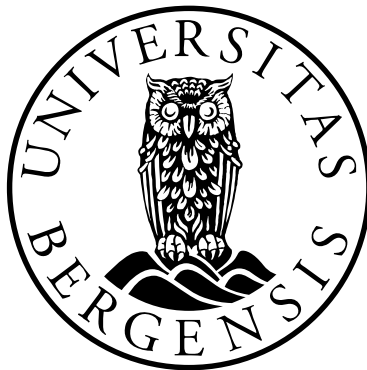# SLEEP AND HEALTH IN SHIFT WORKING NURSES

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Dissertation for the degree philosophiae doctor (PhD)

at the University of Bergen

SCIENTIFIC ENVIRONMENT

I have been employed by the Norwegian Competence Center of Sleep Disorders as a PhD research fellow during the period 2010-2012. My doctoral education has been completed as a member of the Graduate School of Clinical and Developmental Psychology at the Faculty of Psychology, University of Bergen. I have been a member of the Bergen Group for Treatment Research, at the Department of Psychosocial Science, Faculty of Psychology, University of Bergen. This PhD thesis, subsequently referred to as "the thesis", was financed by the Western Norway Regional Health Authority.

My two main supervisors Bjørn Bjorvatn and Ståle Pallesen are affiliated with the Department of Public Health and Primary Health Care, Faculty of Medicine and Dentistry and the Department of Psychosocial Science, Faculty of Psychology, respectively. My co-supervisors Inger Hilde Nordhus and Janne Grønli are affiliated with the Department of Psychosocial Science and Department of Biological and Medical Psychology, respectively, both situated at the Faculty of Psychology. In addition, the research project "The Survey of Shift work, Sleep and Health in nurses" (SUSSH) generated the data used in this PhD thesis. The SUSSH group members Nils Magerøy and Bente Elisabeth Moen, has thus been important in the creation of the research project, as well as co-authoring papers in this thesis.

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When a person has made an achievement, you may hear how brilliantly obstacles were overcome, how the goal was reached despite all the pitfalls in this world. Writing this thesis is an achievement for me, and I am proud to have reached this point. Yet, I am completely overwhelmed by the number of wonderful people who have supported me along the way. I have not felt alone on this project, either emotionally, socially or academically. I have been surrounded by highly competent people who have shared their knowledge and who frequently have engaged in scientific discussions with me.

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ABSTRACT

In this thesis, the prevalence of Shift Work Disorder (SWD) in a sample of nurses, and the association between SWD and work characteristics, health outcome and personality (paper 1) have been investigated. Next, the psychometric properties of the "Bergen Shift Work Sleep Questionnaire" (BSWSQ) were evaluated (paper 2). The BSWSQ evaluates sleep and sleepiness problems in relation to day shifts, evening shifts, night shifts and rest-days. The validated BSWSQ was used to investigate how different work shifts and work schedules affected problems with sleep and sleepiness (paper 3).

In paper 1, three symptom-based questions were used to assess the prevalence of symptoms indicative of SWD. To evaluate the accuracy of these questions, two additional measurement procedures were used for comparison. All three procedures were based on the International Classification of Sleep Disorders, second edition (ICSD-2) diagnostic criteria that entail the presence of a sleep or sleepiness problem associated with a work schedule that imposes wakefulness during the usual time for sleep (American Academy of Sleep Medicine (AASM), 2005). Logistic regression analyses were performed with symptoms indicative of SWD as outcome variables. Nurses (n = 1968) reported their age, gender, type of work schedule, commute duration, fraction of a full-time position, presence of children in household (yes/no), number of nights and number of shifts separated by less than 11 hours worked during the previous year, use of sleep medication, melatonin and bright light therapy. All of the nurses completed the Bergen Insomnia Scale, the Epworth Sleepiness Scale, the Global Sleep Assessment Questionnaire, the Diurnal Scale, the Revised Circadian Type Inventory, the Dispositional Resilience (Hardiness) Scale – Revised, the Fatigue Questionnaire, questions about alcohol and caffeine consumption, as well as the Hospital Anxiety and Depression Scale.

The SWD prevalence varied among nurses depending on assessment procedure (32.4–37.6%) and on type of work schedule (4.8–44.3%). SWD symptoms were reported among over one third of the nurses in the study sample with greater prevalence among those working night shifts and/or rotating shifts. Risk of SWD significantly increased with older age, higher languidity scores (circadian type), night work, more shifts worked in the previous year separated by less than 11 hours, more nights worked during the previous year, and with higher insomnia and anxiety scores. High scores of the circadian type of flexibility and being a female were associated with reduced risk of SWD. The three different SWD-assessment procedures provided similar results. The three symptom-based questions were considered adequate at assessing symptoms indicative of SWD for the purposes of epidemiological investigation.

Paper 2 investigated the psychometric properties of the BSWSQ among 760 nurses working three-shift rotation schedules. The BSWSQ assesses seven symptoms including: >30 min sleep onset latency, >30 min wake after sleep onset, >30 min premature awakenings, non-restorative sleep, being sleepy either at work, during free periods on work days, or on rest-days. The factor structure was investigated using structural equation modeling (SEM) and the test-retest reliability by calculating intraclass correlation coefficients. Pearson-product moment correlation coefficients were calculated to test the convergent/divergent validity between the BSWSQ and the Epworth Sleepiness Scale, the Fatigue Questionnaire, and the Hospital Anxiety Depression Scale. Differences in insomnia symptom mean scores with respect to different shifts and rest-days were also investigated. BSWSQ demonstrated an adequate model fit using SEM, good test-retest reliability and good convergent/discriminant validity. Post hoc comparisons showed that working night shifts predicted higher overall/composite scores on the BSWSQ compared to day and evening shifts and rest-days.

The BSWSQ was concluded to meet necessary psychometric standards and to successfully assess variations in sleep and sleepiness problems by type of shifts and rest-days.

In paper 3, shift-related sleep and sleepiness problems among nurses working different work schedules were studied using the BSWSQ. To assess the severity of the sleep and sleepiness problems, shift-related insomnia was defined as often/always experiencing sleep *and* sleepiness problems (separately for rest days and day, evening and night shifts). Logistic regression analyses were used to assess the associations between shift-related insomnia (during day, evening and night shifts) and type of work schedule (i.e., permanent as opposed to rotational schedules).

There were no differences between the work schedules in prevalence of day shift insomnia. Evening shift insomnia was more prevalent in two-shift (29.8%) compared to three-shift rotations (19.8%). Night shift insomnia was more common among three-shift rotation workers (67.7%) than among permanent night workers (41.7%). Rest-day insomnia was more prevalent among permanent night workers (11.4%) compared to workers with two- (4.2%) and three-shift rotations (3.6%).

In paper 3, it was concluded that shift-related insomnia is most prevalent among nurses working three-shift rotations and night shifts. Nevertheless, sleep and sleepiness problems were present among nurses during all types of shifts and with all types of work schedules.

LIST OF TABLES AND FIGURES

LIST OF PUBLICATIONS

Flo, E., Pallesen, S., Magerøy, N., Moen, B. E., Grønli, J., Nordhus, I. H., & Bjorvatn, B. (2012). Shift Work Disorder in Nurses – Assessment, Prevalence and Related Health Problems. *PloS ONE, 7;* e33981.

Flo, E., Bjorvatn, B., Folkard, S., Moen, B. E., Grønli, J., Nordhus, I. H., & Pallesen, S. (2012). A Reliability and validity study of the Bergen Shift Work Sleep Questionnaire in nurses working three-shift rotations. *Chronobiology International, 297*; 937-46.

Flo, E., Pallesen, S., Åkerstedt, T., Magerøy, N., Moen, B. E, Grønli, J., Nordhus, I. H, Bjorvatn, B. (2012). Shift Related Sleep Problems Vary According to Work Schedule. *Occupational and Environmental Medicine* (Second Revision).

LIST OF ABBREVIATIONS AND TERMINOLOGY

AASM	American Academy of Sleep Medicine
APA	American Psychiatric Association
BIS	Bergen Insomnia Scale
BSWSQ	Bergen Shift Work Sleep Questionnaire
DSM-IV	Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition
EEG	Electroencephalography
ESS	Epworth Sleepiness Scale
HADS	The Hospital anxiety and depression scale
ICD-10	International Classification of Diseases, 10th edition
ICSD-2	International Classification of Sleep Disorders, version 2
NREM	Non-rapid eye movement
PSG	Polysomnography
REK	Regional committees for medical and health research ethics
REM	Rapid eye movement
SCN	Suprachiasmatic nuclei
SEM	Structural equation modelling
SPSS	Predictive analytics software and solutions
SUSSH	The Study of Shift Work Sleep and Health in Nurses (Norwegian acronym)
SWD	Shift work disorder
SWS	Slow wave sleep
SWT	Shift work tolerance
WASO	Wake after sleep onset

CONTENTS

1. INTRODUCTION

Shift work is common in modern society, and includes several professions responsible for the health and safety of others (e.g., health care, police, and fire response) (Wright Jr, Bogan, & Wyatt, 2012a). Shift workers constitute approximately 17% of the European workforce, and 39% of the workforce has irregular work hours (Parent-Thirion et al., 2007). Shift work involves work hours that most people consider unconventional and demanding (e.g., working during the night or starting work very early in the morning). A 24-hour continuous operation is necessary for some public services (e.g., health care) and has been shown as a favourable economic business model for large operations, such as manufacturing plants (Wright Jr, et al., 2012a). Although society may benefit from 24-hour available public services and operations, shift work can have adverse effects on shift workers (e.g., poor health and family/social life problems) as well as for the community (i.e., accidents and errors) (Folkard, Lombardi, & Tucker, 2005). Sleep and sleepiness problems are often experienced in relation to shift work schedules (Åkerstedt, 2003). Better understanding how to improve sleep and to reduce sleepiness (sleep propensity) in relation to shift work will benefit both shift workers and society.

The overall aim of this PhD thesis was to investigate problems with sleep and sleepiness in relation to shifts (different work hours) and work schedules (different organizations of shifts). It was also of interest to investigate the relationship between these work-related sleep and sleepiness problems and health parameters as well as personality variables.

1.1 Shift work

One of the ever-present challenges in the study of shift work is the elusiveness of the term "shift work" itself. Shift work generally refers to a myriad of occupational contexts with varying types of shift organization methods, shift lengths, and organization of rest-days, and it may include irregular, non-standard and flexible work-hours (Sack et al., 2007; Sallinen & Kecklund, 2010). This heterogeneity of work schedules complicates the comparisons between studies and generalizations between occupational groups. Shift work as defined by legislative powers may differ from the definitions used for scientific purposes. For example, the European Union's Working Time Directive defines shift work as, "*any method of organizing work in shifts whereby workers succeed each other at the same work stations according to a certain pattern, including a rotating pattern, and which may be continuous or discontinuous, entailing the need for workers to work at different times over a given period of days or weeks.*" Furthermore, they define night work as, *"any period of not less than seven hours, as defined by national law, and which must include, in any case, the period between midnight and 5.00,"* and that a "night worker's" shifts has at least 3 work hours falling within the defined night work period ("European Union's Working Time Directive," 2003).

In the scientific literature, "shift work" is often defined as any arrangement of working hours outside the standard daylight hours (7 or 8 am to 5 or 6 pm) (Monk & Folkard, 1992). The term may not only refer to rotating shift schedules, but also to permanent night work, as well as to schedules requiring waking up during the night to work (Sack, et al., 2007). Shift work schedules may be characterized as:

i. *Permanent* when the individuals work one shift only, i.e., day or evening or night).

ii. *Rotating* when individuals alternate between different shifts as part of their regular work schedule. Rotations that only include day and evening shifts are defined as two-

shift rotations, while rotations between day, evening and night shifts are defined as three-shift rotations.

iii. *Night work* when work hours include the time period between 00:00 and 05:00. Notably, the working time may include all or part of the night, and the number of nights worked per week/month/year may vary to a great extent.

iv. *Continuous*, covering all days of the week, or *discontinuous* with for example weekend or Sunday breaks.

Variation exists in shift lengths and cycles of work periods between and within occupational groups (Sallinen & Kecklund, 2010). Table 1 illustrates an example of a typical nurse in Norway's shift schedule, showing what type of shift will be worked each day of the week over a period of three weeks. This is an example of a three-rotational continuous work schedule, which is quite common among Norwegian nurses. As shown in table 1, each 24-hour day is divided into three shifts including: day shifts (07:00 to 15:00), evening shifts (14:30 to 22:00), and night shifts (22:00 to 07:00). Nurses who work in outpatient clinics or in administrative positions on the other hand, may have an 08:00 to 16:00 workday.

Table 1: An example of a typical nurse's three-shift rotational continuous work schedule in Norway.

WEEK	Mon	Tues	Wed	Thur	Fri	Sat	Sun
1	Night	Night	Sleep	Rest-day	Day	Day	Evening
2	Day	Rest-day	Evening	Day	Day	Rest-day	Rest-day
3	Evening	Day	Day	Rest-day	Night	Night	Night

Day shifts: 07:00-15:00, evening shifts: 14:30-22:00, night shifts: 22:00 – 07:00.

Not only the work-hours, but also the work context and workload differ between occupations (Sallinen & Kecklund, 2010). Contextual and environmental factors are consequently addressed in this introduction.

Many studies have examined night work in particular, as this has been found to have a negative effect on shift workers' performance, health, and well-being. Being active during the

night and sleeping during the day, is at odds with the normal human circadian rhythm, and disturbs sleep regulation (Datta & MacLean, 2007).

1.2 Sleep Regulation

Sleep is a "reversible behavioural state of perceptual disengagement from, and unresponsiveness to the environment" (Kryger, Roth, & Dement, 2011). Sleep is broadly divided into rapid eye movement (REM) sleep and non-REM (NREM), which are characterized by distinct physiological, neurological, and psychological features (Kryger, et al., 2011). NREM sleep is divided into three stages: N1, N2, and N3 as defined by the American Academy of Sleep Medicine (AASM) (Iber et al., 2007). In short, the transition from wakefulness to N1 is defined by the transition from alpha waves (8-13Hz) to theta waves (4-7 Hz activity), and by reduced muscle tone and conscious awareness of one's surroundings. Stage N2 is recognized by the presence of theta waves in addition to specific electroencephalographic (EEG) features such as "sleep spindles" and "K-complexes", and further reduction in muscle tone and awareness. N3, also called delta sleep or slow wave sleep (SWS), is characterized by waves with high amplitude ($> 75 \mu V$) and low frequency (< 2 Hz) (Iber, et al., 2007).

The sleep stages succeed each other in a sleep cycle which lasts approximately 90 minutes in humans, from NREM to REM sleep (Kryger, et al., 2011). NREM sleep and REM sleep are distributed unevenly throughout the total sleep period. The majority of the deep and restorative NREM (SWS) sleep takes place during the first part of the sleep period while REM sleep dominates the latter half (Iber, et al., 2007; Kryger, et al., 2011). Shift work related disruption of sleep may not only affect sleep duration, but also sleep architecture. Truncated sleep duration often entails reduced amount of N2 and REM sleep, while the quantity of SWS remains relatively unaffected (Kecklund, Åkerstedt, & Lowden, 1997).

The quality, timing and duration of sleep are regulated by interactions between homeostatic, endogenous circadian rhythm, behavioural, environmental and social processes (Bjorvatn & Pallesen, 2009).

1.2.1 The homeostatic process

The amount of sleep necessary to maintain a normal level of daily functioning varies greatly from individual to individual (Banks & Dinges, 2007). The homeostatic process entails an accumulating need for sleep as a function of the preceding period of wakefulness (Borbély, 1982). Sleep deprivation results in an increased sleep propensity (Banks & Dinges, 2007). This increased propensity to fall asleep defines excessive sleepiness which is characterized by increased risk of micro-sleep (seconds of sleep bouts) or nodding off (AASM, 2005).

Sleep deprivation is subsequently followed by "recovery sleep" typically characterized by an increase of SWS, and a subsequent REM sleep rebound (Borbély et al., 1981). The homeostatic process is influential for sleep quality as accumulated need for sleep is positively related to SWS (Banks & Dinges, 2007). Sleep restriction and the homeostatic process may thus affect a shift workers' sleep quality.

1.2.2 The circadian process

Different physiological systems in humans typically show varying activity throughout the day and night. As diurnal primates, humans' physiology is attuned to be active during the day and at rest during the night (Åkerstedt & Gillberg, 1981). Examples of physiological systems that follow a circadian rhythm are body temperature and secretion of hormones. The neurohormone melatonin is secreted by the pineal gland. The release of melatonin is inhibited by light, hence a typical synthesis of melatonin occurs during the night (absence of light)

(Kryger, et al., 2011). Body temperature and melatonin are both recognized as biological markers of the circadian phase (figure 1) (Czeisler et al., 1999).

Circadian rhythms are evident in behaviour and performance, with cyclic variability in terms of sleepiness and alertness. It is well established that sleepiness is increased and performance impaired during the night, as compared to during the day (Wright Jr, Hull, & Czeisler, 2002; Wright Jr, Lowry, & LeBourgeois, 2012b). The lowest point (nadir) in alertness and peak in sleepiness usually coincides with the nadir in core body temperature at approximately 05:00 in the morning (Czeisler et al., 1980). These internal rhythms are coordinated by neurological and endocrinological systems with the circadian pacemaker, the hypothalamic suprachiasmatic nuclei (SCN) functioning as the "master clock" (Datta & MacLean, 2007).

The circadian process affects sleep duration, as the timing of sleep onset according to the phase of core body temperature predicts sleep length (Czeisler, et al., 1980). In other words, sleep length is highly dependent on when you go to bed according to your own circadian rhythm. Normally, sleep onset follows the downward slope of core body temperature, which peaks late in the afternoon (figure 1). Wake-up time usually occurs approximately two hours after the nadir in core body temperature (Bjorvatn & Pallesen, 2009).
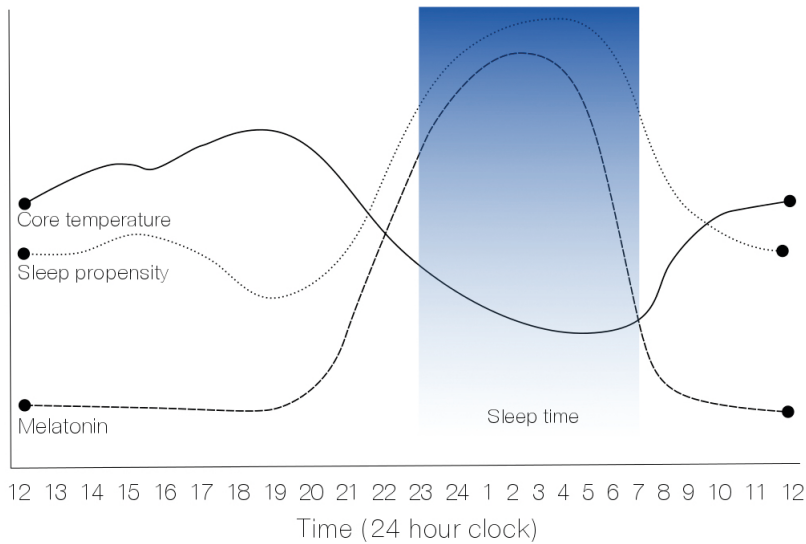
Figure 1: The inverse association between core body temperature and melatonin and their link to sleep propensity over a 24- hour period.

The described homeostatic and circadian processes means that quality of sleep depends on prior wakefulness and that sleep duration depends on the timing of bedtime in relation to the circadian rhythm (Bjorvatn & Pallesen, 2009).

1.2.3 Environmental, social, and behavioural influences on sleep regulation

Sleep is highly influenced by environmental, behavioural and social factors (Carskadon, Acebo, & Jenni, 2004). Since the human biological rhythms are usually somewhat longer than our terrestrial 24 hour day-night cycle, humans are reliant on environmental cues (also termed "zeitgebers") to remain in synchrony with their surroundings (Czeisler, et al., 1999; Roenneberg et al., 2007). In terms of external influences on our sleep-wake cycle, bright light, daylight in particular, is the most important zeitgeber. Light impacts the circadian rhythm by sending a signal through the optic nerve which connects to the SCN

through a monosynaptic pathway, and helps reset the endogenous circadian rhythm to the 24-hour day-night cycle (Datta & MacLean, 2007).

Furthermore, behaviours such as physical activity, meals and social interactions represent other zeitgebers that may have important influence on the timing of sleep (Carskadon, et al., 2004). Human sleep habits are furthermore embedded in cultural beliefs of "good sleep behaviour". While the amount of sleep needed varies between individuals, it is generally more strictly defined by society were approximately 8 hours of sleep is often thought to be necessary (Ursin, Baste, & Moen, 2009).

Social and behavioural factors can to some extent override both the homeostatic sleep pressure and circadian rhythm. It is possible (within limits) to choose to stay awake through a night when both the homeostatic and the circadian factors promote sleep. During night work, behavioural measures such as walking around, talking with colleagues, drinking caffeinated beverages, and increasing the lighting can help night workers to stay awake and alert (Bjorvatn & Pallesen, 2009). Unfortunately, if used incorrectly (i.e. too close to bed time) these actions may make it harder for workers to sleep when the night shift ends (Wright Jr, et al., 2012a).

Adjusting the circadian rhythm is possible and may be optimized by correctly changing behaviour and exposure to external zeitgebers (i.e., light). Adaptation to night activities (i.e., night work) has been shown in terms of normal sleep length (Bjorvatn, Kecklund, & Åkerstedt, 1998). Circadian markers such as melatonin levels rarely adjust completely (Folkard, 2008a). While external factors can help to change the circadian rhythms, they may not necessarily completely converse the cycle. Changes may be manifested as flattened amplitudes of the endogenous circadian rhythm (Banks & Dinges, 2007).

1.3 The adverse effects of shift work

Shift work has been related to various short and long term negative health outcomes. Sleep and sleepiness problems are common and a serious concern among shift workers (Åkerstedt, 2003). Sufficient sleep is necessary for health, performance and wellbeing. Sleep durations of approximately 7 hours a night has been related to the lowest mortality rates (Banks & Dinges, 2007; Cappuccio et al., 2010).

1.3.1 Problems with sleep and sleepiness

Working during the night (the preferred sleep period) disrupts the sleep-wake rhythm. This leads to desynchronization not only between environmental cues and one's internal circadian clock, but also between internal physiological systems (Reinberg & Ashkenazi, 2008).

Complaints of insomnia or excessive sleepiness are defined as dyssomnias by the ICSD-2 (AASM, 2005). Symptoms of insomnia include problems with sleep initiation, wake after sleep onset (WASO), waking up too early and not falling back asleep, and/or feelings of inadequate/nonrestorative sleep. Sleepiness is defined as the propensity to doze off or to fall asleep. Severe excessive sleepiness may lead to sleep episodes during situations that require attention, for instance, while driving a car (AASM, 2005).

Both problems with sleep and sleepiness are quite common in the general population and do not necessarily represent clinically *severe* issues (Sivertsen, Øverland, & Pallesen, 2011b; Ursin, et al., 2009). Studies of sleep habits in the normal population show that individuals often obtain less sleep than desired during a normal work week (Ursin, et al., 2009). It is consequently important to differentiate between clinically severe and "normal" issues with sleep and sleepiness, when examining a shift-working population.

Objective measures such as polysomnographic recordings may reveal details about the sleep length, sleep quality, and particular changes in sleep architecture (such as reduced N2 and REM sleep) (Kecklund, et al., 1997).

However, the severity of sleep and sleepiness problems are also defined by the consequences it has for the individual. In keeping with the Diagnostic and Statistical Manual of Mental Disorders-IV-TR (DSM-IV), the American Psychiatric Association (APA) defines insomnia as not merely an issue of disturbed sleep, but is also related to the subsequent consequences that occur when an individual is awake (APA, 2000). In order to fulfil the diagnostic criteria for insomnia the sleep problems need to be experienced as problematic for the individual, impacting their day-to-day normal functioning. Symptom severity may also be defined by temporal characteristics; length, frequency, and chronicity. For instance, a time limit of 30 minutes has been suggested to define symptom severity (Lacks & Morin, 1992; Lichstein et al., 2003). For example, spending more than 30 minutes trying to fall asleep would constitute a problem with sleep initiation. The symptom frequency (i.e. the number of days of the week a symptom occurs), pertains to the persistence of the problem (Pallesen et al., 2008). Three days or more are often used as a severity cut-off (Lacks & Morin, 1992). Chronicity reflects presence of symptoms over time, where usually 1 or 6 months are used as cut-offs (AASM, 2005; APA, 2000).

Dyssomnias may be considered as intrinsic (for example narcolepsy), extrinsic (for example alcohol-dependent sleep disorder), or as a circadian rhythm disruption. Circadian rhythm sleep disorders involve problems in terms of the daily timing of sleep (AASM, 2005).

Shift work disorder (SWD) is a type of circadian rhythm sleep disorder that occurs when problems with sleep or sleepiness result from work schedules requiring wakefulness during time periods when an individual would usually sleep. SWD symptoms should be due

to circadian misalignments, and not due to other sleep disorders. In addition the symptoms should not be transient, persisting for at least a month (AASM, 2005).

Sleep deprivation is inevitable with sudden changes in one's sleep schedule. For example, night workers may stay awake for 24 hours straight on their first night shift in a rotational schedule, leading them to acute sleep deprivation while on duty (Sack, et al., 2007). Because shift work is at odds with a good regular sleep routine, the distinction between a "normal response" to shift work, and SWD is not straightforward. Few shift work studies have attempted to evaluate SWD in shift worker populations (Sack, et al., 2007). Previously, Waage and colleagues (2009) found a SWD prevalence of 23.3% in oil rig workers (Waage et al., 2009). Drake and colleagues (2004) found a SWD prevalence of 32.1% in night workers and 26.1% in rotating shift workers in an epidemiologic study (Drake et al., 2004).

Different symptoms of insomnia and sleepiness are related to both the circadian and homeostatic sleep regulation. A forced early morning awakening may be close to the nadir in alertness levels. Day shifts, particularly those starting before 07.00, are associated with difficulties waking up (Sallinen & Kecklund, 2010). Furthermore, to fall asleep earlier than preferred is difficult as it brings bedtime closer to the circadian peak in alertness. A late sleep onset relative to an early rise-time has been found to reduce the sleep duration before day shifts with 2-4 hours (Åkerstedt, 2003). Hence, day shifts may lead to sleep debt (accumulated homeostatic sleep pressure) and consequently increased wake-time sleepiness. Night work disrupts both the circadian and homeostatic mechanisms. The night workers have often been awake for a long time resulting in an increased homeostatic sleep pressure at the end of the shift. During the night shifts, feelings of sleepiness are found to be the most severe early in the morning hours. At that time, both circadian (nadir in alertness) and homeostatic (sleep pressure) factors promote sleep (Åkerstedt, 2003). When individuals work night shifts, it is common for the subsequent daytime sleep period to be initiated rapidly. However, the total

sleep time is normally truncated by 2-4 hours (Åkerstedt, 2003). This illustrates how the timing of sleep according to the circadian rhythm affects sleep length. Other factors, such as noise and day light may additionally disrupt sleep during the day time for night shift workers (Wright Jr, et al., 2012a).

The interaction between different aspects of the work schedules and the sleep regulatory processes is complex. Thus sleep and sleepiness problems may vary according to shifts and work schedules. In the study of sleep and sleepiness problems among shift workers it is of interest to assess the differences in symptoms related to both shifts and work schedules.

Many physiological systems follow cyclic activity. Thus, disrupting the sleep-wake rhythm disrupts aspects related to health and well-being such as insulin uptake, metabolism, appetite and mood (Knutsson, 2003). Sleep problems may mediate the relationship between shift work and psychological and physiological health (Banks & Dinges, 2007; Wang et al., 2011).

1.3.2 Health problems

Shift work is related to both acute and chronic health problems (Wang, et al., 2011). Acute problems may relate to sleep deprivation which among other things has a negative impact on mood and performance (Banks & Dinges, 2007).

Chronic illnesses such as cancer (Straif et al., 2007), cardiovascular disease, metabolic deficiencies and obesity have also been related to shift work (Knutsson, 2003; Wang, et al., 2011). Strength of the evidence of carcinogenic effects of shift work varies according to the type of cancer that is considered. While several studies have demonstrated an increased breast cancer risk among shift-working women (Megdal et al., 2005), the evidence for associations between shift work and prostate and colorectal cancer is less conclusive (Wang, et al., 2011). The evidence as to the association between shift work and cardiovascular disease shows

moderate evidential support (Wang, et al., 2011). Different work-related factors, including work scheduling have been associated with increased risk of cardiovascular disease (Knutsson, 2003). Different mechanisms may be involved in the association between shift work and cardiovascular disease. For example, changes in immunologic factors related to increased risk of developing cardiovascular disease have been demonstrated in sleep deprived study participants (Van Leeuwen et al., 2009).

Some evidential support is also present in terms of shift work and increased risk of metabolic disorders and diseases, for example obesity, peptic ulcers, gastrointestinal problems, diabetes and metabolic syndrome (Knutsson, 2003; Lowden et al., 2010). A link between shift work exposure and the risk of metabolic syndrome has also been demonstrated (Tucker et al., 2012).

In relation to the abovementioned health issues, several underlying mechanisms have been suggested including: sleep loss, reduction in circadian rhythm amplitude, individual vulnerability with regard to disease and vulnerability to circadian misalignment, exposure to light during the night, dietary habits misaligned with the optimal time for nutritional intake and circadian misalignment both in the brain and in other bodily systems (Wright Jr, et al., 2012a).

Severe chronic illness and shift work are likely to have multi-causal links. The associations between chronic illness and shift work have been reported in several studies – yet this link needs to be further established, and longitudinal cohort studies are warranted (Wang, et al., 2011). There is also a need to better understand the underlying mechanisms for the association between shift work and negative health outcomes.

1.3.3 Accidents and injury

Previous studies have shown that the risk of accidents and injuries is higher during night and evening shifts than day shifts (Folkard, et al., 2005). Shift work and night work in particular, have been related to increased sleepiness, decreased performance due to reduced cognitive and physiological functioning, and increased likelihood of nodding off or experiencing "micro-sleeps" (Banks & Dinges, 2007). Individuals have been shown to underestimate how impaired they are by being sleep deprived (Banks & Dinges, 2007). These effects of shift work put shift workers at risk of accidents and injuries during work hours and possibly also on their way home from work. Studies suggest that night workers also have a greater risk of car accidents (Stutts et al., 2003).

1.3.4 Social and family life

It has been suggested that the amount of domestic responsibilities an individual has may affect their shift work tolerance (SWT) (Nachreiner, 1998). Social pressures at home may reduce the opportunity to obtain enough sleep (Wright Jr, et al., 2012a). On the other hand, shift work may also negatively affect family life, and these effects may differ by type of work schedule. Using data from the SUSSH study, Kunst and colleagues (2012) showed that nurses on two- and three-shift rotation schedules were more likely than permanent day workers to report that work interfered with their family life. However, a permanent night schedule was less likely to entail such interference (Kunst et al., 2012). Permanent night work is often a chosen work schedule, whereas rotational schedules are standardized schedules that nurses tend to have less control over. While it is less likely that night shifts will interfere with social activities that take place during the day, family responsibilities may still affect the shift worker's sleep. Shift workers may voluntarily cut their sleep short to partake in social and

familial activities, or to manage domestic responsibilities. For example night workers may shorten their sleep in order to drive kids to school. Yet, social and family connections represent a supportive network. Hence, social and family ties may help the shift worker to better cope with the work schedule (Wright Jr, et al., 2012a).

1.4 Factors that affect the tolerance of shift work

Shift work is not problematic for everyone. Some individuals may experience several of the previously mentioned health and sleep issues while others may manage to adapt to shift work without any immediate negative health outcomes. Individuals who experience multifaceted symptoms related to shift work (i.e., sleep problems, fatigue, and digestive troubles) may be characterized as having poor tolerance to shift work (Andlauer et al., 1979). Whether or not an individual has poor SWT is believed to be influenced by both individual disposition as well as contextual and external factors (Nachreiner, 1998).

1.4.1 Individual Differences

Sleep and health issues related to shift work may be a due to interactions between the work schedule and individual factors such as age, gender, personality traits and circadian preferences (Saksvik et al., 2011).

1.4.1.1 Age

Sleep tends to be more fragmented and containing less deep sleep with older age (Dijk et al., 1999). Older shift workers have been shown to have shorter and more disturbed daytime sleep than their younger co-workers. Studies suggest that older age is related to reduced abilities to maintain performance throughout a night shift and also to reduced abilities to cope with several consecutive night shifts (Folkard, 2008b). Older age has also been related to a circadian shift towards a morning preference, becoming more of a "lark". This may give

older shift workers an advantage during early morning shifts (Dijk, et al., 1999). Age effects are not seen for all outcome variables. While younger age is related to better sleep quality and performance, other studies have found better SWT for older than younger workers (Reinberg & Ashkenazi, 2008; Saksvik, et al., 2011). These results may be partly explained by the 'healthy worker effect' where older shift workers are a selected group of individuals who have been coping particularly well with shift work (Choi & Pak, 2005).

1.4.1.2 Gender

Gender differences in shift work tolerance may not only be related to physiological differences, but also to differences in coping techniques, responsibilities, and cultural expectations. It has been suggested that being female is related to poor SWT, although, findings are mixed. Some studies have shown that female gender is related to high SWT, and some studies report no relationship between gender and SWT (Saksvik, et al., 2011). Traditionally females had more domestic responsibilities which in combination with work demands may have led to an increased total workload (Nachreiner, 1998). There are also gender differences in susceptibility to disease regardless of the work schedule. For example, the onset of menopause is related to an increase in sleep problems (Zhang & Wing, 2006). Such differences may confound the possible gender differences related to shift work.

1.4.1.3 Personality

Considerable inter-individual variances exist in sleep parameters and in responses to sleep deprivation. There are however an intra-individual stability to the response to sleep restriction. A trait-like inter-individual difference has been proposed (Banks & Dinges, 2007). The circadian rhythms show individual differences in terms of phase, amplitude and stability (Di Milia, Smith, & Folkard, 2005; Torsvall & Åkerstedt, 1980). The circadian types called "languidity" and "flexibility" represent the ability to stay alert when tired and to adapt to changes in sleep-wake times, respectively (Di Milia, et al., 2005). Flexibility relates to

circadian rhythm stability and languidity to circadian rhythm amplitude. Low scores on languidity and high scores on flexibility have been related to better SWT in a recent study (Saksvik, et al., 2011).

Studies have also established a trait-like preference for early or late bed and rise times (circadian phase), also known as "morningness" or "eveningness", respectively (Torsvall & Åkerstedt, 1980). Preference tends to change from evening preference to morning preference from adolescence to old age (Roenneberg, et al., 2007). Preferences with regard to bed and rise times have also been related to SWT in that evening types seem to cope better with evening and night shifts and morning types seem to handle early morning shifts better. Overall, most studies have linked eveningness to better SWT (Saksvik, et al., 2011).

Lifestyle represents a possible confounding variable when studying the association between personality and SWT. For example, personality traits may affect whether or not an individual conscientiously follows advice on healthy sleep behaviours or whether they worry excessively about sleep (Saksvik, et al., 2011).

1.4.2 Contextual Factors

Contextual factors influencing shift work-related sleep problems and health outcomes include various aspects of an individual's life situation such as working conditions (including work scheduling), as well as living conditions, behaviours and lifestyle choices. The effects that different types of shifts and work schedules may have on sleep and sleepiness have already been outlined in this thesis. Additional aspects with the work organization that may affect the health and sleep of shift workers include: workload, length of each shift, rest-time between shifts, direction and speed of shift rotation, start and end times of shifts, as well as the distribution of rest-days (Sallinen & Kecklund, 2010).

Importantly there are also differences in worker selection. Some positions are easy to attain such as serving positions, while other occupational groups such as oil-rig workers must be considered fit enough for the work. Furthermore, contextual differences that may impact sleep and health outcomes may exist among subgroups within the same occupation. For example, a nurse working at the emergency department in a hospital may experience a more stressful night shift than a nurse working in another less hectic department, where patients are mostly asleep during the night.

Previous studies have suggested that social and motivational factors affect how shift workers perceive their work schedule and its influence on their health. For instance, some schedules may entail more work during weekends and thus give higher value to free weekends resulting in possible positive response bias (Åkerstedt, 2003). Such influences are inevitable, and are not easy to separate from the real effects of shift work. In fact, whether or not employees are satisfied with, and feel to have some control over their work schedule has in itself been shown to affect health and wellbeing (Axelsson et al., 2003; Janssen & Nachreiner, 2004).

The association between shift work and health may be affected by factors such as behaviour and lifestyle choices like diet and alcohol consumption (Costa, 2003; Lowden, et al., 2010). Furthermore home living conditions that may influence the association between shift work and health include domestic responsibilities and social support. As mentioned, demanding domestic responsibilities have been suggested as detrimental to shift workers' health. However a supportive network may have a positive effects since a family may give both social support and practical assistance (Wright Jr, et al., 2012a).

Importantly, more research is needed in terms of association between individual and contextual factors and long-term risks and health outcome (Pallesen et al., 2010; Wang, et al., 2011).

1.5 Methods in shift work research

The study of shift work requires a multifaceted and interdisciplinary approach (Knutsson, 2004). Many levels of human functioning, from genetics to cultural differences need to be considered when studying shift work-related sleep and health problems. Given the differences in units of measurement (e.g. biological measurements and self-report questionnaires) used across studies, findings may be difficult to integrate.

Shift work studies tend to investigate health outcomes of individuals in one particular occupational group in one particular work schedule, and in the same work environment. However "shift work" refers to a multitude of shift organizations (Sack, et al., 2007). Thus, there is a trade-off between accuracy in assessments of work time and work environment and consequently low generalizability to other worker populations. It is possible to examine a population with a broad and general definition of "shift workers" in one study. However, as discussed by Drake and colleagues (2004), although it is possible to generalize to different occupational groups, it is more difficult to control for confounding variables (e.g., work organization and workload) (Drake, et al., 2004). In a recent review concerning the link between shift work and chronic illness, Wang and colleagues (2011) call for more detailed information on the different aspects of shift work, such as shift type, duration and frequency (Wang, et al., 2011).

In addition to the challenge of generalizability (Sack, et al., 2007), the varying timing of shifts, coupled with the individual variance of circadian adaptation and phase also complicate the use of biological parameters in shift work research (Knutsson, 2004). The timing of biological measurements is essential to consider in shift work research since many biological parameters of interest show circadian variation (Pallesen, et al., 2010).

Although there is evidence for certain types of shift work organizations that should be avoided, it is less obvious which measures should be taken to promote health and well-being

(Sallinen & Kecklund, 2010). Thus, controlled intervention and epidemiological studies that systematically differentiate between different types of work schedules and shifts are needed (Sallinen & Kecklund, 2010). These studies will need to rely on assessment tools specifically designed for shift work research.

1.5.1 Concerns in questionnaire based shift work research

Questionnaires can be used to reach a large number of participants in an efficient and standardized manner. Ideally, the use of standardized tools facilitates comparison between studies and improves the generalizability of results. However, these advantages depend on the validity and reliability of the questionnaire used (Streiner & Norman, 2008).

Assessment tools are needed that specifically aim at measuring sleep in a shift working population. Global sleep and health questionnaires may not measure shift workers responses appropriately. For example, questionnaires of excessive sleepiness that focus on everyday situations (e.g. what is one's sleep propensity while driving), but does not cater the questions specifically for night or day, would need adapting for use among shift workers. Thus, shift workers may not appear to experience excessive sleepiness when assessed using a global sleepiness scale, despite experiencing increased sleepiness while driving home in the morning from a night shift.

Surveys are extensively used in health care research, yet questions (or items) are sometimes generated without the necessary process of validation. The advantage of surveys (i.e. standardization) weakens when the psychometric properties remain merely at the level of face validity (Podsakoff et al., 2003; Streiner & Norman, 2008). Although a questionnaire usually requires face value validity, this is not enough to collect reliable survey data.

Creating valid instruments is an extensive process. The first phase of generating questionnaire items is to operationalize the concept/construct to be measured (Streiner & Norman, 2008). The concept "shift-related sleep problems" rests on a theoretical and

empirical model that assumes differences in sleep and sleepiness problems across workers with different types of work shifts and work schedules. Items may be produced by reviewing the field of research, investigating which questions accurately address the issues at hand. Theoretical and empirical knowledge may also be useful to construct possible subscales. When items have been generated for a survey, it is essential to test that the questionnaire has a satisfactory level of test-retest reliability, stability and internal consistency. Often this may be investigated with test-retest correlations and Cronbach's alpha analyses (Streiner & Norman, 2008). Questionnaire validation may also involve testing for face value-, content-, concurrent-, discriminant-, and predictive validity (Streiner & Norman, 2008). Face value or content validity means that the items are initially deemed relevant based on prior knowledge of the subject matter. Convergent and discriminant validity are demonstrated by comparing the new questionnaire to existing interrelated/unrelated assessment tools (Streiner & Norman, 2008). Construct validity refers to the questionnaire's ability to depict the concept which is sought to be assessed. This may be investigated using exploratory or confirmatory factor analyses (Byrne, 2010). A confirmatory factor analysis is rightfully employed when there is prior knowledge on the underlying factor structure. In other words, it is required to have a theoretical basis for the association between items and construct. Confirmatory factor analyses may be completed using Structural equation modelling (SEM) (Byrne, 2010).

A validated questionnaire of sleep and sleepiness problems that systematically differentiates between different shifts and work schedules is needed for the study of shift workers.

2. SCIENTIFIC OBJECTIVES AND HYPOTHESES

2.1 Scientific objectives and hypotheses in paper 1

Shift Work Disorder (SWD) is a clinical diagnosis that specifically demonstrates the link between problematic work hours and difficulties with sleep and sleepiness. Yet, the diagnostic criteria has rarely been used in studies of shift work and sleep issues (Sack, et al., 2007). The objective of paper 1 was to assess the SWD prevalence among nurses working different types of work schedules. So far, no feasible method of assessing SWD in epidemiological contexts has been developed. The first aim of paper 1 was to investigate three symptom-based questions for determining SWD in epidemiological studies. These questions were previously used in a study of SWD among oil rig workers (Waage, et al., 2009). The accuracy of these questions was investigated by additional inclusion criteria (insomnia and sleepiness) and exclusion criteria (symptoms of other sleep disorders).

Subsequently, paper 1 investigated relationships between symptoms of SWD and gender, age, work organization (e.g. fraction of a full-time position, day or night work, number of shifts separated by less than 11 hours of rest-time, and total number of nights worked over the previous 12 months), health problems (symptoms of insomnia, excessive sleepiness, fatigue, anxiety and depression), home life factors (commuting time, presence of children in the household), behaviours (consumption of alcohol and caffeine, and use of sleeping aids), and personality characteristics (circadian type (languidity/flexibility), diurnal type (morningness/eveningness), and hardiness). It was hypothesized that the prevalence of SWD would differ across work schedules and be associated with the presence of health problems and more demanding schedules (i.e. number of night shifts and shifts separated by less than 11 hours). It was also predicted that SWD was positively associated with individual

variables, such as older age, morningness and languidity, and a negatively associated with flexibility.

2.2 Scientific objectives and hypotheses in paper 2

Paper 1 established a high prevalence of SWD in the sample of nurses, and an association between SWD and work scheduling. Yet, further investigation was needed to understand discrete sleep and sleepiness problems among workers of different shifts types. A questionnaire that assesses sleep and sleepiness problems in relation to different shifts was needed, thus, the "Bergen Shift Work Sleep Questionnaire" (BSWSQ) was developed. The objective of paper 2 was to validate the BSWSQ. It was expected that the BSWSQ would yield acceptable test-retest reliability and psychometric fit as demonstrated by SEM evaluation criteria. Furthermore, BSWSQ was expected to show convergent/discriminant validity with the Epworth Sleepiness Scale (ESS), the Fatigue Questionnaire and the Hospital Anxiety and Depression Scale (HADS). It was also predicted that the BSWSQ would have good discriminant validity *between* types of shifts (day, evening and night shifts, and rest-days). Specifically, night shifts were expected to show higher overall/composite scores than day and evening shifts, and all shifts were expected to have higher overall/composite scores than rest-days. Night shifts were expected to show more premature awakenings, non-restorative sleep and sleepiness during work and free periods on workdays compared to day shifts, evening shifts and rest-days. *Within* shifts it was predicted that day shifts showed more tiredness/sleepiness during work and free periods on work days as compared to premature awakenings and WASO. Regarding evening shifts, sleep onset latency was expected to have higher scores than WASO. Sleepiness during work hours was expected to have a higher score compared to sleep onset latency and WASO in relation to night shifts (Sallinen & Kecklund, 2010; Åkerstedt, 2003).

2.3 Scientific objectives and hypotheses in paper 3

The detailed overview of shift-related sleep and tiredness/sleepiness problems provided by the BSWSQ allowed an investigation into the differences between different types of work shifts as well as work schedules. This is of importance as not only work shifts, but also work schedules (shift rotations or permanent shifts) may instigate different shift-related sleep and sleepiness problems (Sallinen & Kecklund, 2010).

Paper 3 therefore aimed to investigate shift-related sleep and sleepiness problems among different types of work schedules: permanent day, permanent night, two-shift rotation (including day and evening shifts) and three-shift rotation (including day, evening and night shifts). Dichotomous scores indicating either the presence or absence of severe sleep and sleepiness problems were calculated for each type of shift, namely "shift-related insomnia". The main objective was to investigate how shift-related insomnia varies with each type of shifts across different work schedules.

It was expected that descriptive analyses would show high problem prevalence rates in rotational schedules and schedules containing night work. It was hypothesized that both the two- and three-shift rotational schedules would show an increased risk of day shift insomnia compared to the permanent day schedule, that the three-shift rotation schedule would show a higher risk of night shift insomnia compared to the permanent night schedule, and that the permanent night workers would show a higher risk of rest-day insomnia compared to the permanent day and rotation workers (Sallinen & Kecklund, 2010; Åkerstedt, 2003).

3. METHODS

3.1 Procedure

The data used in this thesis were obtained from "The Survey of Shift work, Sleep and Health" (SUSSH). The survey sample was randomly selected from the Norwegian Nursing Organization member register. Participants were stratified into different subgroups or strata, defined by the time since their graduation from nursing school as: 0-11 months (stratum 1), 1-3 years (stratum 2), 3.1-6 years (stratum 3), 6.1-9 years (stratum 4) and 9.1-12 years (stratum 5). In each data collection wave, participants received a questionnaire by postal mail, followed by two reminders (one containing a second copy of the questionnaire, and one with a reminder letter only). The nurses were informed that by participating they could win one of 50 gift certificates of 500 NOK (1 US $ ≈ 6 NOK). Out of the 6000 distributed questionnaires, 600 were returned due to incorrect mailing addresses, leaving 5400 contacted nurses. In total, 2059 responses were received in the first wave (carried out during the winter 2008-09) giving a response rate of 38.1%. In the second wave, carried out in the winter-spring of 2010, 1580 nurses responded, yielding a response rate of over 80% when excluding returned letters due to incorrect addresses.

The wave 1 questionnaire asked nurses for their demographic information (e.g. age and gender), their work situation (e.g. work place, work schedules (defined categories), commuting time, fraction of a full position, and number of night shifts and number of shifts worked that were separated by less than 11 hours).

3.2 Participants

All three studies in this thesis used data from the first and second wave of the SUSSH study. Demographic information was not significantly different between these waves. Data from wave 1 included 2059 nurses, 91% of whom were women, the mean age was 33 years (SD 8.2), mean years worked as nurse was 5 (standard deviation (SD) 4.3) and 97% held positions with a full-time workload fraction of 50% or more. 82.4% of the nurses commuted to work in times of 30 minutes or less. The nurses worked in: somatic hospitals (75.6%), psychiatric hospitals (13.6%), nursing homes (3.6%), home care services (3.7%), public health centres (0.1%) and in other institutions (2.8%).

Nurses reported working different types of work schedules including: permanent day schedule (7.5%), permanent evening schedule (0.2%), two-shift rotation (day and evening shifts) schedule (25.1%), permanent night schedule (8.2%), three-shift rotation (day, evening and night shifts) (56.2%), and other work schedules including night work (2.8%). In total, 81.3% of participating nurses had rotational schedules and 64.4% had work schedules that included night work.

3.2.1.1 Participants included in paper 1

Paper 1 included participants working 50% of a full-time position or more from the first SUSSH wave. Participants working a permanent evening schedule or did not report their work schedule, leaving 1968 participants for the analyses.

3.2.1.2 Participants included in paper 2

Analyses presented in paper 2 included questionnaire data from the second wave. Since the statistical method required a complete set of responses, nurses were only included if they worked a three-shift rotational schedules and worked at least a fraction of 50% . Furthermore, in cases where items of the BSWSQ had missing data, that case was excluded, leaving 673 participants for analyses. A subgroup of these nurses were contacted 3 months

later (n = 289 after 11 were returned due to unknown addresses). These nurses received the BSWSQ a second time in order to provide test-retest data. A total of 234 nurses (response rate 81.0%) responded to this second enquiry.

3.2.1.3 Participants included in paper 3

Paper 3 was based on data from the second SUSSH wave. Nurses who were working less than a fraction of 50%, nurses who were working a permanent evening schedule, or who fell into the category of "other schedules involving night shifts" were excluded, leaving 1462 participants for analyses.

3.3 Instruments

3.3.1.1 Shift work disorder (SWD)

The present study employed three questions with bivariate (yes/no) response options to assess the presence of symptoms adhering to the diagnostic criteria of SWD listed in the ICSD-2 (AASM, 2005). These questions included: (1) Do you experience difficulties with sleeping or excessive sleepiness? (2) Is the sleep or sleepiness problem related to a work schedule where you have to work when you would normally sleep? (3) Has this sleep or sleepiness problem related to your work schedule persisted for at least one month? The occurrence of all three symptoms was defined as indicative of SWD caseness (Flo et al., 2012b; Waage, et al., 2009)

3.3.1.2 The Bergen Shift Work Sleep Questionnaire (BSWSQ)

The BSWSQ measures symptoms of insomnia and tiredness/sleepiness in relation to day, evening and night shift and well as on rest-days, respectively (Flo et al., 2012a). The twenty-three items assess a three-month average frequency of experienced symptoms ranging from 0 to 4 (0="never", 1="rarely", 2="sometimes", 3="often", 4="always") and alternatively 5="not applicable". Shift-related insomnia was defined as participants scoring "often" or

"always" on at least one of symptoms 1–4 and on at least one of symptoms 5–6 in relation to a specific shift (symptoms 1–4 and 7, in relation to rest-days).

3.3.1.3 Bergen Insomnia Scale (BIS)

The BIS measures insomnia using six symptom-related questions scored on an eight-point scale indicating the symptom frequencies as number of days with symptoms a week. Participants are categorized as insomniacs if their scores are ≥3 on at least one of the first four items 1–4, and ≥3 on items 5 and/or 6 (Pallesen, et al., 2008).

3.3.1.4 Epworth Sleepiness Scale (ESS)

The ESS consists of eight items assessing the likelihood of falling asleep or dozing off in different everyday situations (0="would never doze" to 3="high chance of dozing") (Johns, 1991). Scores equal to or higher than 11 indicate the presence of excessive sleepiness (Johns, 2000).

3.3.1.5 Hospital Anxiety and Depression Scale (HADS)

The HADS consists of fourteen items, assessing symptom load and presence of anxiety (seven items) and depression (seven items). Self-reported response options range from 0="no symptoms" to 3="severe symptoms" (Zigmond & Snaith, 1983).

3.3.1.6 Fatigue Questionnaire

The Fatigue Questionnaire measures two dimensions of fatigue: physical fatigue (using seven items and a total composite score ranging from 0 to 21 points), and b) mental fatigue (using four items and a total composite score ranging from 0 to 12 points) (Chalder et al., 1993). Higher scores are indicative of the presence of more severe fatigue compared to lower scores.

3.3.1.7 Global Sleep Assessment Questionnaire (GSAQ)

The GSAQ is a general sleep assessment/screening tool which distinguishes between self-reported symptoms of different sleep disorders, such as obstructive sleep apnea, restless legs syndrome, periodic limb movement and parasomnia. Response options include 'never', 'sometimes', 'usually', and 'always' (Roth et al., 2002).

3.3.1.8 Dispositional Resilience (Hardiness) Scale – Revised

The fifteen item hardiness scale assesses three facets of hardiness, termed 'commitment', 'control' and 'challenge'. Response options range from 0 (''not true'') to 3 (''completely true''), and add up to yield a total score with a maximum of 45 points (Hystad et al., 2010).

3.3.1.9 Diurnal Scale

The Diurnal Scale measures the morningness-eveningness dimension. High scores on the Diurnal Scale indicate high levels of 'morningness', which is a preference for waking up, being active and going back to bed relatively early in the day. Low scores, on the other hand, indicate 'eveningness' or a preference for waking up, being active, and going back to bed later in the day. This scale contains seven items scored on a scale ranging from 1 to 4, summarized as a total score ranging from 7–28 points (Torsvall & Åkerstedt, 1980).

3.3.1.10 Revised Circadian Type Inventory (rCTI)

The rCTI assesses flexibility and languidity, by five and six items respectively, answered on a 5-point scale. Flexibility (range 5 to 25) assesses the circadian phase, related to the capacity to adapt the sleep-wake cycle to new times. Languidity (range 6 to 30) assesses the amplitude of the circadian rhythm, related to the ability to overcome sleepiness (Di Milia, et al., 2005).

3.3.1.11 Short Form of the Alcohol Use Disorders Identification (AUDIT-C)

The AUDIT-C consists of three items that assess an individual's quantity and frequency of alcohol consumption. Total scores on this scale range from 0 to 12 (Bush et al., 1998).

3.3.1.12 Lifestyle factors and sleep regulatory behaviours

Participating nurses were also asked to report their average daily caffeine consumption (recorded as number of cups per day). Their use of any sleeping-aids during the last year (including the use of bright light treatment, sleep medications, melatonin, and/or non-prescription sleep medications) was also assessed in the study questionnaire.

3.4 Statistical analyses

3.4.1.1 Statistical analyses in paper 1

For the first analyses, the presence of SWD was assessed using three different procedures: 1) using only the three symptom-based questions described in the instruments section, 2) scored above the described cut-off values for insomnia and excessive sleepiness of the BIS and ESS, respectively, in addition to affirming the 3 SWD symptom-based questions and 3) did not report symptoms of other sleep disorders (measured as occurring "always" using the GSAQ), in addition to affirming the 3 SWD symptom-based questions. SPSS version 18 was used for the statistical analyses described in paper 1. Descriptive data were calculated for each of the three SWD assessment procedures.

Preliminary analyses were performed in order to exclude potential collinearity. The insomnia and sleepiness measures were not included in analyses in which the SWD assessment procedure included insomnia and sleepiness as additional criteria. Logistic regression analyses were used to examine the relationship between SWD (the dependent variable, as assessed by the three aforementioned procedures) and age, gender, night or

daytime work schedule, commuting time, fraction of full position, presence of children in the household, number of night shifts worked over the last 12 months, number of shifts separated by less than 11 hours off duty, insomnia, sleepiness, diurnal type, languidity, flexibility, hardiness, physical and mental fatigue, anxiety, depression, alcohol consumption, caffeine consumption, bright light therapy, melatonin use and sleep medication use (prescription and non-prescription).

The predictor variables were analysed separately (crude analyses) and subsequently in multivariable, or adjusted, analyses. When the 95% confidence interval did not include 1.00, the odds ratios were considered statistically significant.

3.4.1.2 Statistical analyses in paper 2

A confirmatory factor analysis using structural equation modelling (SEM) was conducted using SPSS AMOS version 18 in order to confirm the hypothesized factor structure of the BSWSQ. A good fit was confirmed by the following criteria/indices: Root Mean Square Error of Approximation (RMSEA) values up to .08 were considered reasonable error of approximation in the population; Comparative Fit Index (CFI) values of .90 (Bentler & Yuan, 1999), and non-significant chi-square/degrees of freedom (χ^2/DF) of 5.0 or less (Byrne, 2010; Marsh, 2004) were considered acceptable. The model included the following latent factors: "day shift", "evening shift" and "night shift" (each with six indicators, i.e., items), and "rest-days/vacation" (which had five indicators).

Subsequent analyses were performed using SPSS 19. Intra-class correlation coefficients were used to evaluate the BSWSQ's 3-month test-retest reliability (Yen & Lo, 2002). Nurses who reported to have substantially changed their work schedule, or who did not provide an update on their work schedule status were excluded from the test-retest reliability analysis. To investigate divergent/convergent validity of the BSWSQ, Pearson product-moment correlations were calculated between the BSWSQ and other scales including the

ESS, the Fatigue Questionnaire, and the HADS. In addition, the significance of the

differences between the coefficients was tested. Both the difference *between* the work shifts

and rest-days, and the incidence of symptoms *within* the work shifts and rest-days were

analysed using the Huynh-Feldt adjusted repeated measures ANOVAs, with Bonferroni

corrections.

3.4.1.3 Statistical analyses in paper 3

All analyses in paper 3 were performed using SPSS 19. Participants were not included

in the analyses including shifts that were not a part of their work schedule. Participants

answered "not applicable" regarding shifts that were not included in their work schedule, and

these responses were thus set as 'missing' in the data cleaning process. Cross-tabulations for

each shift-related symptom by type of work schedule (permanent day, permanent night, two-

shift rotation and three-shift rotation schedules), gave a detailed summary of differences in

work schedules and shifts. In paper 3, only the prevalence of those responding "often" or

"always" was considered. Cross-tabulations were also employed to find the prevalence rates

of shift-related insomnia by type of shift (day, evening, and night shifts as well as rest-days)

in relation to type of work schedule (permanent day, permanent night, two-shift rotation or

three-shift rotation schedules).

Potential differences between the nurses in different work schedules in age, gender, and

fraction of a full-time position were investigated. Furthermore, the possible difference

between two- and three-shift rotation workers regarding number of shifts worked during the

last year that were separated by less than 11 hours was investigated.

Preliminary analyses were completed to dismiss the possibility of collinearity. Crude

and adjusted logistic regression analyses were completed, each with day-, evening-, night- and

rest-day insomnia as criterion/dependent variables and work schedules, age, gender and

fraction of a full-time position as predictor/independent variables. The participants included in

the analyses varied according to relevant work schedules; day shift insomnia (n=1227), evening shift insomnia (n=1081), night shift insomnia (n=808) and rest-day insomnia (n=1433). The three-shift rotation schedule was used as a contrast/indicator in the main logistic regression analyses. Day shift insomnia and rest-day insomnia included participants from more than two types of work schedules. In order to assess the association between work schedules in these two shift-related insomnia categories, it was necessary to set the permanent night, permanent day and two-shift rotation schedules as contrasts/indicators. Significance for all analyses was set to $p < .05$.

3.5 Ethical statement

This thesis was based on data from the longitudinal survey SUSSH. This study was approved in its entirety by the Regional Committee for Medical and Health Research Ethics, Health Region West (REK-Vest) in 2008 (case number 088.08, appendix 1). At wave 1, the nurses received a letter informing them of the study goal as well as the longitudinal nature of the study. Nurses were then asked to provide their informed consent by signing and returning a consent form together with their completed questionnaire using a pre-paid envelope. Informed consent was a prerequisite for inclusion in the study.

4. RESULTS

4.1 Paper 1

The prevalence of SWD caseness showed minor variations depending on which of the three assessment procedures that were used. When using the three symptom-based questions, symptoms indicative of SWD were found among 37.6% of the nurses. The SWD prevalence was 36.2% when subjects potentially suffering from other sleep disorders were excluded. When insomnia (BIS) and excessive sleepiness (ESS) were added as inclusion criteria, SWD prevalence was 32.4%.

The prevalence varied between groups with different types of work schedules. While only 6.2% of the nurses working permanent day schedule showed symptoms of SWD, these symptoms were reported among 44.3% of nurses working three-shift rotation schedules.

In adjusted logistic regression analyses, SWD risk increased with: older age, circadian type languidity, working night shifts, more shifts worked separated by less than 11 hours during the previous year, more nights worked during the previous year, symptoms of insomnia (all p<.001) and anxiety (p<.05). Circadian type flexibility and being female reduced one's risk of SWD caseness (p<.001 and p<.05, respectively).

The different SWD-assessment procedures yielded similar results in terms of prevalences and significant predictors in the logistic regression analyses. The three questions were thus argued to adequately differentiate between SWD-positive and SWD-negative participants in epidemiological studies.

While the three symptom-based questions illustrated differences in sleep and sleepiness problems according to work schedules, the SWD diagnosis did not clarify which specific shifts were problematic in the various work schedules, nor the prevalence of different sleep or sleepiness symptoms. These results were further investigated in papers 2 and 3.

4.2 Paper 2

The BSWSQ was structured based on the theoretical and empirical assumption that different sleep and sleepiness problems may be more or less present in different types of shifts and rest-days. The investigations of the psychometric properties of the questionnaire demonstrated the questionnaire's ability to help investigators systematically study sleep and sleepiness problems during different types of work shifts.

The overall validity of the BSWSQ factor structure was tested using SEM. The BSWSQ showed an adequate model fit, as confirmed by the following indices: RMSEA=.071 (90% confidence interval =.066-.076), CFI=.91 and χ^2/DF=4.41. The BSWSQ demonstrated good test-retest reliability, with significant intra-class coefficients (p<.001) between the original survey and the second test which was administered three months later. Convergent/discriminant validity was demonstrated using Pearson product-moment correlation coefficients between BSWSQ and the ESS, Fatigue Questionnaire, and HADS (all p-values were <.001). ANOVA analyses showed significant differences in BSWSQ composite mean scores *between* the shifts and rest-days. The night shifts had higher overall/composite scores than the day shifts, evening shifts and rest-days (p<.001). In addition, significant differences *within* the individual work shifts were demonstrated (all p-values were <.001). Most frequent symptoms were: "being sleepy/tired during periods on workdays" and feelings of "sleepiness/tiredness during work hours" in relation to day shifts, ">30-minute sleep onset latency" in relation to evening shifts and "being sleepy/tired during work hours" in relation to night shifts.

Overall, the BSWSQ met the predetermined psychometric standards required, and was considered effective for use in epidemiological investigations of discrete insomnia symptoms in different shifts and work schedules.

4.3 Paper 3

The BSWSQ was used to identify clinically severe levels of sleep and sleepiness problems among nurses working different types of shifts, termed "shift-related insomnia". Prevalence of shift-related insomnia differed between nurses by their type of work schedule. Initial analyses showed that age and fraction of a full-time position differed between the work schedules. There was no difference between the two-shift and three-shift rotational schedule in terms of number of shifts with less than 11 hours in between.

The BSWSQ provided valuable descriptive data of the prevalences for all shift-related symptoms in different work schedules. In paper 3, the prevalence for symptoms occurring "often/always" was reported. Table 2 provides an overview of the prevalence for symptoms reported to occur "never/rarely", "sometimes" and "often/always".

According to the adjusted logistic regression analyses, there were no significant differences between the types of work schedules in day shift insomnia. However, working a fraction of 90% or more increased one's risk of day shift insomnia ($p<.05$). Evening shift insomnia was more common among nurses working two-shift rotation schedules (29.8%) than nurses working three-shift rotation schedule (19.8%) ($p<.001$). Night shift insomnia showed higher odds ratio with regard to the three-shift rotation schedule (67.7%) compared to permanent night schedule (41.7%) ($p<.001$). Rest-day insomnia was more prevalent among permanent night workers (11.4%) compared to two-shift rotation workers (4.2%) ($p<.05$) and three-shift rotations workers (3.6%) ($p<.01$).

Table 2: Percentage of nurses within specific work schedules reporting to experience different symptoms of sleep and tiredness/sleepiness problems in relation to day shifts, evening shifts, night shifts and rest-days.

	Permanent day			Two-shift rotation			Three-shift rotation			Permanent night		
	Never/ rarely	Some-times	Often/ always	Never/ rarely	Some-times	Often/ always	Never/ rarely	Some-times	Often/ always	Never/ rarely	Some-times	Often/ always
1) Sleep onset latency (using more than 30 minutes to fall asleep)												
Day shift	65.1	23.3	11.6	56.9	26.1	17.0	59.3	28.7	11.9			
Evening shift				22.3	23.4	54.3	19.5	25.3	55.2			
Night shift							51.6	20.8	27.7	63.2	23.7	13.2
Rest-days	63.6	27.1	9.3	67.1	24.6	8.4	64.9	26.7	8.4	58.5	28.0	13.6
2) Wake after sleep onset (bouts of wakefulness lasting more than 30 minutes within the main sleep period)												
Day shift	72.6	17.8	9.6	71.7	21.3	7.1	78.3	16.5	5.3			
Evening shift				56.8	23.7	19.5	62.1	22.1	15.8			
Night shift							47.1	23.9	29.0	62.6	19.1	18.3
Rest-days	77.4	16.1	6.6	81.1	15.9	3.0	84.2	12.2	3.5	71.8	18.8	9.4
3) Premature awakening (waking up more than 30 minutes earlier than wished, without falling asleep again)												
Day shift	66.4	22.6	11.0	61.4	23.8	14.9	73.5	18.2	8.3			
Evening shift				63.3	18.9	17.8	68.4	20.4	11.1			
Night shift							40.0	20.7	39.3	41.2	34.2	24.6
Rest-days	67.9	24.8	7.3	77.6	16.8	5.5	82.1	15.4	2.5	77.1	16.9	5.9

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Table 2–continued

	Permanent day			Two-shift rotation			Three- shift rotation			Permanent night		
	Never/ rarely	Some- times	Often/ always	Never/ rarely	Some- times	Often/ always	Never/ rarely	Some- times	Often/ always	Never/ rarely	Some- times	Often/ always
4) Not feeling adequately rested following sleep												
Day shift	14.2	35.1	50.7	22.7	33.7	43.6	17.3	38.6	44.0			
Evening shift				21.3	28.9	49.9	23.1	33.8	43.1			
Night shift							10.9	25.6	63.5	15.7	42.6	41.7
Rest-days	62.7	23.1	14.2	68.1	22.2	9.7	70.0	20.5	9.5	61.9	24.6	13.6
5) Experience of being tired / sleepy at work												
Day shift	29.7	53.4	16.9	22.3	47.9	29.8	28.3	47.9	23.8			
Evening shift				33.9	43.8	22.4	48.7	40.5	10.8			
Night shift							5.6	24.2	70.2	17.4	40.9	41.7
6) Experience of being tired / sleepy during free periods on workdays												
Day shift	13.0	45.2	41.8	13.0	44.0	43.0	14.0	41.6	44.4			
Evening shift				33.0	42.9	24.2	39.7	41.7	18.5			
Night shift							8.7	25.5	65.8	23.2	33.9	42.9
7) Experience of being tired / sleepy when not working / on vacation												
	43.9	45.1	11.0	52.9	39.7	7.4	56.0	37.4	6.6	50.8	34.7	14.5

5. DISCUSSION

5.1 Impacts of shift work on sleep, sleepiness and health

5.1.1 SWD and shift work-related sleep and sleepiness problems

Shift work disorder represents an important estimate of clinically severe sleep and sleepiness problems in a shift working population. However, few studies have to this day systematically investigated the prevalence of this disorder. Even fewer have looked at the distribution of SWD across different work schedules. There was a need to study SWD in nurses as the literature on SWD in this occupational group was scarce.

The three symptom-based questions that were used to assess SWD in paper 1 were previously used by a study that assessed SWD in petroleum workers (Waage et al., 2009). In paper 1 the aptness of the three questions was further investigated. Two other SWD diagnostic procedures were considered. The prevalence of symptoms indicative of SWD found in paper 1 was 37.6%, 36.2% and 32.4%, depending on the procedure used to assess SWD. Considering that these prevalences represent individuals reporting to have *problems* with sleep and sleepiness specifically in relation to their work schedule, these figures may be conceived as rather high. Yet, on the other hand, it may be just as remarkable that approximately 60% of the nurses did not report sleep or sleepiness problems in relation to their work schedules despite many of them having schedules containing night shifts.

While paper 2 also investigated shift work related sleep problems, the objective was primarily to validate the BSWSQ. Paper 3 on the other hand, used the BSWSQ to further study sleep problems in both different types of shifts and different types of work schedules. As expected, night shift was problematic both in terms of SWD risk (paper 1) as well as concerning the sleep and sleepiness symptoms measured by the BSWSQ (paper 3). Paper 1

demonstrated that night work in contrast to *no* night work entailed an increased risk for SWD. Hence, working nights represented an increased risk of SWD, regardless of the number of night shifts worked. In Paper 1, it was also shown that increasing the number of nights worked the past year entailed increased odds ratios in relation to SWD. Interestingly, this could be suggestive of a dose–response relationship between night work and risk of SWD; however, a threshold cut-off value remains to be established. Few studies have addressed the issue of dose-response patterns of night shift exposure. A longitudinal design is necessary to investigate a possible aggregation of sleep problems with time (Knutsson, 2004). Paper 3 showed that working night shifts in general was associated with high prevalence of many discrete sleep and sleepiness symptoms. The results of both paper 1 and paper 3 are in line with previous findings that suggest that night shifts significant shorten one's total sleep time (Åkerstedt, 2003).

The fact that nurses working a permanent night schedule also showed high prevalence rates both in terms of SWD (paper 1) and problems with sleep and sleepiness (paper 3) suggests that their circadian rhythm was not fully adapted to night work. Previous studies have reported that only a small fraction of permanent night workers ever fully adapt to the night shift schedule (Folkard, 2008a). For many permanent night workers, it may be socially desirable to adjust to a normal night-time and daytime sleep-wake rhythm during rest-days. According to findings in paper 3, permanent night workers had significantly higher prevalence of shift-related insomnia on rest-days than did two- and three-shift rotation workers. Additionally, even though permanent night workers may develop a seemingly healthy sleep schedule or routine, they are still exposed to stimuli that place them at odds with their wake–sleep rhythm (e.g. daylight when driving home from work). Permanent night working nurses reported less problems with night work compared to the three-shift rotation workers, but more problems during free periods. This suggests that the permanent

night workers obtained a better adaptation to night work than the nurses on a rotating work schedule.

A rotational shift schedule demands nurses to undergo frequent adaptation and re-adaptation to different sleep-wake rhythms which has been related to problems with sleep onset, WASO and premature awakening (Sallinen & Kecklund, 2010). As hypothesized in paper 3, the prevalence of night shift insomnia among three-shift rotation workers was higher than among permanent night workers. The constant change in activity-rhythm may also be stressful when only rotating between day and evening shifts. Short recovery times between two consecutive shifts may lead to difficulties related to sleep onset latency and truncated sleep time (Roach, Reid, & Dawson, 2003). Among the nurses described in paper 1, close to 30% of those who worked two-shift rotation schedules reported symptoms indicative of SWD. This suggests that not only night shifts, but also rotations between different work times, can be challenging for nurses. Furthermore, paper 1 showed a significant relationship between SWD and the number of shifts worked in the previous year that were separated by less than 11 hours. However, in paper 3, the prevalence of day shift insomnia among nurses with two- or three-shift rotation schedules was not higher than among those with permanent day schedules. Since moderate levels of day shift insomnia were observed across all the different types of work schedules, it is possible that the early morning start was more problematic than the rotation between shifts. Early morning work has been associated with getting fewer hours of sleep and to feelings of poor sleep quality (Åkerstedt, 2003). No a priori hypotheses were postulated in paper 3 with regard to differences between two- compared to three-shift rotations in evening shift insomnia. Nevertheless, two-shift rotation workers had a significantly higher risk of evening shift insomnia compared to three-shift rotation workers. A possible explanation for this finding is that nurses who do not cope well with night work may seek positions with schedules rotating

only between day and evening shifts. This would mean that a bias such as the "healthy worker effect" may have confounded this result. The issue of biases in the study sample is further addressed in the methodological discussion section.

Evening shifts showed generally low symptom prevalence in paper 3, apart from a high prevalence of problems with sleep onset latency. Both day and night shift insomnia were more prevalent than evening shift insomnia. This is in line with previous studies, reporting longer average sleep in relation to evening shifts as compared to day and night shifts (Åkerstedt & Wright Jr, 2009).

Even though few participants reported sleep and sleepiness problems related to their free periods and rest-days, there was a high prevalence in different work schedules and shifts of reported feelings of "tiredness/sleepiness during the free period on work days". Noticeably, different sleep regulatory mechanisms may affect the same sleep symptoms depending on the different shifts. For night shifts, a nurse's free period usually occurs prior to the start of his or her shift. Sleepiness/tiredness during this free period may be due to both sleep inertia and sleep deprivation. On the other hand, the day shift related free period occurs after the workday ends. At this time, sleepiness could be due to the homeostatic process, fatigue after a demanding shift, and sleep loss due to an early morning (Åkerstedt, 2003).

Sleep during daytime free periods has been shown to be shorter compared to night-time sleep (Roach, et al., 2003). Moreover, having free periods during the day leads to more hours of wakefulness before the following night shift, thus increasing sleepiness during the night shift (homeostatic factor) (Härmä et al., 2002). Number of hours awake before a night shift, which increases the homeostatic pressure for sleep, may have contributed to the high levels of reported night shift-related tiredness/sleepiness among the nurses. In addition, sleepiness during night shifts is also clearly related to the circadian factor. Paper 3 found a high prevalence of feelings of sleepiness during night shifts both among permanent night

workers and among three-shift rotation workers. This was not surprising considering that night shifts involve working at the nadir of the normal human circadian rhythm (Härmä, et al., 2002). A permanent night shift worker may become partly adapted in terms of his or her circadian rhythm, but she or he may still be affected by the homeostatic component. A three-shift worker may be doubly affected, by both the homeostatic and the circadian rhythm. Indeed, there were higher frequencies of tiredness/sleepiness reported among the three-rotational shift workers compared to the permanent night workers.

Even though previous studies have shown relationships between shift work and sleep problems, the complex interactions between sleep and sleepiness problems (pertaining to circadian and homeostatic processes) and different types of shifts and work schedules were further investigated in paper 1 and paper 3. Different associations between SWD, sleep and sleepiness problems and different shifts and work schedules highlight the empirical and theoretic basis for designing the BSWSQ.

5.1.2 Shift work and health

Problems with sleep and sleepiness represent both a health issue as well as a factor that mediates the relationship between shift work and other health issues. Paper 1 aimed to study the relationship between SWD and health issues that had previously been related to shift work, including: fatigue, insomnia, sleepiness, depression and anxiety.

Although reported fatigue was not associated with SWD in paper 1, it is not necessarily unrelated to shift work. Fatigue has previously been associated with shift work in a shift-working population (Åkerstedt & Wright Jr, 2009).

Insomnia was significantly associated with SWD. This association may seem like a tautology. However, as discussed in paper 3, having severe insomnia symptoms in relation to a night shift do not necessarily indicate the presence of general insomnia. Likewise, having SWD may not mean that insomnia symptoms would be present without the work schedule in

place. Thus, it was of interest to investigate whether SWD additionally entailed an increased risk of having general insomnia. Interestingly, excessive sleepiness was not significantly associated with SWD, contrary to what one may expect. However, these results may be explained by the assumption that SWD is highly contextual. Thus, its symptoms may not be detectable using general sleep and sleepiness questionnaires. The ESS assesses sleep propensity in everyday situations, not specifically in work contexts. In addition, fluctuations in work performance and behavioural influences such as caffeine consumption are not considered in the ESS (Sack, et al., 2007).

Sleep problems are an essential feature of many psychiatric disorders, and are related to both anxiety and depression (APA, 2000; Sivertsen et al., 2009). In paper 1, only symptoms of anxiety remained significantly associated with SWD in the adjusted analyses. Nevertheless, depression remained significantly associated with SWD when the ESS and the BIS were employed as additional SWD inclusion criteria. It is possible that the nurses who were SWD-positive based on the three symptom-based questions as well as scoring above cut-offs on the ESS and BIS, were more severely affected by shift work. It is also possible that not adjusting for BIS and ESS sum scores in that logistic regression analysis may have affected this outcome. Concerns regarding the number of variables included in adjusted logistic regression analyses are discussed further in the methodological discussion section.

5.2 Individual factors

When the association between shift work and health have been investigated, demographic variables such as age and gender have often been included in the analyses as possible confounding variables. Individual differences may represent differences in susceptibility to an internal desynchronization of the circadian rhythms (e.g., sleep-wake, body temperature, cortisol levels and so on). This increased susceptibility may subsequently

affect sleep, fatigue, and mood disturbances. Furthermore, individual differences in outcomes may be interpreted as differences in individuals' risk of various health issues that are unrelated to shift work. Some individual differences may represent both confounding variables as well as predictor variables.

In this thesis, gender was considered to be a confounding variable because of the possibility that gender differences in, for example, chosen type of work schedule could also influence the outcome variables. Gender may also be a possible predictor variable in that gender differences may entail differential susceptibility to shift work related sleep and health problems.

In paper 1, female nurses had lower odds ratios than males in association with SWD. Previous studies have found increased risk of developing different health issues in males and females, with gender differences depending on the outcome measured. Still, the majority of studies looking at gender differences show better SWT in males (Saksvik, et al., 2011). Because male and female nurses have similar types of job tasks and work schedules, the gender differences found in paper 1's analyses are unlikely attributable to work-related factors. For example, studies of male shift workers may typically include samples from the transport (Härmä, et al., 2002) or petroleum industry (Waage, et al., 2009) or from the police force (Garbarino et al., 2002). Different occupations tend to have different work scheduling and workloads, making comparisons in the effect of gender difficult across studies.

Because traditional differences in domestic responsibilities between men and women have been posited as a possible confounding variable in terms of gender differences in SWT, 'presence of children in the household' was included in the analyses in paper 1. Although this variable was unrelated to symptoms of SWD, taking the domestic situation into account may correct for some potential gender differences. Then again, would this stereotypic gender difference in male/female domestic responsibilities apply to the male nurses in this study?

The nursing occupation was traditionally comprised of predominantly females and this gender imbalance persists today. There is still a ten-to-one female-to-male gender ratio in the Norwegian nursing population (Køber & Vigran, 2010), which was mirrored in the study sample of which approximately 90% were female. Males were practically left out of nursing education programs until the late 1960's (Svare, 2009). Being a male nurse is still not a typical male career choice, but rather a transgressive occupational choice. It is thus pertinent to consider what gender differences signify in this project. Does it represent a gender difference in susceptibility to shift work related health problems? Conversely, is it a difference between female nurses and a rather selected group of males which have chosen to work in an untraditional occupation as a gender-minority? It is possible that males who choose nursing careers may have different personality traits compared to other men who choose to be police officers or petroleum rig workers.

Age has also been related to SWT where the majority of studies show better SWT among younger workers. For example, as reported in paper 1, older age was related to increased odds of SWD. Age was also positively correlated with evening shift insomnia in the crude analysis. However, in the adjusted analyses, age was not significantly associated with any of the shift-related insomnias examined in paper 3. Age differences in work schedules (permanent day workers tend to be older and more senior nurses) and the "healthy worker effect" (discussed further in the methodological discussion section), may have counteracted possible age effects in the study sample.

As with gender differences, findings of age related effects on SWT in previous studies are not consistent (Saksvik, et al., 2011). Importantly it should be differentiated between the ability to change circadian rhythms and obtain enough sleep, and the ability to perform. While older age has been related to vulnerability to circadian misalignment, it has also been related to lower levels of sleepiness at the circadian nadir (Dijk, et al., 1999).

Adults tend to show increased early morning preference with age (Roenneberg, et al., 2007). This implies that while older age may contribute to greater difficulties with night shifts, it may make an early rise time easier to manage. Nevertheless, getting enough sleep during the day, and staying awake during the night seems increasingly difficult with older age (Folkard, 2008b).

Some individuals tend to cope better with shift work than others. As described in the introduction section, different personality types shown to influence SWT are circadian type (Di Milia, et al., 2005) and diurnal type (Torsvall & Åkerstedt, 1980). The personality characteristic of 'hardiness' has been related to a general coping with stressors at work (Hystad, et al., 2010). Although personality has been related to SWT, it has not been thoroughly investigated in relation to SWD.

In paper 1, SWD showed lower odds ratio in association with circadian type flexibility and increased odds ratios related to circadian type languidity. High scores on flexibility and low scores on languidity have previously been related to the ability to perform at unusual times of the day (Di Milia, et al., 2005). In paper 1, neither hardiness nor morningness were related to SWD when adjusting for other variables. As mentioned, being a morning type may be an advantage in relation to early morning shifts, but may lead to difficulties when working nights. Both evening and morning types may thus experience sleep problems, but related to different aspects of the work schedule. Hardiness represents a general coping style, and is possibly more relevant in relation to coping with other work-related stressors than the demands of shift work.

5.3 Contextual factors

Contextual factors that affect the relationship between shift work and health effects may include work conditions (including work scheduling) and living conditions, behaviours and lifestyle choices.

While the effects of work scheduling on SWD, sleep and sleepiness problems have already been addressed, there are other issues related to work organization that may also influence SWD and shift-related problems with sleep and sleepiness. Differences in workload between occupational groups represent a confounding variable in terms of shift work-related sleep problems and health issues. For example, a previous study using the same three SWD questions showed a lower SWD prevalence of 23.3% in petroleum workers (Waage, et al., 2009). However, nurses have additional social/familial commitments alongside their occupational duties, compared to those working on an oil rig.

There may be workload differences also within occupational groups. A nurse working at an emergency department may have a very dissimilar shift compared to a nurse working at an outpatient clinic. There may not only be differences between nursing positions, but also between different shifts within the same department. A night shift may in some hospital departments by and large consist of monitoring sleeping patients, while all forms of treatment take place during the day shift. In other cases, night shifts may comprise emergencies with reduced on-duty personnel. While a very high workload may have fatiguing effects, it should be taken into consideration that monotonous work tasks may also increase sleepiness (Sallinen et al., 2004).

Although workload differences may be present, the nursing population in this study was randomly selected from several different institutions and departments, reducing the likelihood of a systematic bias.

Sleep and sleepiness problems are not uniquely related to shift work. It is found to be common in the general population to sleep less during the work week than on weekends (Ursin, et al., 2009). Thus, working less than a full-time position may help increase one's sleep time and reduce sleepiness. While there was no association between SWD and fraction of a full-time position reported in paper 1, there was higher prevalence of day shift insomnia among those working a fraction of 90% or more reported in paper 3. This suggests that not only the work schedule, but also the amount of work may affect sleep.

In paper 1, there was no association between commuting time and SWD. Extended commuting times can further truncate sleep times, and thus act as an additional stressor (Caruso et al., 2006). As mentioned, over 80% of the nurses studied in this thesis had a commuting time of 30 minutes or less. It is possible the commuting time in the majority of nurses was too homogenously short to give an effect in terms of SWD.

 Although having children at home has been suggested as an extra workload, children at home may also imply the presence of surrounding family and a supportive social network. There was no relationship between the presence of children at home and SWD in paper 1. A social network may give both emotional support and practical assistance in a busy life which could be mediating factors in SWT (Wright Jr, et al., 2012a).

The lack of significant associations between SWD and other contextual factors highlights work scheduling as a central factor related to SWD. Other work schedule characteristics such as the organization of rest-days may also have influenced differences between nurses working rotational schedules or between the nurses working rotational and permanent schedules. These differences may however vary in different institutions, and were not assessed in this study.

Previous studies have shown that life style variables (e.g. dietary habits and alcohol consumption) can confound the study of shift work and health (Lowden, et al., 2010; Tucker,

et al., 2012). Alcohol consumption was not related to SWD in the adjusted analyses in paper 1. Similarly, neither was the consumption of sleep medication, melatonin, or the use of bright light therapy. The use of sleep aids, however, was significantly related to SWD in the crude analyses, but few nurses in the study sample reported usage, which may have caused insignificant findings concerning these variables in the adjusted analysis.

5.4 Validation and implementation of the BSWSQ

The BSWSQ was constructed based on the theoretical assumption that different work shifts would each affect discrete insomnia symptoms differently. Each insomnia symptom in this scale was furthermore selected as established diagnostic criteria (AASM, 2005; APA, 2000). Since the questionnaire corresponded to predetermined latent constructs (i.e. sleep in relation to shift type) it was considered suitable to conduct a confirmatory factor analysis using SEM. Several items in the scale were worded similarly, so correlations between errors were allowed. By using modification indices, the model was thus modified, albeit only when there was a sound logic for such correlations. Because of this, the analysis may be considered partially explorative.

In paper 2, the model fit indices found using SEM suggested an acceptable but not optimal fit. The χ^2/DF was used as it does not yield the same problems as does the χ^2 when handling a large sample. The χ^2 is basically a test of the null-hypothesis of *perfect* model fit, in effect; any non-zero residuals could then yield a significant χ^2, indicating poor model fit. The χ^2-value is, in comparison to the χ^2/DF-ratio, highly sensitive to sample size (Byrne, 2010). The RMSEA was also used as an established measure of overall fit. RMSEA values less than .05 are considered indicative of a good fit. However, RMSEA values of 0.08 represent reasonable errors of approximation (Byrne, 2010). According to the confidence interval found in paper 2, the true RMSEA value was within the reasonable errors of

approximation. For the CFI, values greater than .95 have been considered representative of a good fitting model. However, there has previously been a consensus for a .90 cut-off value, and some would argue that although CFI values of .95 or higher may be optimal, this cut-off value may in some cases be too stringent and unrealistic for certain types of analyses (Marsh, 2004). As the model showed a CFI above .90, the model fit were on a whole regarded as reasonable.

Since the BSWSQ assesses insomnia symptoms, nurses with general sleep and sleepiness problems would likely report symptoms regardless of work shift. This would in turn lead to an inherent structure in which different symptoms could emerge as latent factors; a competing model. Possible response bias, such as negative response set, would strengthen such a competitive model. This may have affected the results for the BSWSQ model fit.

The test-retest analyses compared the BSWSQ scores of 234 nurses at two time-points separated by three months. This may be considered to be a rather long time break. The objective with the BSWSQ was not to assess either acute or endogenous sleep problems, but to map out sleep problems related to work shifts. Thus, it was expected that the shift-related sleep problems would persist provided the type of work schedule remained the same. The participants who had changed their work schedule were therefore excluded from the test-retest analyses. The change in season from January to April may have confounded the results, as insomnia symptoms have previously been found to vary by season (Øyane et al., 2008). Nevertheless, the temporal stability of the BSWSQ was confirmed.

The tests of convergence/divergence were largely confirmed in the paper 2 analyses. Detailed analyses of the difference between coefficients revealed that the ESS did not show the clear association to sleep and sleepiness problems measured by the BSWSQ as initially expected. Summed ESS scores were not related to SWD in the adjusted analyses in paper 1, and showed weaker correlation coefficients than did physical fatigue scores in relation to

overall BSWSQ results in paper 2. Thus, the ESS may not be sensitive to problems with sleepiness experienced in the context of shift work. Weaker correlations between shifts and rest-days were observed, which agrees with previous studies showing different sleep patterns on work days compared to weekends (Ursin, et al., 2009).

5.5 Methodological discussion

5.5.1 Shift work definitions and assessments

In this study, nurses were asked to report their work schedules in predefined categories. Most nurses worked either in a somatic or psychiatric hospital. The start and end times of the different shifts are fairly similar as these institutions in Norway are governed by the same legislative policies. Nevertheless, the study only asked for type of work schedule, not work times. Hence, a "night shift" may entail some variation in start and end times. This is unfortunate; however, those working nights are working during the night; during the nadir of alertness and the period of interest for our investigations. It is also possible that some nurses in the study sample start their day shifts at 08:00 rather than 07:00. This would give those day workers another advantage over three-shift rotation workers, who start at 07:00. Yet, paper 3 revealed that there were no differences between permanent day workers, two-shift rotation, and three-shift rotation workers in relation to the day shift related sleep and sleepiness problems.

5.5.2 Assessment of diagnostic criteria and symptom severity in questionnaire-based studies

A recurring issue with assessing and diagnosing symptom severity is whether the questionnaire is adequately sensitive and discriminative. An added challenge when dealing with a shift working population is to distinguish between a "normal" reaction to shift work and an illness. In the AASM review, Sack and colleagues (2007) points out *"It is likely that*

people are intolerant of shift work for a variety of reasons, and that the diagnosis is applicable to a large and heterogeneous population" (Sack, et al., 2007).

Few studies have used the formal symptoms criteria of SWD (Sack, et al., 2007). There has not been established consensus as to how SWD should be measured in epidemiological studies. When assessing the possible presence of SWD, the key element is the association between insomnia or sleepiness and the work schedule. The differential diagnoses of insomnia include sleep initiation-related disorders and sleep maintenance disorders. Excessive sleepiness may in some cases be explained by narcolepsy or sleep apnea (AASM, 2005). Ideally, clinical interviews, actigraphy, sleep diaries, and perhaps even polysomnography would be employed to assess the severity of SWD symptoms, and to exclude other potential primary diagnoses. Unlike a self-report questionnaire, a clinical interview gives the opportunity to further probe into the severity and reasons for sleep problems. Unfortunately these methods were unfeasible to employ in an epidemiologic study of this magnitude. That being said, having other health issues or sleep disorders would not eliminate the possibility of the presence of SWD. Other diagnoses/health issues may be present, as long as they do not *better* account for the sleep and sleepiness symptoms (AASM, 2005).

Two other SWD assessment procedures were considered. The other procedures yielded fairly similar results for prevalence of SWD among shift working nurses. Moreover, it is possible that the alternative procedures wrongly excluded some individuals who actually had SWD. For instance, a nurse may have had SWD and also suffered from restless legs. Using The GSAQ as exclusion criteria could have wrongfully led to the exclusion of such a participant. Thus, the three SWD questions were considered as sufficient, to *indicate* SWD caseness, but not to diagnose SWD. In epidemiology studies, there is no absolute guarantee that the reported symptoms are not actually attributable to other disorders. Yet, if the

participants claim to have sleep problems due to their work hours, this should be considered as indicative of SWD. A patient's perceptions and self-reported causal factors for their health symptoms matter to physicians when diagnosing disorders. For example, a medical doctor in a routine outpatient clinic would not base a diagnosis of SWD on actigraphy or other objective sleep measurements, but would rely on a patient's self-reported assessment of temporal consistency between work hours and sleep problems.

Some of the concerns related to diagnosing SWD may be related to the diagnostic criteria as they are currently formulated in the ICSD-2 (AASM, 2005). The diagnostic criteria do not include any clear-cut qualifiers regarding how severe the symptoms have to be (for example, frequency or tenacity of symptoms). In addition, the diagnostic criteria do not address one single specific problem, or a defined combination of problems. Rather, it represents either sleep problems caused by working times, sleepiness problems caused by working times, or a combination of sleep or sleepiness problems caused by working times. The 2007 AASM task force review of the circadian rhythm sleep disorders highlights the potential heterogeneity of the SWD population. It is possible that the SWD diagnosis does not entail an optimal degree of specificity (Sack, et al., 2007).

In order to differentiate between "normal" and clinically severe forms of sleep and sleepiness problems the dichotomized shift-related insomnia categories were created in paper 3. The presence of shift-related insomnia is not a diagnostic cut-off, but helps to assess how severely the work shifts may be affecting sleep and wake-time functioning. Some shift workers may never adapt to shift work schedules, and always experience several discrete sleep problems related to one specific type of shift. However, if the problems are highly confined to a particular type of shift which is rarely part of an individual's schedule, the shift work might not severely impact the individual's overall sleep. Night shift insomnia as assessed with the BSWSQ would not necessarily correspond to either general insomnia or to

SWD. The intention of this work was thus not to diagnose sleep and sleepiness problems but to investigate the associations between types of shifts and work scheduling and problems with sleep and sleepiness. The BSWSQ enables a categorization of symptoms indicative of shift-related insomnias by taking into account several shift-related symptoms. This reduces the possibility that specific sleep problems are neglected and it helps investigators to differentiate between effects observed by schedule type using a greater level of detail than global scales, yet remaining comprehensible. All the same, it is important to emphasize that even though the SWD questions and the BSWSQ are not diagnostic tools, the experienced sleep and sleepiness problems reported among participants are real. Self-reported problems with sleep are important information; it is just not a diagnosis.

In an attempt to assess SWD within the framework of an epidemiological study, some previous investigators have chosen to exclude workers who do not have rotational schedules or who do not work nights. This thesis has included permanent day workers in the population assessed for SWD and shift-related sleep and sleepiness problems. Permanent day workers could be regarded as a control group. However, early morning shifts may be problematic for some. Excluding permanent day workers would disregard individuals who truly have insomnia and sleepiness in relation to their work schedule. Furthermore, the diagnostic criteria of SWD do not specify any restriction on type of schedule the worker should be engaged in.

Importantly, SWD represents a diagnosis based on an unhealthy behaviour, which is partly a lifestyle choice, and partly an occupational necessity. Nurses in this study were employed in a normal work position, and they would in most cases be considered part of the greater healthy population. This is confirmed by the nurses because they reported to have problems with sleep, but mainly in relation to their work schedule.

Working in itself holds a high potential to infringe on sleep. Forced awakenings during weekdays are common, and demographic data suggests that people tend to sleep less during the work week compared to on the weekends, despite having regular daytime positions (Ursin, et al., 2009). Not surprisingly, feelings of sleepiness also represent a common complaint in the working population as a whole. Ursin and colleagues (2009) found that several occupational groups in addition to shift workers reported excessive sleepiness (Ursin, et al., 2009). The ubiquity of sleepiness complaints among workers may partly explain why excessive sleepiness was not significantly related to SWD.

Another challenge in the measurement of sleep and sleepiness problems is the minute, but essential difference between sleepiness and fatigue (Shahid, Shen, & Shapiro, 2010). Both sleepiness and fatigue have been related to reduced performance and to increased risk of errors and accidents (Knutsson, 2004). While feelings of sleepiness are reduced by sleep, fatigue is defined by lack of energy that persists even after a good night's sleep (Knutsson, 2004). In addition, feelings of "tiredness" have also been used along with "sleepiness" in the DSM-IV-TR insomnia inclusion criteria (APA, 2000), and the ICSD-2 insomnia severity index (AASM, 2005). In paper 1, it was differentiated between sleepiness (ESS) and fatigue (Fatigue scale). The BSWSQ assesses sleep problems and problems with sleepiness or *tiredness*. Thus, some participants may have reported feelings of tiredness when they were experiencing symptoms of fatigue.

5.5.3 Statistical analyses

There was a skewed gender distribution of ten-to-one females-to-male ratio in the study sample. Although this may affect interpretation of results, it does not necessarily indicate any sample bias. A 50-50 male-female gender distribution would in many ways be more problematic in this study, because it would represent a sample bias. Results would be less generalizable to other nursing populations because according to surveys both in the US

and in Europe, approximately 90% of the population of nurses are females (Køber & Vigran, 2010; Parent-Thirion, et al., 2007).

Preliminary power analyses were performed to ensure satisfactory statistical power. However, a high number of participants may lead to significant p-values for differences that in any practical sense are trivial. Thus, statistical significance may not necessarily imply clinical significance. Therefore, the odds ratios should be given attention alongside p-values. An odds ratio size should furthermore be interpreted with consideration to the measurement units of the variable examined. For example in paper 1, the number of nights worked each year was significantly associated with increased risk of SWD, with a modest odds ratio of 1.01. While this odds ratio may seem slight, it indicates that working 60 nights each year instead as compared to none would increase the risk of SWD by 60%.

The adjusted logistic regression analyses in paper 1 included over twenty independent variables. Including a high number of variables can affect the ability to accurately detect differences in the analysis due to suppressor effects. Preliminary analyses were conducted to eliminate the possibility of collinearity. Such analyses were also conducted for logistic analyses in paper 3.

It is also problematic when multiple analyses are conducted, as this increases the risk of a type 1 error. In paper 2, ten ANOVAs were performed. Bonferroni corrections were used in order to ensure that the findings were not a result of capitalizing on chance. In paper 3, four logistic regression analyses were performed. This number of analyses is not considered problematic, so no corrections were performed.

5.5.4 Strengths and limitations

Although the SUSSH project is prospective, all results reported in this thesis are based on cross-sectional, self-report survey data. It is therefore not possible to make conclusions regarding the causal direction of the associations. None of the papers in this

thesis claim to ascertain any conclusion of the causal direction of significant associations. On the other hand, a cross-sectional design allows for the description of odds ratios and prevalence-based risk calculations. This has been one of the main aims of this thesis, and the nature of the employed data set thus adhered to the study objective. In papers 1, 2, and 3, cross-sectional data have been used to describe features of the sample of nurses, such as prevalence of SWD and sleep and sleepiness problems in different work schedules. In addition, cross-sectional data are also useful for generating hypotheses for future longitudinal studies. Thus, the results reported in this thesis may inform further investigation into SWD and shift-related sleep and sleepiness problems in different types of work shift schedules.

Studying nurses, which represent a large and homogenous sample of workers, reduced the likelihood of interference from confounding variables (e.g., different workload, environments, socioeconomic status). Unfortunately, using only one occupational group limits the generalizability of the results to other occupations.

The study design does not include a clear-cut control group. The use of permanent day workers as reference group, would have introduced issues related to group differences and potential group biases. Even if the permanent day workers are part of the same occupational group, the comparison could not be said to be between a control group and an experimental group. The permanent day workers also have demanding work schedules if they start at 07:00 or earlier. In addition, in most epidemiological studies on this subject matter, shift work is not introduced to an experimental group; instead, the control group "day workers" often represent nurses who left shift work.

This introduces the healthy worker effect, a phenomenon that workers usually have lower death rates and better health compared to the general population (likely because severely ill and disabled individuals are often excluded from the workforce). In terms of shift

workers, there is a further selection between those who have the health to start and to

continue working rotational schedules and night shifts, and those who seek permanent day

schedules due to health issues. It is relatively rare to find nurses who have only worked

permanent day schedules since they started. Thus, a control group of nurses who has only

worked day shifts would therefore introduce a significant bias. Both a possible impact of the

healthy worker effect and a pre-selection bias were not possible to fully exclude from the

results reported in this thesis. Both biases are likely to mask some of the negative effects of

shift work, increasing the risk of type 2 errors.

As all results are based on data collected with the same questionnaires, the issue of

common method bias needs to be addressed. This bias refers to the fact that variance

observed may be due to the method of measurement rather than to the constructs in focus.

This bias may occur as a result of several aspects with the questionnaire and overall study

design. In the SUSSH study in particular, the combination of several questionnaires and

scales under one common heading of, "Shift work, sleep and health in nurses" creates a

common context for the items and environment of data collection. This may for example

give a priming effect ("my health and sleep are related to my work schedule") or trigger

respondents' desire to remain consistent (Podsakoff, et al., 2003). Furthermore, the results

may additionally be confounded by a learning bias. The questionnaires are formulated in

such a way that it may be possible to deduce the scientific hypotheses, which may in turn

bias the responses (Choi & Pak, 2005). If some work schedules or shifts are more desirable

than others, this may affect answers, introducing motivational biases (Åkerstedt, 2003).

External factors such as conflicting motivations are inevitable, and not easy to separate from

"real" effects of shift work. In fact, to be satisfied with and have control over one's work

schedule, has been shown to promote health and wellbeing (Axelsson, et al., 2003; Janssen

& Nachreiner, 2004). One method to alleviate this methodological issue is to separate the

predictor and outcome measures in an assessment. In the context of questionnaires, this may be done by separating scales in terms of different response formats, for example difference in questionnaire framing, switching between positive or negative valence and introducing different response units for different types of questions (e.g. number of days, different semantic categories, levels of agreement/disagreement, and yes/no responses) (Podsakoff, et al., 2003). These techniques were incorporated in the making of the SUSSH questionnaires.

Importantly, the scales used in papers 1, 2 and 3 are overall well-known questionnaires, which have proven good validity and reliability. In other words, it is possible to be fairly confident in that the included variables represent what they are supposed to measure, and that they are stable and consistent. This strengthens the results and conclusions of this thesis.

The first wave yielded a relatively low response rate of 38.1%. Further investigation of the sample has been recommended when response rates fall outside the range of 60% ± 20% (Baruch, 1999). The response rate in wave 1 was 1.9 percentage points below this norm. Issues regarding response rates should be taken into consideration. For example, there are more nurses working three-shift rotations in the study sample compared to the Norwegian nursing population, suggesting that this group was more compelled to participate. However, working three-shift rotation schedule is also more common in young nurses. In the SUSSH study, young nurses were deliberately recruited since it was important to avoid dropout due to retirement. Hence, the young age and large number of nurses working three-shift rotation schedules do not necessarily represent a response bias. It is also possible that those participating in the survey were more concerned about their sleep than the general nursing population. On the other hand, nonparticipation in surveys has been associated with poorer health status, suggesting that the risk of inflated prevalence rates of sleep and sleepiness problems is less likely (Knudsen et al., 2010). The study sample shared important

characteristics with the general Norwegian nursing population (i.e. distribution of gender and mean weekly work hours) (Køber & Vigran, 2010). Nevertheless, findings need to be interpreted with caution due to the low response rate. It seems as though those participating were motivated and conscientious as subsequent waves have had participation rates of approximately 80%.

5.6 Ethical issues

As mentioned in the method section, this project was approved by the Regional Committee for Medical and Health Research Ethics, Health Region West (REK-Vest). Nevertheless, the study procedure and results raise ethical issues to be considered.

The SUSSH project was financed by the Western Norway Regional Health Authority, which represents a potential or current employer to the participating nurses. The issue of absolute confidentiality and privacy for participants was assured in the written consent form and information given to all study participants. A reduced pressure to participate was achieved by sending the questionnaire to the nurses' home address without work place interference.

However, confidentiality does not protect participants from the impacts the results may have on workplace policies. Paper 1 showed associations between SWD and personality. While several studies point to individual differences, the odds ratios for favourable characteristics may be too small to be used in evaluation of potential job candidates. If results are not properly communicated, personality traits may be overemphasized when evaluating potential employees.

Since this thesis was based on a survey using paper-based self-report questionnaires, no clinical interviews were conducted. Firstly this may remove the clinical insight often provided in an interview setting. Perhaps more importantly from an ethical perspective, a

survey does not provide the same sensitivity for participants that an in-person clinical interview would. The SUSSH questionnaire included several sensitive questions, for example enquiring about symptoms of depression and anxiety. Although contact information of the SUSSH project group is provided in every questionnaire, ensuring the participants integrity remains a challenge in survey studies.

Diagnoses are not created in a vacuum. Several interest groups have a stake in SWD. By labelling the shift work-related sleep problems as a disorder, SWD may be perceived as an individual issue, not an organizational problem or responsibility (Cahill & Balice-Gordon, 2005). The treatment of SWD has vast economic implications, for among others, the pharmaceutical industry. Currently, different treatments are available such as melatonin and bright light (circadian adaptation), hypnotics (daytime insomnia), and stimulant drugs such as Modafinil/Armodafinil (sleepiness) (Cahill & Balice-Gordon, 2005; Roth, 2012). Society needs nurses to work night shifts; if medications can alleviate excessive sleepiness, this may reduce risk of errors and injuries. Also, having a diagnosis such as SWD makes it clear that a problem exists, hopefully facilitating more focus on this issue, and perhaps improving policies to benefit shift workers. A high prevalence of SWD emphasizes the hazards of shift work, and may be used in staff union negotiations for salary and other workers' rights. The scientist is responsible for reporting results from an impartial perspective and to communicate any potential conflict of interests.

5.7 Study implications and future research

This thesis provides a systematic analysis of problems with sleep and sleepiness in a population of nurses. An important implication of the presented findings is that not only night and three-shift rotations workers are affected by work scheduling. In other words, quite different types of work schedules may involve risk of SWD. It is estimated that as many as

39% of the European workforce works irregular hours (Parent-Thirion, et al., 2007). Modern sleep-wake patterns include shorter sleep durations during the work week compared to weekends (Sivertsen, et al., 2011b). It is necessary to determine how many of the work related sleep and sleepiness problems could be attributable to SWD. Some work related sleep problems may be due to poor sleep hygiene practices, and possibly represent "Behaviourally-Induced Insufficient Sleep Syndrome"- not SWD (Sack, et al., 2007). The SWD criteria do not describe a clear-cut threshold of diagnosis severity, as to what constitutes a normal reaction to shift work, and what should be considered SWD.

Paper 1 showed that over one third of shift working nurses have shift-related sleep/sleepiness problems (Flo, et al., 2012b). However, the number of individuals who seek treatment for these problems is considerably smaller. One reason for this disparity may be lack of knowledge about shift work related sleep problems. Few patients are diagnosed with SWD, even in sleep clinics (Sack, et al., 2007). Information about shift work, sleep and health should be more readily available for shift workers and general medical practitioners. This may help ensure the correct diagnosis of SWD so that it is not mistaken for other health problems such as insomnia.

Sleep-related problems impose financial, health, and safety costs to society, not only due to sick leave but also in terms of reduced work performance (Sivertsen, Lallukka, & Salo, 2011a). Sleep deprivation and subsequent excessive sleepiness may result in increased risk of errors and work related injuries and accidents (Banks & Dinges, 2007). Moreover, studies have demonstrated a clear link between insomnia and subsequent disability (Sivertsen, et al., 2009). It is important to further investigate the possible association between SWD and future risk of disability.

The results in paper 1 suggest that approximately one third of nurses have SWD. But what interventions are feasible to implement? For example, it would be unrealistic to suggest

that the SWD diagnosis advocates a change in work schedule or position. Paper 1 showed that over 40% of the nurses who worked night shifts had SWD according to the three symptom-based questions. Society is dependent on most of these SWD-positive nurses to remain in their working schedule. However, for those who are most severely affected by SWD, changing their work schedules should be considered, if it is an option for the worker (Wright Jr, et al., 2012a). Here, the knowledge of the general medical practitioner is of importance as a request for shift changes may be substantiated by a medical statement. Investigating ways to address sleep problems in shift workers as an early intervention is a more feasible approach. Non-pharmaceutical treatments are available to alleviate general insomnia (Morgenthaler, 2006). It is possible that some of these methods, if adapted, may successfully be applied to SWD. To those who are not severely affected by SWD, basic knowledge about sleep hygiene and bright light exposure may be useful. In particular, for daytime sleep, shift workers may benefit from using sunglasses on their commute home from night shifts, proper blinds in the bedroom, and earplugs during sleep to reduce interruptive noise. Raising awareness of the importance of these steps may also encourage shift workers to inform friends and family of their need to get sufficient sleep during the daytime. Phones should be turned off, and other family members should refrain from loud disruptive activities, if possible (Wright Jr, et al., 2012a). If family and friends are aware of the difficulties with shift work, and are considerate in this respect, the surrounding family and friends may be a resource and not cause additional stress for shift workers.

Different symptoms related to different types of shifts (as shown in paper 2 and 3) may facilitate a knowledge-based scheduling of shift work. For example, the difference between permanent night and three-rotational workers highlights the extra burden of adapting or readapting to different sleep-wake cycles. Even though night shifts are an important risk factor, protected sleep and recovery time for three-shift and two-shift rotation

workers are also important. The European Union's Work Directive emphasizes the need for

at least 11 hours of rest between shifts. It is important to keep the number of shifts worked

with less than 11 hours apart at a minimum. Increasing the time lapse between shifts may in

some cases be necessary, and help the attainment of enough sleep (Sallinen et al., 2008;

Wright Jr, et al., 2012a). Although napping opportunities during night work have

demonstrated improved work performance, less is known about the possible beneficial

effects of napping before work. Total sleep time within a 24-hour period may be increased

by supplementing the main sleep period with naps. In addition, introducing naps right before

a night shift may reduce the homeostatic sleep drive during night shifts (Wright Jr, et al.,

2012a). Even though shift workers may obtain better daytime sleep by, for example,

adhering to good sleep hygiene advice, there may still be negative long-term consequences

of shift work (Pallesen, et al., 2010).

A cross-sectional comparative study does not uncover causal links. Stronger evidence

for scheduling recommendations may be provided by intervention studies (Sallinen &

Kecklund, 2010). In addition, even though associations are significant, small effect sizes

may implicate that other negative consequences of changing an already functional existing

shift work system may outweigh the potential benefits. Intervention studies may provide

information on effect size of different work changes. Both intervention studies and larger

longitudinal cohort studies with multiple, properly operationalized outcome variables are

needed.

When SWD is the primary diagnosis, both stimulants (Modafinil or Amodafinil) and

hypnotics have been suggested as treatment alternatives (Roth, 2012). However, simply

providing treatments that increase the alertness of a SWD patient does not address the

importance of recuperating sleep. Thus these treatments do not cure SWD as much as mask

its symptoms. Improvements in wakefulness/alertness and performance do not necessarily

improve general health and wellbeing of shift workers. Thus, the primary aim of treatment should be to prevent rather than treat these symptoms by encouraging improved sleep and/or circadian adaptation.

Correctly administered bright light therapy and melatonin may also help individuals to better cope with changes in their circadian rhythms (Bjorvatn & Pallesen, 2009). Noticeably, complete circadian adaptation to night work is not necessarily ideal for all shift workers. If a work schedule has few nights in a row, it may be more advisable to try to attain as much daytime sleep as possible rather than to use for example bright light and melatonin to affect the circadian rhythm. Reduced work hours may also help alleviate fatigue and sleepiness (Wright Jr, et al., 2012a).

All ergonomic recommendations should be evidence-based. There is still incomplete knowledge as to the intricate relationship between work scheduling, individual differences and sleep regulatory processes.

The SUSSH project has a longitudinal design. With time it will be possible to prospectively investigate the risk factors identified by this thesis. SWD may, for example, be further investigated for its role as a possible predictor of sick leave and turnover.

While this study focuses on nurses, a substantial and invaluable occupational group, other occupations should also be considered, as generalizations to other groups of workers. Furthermore, although associations between shift work and health outcomes may have already been established, the underlying mechanisms are not yet fully understood. Future research that aims to generate knowledge on proposed mechanisms behind the increased risk of disease, sleep/sleepiness and fatigue problems in shift workers would be highly valuable (Wang, et al., 2011).

6. CONCLUSIONS

In this thesis, the prevalence of SWD and associations between SWD and work scheduling, health and personality were investigated. Next, the psychometric properties of the BSWSQ, which evaluates sleep in relation to types of shifts, were investigated for validation purposes. Subsequently, the validated BSWSQ was then used to systematically evaluate how different work shifts and work schedules may affect sleep and sleepiness. In conclusion;

i) The three symptom-based questions used to assess SWD are effective as an assessment tool for epidemiological studies, but not necessarily as a diagnostic instrument. Symptoms indicative of SWD affected over one third of the nurses in the study sample, with higher risk of SWD among those with work schedules that included night shifts. This finding was in line with the observed SWD distribution across different types of work schedules. SWD was related to increased risk of insomnia and anxiety symptoms. There were also observed associations between SWD and the individual variables: age, gender and circadian type.

ii) The BSWSQ demonstrated acceptable, albeit not optimal, psychometric properties. The BSWSQ evaluated variability in symptoms of sleep and sleepiness problems according to shifts and rest-days. This questionnaire systematically measures sleep and sleepiness across day shifts, evening shifts and night shifts as well as rest-days.

iii) Both the type of shift and work schedule appears to affect sleep and sleepiness problems. Although night shifts and rotating schedules were most problematic, those with permanent day schedules also experienced problems with sleep and sleepiness. Furthermore, working 90% of full-time or more increased the risk of day shift related sleep and sleepiness problems.

Work shifts and work schedules demonstrated clear associations with sleep and sleepiness problems among nurses.

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Deres ref	Vår ref	Dato
	2008/3631-ANØL	08.05.2008

Ad. prosjekt: Søvn, skiftarbeid og helse hos sykepleiere (088.08)

Det vises til din søknad om godkjenning av forskningsprosjekt, datert08.03.08 og søknad om opprettelse av forskningsbiobank, datert 08.03.08.

Komiteen behandlet søknaden i møte den 24.04.08.

De regionale komiteene for medisinsk og helsefaglig forskningsetikk foretar sin forskningsetiske vurdering med hjemmel i Forskningsetikklovens § 4. Saker vedrørende forskningsbiobanker behandles i samsvar med Biobankloven. Saksbehandlingen følger Forvaltningsloven.

Komiteen mener dette er en interessant og viktig studie. En har ingen merknader til forelagt protokoll. Når det gjelder samtykkeerklæringen, skal en kun bli bedt om å avgi positivt samtykke. Fravær av positivt samtykke skal anses som et nei til deltakelse. Følgende tekst må derfor strykes i forbindelse med samtykke. "Det er viktig at du besvarer alle spørsmål under,…" og "kryss av for et av alternativene under: Jeg vil delta - Jeg vil ikke delta"

Vedtak:
Prosjektet godkjennes på vilkår av at ovennevnte merknader tas til følge. REK Vest forutsetter at søknad om opprettelse av forskningsbiobank godkjennes av Helsedirektoratet.

REK Vest tilrår at den søkte forskningsbiobanken blir opprettet.

Komiteenes vedtak etter Forskningsetikklovens § 4 kan påklages (jfr. forvaltningsloven § 28) til Den nasjonale forskningsetiske komité for medisin og helsefag. Klagen skal sendes REK-Vest (jfr. forvaltningsloven § 32). Klagefristen er tre uker fra den dagen du mottar dette brevet (jfr. forvaltningsloven § 29).
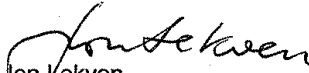
Postadresse	rek-vest@uib.no	Regional komité for medisinsk	Besøksadresse
Postboks 7804	www.etikkom.no/REK	og helsefaglig forskningsetikk,	Haukeland Universitetssykehus
5020 Bergen	Org no. 874 789 542	Vest-Norge	
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Komiteens vurdering av søknad om opprettelses av forskningsbiobank videresendes Sosial- og helsedirektoratet for endelig vedtak der.

Komiteen ber om å få tilsendt sluttrapport evt. trykt publikasjon for studien når dette foreligger.

Vennlig hilsen

Jon Lekven
leder

Anne Berit Ølmheim
førstekonsulent

Kopi
SHDir