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ASLEEP OR NOT ASLEEP?

Evaluation of the Quality of Patients' Sleep in Critical Care Nursing

Marita Ritmala-Castrén

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To all the critical care nurses

who with empathy
patiently and vigilantly
watch over their patients' attempts to sleep
during those sometimes endless feeling nights

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ABSTRACT

Sleep is important for the recovery of a critically ill patient, as lack of sleep is known to influence negatively a person's cardiovascular system, mood, orientation, and metabolic and immune function and thus, it may prolong patients' intensive care unit (ICU) and hospital stay. Intubated and mechanically ventilated patients suffer from fragmented and light sleep. However, it is not known well how non-intubated patients sleep. The evaluation of the patients' sleep may be compromised by their fatigue and still position with no indication if they are asleep or not.

The purpose of this study was to evaluate ICU patients' sleep evaluation methods, the quality of non-intubated patients' sleep, and the sleep evaluations performed by ICU nurses. The aims were to develop recommendations of patients' sleep evaluation for ICU nurses and to provide a description of the quality of non-intubated patients' sleep. The literature review of ICU patients' sleep evaluation methods was extended to the end of 2014. The evaluation of the quality of patients' sleep was conducted with four data: A) the nurses' narrative documentations of the quality of patients' sleep (n=114), B) the nurses' sleep evaluations (n=21) with a structured observation instrument C) the patients' self-evaluations (n=114) with the Richards-Campbell Sleep Questionnaire, and D) polysomnographic evaluations of the quality of patients' sleep (n=21). The correspondence of data A with data C (collected 4–8/2011), and data B with data D (collected 5–8/2009) were analysed. Content analysis was used for the nurses' documentations and statistical analyses for all the other data.

The quality of non-intubated patients' sleep varied between individuals. In many patients, sleep was light, awakenings were frequent, and the amount of sleep was insufficient as compared to sleep in healthy people. However, some patients were able to sleep well. The patients evaluated the quality of their sleep on average neither high nor low. Sleep depth was evaluated to be the worst and the speed of falling asleep the best aspect of sleep, on a scale 0 (poor sleep) to 100 (good sleep). Nursing care was mostly performed while the patients were awake, and thus the disturbing effect was low.

The instruments available for nurses to evaluate the quality of patients' sleep were limited and measured mainly the quantity of sleep. Nurses' structured observatory evaluations of the quality of patients' sleep were correct for approximately two thirds of the cases, and only regarding total sleep time. Nurses' narrative documentations of the patients' sleep corresponded with patients' self-evaluations in just over half of the cases. However, nurses documented several dimensions of sleep that are not included in the present sleep evaluation instruments. They could be classified according to the components of the nursing process: needs assessment, sleep assessment, intervention, and effect of intervention. Valid, more comprehensive sleep evaluation methods for nurses are needed to evaluate, document, improve and study patients' quality of sleep.

Keywords: sleep, critical care, nursing assessment, sleep evaluation, physiological needs

Marita Ritmala-Castrén
NUKKUUKO VAI EIKÖ NUKU?
POTILAAN UNEN LAADUN ARVIOINTI TEHOHOITOTYÖSSÄ
Hoitotieteen laitos, Lääketieteellinen tiedekunta, Turun yliopisto
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TIIVISTELMÄ

Uni on tärkeää kriittisesti sairaalle potilaalle, sillä unen puutteen tiedetään heikentävän verenkierron, aineenvaihdunnan ja immuunijärjestelmän toimintaa, sekä vaikuttavan mielialaan ja orientaatioon. Näin ollen potilaan teho- ja sairaalahoitoaika saattavat pidentyä. Intuboidut ja mekaanisessa hengityslaitehoidossa olevat potilaat kärsivät kevyestä ja sirpaleisesta unesta. Ei-intuboitujen potilaiden unen laadusta ei ole juurikaan tietoa. Unen laadun arviointia vaikeuttaa kriittisesti sairaan potilaan uupumus. Potilaat lepäävät silmät kiinni paikoillaan ilmaisematta, ovatko he hereillä vai eivät.

Tämän tutkimuksen tarkoituksena oli analysoida unen laadun arviointimenetelmiä, ei-intuboitujen potilaiden unen laatua ja hoitajien toteuttamaa unen arviointia tehohoidossa. Tavoitteena oli tuottaa potilaiden unen laadun arvioinnin ohjeistus hoitajille sekä kuvaus ei-intuboitujen potilaiden unen laadusta. Kirjallisuuskatsaus tehopotilaiden unen laadun arviointimenetelmistä ulottui vuoden 2014 loppuun. Unen laadun arviointia tutkittiin neljän empiirisen aineiston avulla: A) hoitajien vapaana tekstinä potilaiden hoitokertomukseen dokumentoimat unen laadun arvioinnit (n = 114), B) hoitajien jatkuvat yöaikaiset potilaan unen laadun arvioinnit (n = 21) mitattuna strukturoidun tiedonkeruulomakkeen avulla, C) potilaiden itsearvioinnit (n=114) mitattuna Richards-Campbell Sleep Questionnaire -mittarilla ja D) unipolygrafiarekisteröinnit (n=21). Lisäksi analysoitiin arviointien A ja C (aineiston keruu 4–8/2011) sekä B ja D (aineiston keruu 5–8/2009) yhtenevyyttä. Hoitajien dokumentoimat unen laadun arvioinnit analysoitiin sisällönanalyysillä. Muu data analysoitiin tilastollisin menetelmin.

Ei-intuboitujen potilaiden unen laatu oli vaihtelevaa. Monen potilaan uni oli kevyttä, heräämisiä oli paljon ja unen kokonaismäärä oli normaalia vähäisempää. Joidenkin potilaiden uni oli kuitenkin lähes normaalia. Potilaat arvioivat unensa laadun keskimäärin hyvän ja huonon puoleen väliin. Unen syvyys koettiin heikoimmaksi ja nukahtaminen parhaaksi unen osa-alueeksi. Hoitotyö ei juurikaan häirinnyt potilaiden unen laatua, sillä hoitotoimet suoritettiin pääasiassa potilaiden ollessa hereillä.

Unen laadun arviointimittareita tehohoitajan käyttöön on rajoitetusti ja suurin osa niistä mittaa vain unen määrää. Hoitajien strukturoidut havainnot potilaiden unesta korreloivat unipolygrafian kanssa kahdessa kolmasosassa arvioinneista vain unen kokonaismäärän osalta. Hoitajien hoitokertomukseen dokumentoimat unen arvioinnit korreloivat potilaiden omien arviointien kanssa noin puolessa tapauksista. Hoitajat dokumentoivat useita unen arvioinnin ulottuvuuksia, joita ei sisälly nykyisiin unen arviointimittareihin. Ne olivat luokiteltavissa hoitotyön prosessin mukaisesti unen tarpeen arviointiin, unen laadun arviointiin, unta tukeviin interventioihin ja interventioiden vaikutuksen arviointiin. Tehopotilaan unen laadun arviointiin tarvitaan luotettavia menetelmiä, jotta unen laatua voidaan arvioida, dokumentoida, tukea ja tutkia.

Avainsanat: Uni, tehohoitotyö, arviointi, fysiologiset tarpeet

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ABBREVIATIONS

AASM	American Academy of Sleep Medicine
APACHE II	Acute Physiology and Chronic Health Evaluation II
BP	Blood pressure
FEV1	Forced expiratory volume in 1 second
FI	(Sleep) fragmentation index, number of awakenings and arousals per hour of total sleep time
FVC	Forced vital capacity
GCS	Glascow Coma Scale
HDU	High dependency unit
HR	Heart rate
ICU	Intensive Care Unit
IQR	Interquartile range
LAeq	Equivalent sound pressure level
MD	Median
N1	nREM sleep stage 1 (drowsiness)
N2	nREM sleep stage 2 (light sleep)
N3	nREM sleep stage 3 (deep sleep)
NAVA	Neurally adjusted ventilatory assist (ventilation mode)
NIV	Non-invasive ventilation
nREM	Non-Rapid eye movement sleep
PAV	Proportional-assist ventilation (mode)
PCV	Pressure controlled ventilation (mode)
PS	Pressure support (ventilation mode)
PSG	Polysomnography
PSV	Pressure support ventilation (mode)
RASS	Richmond Agitation Sedation Scale
RCSQ	Richards-Campbell Sleep Questionnaire
REM	Rapid eye movement sleep
RN	Registered nurse
SAPS II	Simplified Acute Physiology Score II
SD	Standard deviation
SE	Sleep efficiency, total amount of sleep in the time recorded or observed
SICUQ	Sleep in the Intensive Care Unit Questionnaire
SL	Sleep latency, the latency from lights out to sleep onset, the amount of time it takes to fall asleep
SOFA	Sequential Organ Failure Assessment
SP	Skin potential
SWS	Slow wave sleep, N3 sleep
TST	Total sleep time
VSH	Verran-Snyder-Halpern Sleep Scale
WASO	Time spent wake after sleep onset

LIST OF ORIGINAL PUBLICATIONS

This thesis is based on the following publications, which are referred to in the text with Roman numerals I-IV.

I Ritmala-Castren M, Lakanmaa R-L, Virtanen I & Leino-Kilpi H. 2014. Evaluating adult patients' sleep: an integrative literature review in critical care. Scandinavian Journal of Caring Sciences 28(3), 435-448.

II Ritmala-Castren M, Axelin A, Kiljunen K, Sainio C. & Leino-Kilpi H. 2014. Quality of sleep of non-intubated patients in the ICU – do nurses' documentation and patients' perspectives correspond? Nursing in Critical Care; doi: 10.1111/nicc.12102

III Ritmala-Castren M, Virtanen I, Leivo S, Kaukonen K-M & Leino-Kilpi H. 2015. Sleep and nursing care activities in an intensive care unit. Nursing & Health Sciences; doi: 10.1111/nhs.12195

IV Ritmala-Castren M, Virtanen I, Leivo S, Vahlberg T, Kaukonen K-M & Leino-Kilpi H. Nurses´ evaluations of patients' sleep in an ICU. Submitted.

1. INTRODUCTION

Every night nurses in intensive care units (ICU) watch over patients who struggle with the inability to sleep despite the fatigue and exhaustion they may experience. At times, the nurses wonder whether their patients are actually sleeping or just lying on the bed with their eyes closed. One goal of nursing is to promote and enhance patients' sleep. For this, nurses need to evaluate and document the quality of patients' sleep.

Sleep has an important function to people, since through the ages we have always needed sleep despite the threats that unawareness of the surroundings may have caused (Underwood 2013). During sleep the body and mind are cleaned from metabolic waste (Allam & Guilleminault 2011, Xie et al. 2013), and both short and long-term memory are restructured (Hardin et al. 2006). The purpose of sleep seems to be to recover from the psychological and physical strain of the previous wake time and to prepare for new encounters. Sleep deprivation may negatively influence a person's cardiovascular system, mood, orientation, and metabolic and immune function (Salas & Gamaldo 2008, Kamdar et al. 2012a). Thus, it may be detrimental to a person's recovery from any illness.

Patients face the challenge of possible sleep deprivation when they are admitted to an ICU. Several factors related to the illness, nursing and medical care, and the surroundings, are known to menace a good night's sleep (Boyko et al. 2012, Kamdar et al. 2012a). Sleep deprivation acquired in an ICU has been shown to extend beyond hospitalization and affect the patients' quality of life at six months (Parsons et al. 2012, McKinley et al. 2013) and even at one year after discharge (Parsons et al. 2015). Mechanically ventilated patients are known to sleep poorly in an ICU (Ozsancak et al. 2008, Fanfulla et al. 2011, Alexopoulou et al. 2013, Cordoba-Izquierdo et al. 2013). However, there are many patients in ICU's who do not require mechanical ventilation, and as such should be able to sleep well. Only one study has analysed the possible difference in non-sedated, mechanically ventilated and non-ventilated patients' sleep. Rather surprisingly, it demonstrated that the non-ventilated patients' sleep was even more fragmented and shorter than the sleep of the mechanically ventilated patients. (Elliott et al. 2013.) No sleep research has previously been conducted in Finnish ICU patients.

The purpose of this study was to evaluate 1) the sleep evaluation methods used for ICU patients, 2) the quality of non-intubated ICU patients' sleep, and 3) the sleep evaluations performed by ICU nurses. The aims were to develop recommendations of patients' sleep evaluation for ICU nurses and to provide a description of the quality of non-intubated patients' sleep. The recommendations were to be based on both previous research literature; and this study of nurses' sleep evaluations, and their correspondence with patients' self-evaluations and polysomnographic sleep evaluations.

This study consists of a systematic literature search and four empirical data. The literature search was conducted to find all the previous research regarding the quality of ICU patients' sleep and the sleep evaluation methods used in an ICU. The results of the literature search are reported in the theoretical background. The empirical data consisted of the nurses' evaluations documented as narrative free text in patient records (A), nurses' evaluations with a structured observation instrument (B), patients' self-evaluation (C) and polysomnographic evaluations (D) of the quality of patients' sleep.

This study belongs in the field of clinical nursing research, since it focuses on patients' potential suffering from sleep deprivation and nurses' means to evaluate this potential problem in order to plan nursing care accordingly. With the knowledge provided in this study, it is possible to reflect the current practices of patients' sleep evaluation, documentation, promotion, and teaching. This knowledge will be useful in caring for ICU patients and supporting the quality of their sleep. The knowledge provided in this study will also guide nursing curricula to include sleep evaluation and promotion in ICU nursing courses. Furthermore, for research purposes, valid sleep evaluation and documentation methods are essential.

2. DEFINITION OF CONCEPTS

This study is based on the premises (Figure 1) defined in this and the following chapter. In this chapter, the essential concepts of the study, *critical care nursing* and the *quality of sleep* and its significance to human well-being, and the context of the study, *intensive care unit*, are defined. What is previously known about the quality of ICU patients' sleep and the used sleep evaluation methods is described in chapter 3.

ICU NURSE		ICU PATIENT
• aims to promote sleep and deliver patient-centred care • disrupts patients' sleep with nursing care • evaluates the quality of patients' sleep at night	and	• requires good quality sleep for healing and recovery • is the expert of the quality of his/her sleep

Figure 1. Premises of this study.

Critical care, earlier referred to as *intensive care*, has been defined as specialized care of patients whose conditions are life-threatening and who require comprehensive care and constant monitoring (Shiel & Stöppler 2008). In Finland, critical care has been defined as care of patients who suffer from acute, transient, and often multiple organ failure. Critical care requires special technology and a substantial number of personnel, including an intensivist available 24/7 and one-on-one nursing. (Varpula et al. 2007.) *Critical care patients* are at high risk for actual or potential life-threatening health problems. A critical illness causes the patient to be highly vulnerable and unstable with several complex health and illness related needs. Therefore, they require intense and vigilant medical and nursing care. (AACN 2014.)

2.1 Critical care nursing

Critical care nursing can be defined as a nursing specialty, which deals with a person's responses to his/her life-threatening problems (AACN 2014). The aims of critical care nursing are to support critically ill patients, help them to cope with their illness and its treatments, and to promote health or to help the patient to die with dignity. Critical care nursing also aims to support patients' significant others to cope with the patient's illness and to help them support the patient. (Pyykkö et al. 2000.) *Critical care nurses*, in this study also referred to as *ICU nurses*, ensure that patients and their families receive optimal care with respect, and serve as advocates of their patients (AACN 2014). Critical care nurses require special competence (Meretoja et al. 2004, Salonen et al. 2007, Ääri et al. 2008, Lakanmaa et al. 2012) and a specific body of knowledge and skills to be able to provide critically ill patients with healing, caring, and humane nursing care (AACN 2014).

Critical care nursing consists of all the elements of the nursing process: assessment of patients' needs and planning, implementation, and evaluation of care (Yura & Walsh 1967). Nursing intervention is an act of implementing the planned care (Mosby's Medical Dictionary 2009). It is based on nurse's clinical judgment and knowledge and is aimed to enhance patient outcomes (Bulechek et al. 2013). Nursing interventions can be categorized either as autonomous, performed independently of other disciplines and being the responsibility of ICU nurses, or directed by medical or other disciplines (Pyykkö et al. 2001).

Nursing interventions performed in critical care are numerous. Pyykkö et al. (2001) identified 39 nursing interventions that corresponded with critical care patients' potential health problems, using nurses' interviews and shift report analyses in their action research. Yamase et al. (2003) have developed the Comprehensive Nursing Intervention Score to measure the workload of ICU nurses. They described 63 different physical job items ICU nurses may perform while caring for their patients. Miranda et al. (2003) described direct nursing care being 81% of ICU nurses' workload, measured with the 23-item Nursing Activities Score. All the above-mentioned classifications define and categorize nursing interventions somewhat differently. However, they all include physiological care, such as respiratory care, wound care or nutrition care, psychological support, and the support of the patients' significant others.

Nursing interventions are performed constantly. The mean number of nursing care activities in 24 hours varies from 7.8 per hour in intubated patients (Gabor et al. 2003) to 1.7 per hour in a patient group where 54% received mechanical ventilation (Elliott et al. 2013). According to the retrospective studies of nurses' documentation, the mean number of nursing care interactions during the night from 7:00 pm to 7:00 am has varied from 42.6 (Tamburri et al. 2004) to 51 (Celik et al. 2005). Some of the performed interventions may be unnecessary, since in three different types of ICU's, nurses have estimated that 15% to 21% of night-time activities (assessment, intervention, patient care activity, or patient initiated contact) could safely be omitted during the night (Le et al. 2012).

Nursing care aims to be patient-centred (IAPO 2007). It can be summarized as valuing people as individuals (Coyle & Williams 2001). Patient-centred care contains three core elements: 1) patient participation and involvement, 2) the relationship between the patient and the healthcare professional, and 3) the care delivery context. Patient participation includes the respect for patients' values, preferences and expressed needs, and the care plan addressing these individual needs. The relationship between the patient and the health care professional includes open communication, good knowledge and skills of the health care personnel and good co-operation among them. The care delivery context contains the practice policy, the support and barriers to patient-centred care. (Kitson et al. 2013.) Patient-centred care for ICU patients is not always obvious due to the highly technical nature of critical care nursing, and as such should be enforced at any given chance (Kelleher 2006, Ciufo et al. 2011, Rattray & McKenna 2012).

2.2 Intensive care unit

Critical care nursing is carried out in a specially constructed unit, called an *intensive care unit (ICU)*, *critical care unit* or *intensive therapy department*. ICU's are located in hospitals that care for patients with life-threatening conditions. ICU's have a multitude of highly trained staff caring for the most severely ill patients, with available special monitoring and treatment technology. Patients are admitted mainly either from surgical departments, emergency departments, or general wards. The length of an ICU stay varies among patients. (Intensive Care Society UK 2014.) The median length of stay in Finnish ICU's in 2012 was 3.1 (IQR 2.4–3.5) days (Ritmala-Castrén et al. 2014). Worldwide, the median ICU stay is shorter, only 2.1 days (IQR 1–6), with larger variability as judged from the IQR (Metnitz et al. 2005). When critical care is no longer required, a patient is normally transferred to either a high dependency unit (HDU) or a general ward (Intensive Care Society UK 2014).

In Finland, there are sixteen university affiliated adult ICU's and sixteen ICU's in central hospitals (Ritmala-Castrén et al. 2014). The number of critical care beds is 6.1/100,000 of the population, which is much less than the European average of 11.5/100,000 population (Rhodes et al. 2012), or that in the United States of America, 28/100,000 (Carr et al. 2010). In 2012, over 27,500 patients were cared for in the 32 Finnish ICU's (Ritmala-Castrén et al. 2014).

Patients are cared for either in individual cubicles or rooms for several critically ill patients. Individual cubicles are recommended because they provide privacy and a quiet environment for the patient (Valentin et al. 2011). However, they require more nursing staff than larger rooms where one nurse can temporarily watch over more than one patient (Donchin & Seagull 2002). In Finland, patients are most commonly cared for in rooms for two to three patients. However, rooms for six or more patients are also used in several Finnish ICU's. (Ritmala-Castrén et al. 2014.)

The direct physical environment of an ICU patient includes a vast number of equipment and multiple devices and cannulas connected to the patient (Meriläinen et al. 2010). The environment is often well lit, as illumination recommendation for work, such as reading and writing, is 500 lux at the site and one third of it for backlight (British Standards Institution 2011). The light sources are numerous: different lights, such as head-of-bed, sink, overhead and equipment light, safety night-light, light carried in by staff (penlight or flashlight), television, ambient hallway lights, and lighting through windows (Dunn et al. 2010). Measured light intensities in different ICU's vary widely between day and night, and the level of illumination in the patients' close vicinity is maintained most times below the illumination recommendations for office work (Walder et al. 2000, Meriläinen et al. 2010, Gehlbach et al. 2012, Elliott et al. 2013, Verceles et al. 2013). Light cycled automatically with the circadian rhythm has been used in neonatal and pediatric critical care, but not in adult ICU's (Engwall et al. 2014). Natural light sources are recommended for ICU's (Valentin et al. 2011), because they are believed to support patients' circadian rhythm and possibly prevent delirium. However, the orientation of the room seems to make no difference to patients' well-being, although most light is naturally emitted from south (Verceles et al. 2013).

The noise levels in an ICU are rather high, and noise sources are numerous. The loudest noises have been shown to originate from talking, beepers, intercoms, alarms of the medical or monitoring equipment, and nebulizers. Most frequently, noise originates from talking, monitor alarms, and television. Other sources of loud noise in an ICU are air conditioners, ventilators, and telephones. (Kahn et al. 1998.) The World Health Organization recommends that the average noise level (LAeq) in hospital patient rooms should not exceed 30 dB, and the maximum levels (LAmax) at night should not exceed 40 dB (WHO 1999). The Finnish Ministry of Social Affairs and Health (STM) has recommended the following limits for hospital noise: LAeq 35 dB during the day (7 am to 10 pm) and 30 dB during the night (STM 2003). The average noise levels in ICU's frequently exceed the recommended levels. All the reported average noise levels have exceeded 45 dB (Darbyshire & Young 2013) or even 50 dB (Freedman et al. 2001, Akansel & Kaymakci 2008, Meriläinen et al. 2010, Li et al. 2011, Elliott et al. 2013, Patel et al. 2014). Furthermore, sound peaks exceeding 80 dB are frequent (Kahn et al. 1998, Darbyshire & Young 2013, Elliott et al. 2013). The difference of average sound levels between day and night has been minimal (Freedman et al. 2001, Elliott et al. 2013). Yet, the number of sound peaks has been shown to be remarkably reduced at night (Kahn et al. 1998, Elliott et al. 2013). However, as many as 90 sound peaks of over 80 dB per hour at night (Elliott et al. 2013) and the average night time noise level over 50 dB still proves noise to be a serious environmental problem in a general ICU.

2.3 Quality of sleep

Sleep can be defined as a reversible behavioural state, where a person remains perceptually disengaged from and unresponsive to the environment. Sleep contains a melange of physiologic and behavioural processes such as postural recumbence, behavioural quiescence, closed eyes, and changes in the respiratory pattern. (Carskadon & Dement 2011.) Normal or natural sleep differs from general anaesthesia in many ways. Sleep is endogenously induced and maintained by complex hormonal regulation, whereas general anaesthesia is induced and maintained chemically by another person. Normal sleep constitutes of several different sleep stages, while general anaesthesia often contains either continuous slow wave activity or a burst suppression pattern. Sleep is easily interrupted by environmental stimuli, internal signals, e.g. pain, or circadian rhythm, whereas an anesthetized person only wakes up when the delivery of anaesthetic agents is stopped. (Tung & Mendelson 2004.) Laureys (2005) has defined the concepts of wakefulness, sleep stages, general anaesthesia, and coma with the continuum "content of consciousness" representing awareness and the continuum "level of consciousness" representing wakefulness. He perceives natural sleep as having higher states of both awareness and wakefulness during any sleep stage than general anaesthesia.

The quality of sleep contains, in this study, the fulfilment of several different measurable sleep aspects: the appropriate length of sleep, the short latency from lights out to sleep onset (sleep latency, SL), or the time it takes to fall asleep, the small number of awakenings, and the proper composition of different sleep stages (Table 1). The normal amount of night-time sleep in adults is approximately seven and a half hours. After the age of 75, there is a slight decrease in sleep need. The SL is usually less than twenty minutes. After falling asleep, a healthy person wakes up few times and spends time awake (wake after sleep onset, WASO) approximately 20–40 minutes during the night. Sleep efficiency (SE), the portion of time asleep of the time spent in bed, is usually 85–90%. (Ohayon et al. 2004.) Normal sleep consists of four sleep stages: rapid eye movement (REM) sleep and three non-REM (nREM) sleep stages, N1, N2 and N3. A night's sleep usually consists of 2–5% of N1 (drowsiness, a transitional stage between wake and sound sleep), 45–55% of N2 (light sleep), 13–23% of N3 (deep sleep, also called slow wave sleep, SWS), and 20–25% of REM sleep. The alteration of all sleep stages forms a 90-minute sleep cycle, where a cascade of deepening nREM sleep is followed by REM sleep. Normally, at the beginning of the night, N3 predominates a sleep cycle, and towards the morning the portion of REM sleep in successive sleep cycles increases. (Carskadon & Dement 2011.)

Table 1. Content of the quality of adult night-time sleep; normal values as per Carskadon & Dement 2011 and Ohayon et al. 2004.

Sleep aspects	Normal values
Length of sleep	7-8 hours
Falling asleep/sleep latency	< 20 minutes
Number of awakenings	Few
Proportion of N1 in TST	2-5%
Proportion of N2 in TST	45-55%
Proportion of N3 in TST	13-23%
Proportion of REM in TST	20-25%

TST=total sleep time; N1, N2, N3, REM=different sleep stages

Different sleep stages contain distinct changes in brain function, muscle tension, eye movements, respiration, heart rate, and blood pressure. During nREM sleep, a person occasionally changes position, his/her respiratory frequency and minute volume decrease, and due to increased vagal activity his/her blood pressure and heart rate fall (Carskadon & Dement 2011, Rowley & Safwan Badr 2012). During N3 sleep, the vagally modulated heart rate variability is increased while during REM sleep the sympathetically mediated heart rate variability is more pronounced (Virtanen et al. 2007). During REM sleep, muscle tension is minimal, the eyes move under the closed lids, blood pressure and heart rate vary rapidly, and the respiratory pattern is irregular (Carskadon & Dement 2011, Rowley & Safwan Badr 2012).

Sleep is important for many reasons. During sleep, particularly during nREM sleep, the energy stores of our body and brain are refilled (Allam & Guilleminault 2011), and metabolic waste from the cells, especially from the brain, is removed (Xie et al. 2013). Growth hormone secretion peaks during early sleep, helping the body to heal from possible physical damage, and cortisol secretion increases in the course of sleep

(Czeisler & Buxton 2011). REM sleep is thought to be important for the restructuring the memory (Hardin et al. 2006).

Sleep deprivation occurs when a person may not or cannot sleep as long as usual (Banks & Dinges 2011). Furthermore, an increased number of awakenings may induce similar consequences (Bonnett 2011). Sleep deprivation may cause a decline in the immune system function, thus increasing a person's risk for infections (Drouot et al. 2008, Friese 2008, Faraut et al. 2012). Further, a deterioration of different respiratory parameters, *i.e.* FEV1 and FVC, and respiratory muscle weakness have been discovered in sleep deprived patients (Kamdar et al. 2012a). Sleep deprivation is known to cause increased sensitivity to pain, decreased glucose tolerance, increased sympathetic activity (Bonnett 2011), and increased protein catabolism (Friese 2008). The aforementioned knowledge has mostly been gained from research in healthy people. However, the negative effect may be even more significant in critically ill patients, affecting their recovery.

3. BACKGROUND OF THE STUDY

In this section, the results of the literature review (research question 1) are reported as the theoretical background for the clinical study. The sleep of non-sedated patients and the sleep evaluation methods used in an ICU are described according to the results of previous research. While the original literature search (I) focused on sleep evaluation methods, 49 of the 55 studies reported quality of sleep, as the sleep evaluation method was merely a means of collecting data on patients' sleep. Furthermore, to expand the description of sleep with the possible qualitative descriptions, an additional search was executed in Ovid from MEDLINE 1946 to present and Ovid MEDLINE In-Process & Other Non-Indexed Citations with the keywords Critical care and Memory/recall and Sleep. Three qualitative descriptions of sleep in an ICU and six studies focusing on memories of ICU and sleep as one part of them were found.

3.1 Systematic literature search

The original systematic literature search (I) was performed from the electronic databases Ovid MEDLINE from 1950 to 2012 and a combined "All EBM Reviews" database including Cochrane DSR, ACP Journal Club, DARE, CCTR, CMR, HTA, and NHSEED. They were searched with the OvidSP access tool. CINAHL from 1982 to 2012 was searched with the EBSCOhost access tool and the PsycINFO from 1987 to 2012 was searched with the ProQUEST access tool. The search terms used were related to sleep, evaluating the quality of sleep, and critical care. (I) The search was updated with an identical strategy and extended to the 31st of December 2014.

Most sleep evaluation methods have been developed to be used in healthy populations. They are mostly based on a person's ability to evaluate his/her own sleep or registration of the patient's natural movement during the night. Sleep questionnaires may not be usable for critically ill patients due to their length or being too burdensome, and movement detectors may not be valid for ICU patients with limited ability to move normally. Therefore, the literature search was limited to critical care. It was also limited to adult patients because they have documented problems of not being able to sleep while in critical care (Fontaine 1989, Edéll-Gustafsson et al. 1999, Alexopoulou et al. 2007, Kondili et al. 2012). Furthermore, sleep composition and patterns continually change during brain maturation (Axelin et al. 2013), until midadolescence (Carskadon & Dement 2011). Studies of sedated patients were discarded from the review. (I) However, the results of control groups in the sedation studies are included in this discussion.

The electronic database search resulted in 1,597 articles. A manual search of the citations of sleep reviews and articles found in the search and exclusively electronic critical care journals provided twelve additional articles. The inclusion in the literature review was judged by the title and/or abstract. 76 articles were sufficiently relevant to be read in full, after which 52 were determined appropriate for the review. Five studies where data were collected at the same time from the same participants for two or more separate reports were combined, so the final number of analysed studies was 47. (I) The result of the updated search was eight articles published in 2013–2014 in addition to the 47 detected in the original search.

As polysomnography (PSG) is regarded as the gold standard of sleep evaluation methods (Kushida et al. 2005, Bourne et al. 2007), a separate analysis of the search results regarding studies using PSG was performed for the purpose of the description of the patients' sleep. Twenty-five usable studies reporting PSG results of ICU patients' sleep published between 1990 and August 2014 were found. Studies published prior to 1990 were discarded from the analysis due to small sample sizes (5–12 patients) and the case study type presentation of the results. Studies of sedated patients were also left outside the review. However, the results of control groups in studies on sedated patients were included. A study exploring the effect of music on sleep with a recording time of just two hours (Su et al. 2012) was left out as well. Two articles (Richards 1998, Richards et al. 2002) were known to report on same data (I), thus the findings of both are combined for this discussion.

In the studies using PSG, all patients were mechanically ventilated in thirteen studies, received non-invasive ventilation (NIV) in two studies, were extubated during the PSG recording in one study, and were breathing spontaneously in three studies. Studies in which patients were not mechanically ventilated were performed in either an intermediate care unit (Aaron et al. 1996) or a cardiac care unit (Richards et al. 1996, Richards 1998). In seven studies, part of the participating patients received mechanical ventilation. However, only one study analysed the difference in mechanically ventilated and non-ventilated patients' sleep (Elliott et al. 2013).

The reported parameters and their statistical presentation vary widely among all the PSG studies, making it difficult to compare and further explore the results. The reported sleep parameters vary from just total sleep time (Richards et al. 2002) to an extensive description of several parameters (Table 2). Sleep parameters are reported either as actual measured minutes or as the percentage of total sleep time or recording time within the range of 2 to 24 hours. Either means and standard deviations (SD) or median (MD) and interquartile ranges (IQR) are used.

3.2 Quality of ICU patients' sleep

3.2.1 Overall quality of patients' sleep

The overall quality of ICU patients' sleep is good from nurses' perspective. Nurses have evaluated it as 68 on the RCSQ scale zero (no sleep) to 100 (best possible sleep), after a care bundle sleep improvement project in 33 patients in a medical ICU (Kamdar et al. 2012b). This is exactly the same as the observed overall quality of sleep (68) with the same instrument in a study of thirteen mostly surgical patients (Frisk & Nordström 2003).

The overall quality of sleep from patients' perspective has varied rather widely in different studies. Patients have rated it between 39 and 59 (Table 3) on the RCSQ scale. Critically ill patients perceive their sleep in the ICU to be much poorer than at home. The experience of quality of sleep at home prior to hospitalization has been rated 7 on a scale of 1 (poor) to 10 (excellent), and 4 in the ICU. This experience does not seem to change during the ICU stay. (Freedman et al. 1999, Bihari et al. 2012.)

Patients have described sleep in the ICU qualitatively as "longing for normal sleep", as they were not able to sleep, (Tembo et al. 2013), and having the physical need for "continuous sleep" (Chang et al. 2012). The inability to perform one's usual bedtime routines has been reported to be one of the most sleep disturbing factors in the ICU (Simpson & Lee 1996). Addressing this in ICU nursing care would require an evaluation of patients' sleep related habits at home. Such practices have, however, not been reported in the previous research literature.

Patients have scattered memories about sleep in the ICU after discharge (Magarey & McCutcheon 2005, Ballard et al. 2006, Johnson et al. 2006, Löf et al. 2006, Hofhuis et al. 2008, Löf et al. 2008, Rattray et al. 2010). One of the major findings in previous research is "being tormented by nightmares", as Tembo et al. (2013) encapsulate it. In a multicentre study, nightmares had been experienced by as many as 59% of the 103 ICU patients (Rattray et al. 2010). Nightmares have been terrifying and horrible and often associated with death (Magarey & McCutcheon 2005, Ballard et al. 2006, Löf et al. 2008). Talking about the "weird dreams" has been difficult, and being reminded of the events has caused anxiety in patients who had received neuromuscular blockers and were interviewed within 48–72 hours after extubation (Ballard et al. 2006). The inability to fall asleep and disengage oneself at times from the surrounding reality has led patients to feel that they cannot "handle things" or "hang on" anymore (Hofhuis et al. 2008).

3.2.2 Patients' sleep by different aspects

The quality of sleep consists of several different sleep aspects. *Total sleep time* (TST) in non-sedated ICU patients at night appears to be shorter than normal (7.5 h/450 min) in every study (Table 2). The TST of mechanically ventilated patients has varied from the mean of 3 hours and 12 minutes (± 2:36) in an 8-hour observation period (Gabor et al. 2003) to the median of 5 hours 43 minutes [0:11, 11:13] in a 10-hour period (Trompeo et al. 2011). The shortest reported observed TST has been the mean of 2.3 hours in 44 conscious, stable ICU patients, when observed every hour (Chen et al. 2012). Ibrahim et al. (2006) described the TST mean of 4 hours in 32 tracheostomized patients during weaning, when estimated by nurses. The longest TST median of 5.4 hours was estimated in the morning in twelve mechanically ventilated patients (Beecroft et al. 2008).

Table 2. Description of patients' nocturnal sleep in different polysomnographic studies; reported with mean ± SD or MD (range) [IQR]

	n	Vent type	APACHE or SAPS	Rec time	Groups	TST min	N1 %	N2 %	N3 %	REM %	Arousals per hour	Awakenings per hour
Normal sleep						450	2-5	45-55	13-23	20-25	Few	Few
Aaron et al. (1996)	6	Spont		2200-0600		325 ± 33	14 ± 11	43 ± 9	5 ± 3	6 ± 3	19 ± 6	
Alexopoulou et al. (2007)	9	MV		2300-0600	PAV+base		55 ± 38	36 ± 32	3± 7	6 ± 14	12.2±8.0	4.0±3.0
Alexopoulou et al. (2007)	9	MV		2300-0600	PAV+high		33 ± 30	61 ± 28	4 ± 9	2 ± 4	11.4±7.6	4.3±3.2
Alexopoulou et al. (2007)	9	MV		2300-0600	PS base		52 ± 40	43 ± 35	2 ± 4	4 ± 6	8.4±4.8	3.6±3.1
Richards et al. (1998)	17	Spont		Not specified	Control	257 ± 108	18 ± 13	38 ± 19	8 ± 10	5 ± 4		22 ± 14
Richards et al. (1998)	28	Spont		Not specified	Relaxation	273 ± 71	17 ± 12	39 ± 14	11 ± 11	7 ± 6		21 ± 15
Richards et al. (1998)	24	Spont		Not specified	Back massage	320 ± 48	15 ± 8	48 ± 15	9 ± 12	9 ± 6		19 ± 9
Edéll-Gustafsson et al. (1999)	38	Spont/MV		2300-0700			31 ± 27	62 ± 27	7 ± 14	0,4 ± 1	57 ± 33	13 ± 5
Cooper et al. (2000)	20	MV	17 ± 8 (II)	2200-0600	Disrupted sleep	180 ± 114	40 ± 28	40 ± 23	10 ± 17	10 ± 14	20 ± 17	22 ± 25
Cooper et al. (2000)	20	MV	17 ± 8 (II)	2200-0600	Atypical sleep	240 ± 120	37 ± 42	14 ± 32	45 ± 51	4 ± 9	5 ± 8	7 ± 5
Gabor et al. (2003)	7	MV	31 ± 18 (III)	2200-0600		192 ± 156	19 ± 7	64 ± 10	3 ± 3	14 ± 910	11 ± 6	11 ± 8
Cochen et al. (2005)	6	Spont/MV		2200-0800		296 ± 83	14 ± 12	43 ± 19	29 ± 10	14 ± 8	24 ± 7	
Alexopoulou et al. (2007)	9	MV		2300-0600	PS high		35 ± 35	44 ± 32	2 ± 5	19 ± 23	10.5±9.9	3.9±3.4
Bosma et al. (2007)	13	MV	38 ± 7*	2200-0800	PAV	334 ±124			3	9	9	3,5
Bosma et al. (2007)	13	MV	38 ± 7*	2200-0800	PSV	314 ± 140			1	4	16	5,5
Andrejak et al. (2013)	26	MV		2200-0600	PCV			35 ± 23	9 ± 10	3 ± 6		
Andrejak et al. (2013)	26	MV		2200-0600	Low-PSV			20 ± 22	4 ± 9	8 ± 2		
Knauert et al. (2014)	14	Spont/MV	14 ± 8 (II)	2200-0600	>4h sleep	252 ± 96	23 ± 14	61 ± 11	4 ± 7	12 ± 12		
Beecroft et al. (2008)	12	MV	11 (4)	Not specified		186 (196)	21 (67)	74 (69)	0.2 (5)	0.4 (2)	12 (10)	14 (19)
Trompeo et al. (2011)	29	MV		2200-0800		343 [11-673]						
Kondili et al. (2012)	12	MV	23 [16-34]	2200-0700		214[40-285]	31 [5-67]	46 [3–80]	0 [0–0]	1 [0–13]		
Roche Campo et al. (2013)	16	Spont/MV	41 [33, 51]*	2200-0800		296 [148-406]			25 [17-33]	7 [3-10]		

II/III used APACHE=Acute Physiology and Chronic Health Evaluation (version II or III), *used SAPS=Simplified Acute Physiology Score, Vent=ventilation, Rec=recording, TST=total sleep time, MV=mechanical ventilation (mode not specified), Spont=spontaneous ventilation, PAV=proportional-assist ventilation, PS=pressure support, PCV=pressure controlled ventilation, PSV=pressure support ventilation

In consequence of the diminished TST, *sleep efficiency* (SE, the total amount of sleep in the time recorded or observed) is also less than normal (85–90%) in ICU patients. SE has been observed in mechanically ventilated patients in two studies, where it was 51%, when observed hourly (Bourne et al. 2008) and 78%, when estimated in the morning (Beecroft et al. 2008). However, Beecroft et al. (2008) compared the observed SE of 78% with a simultaneous PSG recording, and reported a SE of 42%, which is substantially less than the observed value. Also, a SE as low as the mean of 38% was reported in 26 patients suffering from respiratory failure and ventilated in low PSV mode (Andrejak et al. 2013). The highest reported mean SE has been 76% in a group of nine patients ventilated in PAV with baseline pressure support mode (Alexopoulou et al. 2007). The difference of the studies reporting the extreme TST and SE is a direct result from reporting different aspects of sleep.

Sleep latency (SL, the amount of time it takes to fall asleep after lights out) has only been reported by Fontaine (1989), who reported a mean SL of 21 minutes while according to the simultaneously recorded PSG it was 14 minutes. Both values are close to normal. The ease of falling asleep has most commonly been the best sleep aspect according to patients' self-evaluations as well (Table 3). In Fontaine's aforementioned study of 20 patients suffering from trauma, the patients were observed to be *awake after sleep onset* (WASO) for a mean of 136 minutes. The simultaneous PSG showed a WASO of 127 minutes; when healthy people stay awake only for 20–40 minutes after first falling asleep. Patients have evaluated *the ability to fall asleep again* after being awoken one of the best sleep aspects in most studies (Table 3).

Table 3. Patients' sleep self-evaluations in different studies, measured with the Richards-Campbell Sleep Questionnaire (Richards et al. 2000), scale zero (poorest sleep) to 100 (best sleep).

Sleep aspects, mean (SD)	Richards et al. (2000)	Frisk & Nordström (2003)	Nicolás et al. (2008)	Li et al. (2011) intervention	Li et al. (2011) control	Kamdar et al. (2012b)
Patients	medical	mixed	surgical	surgical	surgical	medical
Sample size	70	31	104	28	27	92
Sleep depth	44 (34)	40	51 (26)	64 (22)	51 (28)	48 (38)
Falling asleep	66 (30)	48	56 (27)	65 (23)	54 (29)	60 (39)
Number of awakenings	66 (29)	53	42 (24)	65 (16)	51 (26)	60 (35)
Time awake	62 (31)	47	56 (26)	66 (20)	54 (30)	61 (35)
Overall quality of sleep	64 (34)	39	53 (20)	65 (20)	51 (26)	59 (35)
Total score	60 (27)	46	51 (22)	65 (19)	52 (26)	57 (30)

The depth of sleep or the amount of deep sleep stage also appears to be insufficient in ICU patients (Tables 2 and 3). According to the patients' self-evaluations, it is the worst sleep aspect (Table 3). In PSG studies, the amount of N3 sleep in mechanically ventilated ICU patients has most commonly varied between the median of 1% (Bosma et al. 2007) and the mean of 9% (Andrejak et al. 2013) as calculated from TST. The average of no N3 sleep has been demonstrated with patients on proportional assist and pressure support ventilation modes (Kondili et al. 2012, Alexopoulou et al. 2013), and the median of 0.2% in patients with mechanical ventilation (mode not reported) (Beecroft et al. 2008). Also, in 53 mixed ICU patients of whom 54% were mechanically ventilated with varying modes, the median N3 sleep was 0% (Elliott et al. 2013). An atypically high amount of N3 sleep, a median of 25%, was recorded in fifteen patients with prolonged mechanical ventilation (MD 51 days) (Roche-Campo et al. 2013). In non-ventilated patients in a respiratory care unit, the amount of N3 sleep averaged 5% (Aaron et al. 1996), and in a sleep intervention study of cardiac patients, the mean was 8–11% (Richards 1998). So, the proportion of N3 sleep among ICU patients seems to be much smaller than in healthy people, regardless of whether the patients are mechanically ventilated or not.

The amount of REM sleep at night varies widely in different studies and within different intervention groups (Table 2). Only 1% of REM sleep has been demonstrated in patients receiving automatically assisted pressure control ventilation. However, in assist control ventilation mode, the proportion of REM sleep in the same patients rose to 7% (Cabello et al. 2008). Representing the large variation in ICU patients, a nearly normal amount of REM sleep, a mean of 19%, has been recorded in patients with high pressure support ventilation, whereas patients with proportional-assist ventilation with high assistance level only had a mean of 1.7% REM sleep (Alexopoulou et al. 2007). The proportion of REM sleep in non-ventilated patients has varied from 4.9 to 8.7%, falling far behind the normal REM sleep amount of 20–25%.

Furthermore, the quality of ICU patients' sleep is weakened by frequent *arousals and awakenings*. The *fragmentation index* (FI, arousals and awakenings/hour) has varied in previous studies from a mean of 13 per hour in patients receiving pressure controlled ventilation with base assistance level (Alexopoulou et al. 2007) to a median of 33 per hour in patients receiving pressure support ventilation (Delisle et al. 2011). In spontaneously breathing patients, reports have shown a mean of 19 arousals per hour in an intermediate respiratory care unit (Aaron et al. 1996) and 19–22 awakenings per hour in cardiac patients participating in a sleep intervention study (Richards 1998).

Mechanical ventilation is known to worsen both the quality and quantity of patients' sleep (Ozsancak et al. 2008, Fanfulla et al. 2011, Alexopoulou et al. 2013, Cordoba-Izquierdo et al. 2013). However, only one study has analysed the possible difference in sleep between non-sedated, mechanically ventilated and non-ventilated patients. Rather surprisingly, it demonstrated that sleep in the non-ventilated patients was even more fragmented and shorter than that observed in the mechanically ventilated patients. (Elliott et al. 2013.)

The variation of heart rate during sleep has only been reported in critically ill patients who suffered from cardiac disease and were on cardiac medications. They were noted to have a 3% to 4% decrease in heart rate during sleep. (Richards et al. 1996.) The variation of blood pressure during sleep has not been studied in ICU patients.

In summary, despite the differences in reporting, the earlier research indicates that the ICU patients' TST is not long enough when compared to the normal TST of 7–8 hours.

ICU patients' sleep is lighter than normal, and the proportions of N3 sleep and REM sleep are low. Arousals and awakenings are also frequent, and WASO times are long. The variability between patients appears to be rather large as well.

3.2.3 Disruptive effect of nursing care on patients' sleep

Several factors may disrupt patients' sleep in an ICU (Elliott et al. 2011b), of which nursing care is one of the most disturbing (Li et al. 2011, Elliott et al. 2013). Nursing care in an ICU includes many interventions such as assessing and caring for patients' physical and psychological needs, and supporting patients and their significant others in the process of critical illness (Pyykkö et al. 2001, Miranda et al. 2003, Yamase 2003).

The disruptive effect of nursing care on sleep has been studied with the Sleep in the Intensive Care Unit Questionnaire (Freedman et al. 1999). With this questionnaire, patients rate how disturbing noise, light, nursing interventions, diagnostic testing, vital signs, blood samples, and administration of medications are on a scale 1 (no disruption) to 10 (significant disruption). The mean disruptive effect of nursing interventions has been rated from 4 (Patel et al. 2014) to 5.2 (Li et al. 2011) and it has been either the fifth most disruptive factor in the 1990's (Freedman et al. 1999) or the third most disruptive factor in 2010's (Elliott et al. 2011a, Li et al. 2011, Patel et al. 2014). This may result from the change in the ICU nursing techniques, as in the 1990's study (Freedman et al. 1999) the most disturbing factors were recording vital signs and taking laboratory tests, which have developed since to be more automatic and not so disturbing to the patient. Alternatively, the patients need for nursing care may have become more complex and demanding.

Different interventions to improve patients' sleep seem to have a positive effect on patients' perception of how disturbing nursing interventions are. Li et al. (2011) demonstrated that with the implementation of sleep care guidelines the disturbing effect of nursing interventions decreased from 5.2 to 3.3. A stronger decrease in the disturbing effect of nursing interventions (from 4 to 1) was achieved with the implementation of a multidisciplinary bundle of sleep interventions (Patel et al. 2014). Thus, the guidelines alone may not be as effective as the care bundle approach, where the compliance of guidelines is followed systematically.

One reason for the sleep disruptive effect of nursing interventions may be that they are performed frequently. It has been reported that nursing interventions occur at least hourly in respiratory and medical ICU's (Meyer et al. 1994). From a patient documentation review of 147 nights, only six 2-hour intervals and three 3-hour intervals between care interventions were found in a study focusing on how many uninterrupted 90-minute sleep cycles patients were able to sleep in three different types of ICU's (Tamburri et al. 2004). Nursing interventions may not be the primary reason for the low quality of patients' sleep. In a study of seven mechanically ventilated patients, 18% of the patient care activities (including nursing interventions, medical care, and family visits) were reported to result in sleep disruption. Care activities constituted for only 7% of all arousals and awakenings. (Gabor et al. 2003.)

3.3 Evaluation of the quality of ICU patients’ sleep

Patients’ sleep in an ICU has been evaluated by observatory methods, by self-evaluation, and by physiologic measures. Sleep evaluation methods employed in ICU patients vary widely from simple notifications of asleep or awake to complex PSG recordings of several physiological parameters. (I)

3.3.1 Observatory evaluation methods

Nurses observe their patients’ condition constantly 24 hours a day in an ICU. However, systematic observation of patients’ sleep with a specific tool or instrument is not common (Table 4). The most simple observation tool has been an asleep/awake scale (e.g. Aurell & Elmqvist 1985). In the two first ever published studies on patients’ sleep in the ICU, a researcher was observing if a patient (a total of four patients) was either awake, asleep, or the researcher could not determine the state (McFadden & Giblin 1971, Woods 1972). The same scale was used again in 2012 in a study of the effect of valerian acupressure on ICU patients’ sleep (Chen et al. 2012). Edwards and Schuring (1993) added one more class defined as “no time to observe” and developed the *Nurse Observation Checklist* for data collection. The “could not tell” category was used in 11% of the observation times and “no time to observe” in 8.5% (n=340). It indicates that nurses considered 80% of the sleep evaluations they performed as valid.

Only the *Echols’ Patient’s Sleep Behavior Observational Tool* has endeavoured to observe patients’ sleep in more than few aspects (Table 4). However, it was developed as a Master’s thesis in 1968 and the only published report is from 1989, when it was noted to correspond rather well with simultaneous PSG data in determining the WASO. The length of sleep onset and the number of awakenings did not correlate with PSG, as nurses overestimated the length of sleep onset and missed two thirds of the awakenings. (Fontaine 1989.)

In the aforementioned studies, patients’ sleep has been observed every 5–15 minutes, except in Chen et al.’s (2012) study. A short observation interval may be necessary to capture the frequent awakenings of ICU patients. However, it may be too burdensome if it is done by the nurse. A 60-minute observation interval was used in Chen et al.’s (2012) and Bourne et al.’s (2008) studies. They argued that this interval was too long and explained the difference between nurses’ observations and simultaneous actigraphy recordings. Besides observing patients’ sleep at certain time intervals, nurses’ general estimations of patients’ TST (Ibrahim et al. 2006, Beecroft et al. 2008) and the number of awakenings (Beecroft et al. 2008) during the night have been collected the following morning. Although ICU patients are continuously watched over by a nurse, these estimations of sleep are subjected to several inaccuracies as nurses may be preoccupied with other matters and miss their patients’ awakenings or sleep. Furthermore, nurses may not be able to evaluate their patients’ sleep status correctly (see Original publication IV).

Table 4. Sleep observation instruments used for ICU patients.

Sleep observation instrument	Scale	Observation interval used	Reference
Unnamed observation checklist	Awake/asleep	5 minutes	Aurell & Elmqvist 1985
Unnamed observation checklist	Awake/asleep/could not tell	5 minutes 10 minutes 60 minutes	McFadden & Giblin 1971 Woods 1972 Chen et al. 2012
Nurse Observation Checklist	Awake/asleep/could not tell/ no time to observe	15 minutes	Edwards & Schuring 1993
Echols' Patient's Sleep Behavior Observational Tool	Awake/drowsy/REM sleep/ nREM sleep	5 minutes	Fontaine 1989
Richards-Campbell Sleep Questionnaire	sleep depth/falling asleep/ number of awakenings/ percentage of time awake/ overall quality of sleep	Once, in the morning	Frisk & Nordström 2003 Kamdar et al. 2012b

In addition to the previously discussed observation tools, the instrument developed for patients' self-evaluation, the *Richards-Campbell Sleep Questionnaire* (RCSQ, see next section), has also been used to measure nurses' evaluations of patients' sleep in two studies (Frisk & Nordström 2003, Kamdar et al. 2012b). It is more comprehensive as it gives estimates of patient's sleep depth, falling asleep, number of awakenings, percentage of time awake, and overall quality of sleep.

Nurses document patients' sleep evaluations in patient care records. Two analyses of the sleep documentations have been reported earlier: a retrospective chart review of nurses' narrative entries focusing on the occurrence and content of the documentation (Edéll-Gustafsson et al. 1994); and a quality of sleep study analysing the correspondence of the quality of sleep documentations with the patients' self-evaluations (Nicolás et al. 2008). According to the results, the documentation frequency varied from 69% (Edéll-Gustafsson et al. 1994) to 100% (Nicolás et al. 2008) of all patients. Nurses documented the quantity of sleep for about half of the nights studied (n=320), and the quality of sleep for 36% of the nights studied. As the study focused on the occurrence and content of the documentation, the actual quality or quantity of sleep was not reported. (Edéll-Gustafsson et al. 1994.) Nicolás et al. (2008) reported from nurses' documentations by a deductive content analysis based on the RCSQ that the quality of patients' sleep was good in 39%, normal in 50% and poor in 12% of patients (n=101).

In summary, observatory instruments employed for patients' sleep evaluations focus mostly on the quantity of sleep, except the RCSQ, which contains five sleep aspects. All observations have been performed at intervals. Continuous observation in actual care situations has not been used in previous studies.

3.3.2 Self-evaluation methods

Several different structured questionnaires have been employed for the self-evaluation of ICU patients' sleep. However, only three of them contain more than just few general questions about the quality of patients' sleep (Table 5). The most commonly used instrument has been the *Richards-Campbell Sleep Questionnaire* (RCSQ). It was originally developed for ICU patients because most available sleep questionnaires were too long and burdensome to be used with the critically ill (Richards et al. 2000). The RCSQ has been used in several studies of ICU patients' sleep (Richards et al. 2000, Frisk & Nordström 2003, Bourne et al. 2008, Nicolás et al. 2008, Li et al. 2011, Elliott et al. 2013, Faraklas et al. 2013, Kamdar et al. 2013, McKinley et al. 2013, Maidl et al. 2014, Patel et al. 2014). Perhaps due to the ease of its use, the RCSQ has also been used in other groups, such as lactating mothers (Hill et al. 2005), hospitalized elders (Lareau et al. 2008), AIDS patients (Ownby 2006), hospitalized mental health patients (de Niet et al. 2010), and relatives of palliative care patients at home (Carlsson 2012).

The RCSQ contains five aspects of sleep: sleep depth, falling asleep, number of awakenings, percentage of time awake, and overall quality of sleep. Each of them is measured with one statement and a visual analogue scale (VAS) of 0–100. Zero represents the poorest sleep and one hundred the best possible sleep. McKinley et al. (2013) have suggested a cut-off point of 70 between good and poor sleep based on the rating of sleep at home on a different scale where 7/10 was interpreted as good sleep. Frisk and Nordström (2003) suggest that a cut-off point of 25 indicates very poor sleep and 75 indicates very good sleep. Nicolás et al. (2008) categorized their results as 0–33 poor sleep, 34–66 fair sleep, and 67–100 good sleep, which is close to McKinley et al.'s definition.

In the development of the RCSQ, an expert panel was used for content validation, and PSG was used to test criterion validity. The item measuring sleep depth correlated significantly with the amount of N3. The item "overall quality of sleep" correlated with the amounts of N2 and REM sleep. The item "falling asleep" was strongly associated with sleep latency in PSG. However, possibly due to the small sample size of nine patients, no significant correlations were found. (Richards et al. 2000.) The internal consistency of RCSQ has been very good in previous studies, as Cronbach's alpha coeffient has varied from 0.89 (Nicolás et al. 2008) to 0.92 (Frisk & Nordström 2003).

Besides the RCSQ, several other tools and instruments have been employed for the self-evaluation of ICU patients. The 15-item *Verran-Snyder-Halpern Sleep Scale* (VSH), which the RCSQ is based on (Richards et al. 2000), was developed in 1987 for the use of hospitalized patients. It consists of several items on awakenings, sleep on the previous day, falling asleep, and the quality of sleep. (Snyder-Halpern & Verran 1987.) Different versions of the VSH, containing 8 to15 items, have been used on ICU patients prior to the RCSQ development (Fontaine 1989, Higgins 1998, Richardson 2003), and also later for reasons not specified in the reports (Scotto et al. 2009, Su et al. 2013).

The *Sleep in the Intensive Care Unit Questionnaire* (SICUQ) was developed in 1999. It contains five questions on the quality of sleep and daytime sleepiness and two questions regarding sleep disruptions and noises in the ICU. All items involving the quality of sleep relate to overall quality in different times: at home and during the first night, middle and last night of the ICU stay. (Freedman et al. 1999.) No other aspects of

Table 5. Sleep self-evaluation instruments used for ICU patients.

Self-evaluation instrument	Content	Reference
Richards-Campbell Sleep Questionnaire	Sleep depth Falling asleep Number of awakenings Percentage of time awake Overall quality of sleep	Richards et al. 2000 Frisk & Nordström 2003 Nicolás et al. 2008 Bourne et al. 2008 Li et al. 2011 Kamdar et al. 2012b Elliott et al. 2013 McKinley et al. 2013 Faraklas et al. 2013 Kamdar et al. 2013 Maidl et al.2014 Patel et al. 2014
Verran-Snyder-Halpern Sleep Scale	Measures fragmentation, delay, length, and depth of sleep with 14 items 15 items 8 items 8 items 15 items	 Fontaine 1989 Higgins 1998 Richardson 2003 Scotto et al. 2009 Su et al. 2013
Sleep in the Intensive Care Unit Questionnaire	Quality of sleep at home, in the ICU first night, middle, end of stay Daytime sleepiness in the ICU first night, middle, end of stay	Freedman et al. 1999 Li et al. 2011 Bihari et al. 2012

sleep are covered. As the major part of the questionnaire covers sleep disruptions, it has been employed in the studies focusing on them (Li et al. 2011, Bihari et al. 2012).

Other studies focusing on sleep disruptions have only used general questions about the quality of sleep (de Haro Marin et al. 1999, Calvete Vazquez et al. 2000), the ease of falling asleep, and the number of awakenings during the ICU stay (de Haro Marin et al. 1999), when patients have left the ICU. Similar general questions about the previous night's sleep have been employed in three intervention studies investigating the effect of earplugs and eye masks (Richardson et al. 2007, Jones & Dawson 2012, Van Rompaey et al. 2012). One simple question of global quality of sleep (no sleep, poor sleep, slept well) has been used in an experimental study of two different ventilation modes in addition to a PSG recording (Toublanc et al. 2007).

Reports on the validity and reliability have been published on the aforementioned RCSQ, VSH, and SICUQ. As for the general one-to-five item questionnaires, the validity and reliability remain undetermined. Moreover, retrospective self-reporting is always subject to recall bias. Especially ICU patients are subjected to memory loss due to several environmental, psychological, physiological, and pharmacotherapy related factors (Samuelson 2011). In previous studies, 5.5% of 289 patients who had been sedated and mechanically ventilated (Rundshagen et al. 2002), and 19% of 250 mixed ICU patients (Samuelson 2011) had no recollection of the time spent in ICU. 64% of 109 non-elective ICU patients described having "blurred memories" (Rattray et al. 2004). All the aforementioned interviews were conducted during the same hospital stay after discharge from ICU. It appears that no change for better has occurred in the course of time. The memory of ICU care seems to fade with time, as only 43% of 51 patients with an average stay in the ICU of only 135 hours, remembered being in an ICU when inquired within two years of discharge (Magarey & McCutcheon 2005).

In summary, the RCSQ is the most extensive and most employed instrument to measure ICU patients' self-evaluation of sleep. There is strong evidence of its validity, and it has been developed for ICU patients, taking into account their special situation. Other instruments with merely general questions about the previous night's sleep may serve as a quality indicator or an indication that sleep deprivation is a considerable problem. However, they do not produce the diverse information needed for supporting and improving patients' sleep. To target the quality of patients' sleep, information is needed on different sleep aspects such as ability to fall asleep, the number of awakenings, and the depth of sleep.

3.3.3 Physiologic evaluation methods

Various different methods for the evaluation of sleep and diagnosing sleep disorders have been developed for the general public. Many of them have been used with ICU patients (Figure 2). The most objective understanding of ICU patients' sleep has been gained with *polysomnographic* (PSG) recordings (Figure 3). PSG is most commonly used in sleep laboratories. It contains measures on brain wave activity (electroencephalogram, EEG), eye movement detection (electro-oculogram, EOG), muscle tension detection (electromyogram, EMG), movement detection, and recording of ventilation, gas exchange and heart rate.

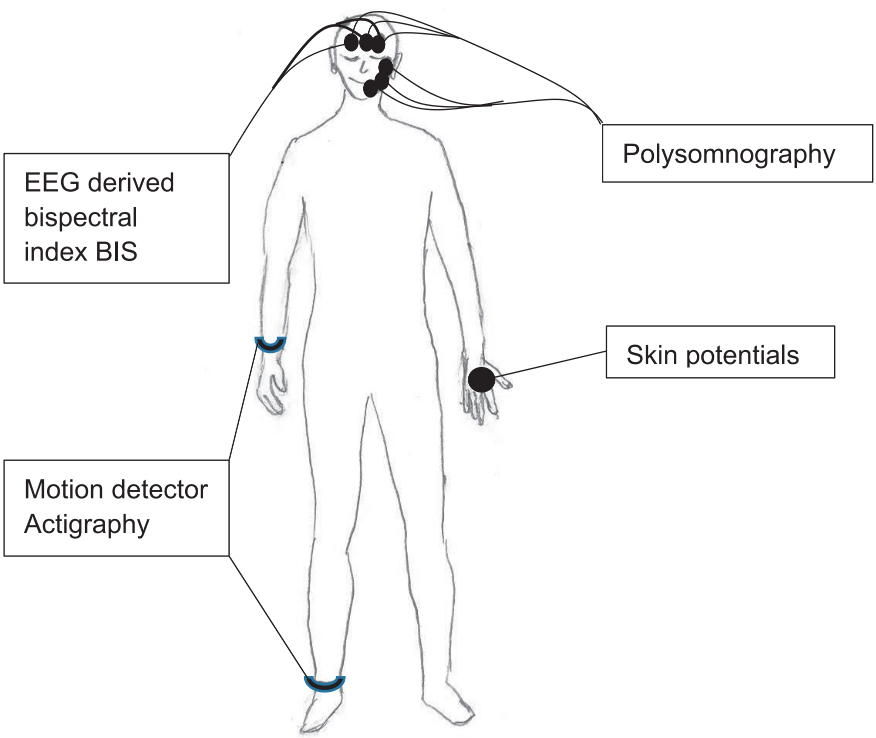

Figure 2. Sleep evaluation methods based on physiologic measurements, used in ICU patients.

PSG has been employed in over forty studies on ICU patients, the oldest report dating back to 1971 (McFadden & Giblin 1971). PSG has most commonly been performed as an 8–10 hour recording during the night (thirteen studies) or as a minimum period of a 24-hour recording (eight studies). Recording times of 16–18 hours were used in four studies. In a study exploring the effect of two ventilator modes (PSV, NAVA) on sleep, four 4-hour periods were used for analysis (Delisle et al. 2011). Daytime recordings in a sleep laboratory were used in a study focusing on the safety of PSG in ICU patients and the possible underlying sleep disorders in patients suffering from respiratory failure (Buckle et al. 1992). In this study, Buckle et al. concluded that PSG is a safe and effective way of detecting underlying sleep disorders. However, they did hope for portable equipment to avoid patient transfers to a sleep laboratory. This kind of equipment has now been readily available for the last 25 years.

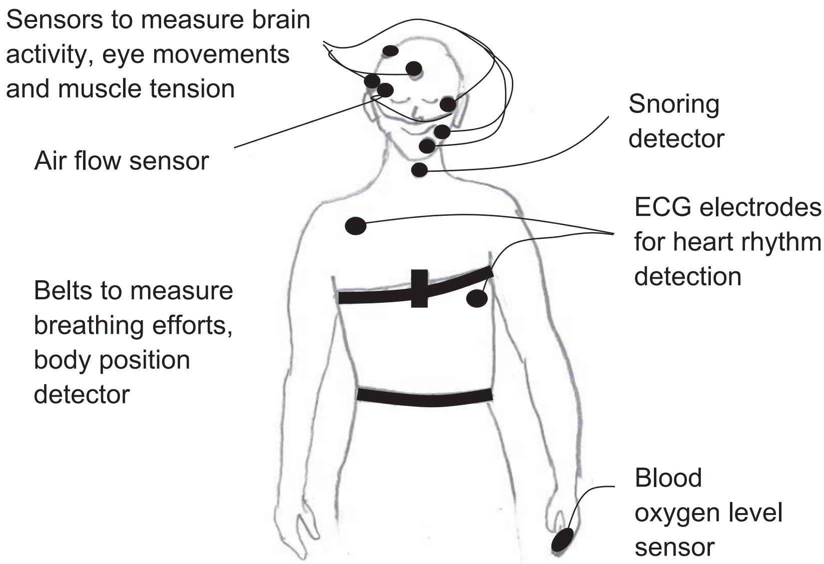

Figure 3. Setup for the polysomnographic (PSG) recording.

PSG is considered the gold standard of sleep recording (Kushida et al. 2005, Bourne et al. 2007). However, its usefulness in ICU patients has been questioned (Watson 2007, Drouot et al. 2008) inasmuch as sleep scoring according to the AASM standards (Iber et al. 2007, Berry et al. 2012) has not been conceivable in all ICU patients due to artefact (Cooper et al. 2000) or the patient's septic condition (Freedman et al. 2001). Questions have also been raised about the effect of other disease states and medications on ICU patients' sleep manifestation (Watson 2007, Drouot et al. 2008).

The PSG used in hospitals and especially in sleep laboratories includes rather massive equipment and several electrodes, sensors and wires (Figure 3). Smaller devices have been developed mainly for home recordings. One wireless monitor, brand name Zeo (Zeo Inc. Newton, Massachusetts), has been employed for the sleep recordings in sedated ICU patients. It contains a headband with electrodes and collects signals similar to EEG, EOG, and EMG. Zeo has an automatic analysing program, which provides information about the proportion of sleep stages: light sleep (N1 and N2 combined), deep sleep (N3), and REM sleep. (Whitcomb et al. 2013.) It has shown a reasonable agreement in healthy volunteers with a simultaneous manually scored PSG (Shambroom et al. 2012). Apparently, no validation studies have been conducted in ICU patients.

The *Bispectral index* (BIS) is based on processing the EEG signal recorded with three or four electrodes on the patient's forehead. The signal is processed with an algorithm, which provides a number from zero (absence of brain activity) to 100 (wakefulness) (LeBlanc et al. 2006). In critical care, BIS monitoring has been used mainly for monitoring the level of consciousness during sedation administration (Shetty et al. 2014). Nicholson et al. (2001) employed BIS to evaluate sleep in non-sedated ICU patients. They claimed a correlation with light sleep and BIS 60–85, deep sleep and BIS <60, and REM sleep and three BIS values (BIS >60, EMG power decrease >30%, presence of rapid eye movement artefacts). Despite these results and a widespread use of BIS in ICU's, no further studies using BIS for sleep detection have been published.

*Actigraph*y (or actometry) is a method using a three-dimensional accelerometer with an electrode band usually worn on a patient's wrist or, occasionally on the ankle. It detects movements based on the changes in acceleration levels. The sleep/wake stage analysis is based on an assumption that while movements are small and scarce, the patient is asleep, whereas large frequent movements indicate wakefulness. (Stone & Ancoli-Israel 2011.) Actigraphy has been employed in ICU patients in three sleep studies (Beecroft et al. 2008, Bourne et al. 2008, van der Kooi et al. 2013) in an attempt to validate it, and in an intervention study as a main method (Chen et al. 2012). It appears to overestimate ICU patients' sleep, possibly due to the extreme exhaustion, muscle weakness and immobility patients experience (Beecroft et al. 2008, Bourne et al. 2008, van der Kooi et al. 2013).

Skin potentials (SP) have been measured by Shiihara et al. (2001) in an attempt to monitor the sleep-wake pattern in ICU patients. The measurement is based on the negative voltage variations on the skin, regulated by the autonomic nervous system (Malmivuo & Plonsey 1995). The voltage changes according to the sleep-wake state and during awakenings from sleep. During sleep, the levels are less negative than when awake. It can be used for differentiation between the patient being asleep or awake, but not for the detection of sleep stages. (Koumans et al. 1968, Shiihara et al. 2000.) Sleep-wake cycles have been demonstrated with a skin potential monitoring in the ICU patients. Furthermore, a rise in SP preceding delirium has been reported. (Shiihara et al. 2001.) However, no further studies in ICU patients have been published.

Several other measures, such as bed motion sensors, eyelid movement and non-invasive arm sensors, a sleep switch and a remote bio-motion sensor, have been tested in healthy volunteers (Van de Water et al. 2011). However, they have not been used in ICU patients. Thus, the data on their function remains lacking. In conclusion, PSG remains the only reliable objective physiological method to evaluate sleep in ICU patients.

3.3.4 *Correspondence of observatory evaluations with other evaluations*

Nurses' sleep evaluations have not corresponded well with either patients' self-evaluations or the physiologic sleep evaluation methods (Table 6). When compared to patients' self-evaluations, no correlation has been found with the use of different observation tools (Fontaine 1989, Bourne et al. 2007). When sleep evaluations have been performed with the same instrument (RCSQ), the correlation has varied from slight or moderate (Kamdar et al. 2012b) to high (Frisk & Nordström 2003), while nurses' evaluations have systematically been higher than patients' self-evaluations. Nurses may overestimate patients' sleep, because ICU patients often look like they are sleeping as

Table 6. Correspondence of nurses' observations with other sleep evaluations. (I)

Nurses' observation method	Compared with	Observation interval	n	Result	Reference
Asleep/awake	PSG	5 minutes	6	Nurses' observations correlated, consistently over-estimated TST	Aurell & Elmqvist 1985
Echols' Patient's Sleep Behavior Observational Tool	VSH sleep scale (patient)	5 minutes	20	No correlation	Fontaine 1989
Echols' Patient's Sleep Behavior Observational Tool	PSG	5 minutes	20	SL and WASO higher, mid-sleep awakenings less by nurses observations	Fontaine 1989
Nurse Observation Check List (awake/ asleep/could not tell/ no time to observe)	PSG	15 minutes	21	73.5 % nurses' observations correlated with PSG on sleep/wake stage	Edwards & Schuring 1993
Not specified	RCSQ (patient)	60 minutes	24	Poor agreement, no tendency to over or under-estimation	Bourne et al. 2007
Not specified	Actigraphy	60 minutes	24	SE lower by nurses' observations than actigraphy	Bourne et al. 2008
Not specified	BIS	60 minutes	24	SE over-estimated by nurses	Bourne et al. 2007
Asleep/awake	Actigraphy	60 minutes	85	TST by actigraphy three-fold over nurses' observations	Chen et al. 2012
Hours asleep, awakenings	Actigraphy	Once, in the morning	12	No correlation	Beecroft et al. 2008
Hours asleep, awakenings	PSG	Once, in the morning	12	No correlation	Beecroft et al. 2008
RCSQ	RCSQ (patient)	Once, in the morning	13	High correlation Nurses' estimations higher	Frisk & Nordström 2003
RCSQ	RCSQ (patient)	Once, in the morning	92	Interrater reliability slight to moderate; nurses tend to overestimate sleep depth, TST, quality	Kamdar et al. 2012b
Nurses' documentation	RCSQ (patient)	Once, in the morning	104	44 % agreement on quality of sleep	Nicolás et al. 2008

PSG=polysomnography, VSH=Verran-Snyder-Halpern, RCSQ=Richards-Campbell Sleep Questionnaire, BIS=bispectral index, TST=total sleep time, SL=latency to sleep onset, WASO=wake after sleep onset, SE=sleep efficiency they lie still with eyes closed, while they are not asleep. Patients' self-estimation may also be biased due to several sleep distractions or lack of recall.

Nurses' documentations of patients' sleep have been analysed for correspondence with patients' self-evaluations in one prior study. Nicolás et al (2008) reported a relatively good agreement between both evaluations of the quality of the patients' sleep. The total agreement in a pairwise analysis was 44% (n=101). When in disagreement, nurses more often overestimated (40 cases) than under-estimated (14 cases) the patients' sleep.

Nurses' sleep evaluations have also been compared to the physiologic sleep measures actigraphy and PSG. Nurses systematically underestimate TST when compared to actigraphic sleep evaluations (Table 6), possibly originating from the poor validity of actigraphy in ICU patients as it is based on movement detection. A fair correlation has been demonstrated between nurses' evaluations and PSG, while nurses tend to over-estimate patients' TST and SL. No summation can be drawn from these different studies as they vary widely by the sample size and the sleep evaluation interval.

In conclusion, the evaluation of patients' sleep is challenging as either nurses seem to overestimate patients' sleep or no correlations have been found. However, ICU nurses are trained and have experience in continuously observing and evaluating changes in patients' condition. In general, nurses play a key role in collecting information about patients' condition, planning and executing the necessary interventions, evaluating the effect of the interventions, and documenting everything. Therefore, nurses should have appropriate tools to evaluate and support patients' sleep as well.

3.4 Summary of the background of the study

ICU patients' sleep has mostly been studied in intubated and mechanically ventilated patients and with PSG. According to these rather small studies, intubated and mechanically ventilated ICU patients sleep less than an average healthy person. However, there are large variations between patients. The sleep in intubated ICU patients is lighter than that of an average healthy person and there are multiple awakenings. However, it is not known how non-intubated patients sleep in an ICU. Nursing care has a moderate disturbing effect on patients' sleep.

Nurses evaluate patients' condition constantly. The instruments for patients' sleep evaluations by nurses focus mostly only on sleep quantity and overall quality. Nurses have a tendency to overestimate them both. For patients' self-evaluation, the five aspects of sleep (sleep depth, falling asleep, number of awakenings, percentage of time awake, and overall quality of sleep) can reliably be measured with the RCSQ. PSG provides accurate sleep data on patients who are not the most severely ill; however, it is a burdensome method and not usable in everyday sleep evaluations. (Figure 4)

THE QUALITY OF ICU PATIENTS' SLEEP

- Fairly good from nurses' perspective
- Fair to poor from patients' perspective
- Fractional, light and not sufficient by physiologic measure
- Evidence obtained with PSG on the sleep quality of non-intubated patients is minimal
- Nursing care is disruptive to patients' sleep

EVALUATION OF THE QUALITY OF ICU PATIENTS' SLEEP

- Most observatory methods for nurses focus on the quantity and general quality of sleep and have been used for observation at preset intervals
- Nurses' evaluations of patients' sleep differ from patients' self-evaluations and physiologic measures
- RCSQ measures several aspects of sleep and can be used for self-evaluation
- PSG is the most valid but a very laborious sleep evaluation method

The quality of non-intubated ICU patients' sleep requires further evaluation
Nurses need more comprehensive methods for sleep evaluation

Figure 4. Summary of the previous research.

4. PURPOSE OF THE STUDY AND RESEARCH QUESTIONS

The purpose of this study was to evaluate 1) the sleep evaluation methods used for ICU patients, 2) the quality of non-intubated ICU patients' sleep, and 3) the sleep evaluations performed by ICU nurses. The aims were to develop recommendations of patient's sleep evaluation for ICU nurses and to provide a description of the quality of non-intubated patients' sleep. The recommendations were to be based on both the previous research literature and studying nurses' sleep evaluations and comparing them to patients' self-evaluations and polysomnographic sleep evaluations. The research questions were

1) How can the quality of patients' sleep be evaluated in an ICU? (I)

2) What is the quality of non-intubated ICU patients' sleep by
   a. the evaluation by nurses? (II, IV)
   b. the self-evaluation of patients? (II)
   c. the physiologic measure PSG? (III)

3) How do nurses' evaluations of the quality of patients' sleep correspond with
   a. the self-evaluation of patients? (II)
   b. the physiologic measure PSG? (IV)

With the knowledge provided in this study, it is possible to reflect on the current practices of performing, documenting, and teaching the evaluation of ICU patients' quality of sleep. Practical and valid sleep evaluation is a prerequisite for the successful sleep promotion.

5. MATERIALS AND METHODS

This study consists of a systematic review of the sleep evaluation methods and four evaluations of the quality of patients' sleep (Figure 5). The systematic review provided information for the method selection and for the recommendations of the evaluation of patients' sleep. The four data, two different nurses' evaluations (A and B), patients' self-evaluations (C), and PSG (D) provided knowledge about non-intubated patients' quality of sleep. The nurses' narrative documentations of the quality of patients' sleep (A) were used to explore the content of the evaluations and the correspondence with the patients' self-evaluations (C, n=114), and the nurses' evaluations with a structured observation instrument (B) were used to explore their correspondence with the PSG (D, n=21).

The four evaluations performed in this study (Figure 5) are referred to with the letters A, B, C, and D from here onwards.

5.1 Study settings and participants

5.1.1 Study settings

The nurses' narrative documentations of the quality of patients' sleep (A) and the patients' self-evaluations (C) were obtained in a university affiliated level three ICU with sixteen patient beds for medical and surgical adult patients. The ICU consists of one open room for ten patients, another room for five patients and one single-patient room. Curtains are used between the patients. The nurse-patient ratio at night is 1:1–2. (II)

The nurses' structured observatory evaluations of the quality of patients' sleep (B) and the PSG recordings of the patients' sleep (D) were obtained in a university affiliated level three ICU with 24 patient beds. The unit operates both as a critical care unit and as a step-down unit for medical and surgical adult patients. Patient rooms have places for 2–5 patients, and each nurse takes care of 1–2 patients at night. (III, IV)

5.1.2 Participant selection

Both units have an extensive orientation programme for new nurses. The nurses will be responsible for a patient only after they have gained enough critical care nursing competence. Thus, all nurses were considered competent, and the participating nurses for both data collections were chosen according to the eligible patient they were to care for during the night.

Patients for the self-evaluation of their sleep (C) were chosen as follows. All alert and oriented adult patients who were able to hear and speak Finnish or Swedish and were not intubated were approached after a full night spent in the ICU and asked to participate in the study. The patients' orientation status was determined by a discussion with their nurse and by the Richmond Agitation Sedation Scale (RASS) score zero (calm, alert, oriented) (Sessler et al. 2002) and the Glascow Coma Scale (GCS) score 15 (fully conscious, able to talk, oriented, able to move all extremities) (Fischer et al. 2010). A convenience sample of 114 patients participated in the study. A study sample of at least 100 participants was considered adequate for a statistical analysis of the data. The additional fourteen patients were included in the study population to ensure that sufficient data would be attained.

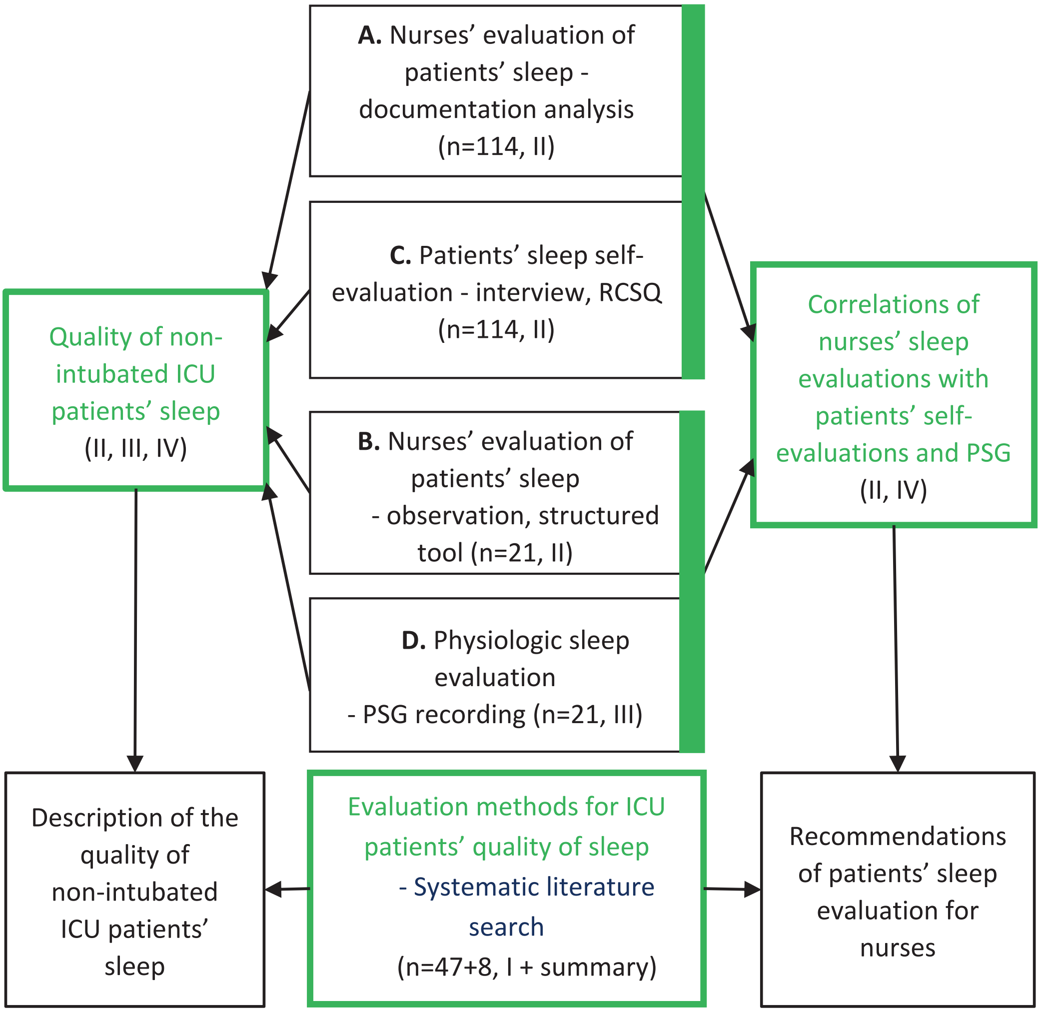

Figure 5. Study design. A-D refer to four different data. ICU=Intensive care unit, RCSQ=Richards-Campbell Sleep Questionnaire, PSG=Polysomnography

Patients for the PSG evaluation of their sleep (D) were chosen as follows. All alert and oriented adult patients who were not intubated were asked to participate in an overnight polysomnographic recording. The patient's orientation was determined through a discussion with the patient and his/her nurse and measured with the RASS which was set to be between -1 (drowsy) to +1 (restless) (Sessler et al. 2002). The patient's GCS prerequisite was to be above 13 whereupon he/she would at least open his/her eyes in response to voice, be oriented and move all extremities on command (Fischer et al. 2010). Patients with neurological trauma were excluded from the study.

The researcher telephoned or visited the ICU to discuss with the intensivist and the internist about the possible candidates for the study. After this, the researcher approached the eligible patients and explained the purpose and the procedure of the study to them. Written information of the study was also given to the potential participants. Patients who were going to a major bladder surgery and known to be cared for in the ICU after surgery were approached the day before the surgery on the ward. Seven patients refused to participate.

A convenience sample of twenty patients was considered sufficient, as it would provide approximately 160 hours of data, which would be enough for the statistical analyses. PSG is a rather burdensome method, as it requires a substantial number of sensors, wiring and electrical equipment and specially trained personnel. Therefore, a larger sample was not considered plausible in this study. The 21st patient was included to assure that sufficient data of good quality would be attained.

5.2 Data collection and analysis

The data of this study contained two sleep evaluations by the nurses (A: nurses' narrative documentations and B: nurses' nurses' structured observatory evaluations of the quality of patients' sleep), one sleep self-evaluation by the patients (C) and one evaluation by PSG (D, Table 7). Several background variables were collected as the demographic data in evaluations B, C, and D. The age and work experience both in an ICU and overall in health care were collected as demographics from the nurses who participated in the structured evaluation of sleep (B). No demographics were collected from nurses (n=114) whose sleep documentations were analysed (A).

Demographic data from the patients' were collected from the medical records. It was equivalent in both data collections (C and D) and included the patients' age, gender, reason for current ICU admission, length of ICU stay, medications given on the night of the study, and three measures of the severity of illness. The Acute Physiology and Chronic Health Evaluation II (APACHE II) (Knaus et al. 1985) and the Simplified Acute Physiology Score II (SAPS II) (Le Gall et al. 1993) were documented within the first 24 hours of ICU care. The Sequential Organ Failure Assessment (SOFA) score (Arts et al. 2005) was documented at midnight during the study night.

Table 7. Data collection and analysis methods of this study.

Sleep evaluation	Data collection	n	Analysis method
A. Evaluation by nurses*	Sleep evaluation documentations	114	Deductive, inductive content analyses
B. Evaluation by nurses*	Structured evaluations	21	Statistical description
C. Self-evaluations by patients*	RCSQ interviews	114	Statistical description
D. PSG evaluations*	PSG recordings	21	Scoring by AASM criteria Statistical description
HR, BP changes	HR, BP	21	Statistical description
Correspondence of nurses' documented evaluations (A) and patients' self-evaluation (C)	Sleep documentations RCSQ	114	Cross-tabulation Pair-wise comparison
Correspondence of nurses' structured evaluations (B) and PSG (D)	Structured evaluations PSG	21	Wilcoxon signed rank test Spearman correlation test
Correspondence of HR, BP changes and sleep stages	HR, BP changes PSG	21	Linear mixed model

*A–D refer to four different data of this study. PSG=polysomnography, RCSQ=Richards-Campbell Sleep Questionnaire, AASM=American Academy of Sleep Medicine, HR=heart rate, BP=blood pressure

5.2.1 Narrative documentation of sleep evaluations by nurses

Nurses' narrative documentations of the quality of patients' sleep (A) during the previous night were collected from the patients who participated in the study with their sleep self-evaluations (n=114). The narrative entries made into the Care Suite® patient information system were collected throughout the study night shift. All entries related to patient's sleep were searched under the pre-existing headlines "Physiological well-being", "Psychological well-being", and "Social well-being". The data were collected between April and August 2011. (II)

Both deductive and inductive content analyses (Elo & Kyngäs 2008, Waltz et al. 2010) were used to analyse the nurses' documentations (term quantitative content analysis used in original publication II). Firstly, the data were coded according to the five domains of the RCSQ (sleep depth, falling asleep, number of awakenings, percentage of time awake, and overall quality of sleep) as a deductive framework. Secondly, the data were analysed with predefined criteria to classify the nurses' sleep descriptions to represent poor (slept poorly/not at all/<2h), fair (slept fairly well/almost the whole night/2h – <7h), or good sleep (slept well/the whole night/>7h). The statistical correspondence of the patients' sleep self-evaluations and the nurses' evaluations were tested with cross tabulation and Kappa coefficient. (II)

All the remaining phrases that did not fall into the domains of the RCSQ were analysed with inductive content analysis (Graneheim & Lundman 2004). The inductively formed codes were collated under higher abstract level sub-categories such as pharmacological, physical, and psychological intervention if appropriate. The four overarching main categories were formed from these sub-categories and the remaining codes. Two independent analysers were used throughout the analysis. In the deductive content analysis, the agreement between the two coders was 91% (99/109 phrases). Consensus on the ten disagreements was reached through discussion. (II)

5.2.2 Structured observatory sleep evaluations by nurses

Nurses' observatory sleep evaluations (B) were collected from the patients (n=21) who consented for a PSG recording to be performed. The nurses' sleep evaluations were obtained with an instrument developed for this study, because no instrument based on the manifestation of sleep and designed for continuous sleep recording was found. The purpose was to explore whether nurses recognized the physiological signs related to sleep (Rowley & Safwan Badr 2012). Sleep evaluations were structured as follows: the patient is awake, sleeping lightly, peacefully, or restlessly, patient's eyes open or closed, detection of movement of patient's eyes under closed eyelids, and twitching or normal movements during sleep. The response options were implemented into the patient information system used for patient care documentation. Nurses were instructed to mark in the system whenever they noticed a change in the patient's sleep status, not at any given time interval. The data were collected between May and August 2009. (III)

All nursing care activities, which involved touching the patient, were collected at the time they were performed for the analysis of the disruptive effect of nursing care activities to the quality of patients' sleep. The data were obtained with a structured instrument implemented in the patient information system. Reported activities were based on previous research and pre-classified as patient assessment/vital signs, care of hygiene, re-positioning, oxygen delivery, airway suctioning, breathing exercise, enteral nutrition, medication and fluid therapy, blood sampling, and other nursing care (Freedman et al. 1999, Calvete Vazquez et al. 2000, Gabor et al. 2003, Tamburri et al. 2004). (III)

The nurses' observations and care activities were analysed statistically. TST, the number of awakenings, the time from the beginning of the recording to the first mark of patient sleeping as the equivalent to sleep latency, the number of patients' movements and the number of nursing care activities per hour and the times between them were calculated. Nursing care activities were clustered into one if they were performed within a 5-minute time frame. The data were presented with medians and interquartile ranges as the sample size was small (n=20). The correlations between patient characteristics, the number of care activities and sleep indices were studied with the nonparametric Spearman correlation coefficients. A P-value below 0.05 was considered statistically significant. (III)

5.2.3 Sleep self-evaluations by patients

Patients' self-evaluations of the previous night's sleep (C, n=114) were collected with the RCSQ, since it is the only validated instrument designed for ICU patients' sleep evaluation (Richards et al. 2000). The RCSQ was translated into Finnish and Swedish. Both translations were back-translated to English (Wild et al. 2005) by authorized language translators, and the back-translations were reviewed and approved by the RCSQ developer Professor K. Richards. (II)

The patients were approached in the morning, after the shift change, by a researcher. After consenting to participate, the patients answered the five questions of the RCSQ regarding the quality of the previous night's sleep. Either they drew a mark on the scale themselves or, if they were unable to do so, the researcher would mark the point the patient had indicated on the scale. (II)

Patients' self-evaluations, measured with the RCSQ, were analysed statistically and presented with means and standard deviations. A sleep index was calculated as a mean of all five items to each patient (Richards et al. 2000). The patients' responses were classified into three classes: low ratings of 0–33 (poor sleep), moderate ratings of 34–66 (fair sleep), and high ratings of 67–100 (good sleep), following Nicolás et al. (2008). (II)

5.2.4 Physiologic sleep evaluation with polysomnography

The patients' sleep was registered with PSG (D, n= 21) measuring the patients' brain activity, eye movements, muscle tension, breathing, heart rate, and body movement (Table 8). The electrodes were placed according to the recommendations of the American Academy of Sleep Medicine (AASM) (Iber et al. 2007). The PSG recordings were performed by a bioanalyst specialized in sleep recordings or the researcher, an ICU registered nurse trained for this study. A standard PSG device EMBLA® A10 with Somnologica 3.3.2 software was used to collect the data. (III, IV)

Table 8. Parameters and electrodes used in the PSG recordings.

Parameter	Abbreviation	Representation	Electrode placement
Electroencephalogram	EEG	Brain activity	Fp_2, C_4, O_2, M_2
Electro-oculogram	EOG	Eye movement	Above right, below left outer canthus
Electromyogram, chin	EMG	Muscle movement and tension	Midline and 2 cm left below mandible
Electrocardiogram	EKG	Heart rate	Lead II with RA and V5 electrodes
Leg movement EMG		Leg movement	EmFit® motion detector under upper body
Respiratory movement, inductive		Ventilation, tidal volume	Thoracic and abdominal belts
Respiratory pressure and flow, cannula		Ventilation, air flow	Nasal cannula
Oxygen saturation	SpO_2	Blood oxygenation	Pulse oximetry, finger
Body position		Position of the body	Angle-XSU sensor on mid-chest over xiphoid
Snoring		Snoring	Piezo electrode on front neck

The recording was started in the evening when the patient's nurse marked in his/her records that the patient was ready to sleep. The recording was finished in the morning when the patient woke up or eventually at seven o'clock. Physiologic parameters (blood pressure and heart rate) were collected from the electronic patient records for the analysis of the possible variations during sleep to determine if they would serve as additional clues for nurses' sleep observations. (III, IV)

The PSG data were analysed according to the AASM scoring criteria (Iber et al. 2007) by a sleep analysis-certified, experienced neurophysiologist. The patients' sleep stages were determined in 30-second epochs. TST, the percentage of each sleep stage, the number of arousals lasting over 3 seconds, awakenings lasting for at least one 30-second epoch, FI, SL, and the number of movements were calculated for each patient and described statistically. (III, IV)

The variation of the patients' heart rate and blood pressure were described statistically. The association of the patients' sleep stages with blood pressure and heart rate was analysed with the linear mixed model where a random intercept for subject was used. A p-value of <0.05 was considered statistically significant. (IV)

5.2.5 Correspondence of sleep evaluations by nurses with self-evaluation of patients and polysomnography

The correspondence between the nurses' documented narrative evaluations (A) and the patients' RCSQ scores (C) was analysed statistically with cross-tabulation of domains having more than 20 entries by the nurses. The domains that had less than 20 entries were described with frequencies of occurrence and agreement. A pairwise comparison of the nurses' and patients' evaluations was done to explore the nurses' possible overestimation or underestimation of sleep (see Nicolás et al. 2008). (II)

The correspondence of the nurses' structured observatory evaluations of patients' sleep/wake stage (B) and PSG results (D) was tested with the Wilcoxon signed rank test of two related samples. A Spearman correlation coefficient was used to analyse the correlation between those two, sleep latency and movement data. The association between the patients' sleep stages and systolic, diastolic, and mean blood pressure and heart rate was tested with the linear mixed model. A p-value <0.05 was considered statistically significant. (IV)

5.3 Ethical considerations

Every phase of the study was conducted with integrity according to The responsible conduct of research (TENK 2012). The study received favourable statements from the ethics board (147/180/2008, 59/13/03/02/2011) and research permissions (§15/2009, §77/2011) from the hospital authorities in question.

ICU patients are in a vulnerable position, as they are often dependent on the caregivers and confined to the ICU (Luce et al. 2004, Silverman 2011). However, the research on ICU patients' sleep may be beneficial to ICU patients in the future, as lessening sleep deprivation may have positive effects on the patients' recovery. ICU patients' sleep cannot be studied in any other way, as the results of healthy persons in an ICU give biased results of the problems (Gabor et al. 2003). Thus, conducting this study was ethically acceptable and necessary despite its focus on highly vulnerable patients.

Informed consent must be based on voluntariness, which may be influenced by both the patients' and their next-of-kin's hope for the best possible care (Luce et al. 2004). The participation in this study did not improve the patients' health, albeit no harm was induced either. Informed consent must also be based on an understanding of the study procedure, and the good and possible harm it may include (Luce et al. 2004). ICU patients' ability to comprehend may be temporarily affected by their illness and the pharmacotherapy used for cure and symptom relief. (Luce 2003).

The orientation of all patients was carefully considered with the patient's nurse prior to approaching the patient and during the recruitment. The patients participating in either data collection were approached with discretion, and the purpose and the procedure of the study were explained. The information was given both verbally and as a written document, so the patients would retain the information for later reference. The patients were informed of the voluntary nature of participation, the right to refuse or withdraw from participation without any consequences, and the anonymity of all data. Written consent was obtained from the patient him-/herself or, in data set D from the next-of-kin if a patient was unable to sign the consent due to physical limitations.

All data were collected without patient or nurse identification (name or social security number) and processed with participant codes only. The data were stored according to the research ethics guidelines. The permit to use the RCSQ was obtained from Professor K. Richards via e-mail on the 11th of November 2008. Further, the permit to translate the RCSQ in Finnish and Swedish was obtained from Professor Richards on the 6th of December 2010. She also participated in the evaluation of the accuracy of the back-translations.

6. RESULTS

The results are presented in the order of the research questions. First, the evaluation methods of the quality of ICU patients' sleep are explained. Second, the quality of patients' sleep is presented according to the results of the four different evaluations. Third, the correspondence of the nurses' narrative documentations and the structured evaluations of the quality of patients' sleep with patients' self-evaluations and the PSG evaluations is described.

6.1 Sleep evaluation methods used for ICU patients

Systematic literature search was performed to discover all the methods used for the evaluation of the quality of ICU patients' sleep. The results are fully reported in chapter 3.3 as part of the theoretical background and in the original publication I.

Several different methods have been developed to evaluate the quality of ICU patients' sleep. Observatory methods vary from plain estimates of a patient being asleep or not to scientifically developed instruments, such as Echols' Patients Sleep Behavior Observational Tool, which measure several different sleep aspects. Most frequently, the observation methods evaluate the quantity of patients' sleep. Validity and reliability have been strengthened by controlling the observer consistency and measuring the inter-rater reliability. (I)

Similarly, the methods used for patients' self-evaluations vary from elementary questions on whether a patient slept well to the scientifically developed RCSQ. The most common sleep aspect in patients' self-evaluation methods is the overall quality of sleep. The RCSQ measures five different sleep aspects. Internal consistency of the RCSQ has been good (Cronbach's alpha 0.89–0.92). Criterion validity has been established with a good correlation between the nurses' and the patients' evaluations. (I)

For the quality of sleep evaluation with physiologic measures, PSG has been employed most often. It is the most valid and objective method, the gold standard of sleep studies (Kushida et al. 2005, Bourne et al. 2007). The other physiologic measure based sleep evaluation methods used in ICU patients include BIS, actigraphy and skin potential measurement, none of which has been able to provide valid information on the quality of ICU patients' sleep. (I)

6.2 Quality of non-intubated ICU patients' sleep

The quality of non-intubated ICU patients' sleep was evaluated from four perspectives: nurses' narratively documented (A) and structured observatory (B) evaluations, patients' self-evaluations (C) and evaluation with PSG (D) to answer the second research question, what the quality of non-intubated ICU patients' sleep was.

6.2.1 *Quality of sleep by nurses' narratively documented evaluations*

Nurses (n=114) participated in this part of the study by providing narrative documentations of the quality of their patients' sleep in patient records (A). The documentations were collected without the information about the documenting nurse. The average age of the nurses in the ICU in question was 40 years at the time of the study. Nurses' documentations of the quality of patients' sleep were discovered for 79% of the patients. The deductive content analysis of these documentations based on the categories of the RCSQ indicated that nurses documented sleep quantity for 71% and quality for 27% of patients (n=90). The quantity of the patients' sleep was described as high in 44% of documentations and moderate in 10% (n=64). Of all the patients (n=114) the proportions were 25% and 5%. Few documentations on falling asleep and the depth of sleep were discovered, and these mainly described poor sleep. The overall quality of sleep, documented for 25 patients, was most commonly (60%) referred as good. (II)

The nurses documented several aspects of sleep not included in the RCSQ. These notes formed categories related to the nursing process: needs assessment, sleep assessment, intervention, and the effect of intervention. In addition to the quality and quantity of sleep, the nurses documented their patients' physiological changes, dreams, and reasons for poor sleep, such as pain. Furthermore, if a sleep promoting intervention was used, the nurses also documented the intervention effect reasonably systematically. Although many aspects of sleep were evident in nurses' documentations, they rarely composed a comprehensive description of a single patient's sleep. (II)

6.2.2 *Quality of sleep by nurses' structured observatory evaluations*

In this part of the study, 21 nurses evaluated the quality of patients' sleep with the structured data collection instrument (B) during the night of the PSG recording. The median age of these nurses was 33 [29, 46] years. The median work experience in an ICU was 6.5 [2, 17.5] years, and overall in nursing it was 9 [6, 19.5] years. The data of one patient who remained fully awake throughout the study night was excluded from the analysis.

The nurses' evaluations indicate that the patients (n=20) slept in total a median of 376 minutes [290, 502] during the night (range 70–693 minutes). The patients fell asleep in a median of 18 minutes [3, 49]. The nurses noticed a median of four awakenings per patient during the recording time [2, 7], and 0.4 [0.2, 0.8] awakenings per hour. (IV)

The nurses recorded a total of 144 individual nursing care activities which involved touching the patient for nineteen patients, as the data of the patient who remained awake was discarded and no care activity entries were made on one patient. After clustering the nursing care activities performed within a 5-minute time frame (17 clusters), these activities were performed 120 times, with a median of 0.6 [0.5, 0.9] per hour. The time interval between the care activities was 47 [22, 102] minutes. The time between the nursing care activities exceeded 90 minutes on 37 occasions (31%), and 120 minutes on 25 occasions. Thirty (25%) care intervals lasted less than 22 minutes. Over half of the nursing care activities (62%, n=144) were performed while patients were already awake.

More nursing care activities were performed on patients who had less N2 and N3 sleep as significant correlations were found with care activities and N2 (Figure 7) and N3 sleep (Figure 8). No significant correlation was found between nursing care activities and other sleep stages (Figures 6, 9). (III)

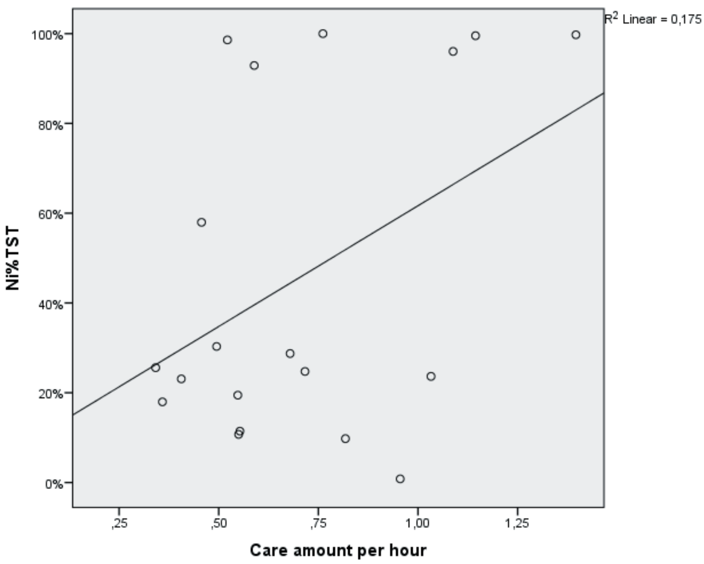

Figure 6. Scatter plot of the number of nursing care activities per hour and the proportion of N1 sleep, rho=0.25, p=0.31.

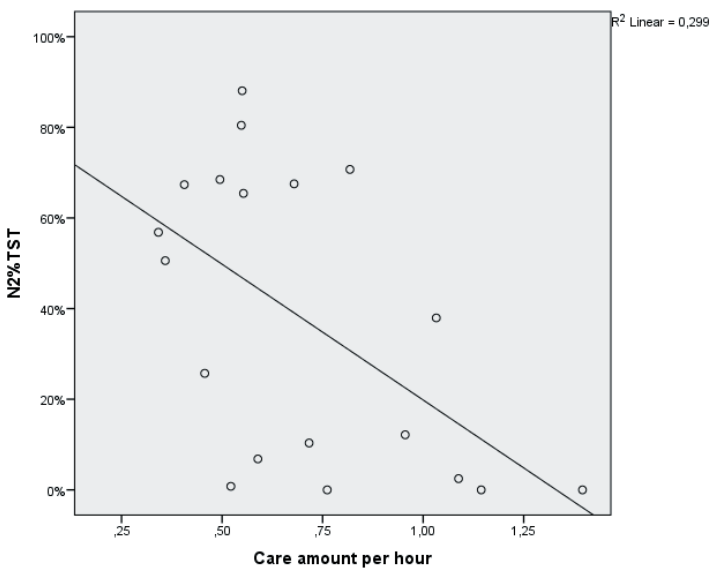

Figure 7. Scatter plot of the number of nursing care activities per hour and the proportion of N2 sleep, rho=-0.49, p=0.035.

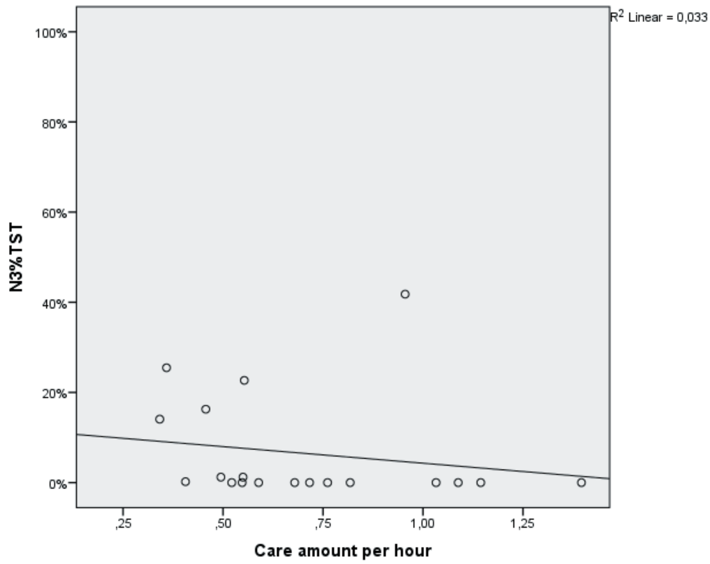

Figure 8. Scatter plot of the number of nursing care activities per hour and the proportion of N3 sleep, rho=-0.55, p=0.016.

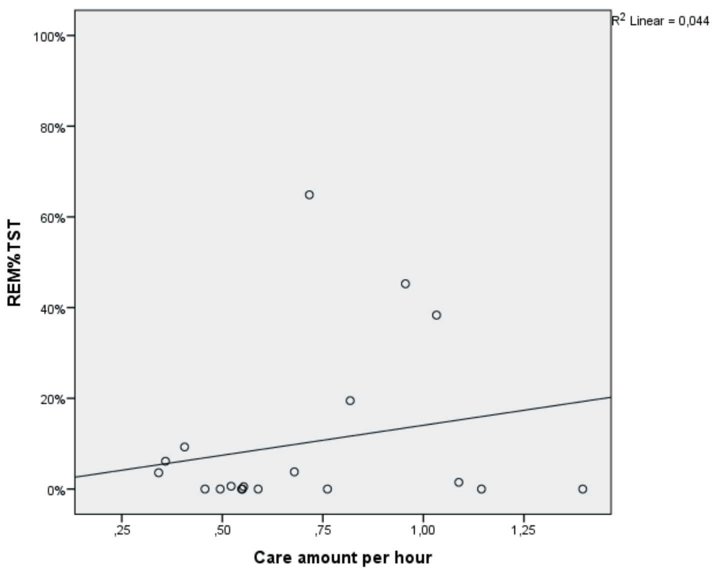

Figure 9. Scatter plot of the number of nursing care activities per hour and the proportion of REM sleep, rho=0.05, p=0.84.

6.2.3 Quality of sleep by patients' self-evaluation

The patients' (n=114) self-evaluations of sleep (C) were measured by asking them about the five aspects of sleep (sleep depth, falling asleep, number of awakenings, percentage of time awake, and overall quality of sleep) with the RCSQ (Richards et al. 2000). All patients were alert and oriented with a RASS score zero and GCS 15 (Table 9). Eighteen eligible patients refused to participate, and two withdrew from the study due to the inability to answer the questions of the RCSQ.

Table 9. Demographics of the participating patients in self-evaluation (Data C) and PSG recording (Data D).

	Data C (n = 114)					Data D (n = 21)				
Variable (normal range)	**n (%)**	**Mean**	**SD**	**Min**	**Max**	**n (%)**	**Median**	**IQR**	**Min**	**Max**
Gender										
Male	72 (63)					18 (86)				
Female	42 (37)					3 (14)				
Age (years)		59	14	25	87		65	58, 72	19	84
ICU stay (days)		3	3	2	21		3	2, 7	1	31
Admitting reason										
Medical	28 (25)					7 (33)				
Surgical	86 (75)					14 (67)				
SOFA (0-24)		4	2	0	14		6	4, 7	2	11
APACHE II (0-71)		16	6	5	35		16	12, 21	7	27
SAPS II (0-163)		28	11	4	70		32	23, 41	10	58
Vasoactive medication	38 (33)					5 (24)				
Medications										
Opiate for pain	96 (84)					18 (86)				
Oral sleep medication	16 (14)					3 (14)				

ICU=intensive care unit, SOFA=Sequential Organ Failure Assessment, APACHE=Acute Physiology and Chronic Health Evaluation, SAPS=Simplified Acute Physiology Score

The evaluations varied extensively as the patients' answers fell into the whole scale from zero to 100, and standard deviations were high (Table 10). Sleep depth was rated the lowest and falling asleep the highest of the RCSQ sleep domains. (II) The sleep index (mean of five aspects) was more often high indicating good sleep (42%) than low indicating poor sleep (26%). Most of the sleep indices (65%) fell under 70, the cut-off point between good and poor sleep defined by McKinley et al. (2013).

Table 10. Patients' self-evaluations of previous night's sleep, measured with the Richards-Campbell Sleep Questionnaire (Richards et al. 2000), scale zero (poorest sleep) to 100 (best possible sleep), n=114.

Sleep aspects	**Mean**	**SD**	**Poor (<34) %**	**Fair (34-66) %**	**Good (>66) %**
Sleep depth	44	34	49	15	36
Falling asleep	64	31	19	22	59
Number of awakenings	52	32	34	25	40
Time awake	61	32	27	15	58
Overall quality of sleep	50	35	39	20	41
Total score (Sleep index)	55	28	26	32	42

The patients' age was positively correlated with the sleep index (rho=0.21, p=0.028) indicating that older patients evaluated their sleep as better than younger patients did. The analysis of the different sleep aspects indicated that the older patients estimated that they fell asleep faster (rho=0.33, p<0.001), and had deeper sleep (rho=0.22, p=0.020) and a better general quality of sleep (rho=0.21, p=0.022). (II)

6.2.4 Quality of sleep by polysomnography

Twenty-one patients participated in the study by consenting to an overnight PSG recording (D). Fourteen of these patients had a RASS score zero, six patients were drowsy (RASS -1), and one was slightly restless (RASS +1). GCS varied from full 15 points in fifteen patients to 14 points in six patients: three patients only opened their eyes to verbal stimuli, and another three patients answered with only a few words. (Table 9) Eight eligible patients refused to participate due to potential extra discomfort from the PSG recording. (III, IV)

The average recording time was 8.9 hours per patient (min 7.3, max 10.3 hours). One recording was discontinued after seven hours due to patient transfer out from the ICU. According to the PSG recordings, the patients slept a median of 6.5 hours [2.8, 8.1] during the night. Variation was extensive as TST ranged from zero to 10.3 hours. Seven patients slept longer than 7.5 hours, and five patients slept less than two hours. Sleep was mostly light as the relative amount of N1 sleep was high and the amounts of N3 sleep and REM sleep were low (Figure 10). Once again, the variation between patients was large. The amount of deep sleep ranged from none in thirteen patients to 42% in the patient who slept a total of 10.3 hours. The amount of REM sleep ranged from none in 10 patients to 65% in one patient who slept for 7.7 hours. (III)

There were a median of 33 [16, 44] awakenings per patient and 3.7 [1.8, 5.9] awakenings per hour during the PSG recording. FI varied from two to 73 per hour (MD 27 [15, 39]). Sleep was less fragmented in the patients who slept longer (rho=-64, p=0.002). Furthermore, patients with higher APACHE II scores had less awakenings (rho=-0.64, p=0.002) indicating that sleep was less fragmented in more severely ill patients. (III)

In the analysis of the patients who slept over 7.5 hours (n=7) it was discovered that despite the TST within normal range the quality of sleep was low. Only two patients had REM sleep ≥ 20% of the TST and just two patients had N3 sleep ≥ 13% of the TST. Arousals and awakenings were frequent, with the FI median of 13 [7, 21] in this group of patients.

A decrease in both blood pressure and heart rate was seen in most patients at sleep onset. There was a median of 8 mmHg drop in systolic blood pressure in thirteen patients, and a median of 5 mmHg blood pressure drop was seen in sixteen patients. The heart rate dropped for a median of 2 beats per minute in eighteen patients. The drop in both blood pressure and heart rate was less in patients who were given noradrenalin infusions during the recording. No significant correlation was found between blood pressure or heart rate changes and different sleep stages. (IV)

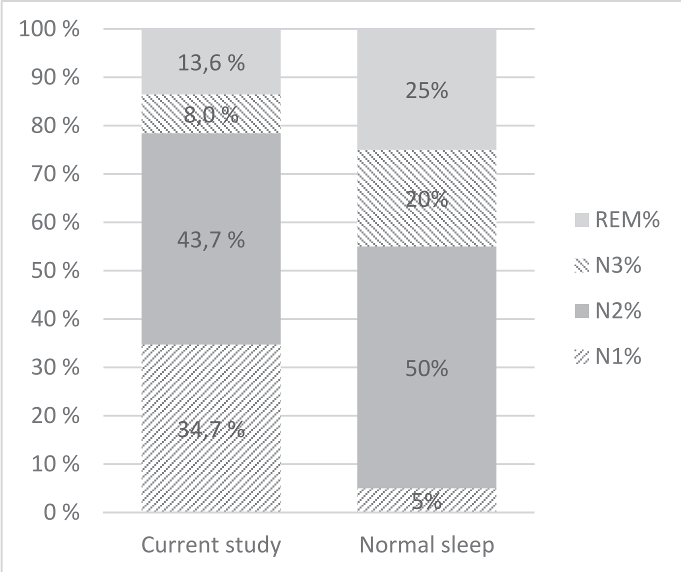

Figure 10. Percentages of different sleep stages from TST (110 h), in the current study and normal healthy adults. N1% =the percentage of sleep stage N1 from TST.

6.3 Correspondence of nurses' sleep evaluations with patients' self-evaluations and polysomnography

The correspondence of the nurses' narrative documentations of the quality of patients' sleep (A) and the patients' self-evaluations (C) was analysed, as well as the correspondence of the nurses' structured observatory evaluations (B) and PSG evaluations (D), to answer the research question three, how nurses' evaluations of the quality of patients' sleep correspond with the self-evaluation of patients and the physiologic measure PSG.

6.3.1 Nurses' narratively documented sleep evaluations and patients' self-evaluations

One hundred phrases of the nurses' narrative documentations of the quality of patients' sleep fitted into the RCSQ categories. Of them, 57% corresponded with the patients' own evaluations. The nurse overestimated different aspects of the patient's sleep in 26% and underestimated them in 17% of the cases (Table 11). For statistical analysis, there were enough entries in only two of the sleep domains, 'number of awakenings' and 'quality of sleep'. Entries regarding the patients' sleep depth, falling asleep, and time awake, were few. (II)

Table 11. Number of nurses' entries, which did and did not correspond to patients' self-evaluation.

Sleep domain	Corresponding items	Nurses' evaluation higher	Nurses' evaluation lower	Total	Kappa coefficient	p
Sleep depth	7	2	0	9		
Falling asleep	0	1	1	2		
Number of awakenings	31	15	15	61	0.24	0.008
Percentage of time awake	3	0	0	3		
Quality of sleep	16	8	1	25	0.41	0.003
Total	57	26	17	100		

6.3.2 Nurses' structured observatory sleep evaluations and polysomnographic evaluations

The nurses' observatory evaluations of the patients' sleep/wake state corresponded with the PSG recording in 68% of the recording time. No significant correlations were found in the more in-depth evaluation of sleep, i.e. between the nurses' observations of their patient sleeping lightly, peacefully, or restlessly, and the PSG sleep stages N1, N2, N3, and REM. The patients slept for a median of 6 hours and 16 minutes [4:50, 8:22] according to the nurses' observation and for 6 hours and 27 minutes [2:51, 8:07] according to the PSG recording (p=0.46). The nurses' observations and PSG recordings of TST were significantly correlated (rho=0.55, p=0.009) (Figure 11). However, in case-by-case comparison, the difference between the nurse's observation and the PSG recording varied from a nurse's overestimation of TST by 528 minutes (5 hours 48 minutes) to an underestimation of 251 minutes (4 hours 11 minutes). In six cases, the difference between the nurse's estimation and PSG was less than one hour. No significant correlation was found between the nurses' observations and PSG recordings of sleep latency (Figure 12), the number of awakenings (Figure 13), and the patients' movements while asleep. (IV)

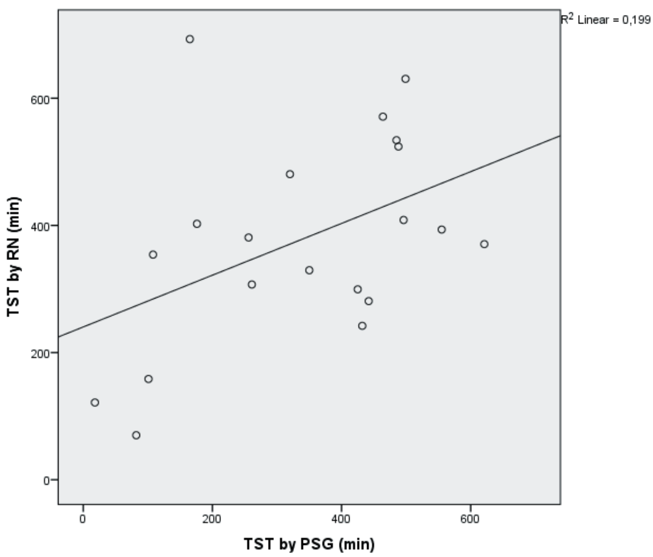

Figure 11. Scatter plot of total sleep time (TST) recorded by nurse (RN) and polysomnography (PSG), rho=0.48, p=0.03.

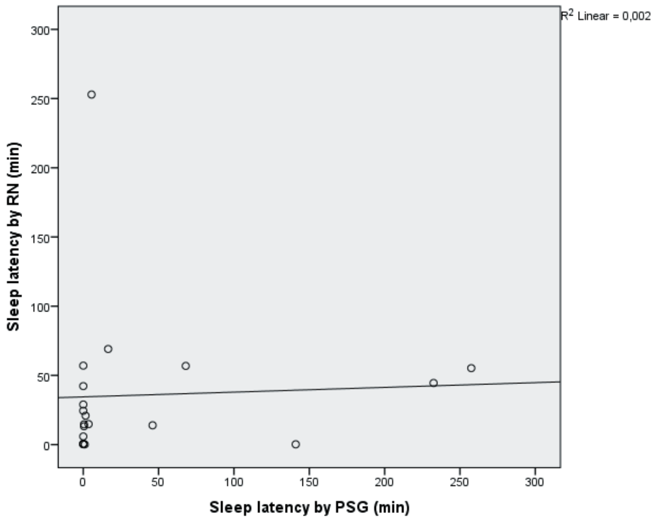

Figure 12. Scatter plot of sleep latency recorded by nurse (RN) and polysomnography (PSG), rho=0.28, p=0.23.

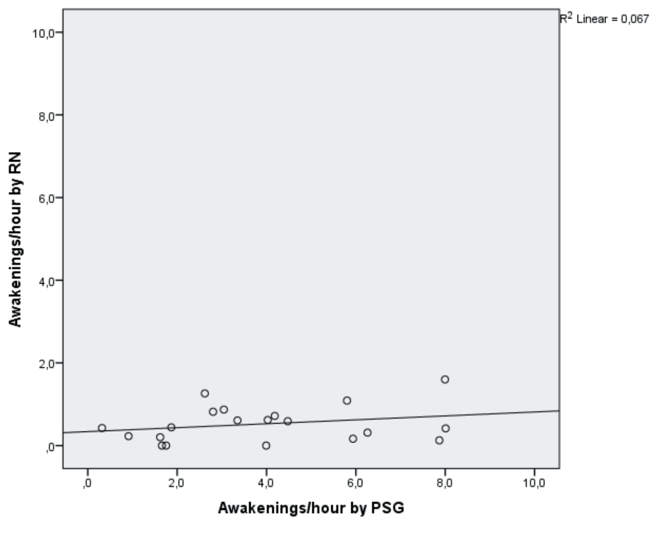

Figure 13. Scatter plot of awakenings recorded by nurse (RN) and polysomnography (PSG), rho=0.24, p=0.30.

6.4 Summary of the results

6.4.1 Sleep evaluation methods used for ICU patients

The main findings of the review are (I)

1. The sleep evaluation methods employed for ICU patients are mostly undeveloped plain observations about a patient being asleep/awake or questions about the overall quality of sleep.

2. The RCSQ is the only sleep evaluation method specifically developed for and much used in ICU patients. Its reliability has been strengthened with several different patient groups. The internal validity of the RCSQ has been strengthened by the thorough description of conceptual development. The criterion validity has been strengthened by establishing a good correlation between the patients' and the nurses' evaluations.

3. At present, no valid and usable physiologic sleep evaluation methods are available for a daily evaluation of the quality of ICU patients' sleep. PSG is too laborious and requires specially trained personnel. Thus, its use is restricted to research purposes.

6.4.2 Quality of non-intubated ICU patients' sleep

The quality of non-intubated ICU patients' sleep was evaluated from three perspectives: nurses' two divergent evaluations, patients' self-evaluations, and physiologic evaluations. According to all these perspectives, the main results are

1. The quality of sleep in non-intubated patients varied widely between individuals (Table 12).

2. The quality of sleep was rather low in most patients, as sleep was light and awakenings were frequent, even if the TST was normal.

3. The amount of sleep was insufficient in 67% of the patients (n=21).

4. The patients evaluated the quality of their sleep on average neither high nor low. Sleep depth was evaluated to be the worst and the speed of falling asleep the best aspect of sleep. Of 114 patients, 40% evaluated their sleep as good.

5. Most patients' blood pressure and heart rate varied significantly between wake and sleep.

6. Nursing care, which included touching the patient, was mostly performed while the patients were awake, and as such the disturbing effect was minimal. The patients with most nursing care activities had the least N3 and REM sleep, which indicates either that the quality of sleep of the patients, who need much nursing care, is low, or that the nursing care activities actually lower the quality of sleep.

Table 12. Summary of non-intubated patients' quality of sleep.

Sleep aspects	Nurses' evaluation MD	IQR	Min	Max	Patients' self-evaluation (n=114)	PSG (n=21) MD	IQR	Min	Max	Normal values[c]
Length of sleep (minutes)	376 [a]	[290, 502]	70	693	good in 58%	387	[170, 486]	18	621	420-480
Falling asleep/sleep latency (minutes)	18 [a]	[3, 49]	0	253	good in 59%	1	[0, 31]	0	257	< 20
Number of awakenings	4 [a]	[2, 7]	0	14	good in 40%	34	[17, 44]	3	77	Few
Proportion of N1 in TST						35%				2-5%
Proportion of N2 in TST						44%				45-55%
Proportion of N3 in TST /sleep depth					good in 36%	8%				13-23%
Proportion of REM in TST						14%				20-25%
Overall quality	good in 13%[b]				good in 41%					

[a] structured continuous observations (n=21), [b] narrative documentations (n=90), [c] according to Carskadon & Dement 2011 and Ohayon et al. 2004
PSG=polysomnography, TST=total sleep time, N1, N2, N3, REM=different sleep stages

6.4.3 Correspondence of nurses' sleep evaluations with patients' self-evaluations and PSG

According to the analysis of the correspondence of the nurses' narrative documentations of the quality of patients' sleep and the patients' self-evaluations, the main results are

1. Documentations of sleep were done for 79% of the patients (N=114).
2. The nurses' documented evaluations corresponded with the patients' self-evaluations in just over half of the cases.
3. The nurses documented several other dimensions of sleep according to the components of the nursing process: needs assessment, sleep assessment, intervention, and effect of intervention.

According to the analysis of the correspondence of the nurses' structured observatory evaluations of the quality of patients' sleep and the physiologic evaluations attained with PSG

1. The nurses' evaluations did not correlate with PSG parameters except for total sleep time.

6.4.4 Recommendation of sleep evaluation practices for nurses

The evaluation of patients' sleep should be as routinely done as evaluating their vital signs. The following is suggested for daily practice:

- Patients' sleep should be evaluated both during the day and night, as half of the sleep occurs during the daytime (III, IV) (Edéll-Gustafsson et al. 1999, Gabor et al. 2003)
- The evaluation should be done together with the patient if possible (II)
- The evaluation should follow the structure of the nursing process: needs assessment, sleep assessment, sleep promoting intervention, and the evaluation of the effect of the intervention (II)
- The evaluation should contain aspects presented in Figure 14 on the following page (II, IV)
- Patients' self-evaluation should be measured with the Richards-Campbell Sleep Questionnaire (II)
- Patients' sleep evaluation should be documented comprehensively and with regular intervals in the patient care documentations (II) (Edéll-Gustafsson et al. 1994, Nicolás et al. 2008)

Sleep evaluation practices in ICU patients should be included in nursing curricula and hospital orientation programmes to improve nurses' knowledge and practices of sleep evaluation.

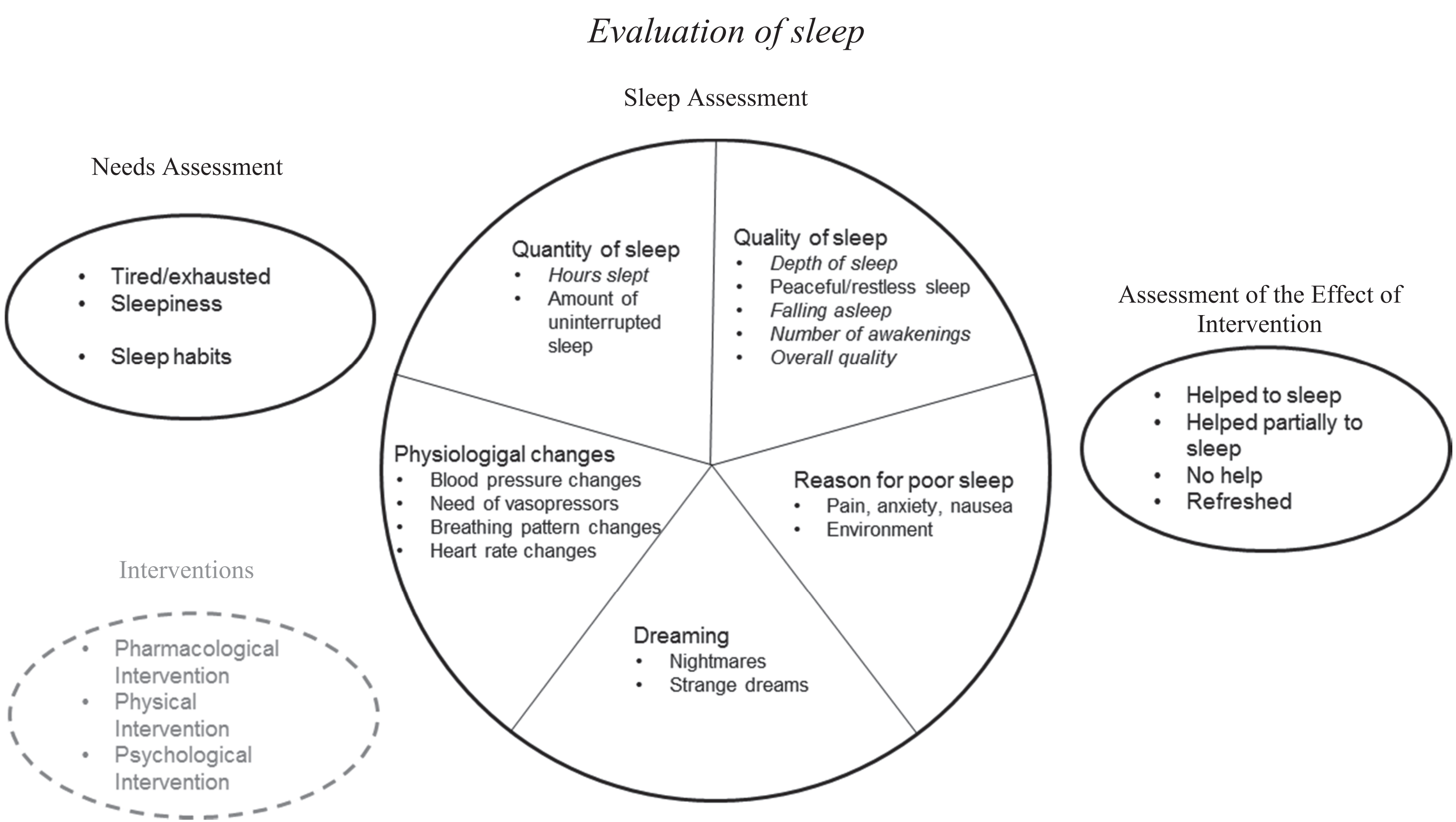

Figure 14. Content of patient's sleep evaluation in an ICU (II). Sleep aspects in italics are measurable with the Richards-Campbell Sleep Questionnaire.

7. DISCUSSION

7.1 Discussion of the results

This study demonstrated that for the evaluation of the quality of ICU patients' sleep there are no valid and reliable methods for clinical use; the quality of non-intubated patients' sleep is not good, judged by either the nurses' evaluations, the patients' self-evaluations, or PSG; and that the nurses' evaluations do not correspond well with the patients' self-evaluations or PSG.

The narrative documentations of the quality of patients' sleep (A) were collected without any information about the documenting nurses (n=114). The average age of the nurses in the ICU in question was 40 years at the time of the study. While the nurses participated in the study at random, their age may have been less than average as older nurses tend to work less frequently in night shifts. In data set B, the median age of the participating nurses (n=21) was 33 years, much less than the assumed age of the nurses in data set A. It may indicate that the nurses were selected by a charge nurse according to their interest in participation, as the patients were selected prior to the start of the night shift. However, their median ICU work experience was over six years indicating that their ICU nursing competence had developed close to the expert level. The small variety of demographic data prevents further discussion about the representativeness of the nurse participants.

The non-intubated patients who participated in this study were not very critically ill, judging from the illness severity scores (APACHE II, SOFA, SAPS II). Thus, they represented well the target population, as the aim of the study was to evaluate sleep in non-intubated patients who are not sedated and not very critically ill. They were assumed to be able to sleep better than e.g. mechanically ventilated patients do, as it has been shown that mechanical ventilation is a major sleep disturbing factor in an ICU (Alexopoulou et al. 2007, Bosma et al. 2007, Beecroft et al. 2008, Cabello et al. 2008, Delisle et al. 2011, Kondili et al. 2012, Alexopoulou et al. 2013, Andrejak et al. 2013). The previous research on the sleep in non-intubated patients has been minimal, and the data have been collected in units with a lower level of care than third level ICU's (Aaron et al. 1996, Richards et al. 1996, Richards 1998).

The patient groups in this study represented well a general ICU population by age. They were of the same age as in a Finnish study of over 85,500 patients (Reinikainen et al. 2012) and a worldwide study of over 19,500 patients in 35 countries (Metnitz et al. 2005). The gender distribution was also similar in data set C, but the proportion of females in data set D of this study was much smaller than in the aforementioned larger studies. This may be explained by the small number of participants in total. Another possibility is that women may suffer more from ICU care, as they more often refused to participate. The patients in this study were significantly more often admitted to ICU for surgical reasons (75% and 67%) than in the other studies (34% and 43%) (Metnitz et al. 2005, Reinikainen et al. 2012). This difference may originate from different methodologies. The two aforementioned large studies are patient registry studies, where data from all eligible patients are included, and no informed consent is needed from an individual patient. In this study, the major proportion of surgical patients may also be explained by the shorter length of stay in the ICU in general (Higgins et al. 2003) and as such a faster recovery than medical patients. Therefore, they may have reached the condition required for this study and become eligible to participate sooner. Thus, the results of this study are more generalizable to a surgical population of ICU patients than to medical ICU patients.

7.1.1 Sleep evaluation methods used for ICU patients

The review answered the first research question about the methods available for the evaluation of the quality of ICU patients' sleep. It aimed to form a comprehensive overview of the sleep evaluation methods, their content and the quality represented by the reliability and validity in critical care.

Several different instruments for sleep observation or patients' self-evaluation have been introduced for critical care patients compared to a sleep evaluation instrument review done nearly 30 years ago (Richards 1987). However, the study populations have remained small, and the reliability and validity of the instruments still require further testing. Skin potentials is the only new physiologic sleep evaluation method introduced for ICU patients since 1987, and the static charge-sensitive bed and the dream detector have not been tested in ICU patients despite the potential seen in them by Richards (1987). This study confirms the results of Bourne et al.'s (2007) review of the available methods and introduces some other instruments for the observation of the quality of sleep and patients' self-evaluation. The newer instruments focus on general estimations of TST, awakenings, and the general quality of sleep, and they lack the evidence on the validity, reliability and usability.

The review of this study found many more sleep evaluation instruments than previous reviews (Richards 1987, Bourne et al. 2007), partly due to a different timeline. However, the objective of this study was to find all the methods used, no matter how undeveloped or untested the instruments were. The result, the number of different instruments, indicates that the objective was reached by systematic and extensive search and by not using time or language limits.

In conclusion, despite the vast continuous technical advance within critical care, physiological methods for the evaluation of the quality of ICU patients' sleep remain lacking. Patients must rely on their self-evaluations and nurses' evaluations which both need further research and development to be reliable, valid, and usable.

7.1.2 Quality of sleep by nurses' narratively documented evaluations

The research question two, the quality of non-intubated ICU patients' sleep, will be discussed based on the four different data: the nurses' narratively documented evaluations, the nurses' structured observatory evaluations, the patients' self-evaluations, and PSG evaluations of the quality of patients' sleep.

The nurses documented some aspects of the patients' sleep evaluations in most of the participating patients (79%) in the present study. This number is close to a previous retrospective chart review, where nurses' documentations covered 69% of patients on the patient's first night in the ICU and 86% on the second night (Edéll-Gustafsson et al. 1994). A much higher compliance (100%) was reported in a Spanish study although the nurses were blinded to which patients were included in the study (Nicolás et al. 2008). Because sleep may be vital for patients' recovery, the evaluation and documentation of patients' sleep should cover all patients, following the Spanish example.

Documentation practices could be improved with pre-set reminders in the information management systems. Certain aspects could be "mandatory" requiring an entry before disappearing from the screen. Structured documentation with pre-classified choices of the sleep evaluation would serve as a quality improvement tool in directing the nurse to perform sleep evaluations. It would also enable the re-use of the data for research.

The nurses' narrative documentations of the quality of patients' sleep were highly variable. Several different aspects not captured by the instruments available were documented. The content of sleep documentations has not been inductively analysed before. Rather, predetermined general statements of the quality and quantity of sleep have been sought (Edéll-Gustafsson et al. 1994, Nicolás et al. 2008). Thus, the results of this study provide several aspects of sleep evaluation that need to be taken into account when performing a comprehensive and systematic sleep evaluation. These include sleep related changes in vital signs, the occurrence of dreams, or the reasons for not sleeping. The new aspects could be classified as part of the nursing process. However, none of the individual documentations covered the nursing process completely with regard to sleep. Therefore, a systematic approach to sleep evaluation is needed.

7.1.3 Quality of sleep by nurses' structured observatory evaluations

The nurses evaluated the patients' mean TST much longer (6.3 hours) than in Chen et al.'s (2012) valerian acupuncture intervention study. In Chen et al.'s study, the mean observed TST was less than three hours prior to the intervention and 3.4 hours after the acupuncture treatment. However, hourly observations may have biased the data. The variety of the individual results among Finnish patients was also much wider as judged by the difference in standard deviations.

The number of nursing care activities performed at night (0.6/hour) was rather similar to a study demonstrating nursing care activities in a similar type of ICU, less than one per hour (Elliott et al. 2013). These figures are much lower than in an earlier study by Gabor et al. (2003), who reported a total of 7.8 nursing care activities per hour of sleep in 24 hours. The differences in the recording time (overnight vs 24 hours) and patient selection (non-intubated vs mechanically ventilated patients) probably explains most of this difference. The definition of a nursing care activity may also have differed in these studies. However, the care activities were not described in sufficient detail to judge this. This may also explain the much higher numbers of care activities in the retrospective documentation analyses, 42.6 (Tamburri et al. 2004) and 51 per night (Celik et al. 2005), as what is understood as a nursing activity in these studies was not reported. However, there may be some improvement in the culture of ICU nursing as the amount of uninterrupted time and the possibility to sleep a full sleep cycle in this study was also much more frequent than in a study published in 2004 (Tamburri et al. 2004). (III)

The structured evaluation method of this study could further be improved by developing a description of the signs and changes in a person's habitus, movements, and respiration characteristics during sleep. The sleep related variations of a patients' heart rate and blood pressures could also be added to the evaluation.

7.1.4 Quality of sleep by patients' self-evaluation

Patients' self-evaluation of sleep is important in pursuit of patient-centred care, which values a patient's experience and opinions (Coyle & Williams 2001, Ciufo et al. 2011). Thus, any method to help patients to evaluate sleep systematically in an ICU is recommended. In this study, the patients' self-evaluations were measured with the RCSQ, the best-validated sleep evaluation tool available. If a cut-off point of 67 (Nicolás et al. 2008) or 70 (McKinley et al. 2013) for good sleep is used, the patients did not sleep well. The patients estimated that they had a mean general sleep quality (sleep index) of 55, on a scale of 0 to 100, which seems rather similar to previous studies (Table 13). Only cardiac care patients in the original RCSQ development study (Richards et al. 2000), and ICU patients in intervention studies (Li et al. 2011, Patel et al. 2014) have evaluated their sleep to be better. A cardiac care unit may be a less sleep disruptive environment, as the acuity level of care does not reach level three ICU care, and the intervention studies aimed at improving sleep, which they evidently achieved. No explanation was found in the report on why the median RCSQ scores in Patel et al.'s (2014) intervention study prior to the intervention were remarkably lower than in any other study. The other intervention (noise reduction) study showed a steady improvement in all aspects of sleep. All five aspects were at a strikingly similar level in comparison to each other both before and after the intervention (Li et al. 2011).

Light sleep appears to be the worst problem according to the patients' self-evaluation in this study, confirming the previous results (Richards et al. 2000, Frisk & Nordström 2003, Kamdar et al. 2012b, Patel et al. 2014). Also, in line with most of the earlier results (Richards et al. 2000, Nicolás et al. 2008, Li et al. 2011, Kamdar et al. 2012b, Patel et al. 2014), the patients participating in this study evaluated falling asleep in the evening and after nocturnal awakenings to be the best aspects of their sleep. Other aspects of sleep are rated somewhat differently in each study including the present study (Table 13), and therefore, more research is needed.

The sleep evaluations improved with age towards the best possible sleep in this study. The correlation was evident in the overall sleep index as well as in the aspects of falling asleep, depth of sleep and overall quality of sleep. Bihari et al. (2012) have reported similar results; however, their study population consisted of female patients only. Normally the quality of sleep worsens with age in healthy adults, as sleep becomes lighter and total sleep time is shortened (Ohayon et al. 2004). This contradiction may be due to older patients' modest nature and to the fact that they are less likely to complain (Bacon & Mark 2009), which leads them to decline to answer accurately about their experience. It is also possible that they experience less anxiety in an ICU (Rattray et al. 2004) and are therefore actually able to sleep better.

The usability of the RCSQ could be further developed. The necessity of the fifth question about the overall quality of sleep should be discussed, as it seems to give no new information about the quality of patients' sleep (II). In addition, the usability of a VAS scale needs further consideration as numeric rating scales are considered the most accurate and usable for the self-evaluations of ICU patients' pain (Barr & Pandharipande 2013).

7.1.5 Quality of sleep by polysomnography

The non-intubated ICU patients slept considerably more than the mechanically ventilated patients in the earlier studies (Table 14). The differences in TST are more obvious when the results are reported using the medians rather than the means. The wide range of the interquartile ranges in both previous studies and the present study indicates large variation between patients. The results of this study support the findings in the two previous studies in spontaneously breathing patients, a group of patients in a respiratory intermediate care unit and an intervention group receiving back massage in a cardiac care unit. The patients' sleep was of similar length in all three studies. However, also Bosma et al.'s (2007) mechanically ventilated patients slept as long as the patients in this study; and the non-intubated patients in Elliott et al.'s (2013) study slept much less than the mechanically ventilated patients. Therefore, more research is needed on the sleep of non-intubated patients and the sleep-influencing factors.

In this study the median proportion of N2 sleep was considerably less than in two earlier studies on mechanically ventilated patients (Beecroft et al. 2008, Kondili et al. 2012), and it was supplanted with both N1 and N3 (Table 14). When the means are compared, this difference disappears, and the proportions vary widely in each study, with no detectable trend. This is explained by the small sample sizes. Small data sets are rather sensitive for divergent values, and therefore the means do not describe the data as reliably as median and interquartile range do. The same discrepancy applies to the number of awakenings, which are also reported using several different approaches, if reported at all. However, it can be concluded that ICU patients have much more arousals and/or awakenings than normal healthy adults do.

PSG in the form it was used in this study is a complex method and as such not usable in clinical sleep evaluations. Portable applications have been developed for recordings outside hospital environment. Their feasibility for critically ill patients should be tested. Furthermore, an automatic analysis of the recorded data needs improvement and research in both healthy persons and ICU patients.

Table 13. Results of the patients' self-evaluation of sleep with the Richards-Campbell Sleep Questionnaire (Richards et al. 2000) in previous studies and the present study.

Sleep aspects, mean (SD) Scale 0 (poorest sleep) to 100 (best sleep)	Richards et al. (2000)	Frisk & Nordström (2003)	Nicolás et al. (2008)	Li et al. (2011) intervention	Li et al. (2011) control	Kamdar et al. (2012b)	Patel et al. (2014) before int.	Patel et al. (2014) after int.	*Current study (Article II)*
Patients	medical	mixed	surgical	surgical	surgical	medical	surgical	surgical	mixed
Sample size	70	31	104	28	27	92	30	29	114
Sleep depth	44 (34)	40	51 (26)	64 (22)	51 (28)	48 (38)	25*	51*	*44*
Falling asleep	66 (30)	48	56 (27)	65 (23)	54 (29)	60 (39)	62*	80*	*64*
Number of awakenings	66 (29)	53	42 (24)	65 (16)	51 (26)	60 (35)	30*	71*	*52*
Time awake	62 (31)	47	56 (26)	66 (20)	54 (30)	61 (35)	34*	80*	*61*
Overall quality of sleep	64 (34)	39	53 (20)	65 (20)	51 (26)	59 (35)	20*	75*	*50*
Total score	60 (27)	46	51 (22)	65 (19)	52 (26)	57 (30)	37*	63*	*55*

* Median reported, estimated from a box-and-whiskers figure
int.=intervention

In conclusion, this study supports the scarce evidence that even though spontaneously breathing, non-intubated patients may sleep longer than mechanically ventilated patients do, the quality of their sleep is not optimal for recovery. Light sleep and frequent awakenings lessen the overall quality of patients' sleep. Nursing care was not as disruptive as in previous studies. However, patients' quality of sleep and the chances for full 90-minute sleep cycles may be enhanced by further planning and clustering nursing care performed at night.

7.1.6 Correspondence of nurses' sleep evaluations with patients' self-evaluation and polysomnographic evaluations

The third research question was, how nurses' evaluations of the quality of patients' sleep correspond with the self-evaluation of patients and the physiologic measure PSG. The results of this study support the earlier findings indicating that the correspondence of nurses' evaluations with any other evaluation method is not very high (Table 15). The nurses' narrative documentations of the quality of patients' sleep corresponded with the patients' self-evaluations in this study somewhat better than in an earlier Spanish study (Nicolás et al. 2008). More contradiction between these two studies can be seen in nurses' overestimations and underestimations of the patients' sleep, compared to patients' own evaluations. In this study, the nurses overestimated the patients' sleep in 26% of the evaluations, when in the Spanish study this occurred in 38% of the evaluations. Underestimations occurred in 17% of the evaluations in this study vs. in 13% of the evaluations in Nicolás et al.'s (2008) study. Thus, Finnish nurses seem more likely to be correct in their evaluations, yet inclined to evaluate patients' sleep poorer more often. Possibly Finnish nurses are more skilful in evaluating sleep as their evaluations corresponded better with their patients' self-evaluations. They may also be more cautious and try to avoid overestimation of patients' sleep in documentation. The documentation of patient's sleep was missing from one fifth of the patients, while the compliance was 100% in Nicolás et al.'s (2008) study. This may also explain some of the differences in the results, as nurses who are not very familiar with sleep evaluation may not have documented anything in this study.

The correspondence of the nurses' structured evaluation of the patients' sleep and the PSG recordings in this study also supports the earlier findings. Edwards and Schuring (1993) reported an accurate evaluation of wake in 20% of the evaluations and sleep in 53% of the evaluations, while in this study the values were 18% and 49% respectively. Edwards and Schuring used a 15-minute interval and had an option of "no time to observe" which was used in 8.5% of the evaluation times (n=340). It appears that regardless of the method, nurses' evaluations correspond with PSG in approximately 70% of the cases. In this study, the nurses evaluated sleep latencies more apart from PSG values than in Fontaine's (1989) study. The difference in noticed awakenings between the nurses' evaluations and PSG was also greater in this study than in Fontaine's study. The difference may be explained by the fact that Fontaine et al. used an independent researcher, whereas in this study the patients' nurses performed all the observations.

Therefore, these results indicate that the use of an independent observer might give results that are more reliable.

This study also demonstrates the correspondence of changes in both blood pressure and heart rate with patients' sleep/wake state. Despite all the interfering factors, such as medication and temperature regulation, the patients' blood pressure and heart rate seemed to follow the natural sleep-related variation (Carskadon & Dement 2011, Rowley & Safwan Badr 2012). A slightly lower decrease in heart rate during sleep (3-4% vs 5%) has also been demonstrated in critically ill patients who suffer from a cardiac disease and are on cardiac medications (Richards et al. 1996). In this study, the variation was larger in patients who did not receive pharmacotherapeutic hemodynamic support. The changes in patients' blood pressure and heart rate should be taken into consideration in the evaluation of patients' sleep by nurses.

In conclusion, this study has shown that non-intubated patients sleep longer than mechanically ventilated patients do. However, the quality of their sleep is not optimal for their recovery. Thus, methods for improving patients' sleep need further attention. Nurses evaluate patients' sleep correctly in two out of three cases, which it is not enough. Therefore, the evaluation of patients' quality of sleep needs further development. Patients' self-evaluations should be included in systematic sleep evaluations, since they are the experts of their own experience of the quality of sleep.

Table 14. Description of patients' nocturnal sleep in earlier studies and the present study, measured with PSG; reported with mean ±SD or MD (range) [IQR]

	n	Vent type	SAPS	APACHE	Rec time	Groups	TST min	N1 %	N2 %	N3 %	REM %	Arousals per hour	Awakenings per hour
Normal sleep							450	2-5	45-55	13-23	20-25	Few	Few
Aaron et al. (1996)	6	Spont			2200-0600		325 ± 33	14 ± 11	43 ± 9	5 ± 3	6 ± 3	19 ± 6	
Alexopoulou et al. (2007)	9	MV			2300-0600	PAV+base		55 ± 38	36 ± 32	3± 7	6 ± 14	12.2±8.0	4.0±3.0
Alexopoulou et al. (2007)	9	MV			2300-0600	PAV+high		33 ± 30	61 ± 28	4 ± 9	2 ± 4	11.4±7.6	4.3±3.2
Alexopoulou et al. (2007)	9	MV			2300-0600	PS base		52 ± 40	43 ± 35	2 ± 4	4 ± 6	8.4±4.8	3.6±3.1
Richards et al. (1998)	17	Spont			Not specified	Control	257 ± 108	18 ± 13	38 ± 19	8 ± 10	5 ± 4		22 ± 14
Richards et al. (1998)	28	Spont			Not specified	Relaxation	273 ± 71	17 ± 12	39 ± 14	11 ± 11	7 ± 6		21 ± 15
Richards et al. (1998)	24	Spont			Not specified	Back massage	320 ± 48	15 ± 8	48 ± 15	9 ± 12	9 ± 6		19 ± 9
Edéll-Gustafsson et al. (1999)	38	Spont/MV			2300-0700			31 ± 27	62 ± 27	7 ± 14	0,4 ± 1	57 ± 33	13 ± 5
Cooper et al. (2000)	20	MV		17 ± 8 (II)	2200-0600	Disrupted sleep	180 ± 114	40 ± 28	40 ± 23	10 ± 17	10 ± 14	20 ± 17	22 ± 25
Cooper et al. (2000)	20	MV		17 ± 8 (II)	2200-0600	Atypical sleep	240 ± 120	37 ± 42	14 ± 32	45 ± 51	4 ± 9	5 ± 8	7 ± 5
Gabor et al. (2003)	7	MV		31 ± 18 (III)	2200-0600		192 ± 156	19 ± 7	64 ± 10	3 ± 3	14 ± 910	11 ± 6	11 ± 8
Cochen et al. (2005)	6	Spont/MV			2200-0800		296 ± 83	14 ± 12	43 ± 19	29 ± 10	14 ± 8	24 ± 7	
Alexopoulou et al. (2007)	9	MV			2300-0600	PS high		35 ± 35	44 ± 32	2 ± 5	19 ± 23	10.5±9.9	3.9±3.4
Bosma et al. (2007)	13	MV	38 ± 7		2200-0800	PAV	334 ±124			3	9	9	3,5
Bosma et al. (2007)	13	MV	38 ± 7		2200-0800	PSV	314 ± 140			1	4	16	5,5
Andrejak et al. (2013)	26	MV			2200-0600	PCV			35 ± 23	9 ± 10	3 ± 6		
Andrejak et al. (2013)	26	MV			2200-0600	Low-PSV			20 ± 22	4 ± 9	8 ± 2		
Knauert et al. (2014)	14	Spont/MV		14 ± 8 (II)	2200-0600	>4h sleep	252 ± 96	23 ± 14	61 ± 11	4 ± 7	12 ± 12		
Current study (III)	21	Spont	33 ± 12	16 ± 5	Not specified		321 ± 119	46 ± 39	34 ± 33	6 ± 12	9 ± 18	16 ± 19	
Beecroft et al. (2008)	12	MV	5 (5.5)*	11 (4)	Not specified		186 (196)	21 (67)	74 (69)	0.2 (5)	0.4 (2)	12 (10)	14 (19)
Trompeo et al. (2011)	29	MV			2200-0800		343 [11-673]						
Kondili et al. (2012)	12	MV		23 [16-34]	2200-0700		214[40-285]	31 [5-67]	46 [3–80]	0 [0–0]	1 [0–13]		
Roche Campo et al. (2013)	16	Spont/MV	41 [33, 51]		2200-0800		296 [148-406]			25 [17-33]	7 [3-10]		
Current study(III)	21	Spont	32 [23, 41]	16 [12, 21]	Not specified		387 [170, 486]	27 [19, 97]	32 [2, 67]	0 [0,8]	1 [0, 8]	12 [2, 20]	5 [2, 13]

* Used APS Acute Physiology Score

Vent=ventilation, SAPS=Simplified Acute Physiology Score, APACHE=Acute Physiology and Chronic Health Evaluation (version II or III), Rec=recording, TST=total sleep time, MV=mechanical ventilation (mode not specified), Spont=spontaneous ventilation, PAV=proportional-assist ventilation, PS=pressure support, PCV=pressure controlled ventilation, PSV=pressure support ventilation

Table 15. Correspondence of nurses' observations with other sleep evaluation methods in earlier studies and in the present study.

Nurses' observation method	Comparison method	Observation interval	n	Result	Reference
Asleep/awake	PSG	5 minutes	6	Nurses' observations correlated, consistently over-estimated TST	Aurell & Elmqvist 1985
Echols' Patient's Sleep Behavior Observational Tool	VSH sleep scale (patient)	5 minutes	20	No correlation	Fontaine 1989
Echols' Patient's Sleep Behavior Observational Tool	PSG	5 minutes	20	SL and WASO higher, mid-sleep awakenings less by nurses observations	Fontaine 1989
Nurse Observation Check List (awake/ asleep/could not tell/ no time to observe)	PSG	15 minutes	21	73.5% of nurses' observations correlated with PSG on sleep/wake stage	Edwards & Schuring 1993
Not specified	RCSQ (patient)	60 minutes	24	Poor agreement, no tendency to over or under-estimation	Bourne et al. 2007
Not specified	Actigraphy	60 minutes	24	SE lower by nurses' observations than actigraphy	Bourne et al. 2008
Not specified	BIS	60 minutes	24	SE over-estimated by nurses	Bourne et al. 2007
Asleep/awake	Actigraphy	60 minutes	85	TST by actigraphy three-fold over nurses' observations	Chen et al. 2012
Hours asleep, awakenings	Actigraphy	At the end	12	No correlation	Beecroft et al. 2008
Hours asleep, awakenings	PSG	At the end	12	No correlation	Beecroft et al. 2008
RCSQ	RCSQ (patient)	At the end	13	High correlation Nurses' estimations higher	Frisk & Nordström 2003
RCSQ	RCSQ (patient)	At the end	92	Interrater reliability slight to moderate; nurses tend to overestimate sleep depth, TST, quality	Kamdar et al. 2012b
Nurses' documentation	RCSQ (patient)	At the end	104	44% agreement on sleep quality	Nicolás et al. 2008
Nurses' documentation	*RCSQ (patient)*	*At the end*	*114*	*57% agreement on sleep quality*	*Current study*
Nurses' observations (awake, sleeping lightly, peacefully, restlessly)	*PSG*	*Continuously*	*21*	*67% nurses' observations correlated with PSG on sleep/wake stage*	*Current study*

PSG=polysomnography, VSH=Verran-Snyder-Halpern, RCSQ=Richards-Campbell Sleep Questionnaire, BIS=bispectral index, TST=total sleep time, SL=latency to sleep onset, WASO=wake after sleep onset, SE=sleep efficiency

7.2 Strengths and limitations of the study

7.2.1 Strengths of the study

This study has several strengths. The quality of ICU patients' sleep and its evaluation were explored extensively. Several different methods were used, as sleep was studied from the perspectives of both patient and nurse, and using physiologic measures.

The patient group, non-intubated ICU patients, has not been studied before from the perspective of the quality of sleep. Thus, this study has produced a multifaceted description of sleep in the patient group suffering from a poor quality of sleep while being cared for in an ICU. The patients selected for this study were carefully screened for their orientation to attain the most suitable participants. They represent well the wide ICU population of the non-intubated patients, as judged from their age and gender.

Validated methods were employed for data collection if such were available. Polysomnography (PSG) is the gold standard of sleep research (Kushida et al. 2005, Bourne et al. 2007). The analysis of the PSG's was done by a clinical neurophysiologist certified in sleep medicine. All PSG's were analysable according to the AASM criteria (Iber et al. 2007). The Richards-Campbell Sleep Questionnaire (RCSQ) has been scientifically developed (Richards et al. 2000). Its validity and reliability have been well established in prior studies (Richards et al. 2000, Frisk & Nordström 2003, Nicolás et al. 2008, Kamdar et al. 2012b). Its internal consistency is good, as the Cronbach's alpha coeffient has varied from 0.89 (Nicolás et al. 2008) to 0.92 (Frisk & Nordström 2003). This study further supports the internal consistency of the RCSQ with a Cronbach's alpha of 0.92. The RCSQ is a relatively short questionnaire, and most of the patients had no difficulties in answering the questions.

The nurses' narrative documentations of the quality of patients' sleep covered 79% of the patients (n=114), and the content produced several new aspects to sleep evaluation. During the inductive part of content analysis saturation occurred, as towards the end of the analysis the data did not produce any new aspects to sleep evaluation. Thus, it can be assumed that the amount of data was adequate. The data were analysed and coded by two independent researchers with high agreement (91%).

The structured instrument used to collect the nurses' evaluations (B) was specifically developed for this study. Its content and face validities were confirmed by a certified somnologist, sleep technicians and expert nurses in a doctoral nursing science programme. No comments were received during the data collection from the participating nurses regarding the use of the instrument, although an open space for comments was provided. The use of the instrument was based on the nurses' real-time documentation of any changes related to the patients' sleep, and as such, it provided similar results as observation with set intervals (Edwards & Schuring 1993).

7.2.2 Limitations of the study

There are some limitations in this study. While four different data collection methods were employed, the validity of the results would undoubtedly have been better if all patients had been studied with all the methods. However, the burdensome nature of the PSG method limits the number of participating patients. Whereas, the use of the RCSQ requires a large sample for a valid statistical analysis. Therefore, these methods are very challenging to combine.

Nurses were not selected to participate in this study, instead they were chosen along with the patient they were assigned to care for during the night. Thus, it is not known how competent they were in caring for their patient and documenting the quality of sleep evaluations they performed. This may have biased the data. However, it is customary that all the nurses are well oriented and their competence is evaluated before they are able to care for a patient without supervision. Therefore, it can be assumed that the competence level of the ICU nurses in this study was high.

The patient samples might have been more comprehensive, if patients' orientation had not been a prerequisite. The patients in this study do not represent the whole ICU population of non-intubated patients, as a vast number of ICU patients suffer from disorientation (Peterson et al. 2006, Pandharipande et. al 2008). Therefore, it remains unknown what the quality of disoriented non-intubated patients' sleep is. However, the potential disorientation of the participants would have made the process of informed consent complicated. Furthermore, the data collection could have been compromised by disoriented patients' common restlessness during the PSG recording and the reliability of the participants' answers to the RCSQ questions would have been arguable.

In data set D, the number of female patients participating in the PSG recording was rather low, since more women than men refused to participate in the study. However, men are normally over-represented in ICU patient populations by almost at a ratio of 3 to 2 (Metnitz et al. 2005, Reinikainen et al. 2012). Nevertheless, sleep quality may vary between males and females, and the results of this study represent more the quality of the male patients' sleep.

Nurses' opportunity and vigilance to notice or document all changes in patients' sleep status may have been compromised. This possible bias must be considered when interpreting the results. The use of an independent researcher to assess the patients' sleep would have strengthened the results. However, one aim of this study was to explore how nurses can evaluate their patients' sleep during normal ICU care.

The reliability of the patients' answers can be questioned because of the poor recollection of the time spent in the ICU, often related to the patients' condition or pharmacotherapy. Memory loss may have affected the patients' self-evaluations, as it is rather common in an ICU (Rundshagen et al. 2002, Rattray et al. 2004, Samuelson 2011). Only two patients withdrew from the study because of the inability to remember how they had slept during the preceding night. Despite the possibility of erroneous recollections, it is important to collect patients' self-evaluations to advance patient-centred care and to gain knowledge of patients' perception.

The usefulness of PSG in ICU patients has been questioned (Watson 2007, Drouot et al. 2008), and the sleep scoring according to the AASM standards (Iber et al. 2007, Berry et al. 2012) has not always been successful due to artefacts (Cooper et al. 2000) or patients' septic condition (Freedman et al. 2001). Other disease states and medications may also affect ICU patients' PSG results (Watson 2007, Drouot et al. 2008). In this study, all the recorded PSG data were analysable. This may be accounted for by the patient selection, because the patients in this study represented the least critically ill patient population. In two earlier studies (Fontaine 1989, Richards et al. 2000), two analysers have been used to strengthen the validity of the PSG results (I). However, while the interrater agreement on PSG of healthy people is substantially good, e.g. 0.63 by Magalang et al. (2013) and 0.74 by Ambrogio et al. (2008), the disagreement increases in the analyses of the ICU patients' PSG. The early studies in ICU patients demonstrated interrater reliabilities of over 0.80 (Fontaine 1989, Richards et al. 2000), while the more recent investigation on the analysis of ICU patients' PSG demonstrated the agreement of only 0.19 (Ambrogio et al. 2008). Thus, as an experienced, certified somnologist was used in this study, the second analyser might not have further improved the validity of the PSG data.

The generalisation of the results of PSG evaluations requires caution, since the number of participants (n=21) was somewhat small, albeit in line with previous studies (see Table 14). The PSG recording may also have weakened the quality of the patients' sleep, as it requires several electrodes and connecting wires, sensors, cannulas and belts, which may disturb sleep. This must be taken into account when interpreting the results, even though none of the participants complained about the recording, and ICU patients have several other cannulas, electrodes and wires connected to them.

7.3 Suggestions for further research

Concept "quality of sleep" in critically ill patients

The concept "quality of sleep" needs further defining in relation to critically ill patients. The results of this study suggest that it contains more aspects (e.g. presence of nightmares and variation of heart rate and blood pressure) than what has been measured in previous research.

Improvement of the quality of ICU patients' sleep

ICU patients' quality of sleep in general is low and the amount of sleep they get is not sufficient. Therefore, it is important to look for and test different interventions to improve the quality and quantity of their sleep. Auspicious interventions include the improvement of all measures of sleep hygiene, such as a quiet and dark environment, a comfortable bed and position, the enabling and supporting of the patient's own sleep habits, the planning and clustering of night time nursing care, and the provision of ear plugs and eye shades, music, therapeutic touch, relaxation and/or guided imaginary therapies. Evidence on the effect of these measures, however, remains yet lacking.

As some patients seem to be able to sleep rather well while in an ICU, exploring the factors that enable them to sleep might provide new information on how to enhance patients' sleep. All the previous studies have focused on what disturbs sleep in an ICU, and as such only provide information about the factors that need to be addressed or eliminated.

Evaluation of the quality of ICU patients' sleep

The evaluation of the quality of patients' sleep should be as axiomatic as the evaluation of patients' gas exchange or circulation. Thus far, the sleep evaluation methods for ICU use are limited to observatory evaluations or patients' self-evaluations.

This study demonstrated that nurses' sleep evaluation practices need further improvement. However, sleep evaluations should also be studied concurrently from the three perspectives used in this study. The content and applicability of the recommendations generated in this study should be further explored, as well as the effect the use of the recommendations may have on the quality of patients' sleep.

Sleep observation methods need further development. The validity of the structured evaluation method used in this study could be strengthened if the observation data of patients' heart rate and blood pressure were included. Furthermore, the effect of education regarding sleep and its manifestations associated with the accuracy of the observations should be studied. The usability of the structured sleep evaluation method could be improved with the development of a computer program to automatically calculate and produce sleep data, such as total sleep time and the number of awakenings.

In the development of nurses' evaluation method, qualified sleep technologists could be used as observers and informants in search for new clues into the sleep evaluations by nurses. The think-aloud technique by the sleep technologists could be useful in providing new information about sleep evaluation.

Nurses' knowledge of the importance and the function of sleep needs to be evaluated, as well as their knowledge and skills of evaluating and promoting sleep. In conjunction with the development of education of sleep, the effect of increased nurses' knowledge on patient's sleep and sleep evaluation should be studied.

Systematic documentation practices should be developed. Structured and timed sleep evaluations should be included in patient information systems to guide nurses' sleep evaluations. The automatically gathered documentation data could collectively be used further for research.

Patients' self-evaluations with RCSQ should be developed further. The necessity of all the five items should be reconsidered as well as the scale used. Data on how the RCSQ performs and the limits of good and poor sleep in a healthy population are lacking and would be useful for future research. The use of additional sleep aspects, such as the presence of nightmares or vivid dreams, should be considered along with the RCSQ.

Because polysomnography is too burdensome for ICU patients and requires specially trained personnel for data collection and analyses, reliable and easy to use physiologic evaluation methods based on EEG or other brain activity measures will hopefully be developed in the future for daily practice and research to enable large data collections.

Consequences of sleep deprivation in ICU patients

It is not known how sleep deprivation affects ICU patients' course of recovery. More research is needed on the effect of patients' sleep quantity and quality on the symptoms and complications they may experience during and after ICU care. The possible connection between patients' sleep deprivation and the length of ICU and hospital stay needs to be explored. Systematic sleep documentation would likely provide data that could be analysed in connection with patient outcome data.

8. CONCLUSIONS

This study provided new information about the quality of non-intubated ICU patients' sleep and, for the first time, of ICU patients' sleep in Finland. These patients' sleep appears to be as light and fragmented as is the sleep of mechanically ventilated patients, and the quantity of sleep is much less than in healthy adults. However, there is large variation between the patients, a finding that could not be accounted for in this study.

The instruments available for nurses to evaluate patients' sleep are limited and measure most commonly the quantity of sleep. Several aspects of sleep are currently documented narratively, yet not consistently. Regardless of the method used, nurses' sleep evaluations seem to be correct only for approximately two thirds of the cases. The remaining third are most often overestimations of the patients' sleep. Valid, more comprehensive sleep evaluation methods for nurses are needed in order to evaluate, document and improve the quality of patients' sleep.

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