design

A research design is a framework for the conduction of a study, and helps the researcher to plan a study that will allow for the best way to answer the research question (87). A prospective, contextual, descriptive research design was followed in this study.

A prospective study involves the collection of data at the start of the study and then measures the effect from the data collected (88). This study was prospective as data was collected at the time the study took place.

A contextual study involves research conducted within a specific population group (89). This study was contextual because it was conducted on anaesthetists working in the Department of Anaesthesiology at Wits.

A descriptive study design involves the analysis of variables, with the intention of answering the problem, without necessarily finding a direct link between cause and effect (88). This study was descriptive because it provided more information on the perceptions and effects of sleep deprivation on anaesthetists.

3.5.2 Study population

The study population consisted of anaesthetists working in the Department of Anaesthesiology.

3.5.3 Study sample

Sample method

In this study a convenience sampling method was used. Convenience sampling encompasses the use of participants who are easily accessible to the researcher (90). The sample group for this study comprised of anaesthetists in the Department of Anaesthesiology, where the researcher works.

Sample size

At the time of the study it was known that there were 164 eligible anaesthetists for the study. At the time of data collection it was calculated that approximately 33 (20%) anaesthetists would be inaccessible due to leave, out of town rotations etc. Out of the 131 available anaesthetists, a response rate of 79 (60%) anaesthetists was deemed an appropriate sample size, however 105 (80%) of the population was targeted.

Inclusion and exclusion criteria

The inclusion criteria for this study were:

- all registrars and medical officers working in the department
- interns who were rotating through the department.

The exclusion criteria in this study were:

- consultants within the department
- blank questionnaires were excluded from the data analysis, but used to calculate the response rate.

3.5.4 Collection of data

Questionnaire

It was decided to use a questionnaire to collect data. Although neurocognitive testing is mentioned in the literature, it was decided it would be too expensive and beyond the scope of this study. Furthermore, neurocognitive testing would not provide information on the perceptions and subjective effects of sleep deprivation amongst anaesthetists which is what this study aimed to investigate. A questionnaire allows for objective and subjective data collection such as beliefs and opinions of the participants. Questionnaires also allow for data collection among a large sample group (87).

Following an extensive literature review, numerous questionnaires on the effects of sleep deprivation were found. A sleep questionnaire published by Kim et al (9)

(Appendix Four) and the validated ESS (37) (Appendix Five) were deemed the most appropriate in addressing the aim of this study. Permission to use the sleep questionnaire by Kim et al (9) was granted by the author (Appendix Six). The ESS is freely available on the Internet and permission to use the ESS was not obtained.

A draft questionnaire (Appendix Seven) was drawn up and adapted to the South African vernacular, using questions from Kim et al (9). Five additional questions were added to the questionnaire regarding percutaneous injury, motor vehicle accidents, and more detail on strategies to reduce sleepiness. Two experts in anaesthesiology and a sleep expert reviewed the questionnaire, ensuring face validity. Minor changes were made following further suggestions on more detailed explanations for some scenarios. The ESS was used unchanged.

The questionnaire presented to anaesthetists had three parts. The first part included the following demographic data:

- gender
- age group
- professional designation
- current hospital in which the participant is rotating.

The second part was the adapted questionnaire by Kim et al (9) with 21 questions which addressed:

- perceptions of sleep adequacy
- perceptions of the effects of sleep deprivation on work and social life
- measures taken to overcome sleepiness.

The third part was the ESS (37), which is a four point scale that assesses the likelihood of dozing off in eight different situations in order to assess daytime sleepiness. It has no specific time scale and refers to “recent times” which can imply weeks or months (37).

Data collection process

Data was collected at departmental academic meetings of the Department of Anaesthesiology. The conveners of the meetings were asked for permission to address the anaesthetists. The researcher explained the study and invited them to take part. The information letters and questionnaires were distributed to those interested. The researcher was present to answer questions pertaining to completion of the questionnaire. The anaesthetists had 15 minutes during the meeting to complete the questionnaire. The anaesthetists then placed the questionnaire, into a sealed collection box.

Data analysis

Using Microsoft Excel 2011®, data was captured onto spreadsheets. The statistical program, GraphPad InStat™, was used to analyse data. Descriptive statistics were used. Categorical variables were described using frequencies and percentages. ESS scores were assessed as interval data as ESS scores were initially presented as interval data in initial validation studies and subsequently in the literature. ESS total scores were normally distributed and the mean and standard deviation were used to describe the results.

3.6 Validity and reliability of the study

Validity has been defined by Botma et al (91) as the “degree to which a measurement represents a true value.” It may be defined as the accuracy of a measurement. There can be various threats to validity. These can occur within the study design or can be external factors.

Reliability explains the concept of reproducibility of a measurement (91).

The validity and reliability of this study were ensured through the use of:

- an appropriate study design
- a previously published questionnaire by Kim et al (9)
- the ESS (37), which is a validated tool
- a researcher available to answer questions pertaining to the questionnaire
- all questionnaires being placed anonymously into a sealed box, thereby facilitating a non-threatening environment

- checking every eighth entry onto the spreadsheet for accuracy.

3.7 Summary

This chapter discussed research methodology of the study. Chapter Four includes the presentation of results with a discussion.

CHAPTER FOUR
RESULTS AND DISCUSSION

4.1 Introduction

This chapter will present the results according to the objectives of the study, followed by a discussion of the results. The objectives of the study were to:

- document longest time spent without sleep due to work schedule
- describe the perceptions of sleep insufficiency in anaesthetists
- describe the perceptions of the effects of sleep deprivation on the work and social life of anaesthetists
- describe the degree of sleepiness and daytime fatigue symptoms through the use of the ESS
- describe measures taken by anaesthetists to overcome sleepiness.

4.2 Sample realisation

Data was collected at departmental meetings during October and November 2015. Of the 131 distributed questionnaires 107 (81.7%) were returned.

4.3 Results

Not all questions were answered by all anaesthetists and the number of anaesthetists who answered the question is indicated where appropriate. Percentages are rounded off to one decimal place.

4.3.1 Demographics

The demographics of the anaesthetists are presented in Table 4.1.

Table 4.1 Demographics of anaesthetists

Demographic	**Number (n)**	**Percentage (%)**
Gender		
Male	35	32.7
Female	72	67.3
Age group (years)		
20 to 25	7	6.5
26 to 30	47	43.9
31 to 35	46	43
36 to 40	5	4.7
41 to 45	0	0
Older than 45	2	1.9
Professional designation		
Intern	22	20.6
Medical officer	15	14
Registrar first year	13	12.1
Registrar second year	28	26.2
Registrar third year	15	14
Registrar fourth year	14	13.1
Current rotation		
CMJAH theatre	32	30
CHBAH theatre	37	34.6
HJH/RMMCH theatre	34	31.8
DGMC ICU	4	3.7

4.3.2 Objective: to document longest time spent without sleep due to work schedule

The longest time spent without sleep due to work schedule was 31 (SD 9.1) hours. Only 83 of the 107 anaesthetists answered this question.

4.3.3 Objective: to describe the perceptions of sleep insufficiency in anaesthetists

The majority, 36 (33.6%) anaesthetists reported somewhat insufficient sleep and only three (2.8%) anaesthetists felt their sleep was completely sufficient while 76 (71%) felt their sleep was insufficient to varying degrees. Table 4.2 illustrates the perceptions of general sleep sufficiency.

Table 4.2: Sleep sufficiency

Response	Number (n)	Percentage (%)
Completely sufficient	3	2.8
Fairly sufficient	28	26.2
Somewhat insufficient	36	33.6
Clearly insufficient	32	29.9
Highly insufficient	8	7.5

The perceptions of anaesthetists on how rested they felt on awakening are shown in Table 4.3. The majority, 62 (57.9%) anaesthetists indicated that they felt groggy on awakening and only 2 (1.8%) felt very well rested on awakening.

Table 4.3 Feeling on awakening

Response	Number (n)	Percentage (%)
Very well rested	2	1.9
Fairly well rested	21	19.6
Groggy	62	57.9
Very tired	15	14
Extremely tired	7	6.5

Perceptions regarding sleep insufficiency secondary to work schedule and frequency of difficulty in awakening in the morning are shown in Table 4.4. The majority, 61 (57%) anaesthetists perceived insufficient sleep due to work schedule 1 to 2 nights per week and no anaesthetist reported never having insufficient sleep due to work schedule. Thirty (28%) anaesthetists reported having difficulty in awakening 1 to 2 nights per week and another 30 (28%) anaesthetists reported having difficulty in awakening 3 to 4 nights per week.

Table 4.4: Insufficient sleep and difficulty in awakening

Response	Insufficient sleep due to work schedule n (%)	Difficulty in awakening in the morning n (%)
Never	0	3 (2.8)
1 to 2 nights per month	13 (12.1)	20 (18.7)
1 to 2 nights per week	61 (57)	30 (28)
3 to 4 nights per week	26 (24.3)	30 (28)
Almost always every day	7 (6.5)	24 (22.4)

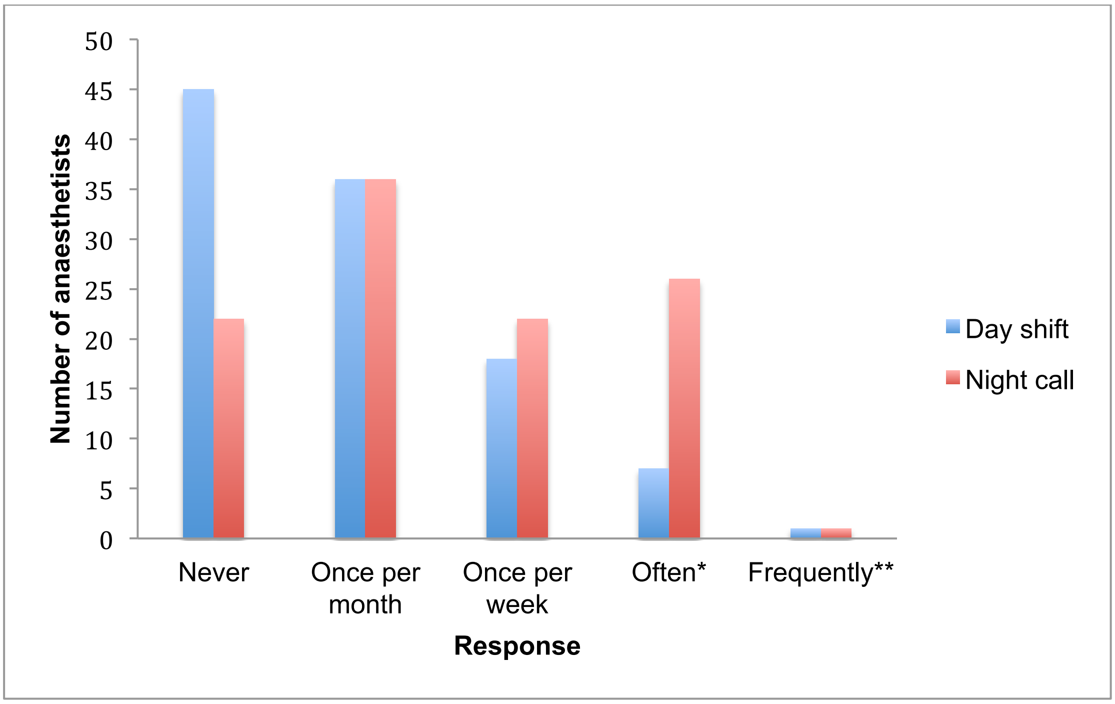
4.3.4 Objective: to describe the perceptions of the effects of sleep deprivation on the work and social life of anaesthetists

Feeling tired at work, difficulty in concentrating at work, effects of sleepiness on academic development and feeling stressed or irritable due to sleepiness is shown in Table 4.5. The majority of anaesthetists responded in the 1 to 2 days per week category for all four questions with 48 (44.9%) anaesthetists feeling tired at work, 42 (39.3%) anaesthetists having difficulty in concentrating at work, 46 (43%) anaesthetists noting effects of sleepiness on academic development and 47 (43.9%) anaesthetists feeling stressed or irritable.

Table 4.5 Sleep deprivation at work

Response	Tired at work n (%)	Difficulty in concentrating n (%)	Sleepiness on academic development n (%)	Stressed or irritable n (%)
Never	1 (0.9)	4 (3.7)	2 (1.9)	3 (2.8)
1 to 2 days per month	12 (11.2)	39 (36.4)	17 (15.9)	27 (25.2)
1 to 2 days per week	48 (44.9)	42 (39.3)	46 (43)	47 (43.9)
3 to 4 days per week	28 (26.2)	15 (14)	26 (24.3)	24 (22.4)
Almost always every day	18 (16.9)	7 (6.5)	16 (15)	6 (5.6)

The majority 45 (42%) anaesthetists never doze off during a day shift and 85 (79.4%) have dozed off in theatre on a night call with varying degrees of regularity. One (0.9%) anaesthetist indicated dozing off frequently on both day shift and during night call. Figure 4.1 illustrates how many anaesthetists will doze off during a day shift and night call.



Often*: More than once per week/ Almost every day
Frequently**: Almost every day/ More than once per night call

Figure 4.1 Dozing off in theatre during a day shift and night call

Effects of sleep deprivation on work are shown in Figure 4.2. Six (5.6%) anaesthetists had missed work due to sleep problems, while 71 (66.4%) had been late for work due to sleep problems. Fifty-two (48.6%) anaesthetists perceived that they had made a mistake at work due to sleepiness and 74 (69.2%) anaesthetists stated that they believed they had made a mistake at work unrelated to sleepiness.

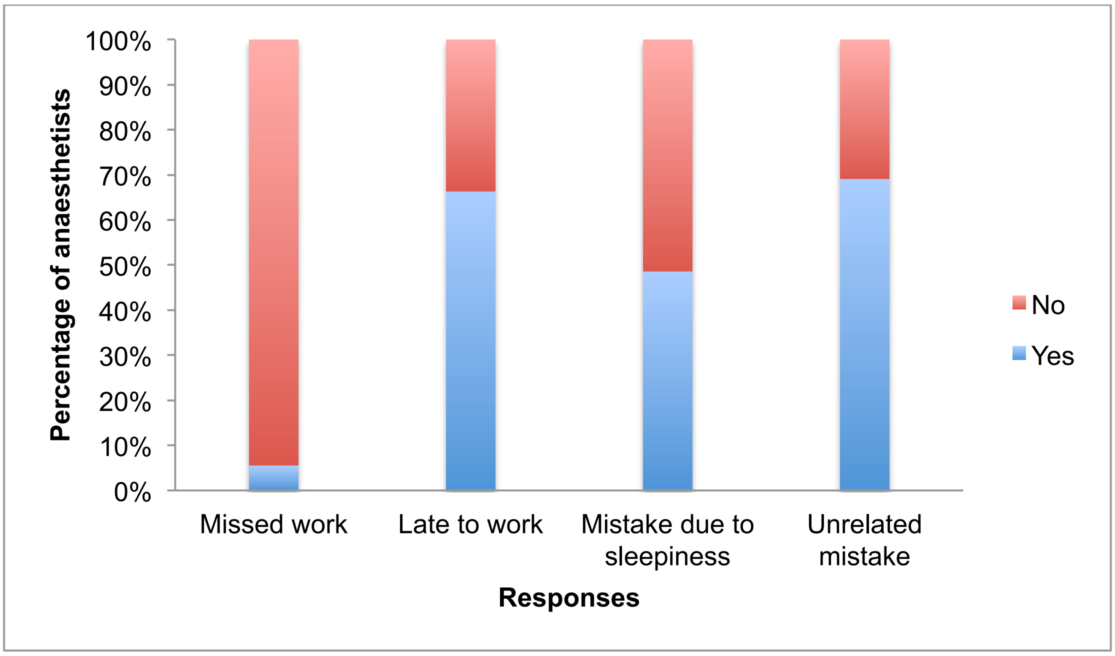


Figure 4.2 Effects of sleep deprivation on work

The majority, 99 (92.5%) anaesthetists have missed social and family activities because of sleepiness. Forty-four (41.1%) anaesthetists have had a percutaneous injury on duty due to sleepiness and 101 (94.4%) anaesthetists have felt at risk of having a motor vehicle accident because of sleepiness.

4.3.5 Objective: to describe the degree of sleepiness and daytime fatigue symptoms through the use of the ESS

ESS scores were presented as interval data in initial validation studies and subsequently in the literature. Therefore, ESS results are presented as interval data for this study. The mean ESS score was 11.5 (SD 4.4). The scores are presented in Table 4.6. One anaesthetist did not complete the ESS.

Table 4.6 Total ESS scores

Score	Number (n)	Percentage (%)
0-10 (normal)	46	43.4
11-14 (mild sleepiness)	32	30.2
15-17 (moderate sleepiness)	19	17.9
18 or higher (severe sleepiness)	9	8.5

Table 4.7 presents the ESS scenario scores. The data was not normally distributed, therefore both the mean (SD) and median for each scenario are presented, however due to the narrow range of the scenario score no interquartile range is reported. Lying down in the afternoon had the highest mean and median score and 59 (55.7%) anaesthetists reported a high chance of dozing, where as sitting and talking to someone had the lowest score with 73 (68.9%) anaesthetists reported they would never doze.

Table 4.7 ESS scenario scores

Scenarios	**Mean (SD)**	**Median**	**Chance of dozing**			
			Never n (%)	**Slight n (%)**	**Moderate n (%)**	**High n (%)**
Sitting and reading	2 (0.9)	2	7 (6.6)	18 (17)	51 (48.1)	30 (28.3)
Watching TV	1.9 (0.8)	2	5 (4.7)	30 (28.3)	44 (41.5)	27 (25.5)
Sitting inactive in a public place	1.3 (0.9)	1	23 (21.7)	41 (38.7)	33 (31.1)	9 (8.5)
Being a passenger in a car for an hour	1.7 (1.1)	2	15 (14.2)	34 (32.1)	22 (20.8)	35 (33)
Lying down in the afternoon	2.4 (0.7)	3	2 (1.9)	9 (8.5)	36 (34)	59 (55.7)
Sitting and talking to someone	0.3 (0.5)	0	73 (68.9)	30 (28.3)	3 (2.8)	0
Sitting quietly after lunch (no alcohol)	1.2 (0.9)	1	2 (1.9)	46 (43.4)	29 (27.4)	29 (27.4)
Stopping for a few minutes in traffic while driving	0.9 (0.9)	1	48 (45.3)	40 (37.7)	12 (11.3)	6 (5.7)

4.3.6 Objective: to describe measures taken by anaesthetists to overcome sleepiness

The majority, 32 (29.9%) anaesthetists drink caffeinated beverages 1 to 2 times per day. Table 4.8 illustrates the use of caffeinated beverages during the day by anaesthetists.

Table 4.8 Daytime frequency of caffeinated beverage consumption

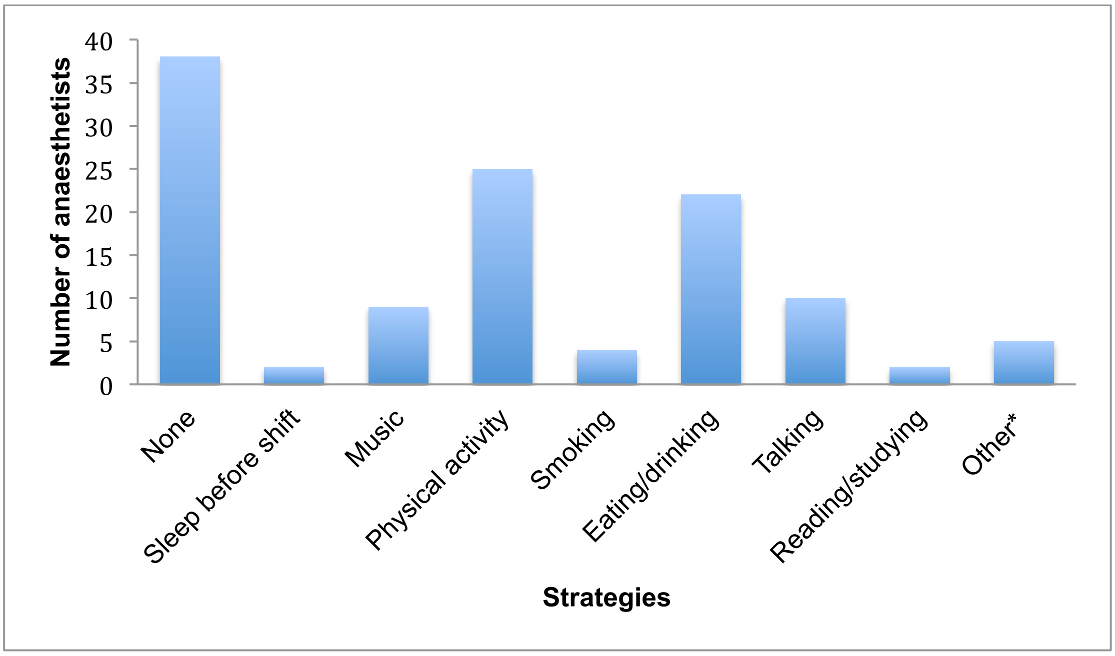
Response	Number (n)	Percentage (%)
Never	20	18.7
Once a day	21	19.6
1 to 2 times per day	32	29.9
3 to 4 times per day	25	23.4
More than 4 times per day	9	8.4

During a night call, the majority, 80 (74.8%) anaesthetists reported having no filter coffee, 55 (51.4%) anaesthetists reported having no instant coffee and 88 (88.2%) reported having no Ceylon tea. The number of units of caffeinated beverages of caffeinated drinks during a night call are shown in Table 4.9.

Table 4.9: Number of units of caffeinated drinks consumed during a night call

Units	Filter coffee n (%)	Instant coffee n (%)	Ceylon tea n (%)	Herbal tea n (%)	Cold drink n (%)	Energy drink n (%)
0 units	80 (74.8)	55 (51.4)	88 (82.2)	96 (89.7)	68 (63.6)	91 (85)
1 to 2 units	19 (17.8)	42 (39.2)	14 (13.1)	10 (9.3)	38 (35.5)	16 (15)
3 to 4 units	4 (3.7)	9 (8.4)	5 (4.7)	1 (0.9)	1 (0.9)	0
> 4 units	4 (3.7)	1 (0.9)	0	0	0	0

The strategies to resist sleepiness are presented in Figure 4.4. Two anaesthetists left this question blank while 13 (12.1%) anaesthetists responded with more than one strategy therefore the numbers shown are more than the number of anaesthetists in the study. The majority of anaesthetists used no strategies to resist sleepiness.



Other*: games, social media, cleaning etc

Figure 4.3 Strategies used to resist sleepiness

4.4 Discussion

One hundred and seven anaesthetists took part in the study of which 93 (86.9%) were between the ages of 26 and 35 years and 70 (65.5%) were registrars.

Sleep deprivation and the effects thereof are well described in the literature, however no South African study on the effects of sleep deprivation on anaesthetists could be identified. Despite the extensive research on sleep deprivation amongst health care workers, it is important to note that a wide variety of methods were used to describe the phenomena. Where standardised scales or questionnaires where used the results were not always reported in a standardised manner. This makes direct comparison with the literature difficult.

In my study a questionnaire by Kim et al (9), was used. The authors reported their Likert scale data as mean and standard deviations, in my study my data was not normally distributed and I chose to follow the more puristic approach (92) and reported the Likert scale data as ordinal data. The ESS data in my study is reported as stipulated by the original authors of the ESS Scale (37) that is as interval level data.

SASA guidelines (20) suggest that a work period in excess of 24 hours should be condemned. Working hours do vary from approximately 12 to 28 hours between hospitals and departments within the Department of Anaesthesiology at Wits. Kim et al (9) reported a mean work duration of 14.9 (SD 2.7) hours per day. Gander et al (83) conducted a national survey of work hours and other perceptions of safe working hour limits amongst anaesthetists. They reported mean continuous work hours of 18.6 (SD 6.86) for training anaesthetists and 20.5 (SD 4.96) for specialist anaesthetists.

The average longest length of time anaesthetists had gone without sleep due to work schedule was 31 (SD 9.1) hours. It is presumed that anaesthetists may be awake for some time before and after their work period and therefore the cumulative time spent awake could amount to an average of 31 (SD 9.1) hours. Additional hours spent awake may involve meetings or academic tutorials and include travel time and other family or social activities. The longest length of time participants had gone without sleep due to work schedule in the study by Kim et al (9) was a mean of 38.5 (SD 15.7) hours. The mean work duration from the study by Kim et al (9) is shorter than those in our department, however the longest mean length of time without sleep due to work schedule is much longer than the mean from my study. The authors suggest frequent calls with resulting sleep fragmentation as a reason for their long hours of wakefulness.

Only 3 (2.8%) anaesthetists felt their sleep was completely sufficient and 28 (26.2%) felt their sleep was fairly sufficient, while 76 (71%) felt their sleep was insufficient to varying degrees. The three different groups (non, moderately and severely sleep deprived) in Kim et al (9) study indicated that they experienced insufficient sleep, especially the severely sleep deprived group. The groups scored means of 3.4 to 4.3 on a five point Likert Scale with no statistically significant difference between groups.

Results from my study showed that 61 (57%) anaesthetists perceived insufficient sleep due to work schedule 1 to 2 nights per week and no anaesthetist reported never having insufficient sleep due to work schedule. It can be suggested that this frequency of insufficient sleep is because anaesthetists experience night calls 1 to 2 nights per week. However, this sleep deprivation perceived by anaesthetists could not only be from acute shift work but also from long standing chronic sleep loss. Kim et al (9) reported mean scores that indicated a frequency of sleep deprivation 3 to 4 times per week in the severely sleep deprived group, 1 to 2 times per week in the moderately sleep deprived group and 1 to 2 times per month in the non sleep deprived group.

The majority, 84 (78.5%) anaesthetists in my study had difficulty in awakening from 1 to 2 nights per week to almost everyday. Kim et al (9) showed similar results with mean scores ranging form 3.2 (SD 1.19) in the non-SD group to 4.3 (SD 0.65) in the S-SD group (9).

A consistency in the perceptions of the effects of sleep deprivation at work was noted on the 1 to 2 times per week category. More specifically, 48 (44.9%) anaesthetists felt tired at work; 42 (39.3%) had felt difficulty in concentrating at work; 46 (44%) felt sleepiness effected academic development and 47 (43.9%) felt stressed or irritable due to sleepiness 1 to 2 times per week. It can be assumed that anaesthetists will be on night duty 1 to 2 times per week. This could suggest a direct link between night calls and the effects of sleep deprivation in the work place. This is re-enforced by the majority, 61 (57%) anaesthetists responding that they had insufficient sleep due to work schedule 1 to 2 times per week. Kim et al (9) stated that “severe sleep deprivation was related with more stress and difficulty in learning and concentration.”

Of the anaesthetists in my study, 45 (42.1%) reported never having dozed off during a day shift, but 62 (57.9%) have dozed off in theatre during the day. Eighty-five (79.4%) anaesthetists have dozed off in theatre on a night call with varying degrees of regularity. One anaesthetist stated that he/she would doze off almost every day and more than once per night call. In the simulation study by Howard et al (7) one third (four out of a group of 12) of the sleep deprived participants fell asleep during the simulation shifts, which is lower than my study.

Only 6 (5.6%) anaesthetists had missed work yet 71 (66.4%) had been late to work due to sleep problems. Kim et al (9) reported a higher rate with 37.9% of the participants admitting to missing work and a similar 60.3% of the participants admitted to lateness because of sleep problems.

In my study almost half, 52 (48.6%) anaesthetists admitted to making a sleepiness related mistake and 74 (69.2%) anaesthetists admitted to making a mistake at work unrelated to sleepiness. Kim et al (9) stated a higher 60.3% of the participants admitted to making a sleepiness related mistake and a similar 67.2% making a non-sleepiness-related mistake. Both studies illustrated making mistakes unrelated to sleepiness is more common than mistakes related to sleepiness. One could argue that anaesthetists felt mistakes are multifactorial and can occur regardless of fatigue status. This is supported by the findings of Morris and Morris (79), who documented other factors such as haste, distraction, other stress and equipment issues could be linked to errors, but showed that fatigue may play a more significant role for specific errors such as pharmacological errors. However a large ICU study by Landrigan et al (75) found that interns made 35.9% more errors when following the traditional work program as opposed to an interventional program allowing for more rest indicating more errors are made when less rested.

Forty-four (41.1%) anaesthetists from my study reported a percutaneous injury secondary to sleepiness. It can be argued that the cause of a percutaneous injury is also perceived as multifactorial. A survey published by Ayas et al (19) showed that 31% of interns linked fatigue to percutaneous injuries. However these authors also made other links such as lapse in concentration, inadequate lighting and patient movement, supporting the theory that multiple factors may lead to percutaneous injuries.

A perception of risk with regards to driving while sleep deprived was found, with 101 (94.4%) anaesthetists reporting that they felt at risk of having an accident because of sleepiness. Papp et al (18) reported 19 out of 22 focus groups discussed impairment in driving ability due to sleep deprivation indicating similar perception of risk of an accident. These perceptions are supported by Barger et al (22) who published results from a national survey on the risk of motor vehicle accidents. Their findings included an increase of 9.1% in the monthly rate of accidents and an increase of 16.2% for the monthly rate of accidents related to the commute from work, with every extended shift worked.

With regards to effects of sleep deprivation on social life, my study showed that 99 (92.6%) anaesthetists had missed social or family activities because of sleepiness. Kim et al (9) reported a much lower rate of 43 % in their study.

The ESS (37) was used to assess the level of sleepiness of anaesthetists. My study demonstrated a mean score of 11.5 (SD 4.4) which falls into the mild sleepiness category according to the Division of Sleep Medicine at Harvard Medical School (38). It is much higher than the mean score of normal adults of 4.6 (SD 2.8) suggested by the ESS authors (37), however lower than the mean score of 14.6 (SD 4.4) reported by Papp et al (18). More specifically, scores for each scenario from my study, were all lower than the scores reported by Papp et al (18), while following a similar pattern of sleepiness between the scenarios.

On the ESS, results from my study showed 32 (30.2%) anaesthetists fell into the mild, 19 (17.9%), into the moderate and 9 (8.5%) into the severe sleepiness category. Only 46 (43%) anaesthetists were classified as normal or not sleepy. Papp et al (18) used slightly different scores for the ESS (0 – 5 = desirable, 6 – 10 = mild sleepiness, 11 – 15 = moderate sleepiness, and 16 – 24 = severe sleepiness). The authors demonstrated a higher sleepiness level with only 2 (1%) residents in the desirable range, 22 (15%) in the mild sleepiness range and 61 (41 %) in the moderate sleepiness range and 64 (43%) in the severe sleepiness range. It has to be noted that their study did not include any anaesthetists. The lower reported ESS results in this study may be that doctors have, to some degree, become used to a lack of sleep as conditions in the South African healthcare systems require them to work long hours from internship level.

My study assessed the use of caffeine by anaesthetists and found that 32 (29.9%) anaesthetists drink caffeinated beverages 1 to 2 times per day. Kim et al (9) reported mean scores between 1.3 (SD 0.9) and 1.9 (SD 1.1) which showed that their participants seldom drank caffeinated beverages. Although few anaesthetists reported drinking caffeinated beverages during a night call, results from my study demonstrated that instant and filter coffee are the preferred beverages on a night call. It is known that each hospital facility has readily available tea and coffee.

Regarding strategies to reduce sleepiness, 13 (12.1%) anaesthetists reported more than one strategy. Only 2 (1.9%) anaesthetists sleep before a shift and 22 (21%) reported the use of eating and drinking. Other strategies suggested in the guidelines (31) to reduce sleepiness such as napping and bright light were not mentioned by anaesthetists in my study. It was noted that no anaesthetist reported the use of medication or other substances, however this could be because it is a socially unacceptable answer.

4.5 Summary

This chapter comprised the results and discussion. In the final chapter a summary of the study is presented together with limitations, recommendations and conclusion of the study.

CHAPTER FIVE
SUMMARY, LIMITATIONS, RECOMMENDATIONS AND CONCLUSION

5.1 Introduction

The summary, limitations, recommendations and conclusion of the study will be presented.

5.2 Summary of the study

5.2.1 Aim

The aim of this study was to describe the perceptions and effects of sleep deprivation in anaesthetists in the Department of Anaesthesiology at Wits.

5.2.2 Objectives

The objectives of this study were to:

- document longest time spent without sleep due to work schedule
- describe the perceptions of sleep insufficiency in anaesthetists
- describe the perceptions of the effects of sleep deprivation on the work and social life of anaesthetists
- describe the degree of sleepiness and daytime fatigue symptoms through the use of the ESS
- describe measures taken by anaesthetists to overcome sleepiness.

5.2.3 Summary of methodology

A prospective, contextual, descriptive research design was followed in this study. The study population consisted of anaesthetists working in the Department of Anaesthesiology and convenience sampling was used.

A questionnaire was drafted using a sleep questionnaire published by Kim et al (9) and the ESS (37). Data was collected at departmental academic meetings. The anaesthetists had 15 minutes during the meeting to complete the questionnaire, which was then placed into a sealed collection box.

Data was captured on Microsoft Excel 2011® spreadsheets. Descriptive statistics were used to analyse the data.

5.2.4 Summary of results

All anaesthetists stated that they had insufficient sleep due to work schedule to varying degrees. The mean score of the longest number of hours spent awake due to work schedule was 31 (SD 9.1) hours.

The mean ESS score was 11.5 (SD 4.4), which is classified as mildly sleepy. Nine (8.5%) anaesthetists were classified as severely sleepy while 46 (43.4%) anaesthetists were classified as normal.

Sixty-two (57.9%) anaesthetists have dozed off in theatre during the day, and 85 (79.4%) have dozed off in theatre during the night at least once per month.

Forty-eight (44.9%) anaesthetists felt tired at work 1 to 2 days per week; 42 (39.3) felt difficulty in concentrating at work 1 to 2 days per week; 46 (44%) felt sleepiness effected academic development and 47 (43.9%) felt stressed or irritable due to sleepiness 1 to 2 times per week.

With regards to mistakes at work: 52 (48.6%) reported mistakes due to sleepiness, while 74 (69.2) reported mistakes made at work, unrelated to sleepiness. Forty-four (41.1%) anaesthetists reported a percutaneous injury due to sleep deprivation. A strong link was made between the risk of motor vehicle accidents and sleep deprivation with 101 (94.4%) anaesthetists stating that they perceived a risk of having a motor vehicle accident, because of sleepiness, when driving home from work.

Strategies to reduce sleepiness were discussed including the use of caffeinated beverages. Most anaesthetists consume at least one caffeinated beverage per day and instant and filter coffee are the preferred beverages on a night call.

5.3 Limitations of the study

Certain limitations were evident when conducting this study. The study was contextual and limited to a certain population. Results obtained were only relevant to interns, medical officers and registrars working in the Department of Anaesthesiology at Wits and may therefore not be applicable to other anaesthetic departments. The anaesthetists were asked to report on their experience overall. However, their subjective response may be influenced by their most recent experience. For example, had an anaesthetist been on call the previous day, they might report higher levels of sleepiness than an anaesthetist who may have just come back from leave.

The study aimed to describe the perceptions of anaesthetists but it is important to be aware that perceptions may not reflect reality.

5.4 Recommendations from the study

5.4.1 Recommendations for clinical practice

It is acknowledged that "night calls" and shift work is inevitable for anaesthetists. SASA (20) has also made a recommendation on specified working hours for anaesthetists. Various strategies could also be put in place to reduce the effects of sleep deprivation in the department.

These strategies could include the following.

- A specific departmental guideline with strategies on how to prepare for night shift work, promote wakefulness while at work and ensure adequate rest after night work is suggested. A document similar to that of Horrocks et al (30) would be suggested.

- The provision of nap times during a night call. The literature has stated a time of 20 to 45 minutes is recommended for napping (30, 31, 58). A suggestion of a compulsory break of this duration during a night call could be made.

- The provision of resting facilities for anaesthetists before they drive home, with the intention of reducing the risk of motor vehicle accidents.

5.4.2 Recommendation for further research

Should the above recommendations for clinical practice and strategies to reduce the effects of sleep deprivation be introduced, follow-up studies could evaluate the effectiveness of these strategies.

A national study on the effects of sleep deprivation on anaesthetists is recommended.

Further research on factors leading to, and consequences of, percutaneous injuries at work is recommended.

5.5 Conclusion

Anaesthetists reported perceptions of inadequate sleep and the subsequent effects. The mean score from the ESS indicated a mild sleepiness level. Few anaesthetists used strategies to reduce the effects of sleep deprivation.

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APPENDIX ONE

APPROVAL FROM POSTGRADUATE COMMITTEE

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Dr MA Sanders 55 Edward Ave Sandringham 2192

South Africa

Dear Dr Sanders

Master of Medicine: Approval of Title

Private Bag 3 Wits, 2050 Fax: 027117172119 Tel: 02711 7172076

Reference: Ms Thokozile Nhlapo E-mail: thokozile.nhlapo@wits.ac.za

09 February 2015 Person No: 1022582 PAG

We have pleasure in advising that your proposal entitled *The perceptions and effects of sleep deprivation in Anaesthetists* has been approved. Please note that any amendments to this title have to be endorsed by the Faculty's higher degrees committee and formally approved.

Yours sincerely

Mrs Sandra BennFaculty RegistrarFaculty of Health Sciences

APPENDIX TWO
APPROVAL FROM ETHICS COMMITTEE

R14/49 Dr Megan Adel Sanders

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M150106

NAME: **(Principal Investigator)**	Dr Megan Adel Sanders
DEPARTMENT:	Anaesthesiology Charlotte Maxeke Johannesburg Academic Hospital
PROJECT TITLE:	The Perceptions and Effects of Sleep Deprivation in Anaesthestists
DATE CONSIDERED:	30/01/2015
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Helen Perrie et al
APPROVED BY:	Professor P Cleaton-Jones, Chairperson, HREC (Medical)
DATE OF APPROVAL:	02/03/2015

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Secretary in Room 10004, 10th floor, Senate House, University.

I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. **I agree to submit a yearly progress report.**

Principal Investigator Signature ____________ Date ____________

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

APPENDIX THREE
INFORMATION SHEET

Dear Colleague

Hello, my name is Megan Sanders. I am a registrar in the Department of Anaesthesiology, and am currently busy with my MMed. I would like to invite you to participate in my research.

The aim of this study is to describe the influence of sleep deprivation on anaesthetists in the Department of Anaesthesiology of the University of the Witwatersrand. Results from this study may influence guidelines on anaesthetic working hours and thereby improve general well-being of anaesthetists.

Should you agree to participate in my study, I will ask you to complete a written questionnaire. This should take approximately 15 minutes to complete and your participation is voluntary. You will remain anonymous, as there is no identifying information requested on the questionnaire. Please place the questionnaire in a sealed collection box. Return of a completed questionnaire will imply consent.

Confidentiality will be ensured as only my supervisors and I will have access to completed questionnaires. Results of the study will be made available to you, if you so wish. I realise that you will not benefit directly from participation in this study. However, I hope that the results will help to provide insight into the effects of sleep deprivation and improve on current working hours and conditions.

This study has been approved by the Human Research Ethics Committee (Medical) (150106) and the Post Graduate Committee of the University of the Witwatersrand and your health care institution. Should you require more information, or wish to contact me regarding this study, my mobile number is: 0826642413 or the chair of the Human Research Ethics Committee (Medical) on 0117171234.

Thank you for taking the time to read this letter.

Yours Sincerely

Megan Sanders

APPENDIX FOUR

QUESTIONNAIRE FROM KIM ET AL

. **(1) Do you think your sleep is sufficient?**

(1. Completely sufficient, 2. Fairly sufficient, 3. Somewhat insufficient, 4. Clearly insufficient, 5. Highly insufficient)

. **(2) How well rested do you feel when you wake up?**

. 1. Very well, 2. Fairly well, 3. Groggy, 4. Very tired, 5. Extremely tired

. **(3) How often do you have insufficient sleep due to work schedule?**

. 1. Never, 2. 1-2 per month, 3. 1-2 per week, 4. 3-4 per week, 5. Almost always/every day

. **(4) What is the longest length of the time you have gone with- out sleep due to work schedule?**

. **(5) How often do you have difficulty in awakening in the morning?**

. **(6) How often do you feel tired during the day at work?**

. **(7) How often do you feel difficulty in concentration at work?**

. **(8) How often does sleepiness negatively affect your academic relations?**

. **(9) How often do you feel stressed as a result of lack of sleep?**

. **(10) How often do you drink caffeinated beverage to resist sleepiness during the day?**

. **(11) How often do you take a nap at work?**

. **(12) Have you missed work due to sleep problem over the previ ous month?** Yes/No

. **(13) Have you been late to work due to sleep problem over the previous month?** Yes/No

. **(14) Have you made a mistake due to sleepiness at work over the previous month?** Yes/No

. **(15) Have you made a mistake unrelated to sleepiness at work?** Yes/No

. **(16) Have you missed social or familial activities due to sleep problem over the previous month?** Yes/No

APPENDIX FIVE
EPWORTH SLEEPINESS SCALE

How likely are you to doze off or fall asleep in the following situations, in contrast to just feeling tired? This refers to your usual way of life in recent times. Even if you haven't done some of these things recently try to work out how they would have affected you. Use the following scale to choose the most appropriate number for each situation:

0	Would never doze
1	Slight chance of dozing
2	Moderate chance of dozing
3	High chance of dozing

Situation

Sitting and reading	
Watching TV	
Sitting inactive in a public place (e.g. theatre or meeting	
As a passenger in a car for an hour without a break	
Lying down to rest in the afternoon when circumstances permit	
Sitting and talking to someone	
Sitting quietly after lunch without alcohol	
In a car, while stopped for a few minutes in traffic	
Total	

APPENDIX SIX
APPROVAL LETTER

From: **Hyang Woon Lee** leeh@ewha.ac.kr
Subject: Re:Re: Sleep deprivation questionnaire
Date: 30 October 2014 at 1:16 PM
To: megan sanders nutmeg.m@gmail.com

HW

Dear Dr. Sanders,

Thanks for your interest on my research. Of course, I would be happy to help you.

Please feel free to ask any help. Just acknowledge that you adapted our questionnaires and refer my paper whenever you present your works.

Good luck, and all the best,

hw

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

Hyang Woon Lee, MD, PhD
Professor, Department of Neurology
Director, Epilepsy and Sleep Center
Ewha Womans University School of Medicine
1071, Anyangcheon-ro, Yangcheon-ku,
Seoul, 158-710, South Korea
Tel: 82-2-2650-2673
Fax: 82-2-2650-5958
E-mail: leeh@ewha.ac.kr

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------------ 원본 메일 내용 ------------
보낸 사람 : "megan sanders"<nutmeg.m@gmail.com>
받는 사람 : leeh@ewha.ac.kr
메일 제목 : Re: Sleep deprivation questionnaire
보낸 날짜 : Thu, 30 Oct 2014 08:07:09 +0200

> On 30 Oct 2014, at 7:42 AM, megan sanders <nutmeg.m@gmail.com> wrote:
>
> Dear Dr Lee
>
> My name is Megan Sanders. I am a registrar in the Department of Anaesthesiology at the University of the Witwatersrand, Johannesburg, South Africa. I am currently working on a research project on the effects of sleep deprivation on anaesthetists. I would like to ask for your permission to use and adapt some of your questions from your questionnaire published in Sleep Medicine, for my study.
>
> I appreciate your help in this regard.
>
> Yours Sincerely
>
> Dr Megan Sanders

APPENDIX SEVEN
QUESTIONNAIRE

Study number	

1. Gender

Male	
Female	

2. Age group

20-25	
26-30	
31-35	
36-40	
41-45	
Older than 45	

3. Professional ……………………………………………………………………………designation

Intern	
Medical Officer	
Registrar first year	
Registrar second year	
Registrar third year	
Registrar fourth year	

4. In which hospital are you currently rotating?

Hospital	Theatre	ICU
CMJAH		
CHBAH		
HJH/Rahima Moosa		

DG		

Sleep questions

With regards to your every day life in the **previous** month:

1 Do you think your sleep is sufficient?

Completely sufficient	
Fairly sufficient	
Somewhat insufficient	
Clearly insufficient	
Highly insufficient	

2 How well rested do you feel when you wake up?

Very well	
Fairly well	
Groggy	
Very tired	
Extremely tired	

3 How often do you have insufficient sleep due to work schedule?

Never	
1–2 nights per month	
1-2 nights per week	
3-4 nights per week	
Almost always every day	

4 What is the longest length of time you have gone without sleep due to work schedule?

____

5 How often do you have difficulty in awakening in the morning?

Never	
1-2 days per month	
1-2 days per week	
3-4 days per week	
Almost always every day	

6 How often do you feel tired during the day at work?

Never	
1-2 days per month	
1-2 days per week	
3-4 days per week	
Almost always every day	

7 How often do you feel difficulty in concentrating at work?

Never	
1-2 days per month	
1-2 days per week	
3-4 days per week	
Almost always every day	

8 How often does sleepiness negatively affect your academic development?

Never	
1-2 days per month	
1-2 days per week	
3-4 days per week	
Almost always every day	

9 How often do you feel stressed or irritable as a result of lack of sleep?

Never	
1-2 days per month	
1-2 days per week	
3-4 days per week	
Almost always every day	

10 How many caffeinated beverages do you drink to resist sleepiness during the day?

Never	
Once a day	
1-2 times per day	
3-4 times per day	
More than 4 times per day	

11 How many units of the following do you drink per night call?

One unit is 250 ml or one cup

Filter coffee	
Instant coffee	
Ceylon tea	
Herbal tea	
Caffeinated cold drink	
Energy drink such as red bull	

12 What other strategies do you use to resist sleepiness?

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13 How often do you doze off in theatre during a day shift?

Never	
Once in a month	
Once in a week	
More than once a week	
Almost always every day	

14 How often do you doze off in theatre during a night call?

Never	
Once in a month	
Once in a week	
Almost always every night call	
More than once per night call	

15 Have you missed work due to sleep problems?

Yes	
No	

16 Have you been late to work due to sleep problems?

Yes	
No	

17 Have you made a mistake at work due to sleepiness?

Yes	
No	

18 Have you made a mistake at work unrelated to sleepiness?

Yes	
No	

19 How often have you missed social and family activities because of sleepiness post call?

Yes	
No	

20 Have you had a percutaneus injury on duty due to sleepiness?

Yes	
No	

21 Have you felt at risk of having a motor vehicle accident, because of sleepiness, on your way home from work?

Yes	
No	