Hochschule für Angewandte Wissenschaften Hamburg
Hamburg University of Applied Sciences

Hamburg University of Applied Sciences

Faculty Life Sciences

Web-Based Cognitive Behavioral Therapy (CBT) for Insomnia:

An Analysis of its Effectiveness and Applicability to the Hospital Setting

Master thesis

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Submitted by:	Christina Jansen
	[redacted]
	[redacted]
[redacted]	[redacted]
Supervision:	Prof. Dr. York Zöllner
Second Supervision:	Prof. Dr. med. Michael Haufs
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Abstract

Background: Insomnia is an underrepresented and growing problem in society. About half of society is affected by sleep disturbances occasionally. Especially hospital employees require further attention due to the increased risk of sleep disturbances. The risk of being affected by poor sleep quality is almost twice as high for nurses working in rotating shifts and almost three times as high in night shift nurses compared to day and evening shift working nurses. As there is a lack of professionals who can treat the increasing number of affected people, web-based Cognitive Behavioral Therapy for insomnia (CBT-I) can provide a feasible and easily available treatment to change sleep behavior. Using a self-induced program, light to severe sleep impairments can be reduced.

Aim: The following thesis examines the effectiveness of web-based CBT-I on sleep-related outcomes considering currently available randomized controlled trials. In addition, a SWOT-Analysis assesses the applicability of such web-based CBT-I approaches for the target group of hospital employees.

Methods: A systematic literature research was conducted in the databases PubMed, Cochrane Library, Ebsco and Google Scholar as well as a free search in previous articles. Predefined inclusion and exclusion criteria enabled the inclusion of 15 randomized controlled trials (RCT). To assess the applicability for hospital employees, a SWOT-Analysis was executed to consider strengths, weaknesses, opportunities and threats of web-based CBT-I for the target group of hospital personnel.

Results: The literature review identifies improvements through web-based CBT-I in outcomes like insomnia severity, sleep efficiency and sleep quality. Other sleep-related outcomes and secondary outcomes reveal inconsistent results. Face-to-face CBT-I shows either equal or higher effectiveness than web-based approaches. Analysis of the applicability to hospital employees identifies requirements for adaptation, as the coverage of a high number of participants, automated reminders and support by the employer.

Conclusion: As an overall result, there is a clearly given effectiveness in decreasing the severity of insomnia and increasing sleep efficiency and sleep quality but inconsistent results regarding other outcomes. Web-based CBT-I is applicable to hospital employees with a few adaptations to address this target group. Further research is required to assess the effectiveness of web-based CBT-I for this particular target group.

Content

List of Tables

List of Figures

Abbreviations

CBT	Cognitive Behavioral Therapy (oCBT = online Cognitive Behavioral Therapy)
CBT-I	Cognitive Behavioral Therapy for Insomnia
CG	Control group (aCG = active control group)
d	Cohen's d effect size
DASS	Depression Anxiety Stress Scale
DBAS-10	Dysfunctional Beliefs and Attitudes about Sleep Scale
DSM	Diagnostic and Statistical Manual of Mental Disorders
ES	Effect size
F2f	Face-to-face Therapy
FSJ	Voluntary social year (Freiwilliges soziales Jahr)
GPA	Nursing assistant (Gesundheits- und Pflegeassistent/in)
HR	Human resources
IG	Intervention group
ISI	Insomnia Severity Index
ITTA	Intention-to-treat Analysis
IRT	Imagery Relief Therapy (control condition)
MA	Meta-Analysis
MFA	Physician assistant (medizinische/r Fachangestelle/r)
MFI	Multi-Dimensional Fatigue Inventory
MTA	Medical technical assistant (medizinisch-technische/r Assistent/in)
NWAK	Number of awakenings
OPE	Online Patient Education (control condition)
OR	Odds Ratio
PICO	Scheme for the definition of a research question (by definition of: population, intervention, comparison, outcome)
PJ	Practical year (praktisches Jahr)
ppCBT	Paper-and-pencil Cognitive Behavioral Therapy
PSQI	Pittsburgh Sleep Quality Index
QoL	Quality of Life
RCT	Randomized Controlled Trial
SCI	Sleep Condition Indicator
SE	Sleep efficiency
SHUTI	Sleep Healthy Using the Internet
SOL	Sleep onset latency
SQ	Sleep quality
SWOT	Strength-Weakness-Opportunity-Threat-Analysis
TAU	Treatment as usual (control condition)
TIB	Time in bed
TST	Total sleep time
TWAK	Terminal wakefulness
TWT	Total wake time
WASO	Waketime after sleep onset
WL	Waiting list /waitlist-control group

1. Introduction

Insomnia is a common problem in German society. Approximately half of the German population is affected by sleep disturbances at least sometimes. 11.1% claim about having problems falling asleep three or more times per week, while 16.5% have those problems one to two times per week and 25.3% report about insomnia symptoms less than once a week. Only 47.1% are symptom-free. Looking at the sleep quality, one-quarter of the participants (23.1%) claim their sleep quality as poor. (Schlack et al., 2013)

As affected people rarely go to the doctor or state sleep disorders as the reason for not being able to go to work, sleep disorders are an underrepresented and underestimated problem in society and sick leave reports (Marschall et al., 2017). Approximately half of the affected individuals living in Western Europe do not visit a physician (Léger et al., 2007). Therefore, surveys and other measurements need to be used to get a more reliable prevalence of sleep disorders instead of referring to sick leave reports. Sleeping disorders become a larger burden these days. Comparing the rate of sleeping problems in 2009 and 2016, the prevalence increased extremely. In 2009, 19.4% claimed about sleeping problems ≥3 times per week, while 52.5% stated that they are having no problems falling asleep or sleeping through. In 2016, 30.9% had episodes at least three times per week and only 21.1% were not affected at all. (Marschall et al., 2017)

Somers describes Cognitive Behavioral Therapy (CBT) with the aim of changing thoughts and behaviors to fight psychological impairments like depression, burnout or anxiety. It addresses cognitive, emotional and behavioral aspects and implements practical techniques to reduce symptoms in all-day-life. In general, CBT is time-limited to 10 to 20 sections, which are covering a certain topic and the execution of between-session exercises (2007).

This approach is also used to treat sleep disorders through learning how to deal with their own sleep behavior and improving knowledge in order to change aspects of sleep behavior and sleep hygiene. Due to the lack of psychological personnel and long waiting time for therapy (Ärzteblatt, 2017, Statistik der Bundesagentur für Arbeit, 2019), web-based programs become more relevant. In addition, the inhibition threshold is much lower in online courses compared to starting psychotherapy. Thus, self-induced online treatment is a good alternative to face-to-face therapy with the aim to prevent severe and chronic sleep disorders and psychological impairments.

Clinical staff, especially shift workers, tend to be among the most affected by sleep disorders. Chien and colleagues admit a rate of 75.8% of poor sleepers in hospital nurses in general (2013). Looking at shift work, Ohayon et al. state that 20% of the employees with changing daytime shifts (not only hospital staff) report problems falling asleep, while only 12% of employees with fixed daytime schedules report disabilities, even if it is not significant. But insufficient sleep syndrome was significantly higher in the case of shift and night work compared to fixed scheduled work (2002b). Other studies focusing on nurses, indicated similar results showing that rotating shifts (Odds Ratio=1.8) and night work (OR=2.8) lead to poor quality sleep in comparison to day and evening work (Gold et al., 1992). In consequence of the Act strengthening nurses in Germany ("Pflegepersonal-Stärkungsgesetz"), the target group of hospital employees, as well as nursing staff, becomes more relevant. The hospitals and health insurance companies have more resources to implement occupational health actions for hospital staff (Bundesgesundheitsministerium, 2018). Since hospital employees have a need for insomnia treatment, web-based Cognitive Behavioral Therapy (CBT-I) can be a feasible and reasonable tool for occupational health and prevention by health insurance companies.

Previous reviews and meta-analyses have proven the effectiveness of web-based CBT-I programs (Seyffert et al., 2016, Cheng et al., 2012, Ho et al., 2014, Ye et al., 2015, Zachariae et al., 2015). Despite this fact, some authors claim web-based CBT-I only as an introductory alternative (Ho, et al., 2014) and low-intensity treatment (Cheng et al., 2012). Articles are based on different primary and secondary outcomes, mostly sleep-related as well as other outcomes like depressive symptoms, anxiety and dysfunctional beliefs. Recent reviews and meta-analyses showed that web-based CBT-I result in reduced severity of insomnia (Cheng, 2012, Seyffert, 2016, Ye, 2015), improved sleep efficiency (SE) (Cheng, 2012, Ho, 2014, Seyffert, 2016, Ye, 2015, Zachariae, 2015), improved sleep quality (SQ) (Cheng, 2012, Ho, 2014, Zachariae, 2015) and other improved sleep-related outcomes. Critical appraisal of the previous research projects achieved a score from 8 to 10 of a maximum score of 12 (Appendix 3). These latest systematic reviews and meta-analyses included RCTs up to publications from 2015 (Seyffert, 2016, Ye, 2015, Zachariae, 2015) or older (Cheng, 2012, Ho, 2014). At least four of the RCTs included in this work are not covered by previous analyses. Due to discrepancies in results, limited long-term follow-up measurements and outdated RCTs used in previous research, this work aims to gain comprehensive and updated information about the effectiveness of web-based CBT-I in adults. Beside the general assessment of the effectiveness of such programs, this work further focuses on web-based CBT-I's suitability and applicability to hospital employees. No research about web-based CBT for sleep disorders has been found for this particular target group. One non-randomized study from Järnefelt and colleagues focus on media shift-workers, showing no

difference of effectiveness in daytime and shift workers (2014). Only one article was found for shift-working nurses: Kim and Kim found significant changes in irrational thoughts and beliefs as well as improvements in sleep, sleep quality, daytime sleepiness and quality of life for rotating shift nurses (2005). Nonetheless, there is a prominent lack of research about web-based approaches for shift workers or hospital personnel. A Strength-Weakness-Opportunity-Threat-Analysis (SWOT-Analysis) is conducted to establish whether such programs can be applied for the variety of hospital professions.

This thesis aims to assess the effectiveness of web-based Cognitive Behavioral Therapy to decide whether such interventions are effective in general as well as suitable for hospital employees. Following research questions are the focus of this thesis:

What effect does web-based Cognitive Behavioral Therapy for insomnia have on the severity of insomnia, sleep quality and other sleep-related variables? To what extent is web-based CBT-I applicable to hospital personnel?

2. Objectives and Hypotheses

The present work consists of two analytical parts to give a broad overview of current research about the effectiveness of web-based CBT-I as well as an analysis of its applicability to hospital employees. The first analysis is based on a systematic literature review, while the second part uses a SWOT-Analysis to assess web-based CBT-I and its applicability to an exemplary hospital.

The Objectives for the Systematic Review are:

- To determine the effectiveness of web-based CBT-I interventions
- To assess in which way web-based CBT-I has an influence on insomnia severity, sleep quality, sleep efficiency and other sleep-related variables

The aim of the systematic literature review is to test the null-hypothesis of web-based CBT-I not being effective and having no influence on sleep variables. As there can be found only several older reviews about the effectiveness of web-based CBT-I with hardly comparable measurements and discrepancies in outcomes, an updated evaluation is provided in this work. The focus of outcome are sleep-related dependent variables, like insomnia severity, sleep quality (SQ) and sleep efficiency (SE), depending on the outcomes given in the analyzed articles.

The Objectives for the SWOT-Analysis are:

- To assess the applicability of web-based CBT-I for hospital personnel
- To analyze web-based CBT-I including strengths, weaknesses, opportunities and threats for the use in hospital personnel

The aim of the SWOT-Analysis is the rejection of the null-hypothesis that web-based CBT-I can be used for hospital personnel without the need for adaptation. The variety of international and national web-based CBT-I approaches gives the opportunity to choose the best one for a particular setting. As hospital employees are an important target group due to the burden of sleep disorders and the rising interest for health promotive actions, this analysis aims to assess practical adaptations for such approaches for implementation into the setting. Aspects of web-based CBT for insomnia and environmental aspects of the hospital setting are analyzed in order to get information for the applicability and implementation.

Before describing the methodology and procedure of this work, the following chapter gives further information about the topic of sleep disorders.

3. Sleep Disorders and CBT-I

Sleep disorders are one of the most common health problems in society. In Germany, nearly one-third of the population is affected by having problems falling asleep at least one time per week (Schlack et al., 2013). Sleep is essential for us to manage all-day-life and feel healthy. This is supported by several studies that subjective sleep quality and quality of life are correlated (Shao et al., 2010, Zeitlhofer et al., 2000, van Straten et al., 2014). Additionally, the influence of sleep on anxiety and depressive symptoms can be observed (van Straten, 2014, Horsch, 2017). The following chapters describe the burden of sleep disorders in Germany, influencing factors occurring in the hospital setting and web-based Cognitive Behavioral Therapy for insomnia.

3.1 Sleep Disorders

Classification

Sleep disorders are defined by the International Classification of Sleep Disorders and have been revised several times since then. Besides the term insomnia, there are: hypersomnia with a central cause (cause in the brain), apnea syndromes, parasomnia, movement disorder and isolated symptoms or idiopathic symptoms (Rodenbeck et al., 2015). While parasomnia includes sleepwalking, rapid-eye-movement and other behavioral abnormalities disturbing sleep, hypersomnia encompasses narcolepsy, Kleine-Levin syndrome or symptoms of daily sleepiness (Rodenbeck et al., 2015). Insomnia includes several constraints such as problems falling asleep, sleeping through, disturbed circadian rhythm or waking up too early (Penzel, 2005, Krollner, 2019). According to the classification system of ICD-10, insomnia can be differentiated between organic insomnia (ICD-10 G47) or non-organic insomnia (ICD-10 F51) (DIMDI, 2019). The German Institute of Medical Documentation and Information (“Deutsches Institut für Medizinische Dokumentation und Information“) describes non-organic insomnia as the deprivation of length of sleep and quality of sleep for a longer period of time. Organic sleep disorders are described as any kind of constraints regarding sleep as long as they can be attributed to a cause. This includes problems falling asleep, sleeping through, sleep apnea, hypersomnia, narcolepsy and other disorders with an organic cause (DIMDI, 2019, Krollner, 2019). The present work focuses on non-organic insomnia but includes comorbidities in some of the analyzed RCTs. Looking at the articles described in this review, different inclusion criteria have been applied. The most common inclusion criterion is the diagnosis with DSM-IV or DSM-5 insomnia criteria (Diagnostic and Statistical Manual of Mental Disorders). While DSM-IV was

the initial definition and is labeled as primary insomnia in the class of sleep disorders, the revision DSM-5 covers insomnia disorder as a part of sleep-wake disorders (Glasheen et al., 2016). The main changes were: the revision of the duration of one month (DSM-IV) to at least three nights per week for at least three months of duration (DSM-5) as well as the precise definition of symptoms and the exclusion of other causes (DSM-5) (Glasheen et al., 2016).

Burden of Disease

Referring to the burden of disease described in chapter one, sleep constraints occur in approximately half of the German population (Schlack et al., 2013). In 2010, there are approximately 45 million persons affected by sleep disorders in Europe in 2010 including sleep apnea, insomnia, narcolepsy and hypersomnia (Gustavsson et al., 2011). But against expectations, the *DAK Gesundheitsreport* (health report by a German health insurance company) by Marschall and colleagues shows that sleep constraints do not have a significant influence on sick leave days in Germany. In 2015, only 0.29% of all employed people stated sleep issues as the reason for sick leave. The duration of sick leave attributed to sleep disorders is eleven days on average (Marschall et al., 2017). Discrepancies between sick leave reports and sleep assessments via questionnaires can be explained by a minority of affected people going to the doctor or stating sleep disorders as the reason for not being able to go to work (Marschall, 2017). Problems sleeping through the night are more common than problems falling asleep, especially in men (Schlack et al., 2013). Both constraints, within the term of insomnia syndrome, occur in about one-third of the participants (Schlack et al., 2013). 12.3% sleep five or fewer hours a night (Schlack et al., 2013). 5.7% of Schlack's study participants took sleep medication during the last four weeks (2013). The prevalence of insomnia increased during the past years. While in 2009, 47.5% claimed about sleep constraints, it increased to 78.9% in 2016 (Marschall et al., 2017). Sleep interventions are not only reasonable to reduce sleep impairments but also with regard to quality of life (Shao et al., 2010, Zeitlhofer et al., 2000, van Straten et al., 2014), anxiety (Horsch et al. 2017, Morris et al., 2016, Lancee et al., 2016, van Straten et al., 2014, Lancee et al., 2012, 2015), depressive symptoms (Blom et al., 2015, Horsch et al., 2017, Morris et al., 2016, Lancee et al., 2012, 2013, 2015), work and social impairment (Holmqvist et al., 2014), worrying (Thiart et al., 2015) and other factors.

Besides the burden of disease, economic factors need to be considered as well. As there is a lack of research about the economic burden of insomnia in Germany, other countries need to be considered. Daley's analysis of Quebec's annual costs caused by insomnia showed a burden of 6.6 billion Cdn$ including direct costs (health care costs, transportation, prescription,

medication) and indirect costs (absenteeism, productivity loss). This causes 5,010$ annual costs per person, while good sleepers evoke only 420$ (2009). Another study by Gustavsson et al. resulted in costs of 35 billion Euro for sleep disorders in Europe (sleep apnea, insomnia, narcolepsy and hypersomnia). This large number is mainly attributed to a large number of affected persons rather than high individual costs (2011). Still, the indirect cost of insomnia is underrepresented and hardly measurable but nevertheless, the economic burden of sleep disorders is indisputable.

Risk Factors and Comorbidities

Insomnia is influenced by many factors. In general, women are more likely to have insomnia than men (Schlack et al., 2013, Penzel et al., 2005, Marschall et al., 2017) with 8% female and 3% male Germans complaining about severe insomnia (Penzel et al., 2005). While men are more likely to develop sleep apnea, women suffer from insomnia more often (Marschall et al., 2017). Age seems to influence sleep behavior as well. In the group of 40-year-old and older, the risk of too little sleep rises by 1.7 - 1.8 compared to the age group of 18 - 39 (Schlack et al., 2013). Holzinger and Klösch describe the phenomenon with decreasing sleep time, the difficulty of deep sleep phases and changed sleep patterns into fragmented episodes with rising age (2018). Beside the age, gender is another factor that seems to influence sleep constraints.

Insomnia is not always a primary and single constraint. It can be associated with other diseases or disorders such as obesity, diabetes, hypertension, cardiovascular disease, anxiety and depression. Insomnia symptoms are present in the majority of these diagnoses. For instance, in depressive illness, insomnia is existing in more than 80% of the cases (Ohayon, 2002a). Sivertsen and colleagues describe a bidirectional relation between depression and insomnia: following depressive patients and insomnia patients, both groups tend to develop the other disease over time. Having one of the disorders increases the risk by approximately six times to develop the other constraint as well (2012). Even overweight, obesity and diabetes can be caused by insomnia, due to lack of energy and its compensation (Markwald et al., 2013). Holzinger and Klösch describe the association between duration of sleep and life expectancy on the one hand and morbidity on the other hand (2018). This is supported by a meta-analysis claiming that “short duration of sleep was associated with a greater risk of death (RR: 1.12; 95% CI 1.06 to 1.18; P < 0. 01)“ (Capuccio et al., 2010). If insomnia is not treated, it tends to persist for at least one year (Morin et al., 2009).

3.2 Hospital Work and Shift Work

The following chapter describes the relationship between sleep and working condition such as working in a hospital and working in shifts. Apart from the impact on sleep outcomes, accidents and quality of life are described in relation to shift work and sleep impairments.

Sleep Outcomes

Previous research has shown that many aspects can influence sleep quality. Shift work, rotating shift work and night shifts are a proven negative influence on sleep time or quality of sleep (Escribá et al., 1992, Ferri et al., 2016, Gold et al., 1992, Short et al., 2015, Ohayon et al., 2002b, Zhang et al., 2016, Chien et al., 2013).

Comparing hospital workers to the general population, a much higher prevalence of sleep disturbances can be found: insufficient sleep is settled at 48% and very insufficient sleep at 8.4% (Suzuki et al., 2005), while 21.2% of the general population claimed their sleep quality as insufficient and 1.9% as very insufficient (Schlack et al., 2013). Nurses working night shifts show reduced sleep time by two hours and nurses working rotating night shifts show a reduction of sleep by 30 minutes (Escribá et al., 1992). Gold et al. compared different shift groups with the outcome of sleep quality and errors, showing that poor sleep quality is almost twice as high in night shift nurses and even almost three times as high in rotating shift nurses (1992).

Shift work has a major influence on sleep quality, sleep latency, duration of sleep, sleep efficiency and daytime-disfunction. Surprisingly, even previous shift work (>6 months ago) still influences sleep quality, sleep latency and daytime dysfunction (Zhang, 2016). Especially rotating night shift workers deserve special attention on the basis of “lower job satisfaction, quality and quantity of sleep, with more frequent chronic fatigue, psychological and cardiovascular symptoms in comparison with the day shift workers“ (Ferri et al., 2016, p. 203).

Short and colleagues report about shift schedules as an influence on sleep quality and sleepiness. They indicate that four hours on/eight hours off schedules result in approximately one more hour of sleep compared to six hours on/6hours off schedules and even 1.3 hours more sleep than eight hours on/eight hours off schedules. This study also revealed the highest level of sleepiness between 2 am and 8 am (2015). Along with these results, Niu et al. indicate that the cortisol level needs time to adjust to the changing shift, meaning that nurses need at least 3 days off before changing to another shift (2015). The *Robert-Koch-Institut* (an independent German agency for communicable and non-communicable diseases) recommends scheduling shifts antegrade, e.g. from morning shift, to midday shift, to evening and night shift –

not the other way around. Furthermore, there need to be appropriate breaks in between shift changes (Penzel et al., 2005).

Besides the existing research about shift work and nursing, there is a prominent lack of research about other hospital professions in regard to sleep outcomes.

Consequences of Shift Work and Sleep Constraints

About 20% of the changing dayshift workers complain about problems falling asleep, while only 12% of fixed daytime workers are affected (Ohayon et al., 2002b). These numbers align with Booker's results showing that 20-30% of shift workers are affected by insomnia, daytime sleepiness or shift work disorder (Booker et al., 2018). The shift work disorder syndrome can include high blood pressure, gastrointestinal constraints, myocardial infarction, stroke, depression, lack of vitamin D and other constraints, of which 4% of shift workers are affected (Holzinger & Klösch, 2018). Other studies focusing on nurses reveal that rotating shifts (OR=1.8) and night work (OR=2.8) lead to poor quality of sleep in comparison to day and evening shifts (Gold et al., 1992). However, Valliérres and colleagues claim that insomnia symptoms are highly related to sleep time, more than shift work itself (2014).

Poor sleep, whether short-term or chronic, can further lead to different social, occupational or personal impacts. Owens describes several negative impacts due to the lack of sleep and shift work in healthcare workers such as impacts on personal life and family, restraints in attention and reaction time, consequences for occupational duties, decreased ability to learn, worsened care quality and an increase of errors (2007).

In around 26% of hospital nurses, excessive daytime sleepiness is significantly associated with occupational accidents occurring during the past 12 months (Suzuki et al., 2005). Gold et al. found out that accidents and errors occur more often in rotating shifts (OR 1.97 for any accidents/errors) than in day and evening shifts (1992). This aligns with the results of Niu et al., which showed a 0.44 (B) higher error rate in attention tests in night shifts compared to fixed day shift workers and a 0.62 times higher rate compared to evening shifts (2013).

Another consequence of rotating shifts is the number of sick leave days and thus, the cost for the employer. Sick leave days are significantly more frequent in rotating daytime shifts (62.8%) than in fixed daytime employees (38.5%) (Ohayon et al., 2002b). Sick leave days are highest for people sleeping less than six or more than nine hours per night. Especially in men, insomnia-related symptoms show strong correlations with sickness absence days per year (Rate Ratio=

1.91 - 2.34, adjusted for education, age, health behaviour and working conditions) (Lallukka et al., 2014). These findings indicate that, despite women being more likely to be affected by sleep disorders (Marshall, 2017, Penzel et al., 2005), there is a higher risk of sick leave and insomnia symptoms in men (Lallukka et al., 2014), as well as a higher number of sick leave days (Marshall et al., 2017).

Quality of Life

Between quality of life and sleep quality can be found a small (Shao et al., 2010) to moderate correlation (Zeitlhofer et al., 2000). PSQI components, like subjective sleep quality, sleep disturbances and daytime dysfunction are significantly associated parameters with quality of life (Zeitlhofer et al., 2000). It is questionable what direction of influence can be drawn, as quality of life is a complex system with many influencing factors. Poor sleep quality could influence the quality of life negatively as well as poor quality of life could have a negative influence on sleep quality. Looking at the quality of life in different shift schedules, Guerra et al. do not find any significant difference in comparing morning, afternoon and evening shifts with the exception of the item “social role functioning“, which is significantly different in evening shifts compared to morning and afternoon shifts (2016). A medium effect is found for the change from pre- to post-treatment assessed by one question of the current quality of life (van Straten et al., 2014). However, Shao and colleagues add that poor sleep quality and poor quality of life of female nurses can be correlated with menstruation-related problems (2010).

3.3 Cognitive Behavioral Therapy for Insomnia

General CBT has the aim to “identify, question and change the thoughts, attitudes, beliefs and assumptions related to your problematic emotional and behavioral reactions to certain kinds of situations“ (Neil, 2010, p. 3). Somers describes its origin in the treatment of depression, anxiety and other mental diseases. It focuses on setting individual goals to reduce psychological strain through either one-on-one CBT, group-based CBT or self-induced programs (2007).

Hölzinger and Klösch characterize CBT as an intensive short-term treatment, which aims to improve long-term skills. Through CBT, the affected person analyses and changes his or her own behavior step-by-step in order to optimize health behavior (2018). Aaron T. Beck, the developer of CBT, started this kind of psychotherapy with the aim of reducing negative thinking patterns in depressive patients (Beck Institute for Cognitive Behavior Therapy, 2016). As self-

help approaches clearly have its support in the research (Vernmark et al., 2010), self-monitoring and self-induced tasks are a major part of CBT in order to change behavior in the long run (Neil, 2010).

Cognitive Behavioral Therapy for Insomnia (CBT-I)

CBT offers an ideal basis for the treatment of insomnia. Holzinger and Klösch describe CBT in the range of sleep constraints as most effective in older patients, sleep-wake disorders, bruxism, and insomnia complaints. The reason for the target group of adults and elderly are the needed level of motivation and control of sleep behavior, which is difficult to implement in children and adolescents (2018). Components of CBT-I are mainly: behavioral components (like stimulus control and sleep restriction), cognitive components, sleep hygiene and relaxation (Bastien et al., 2004). Stimulus control includes rearrangements of the bed and bedroom to ensure best requirements for good sleep (darkness, no noises, go to bed only when tired, no other activities in bed, leave the bed if unable to sleep, same time to stand up) (Bootzin & Perlis, 2011). Sleep restriction is about limiting the time in bed to increase actual sleep efficiency (Spielman et al., 1987). However, cautious use of sleep restriction exercises is advisable to reduce daytime sleepiness, especially in working participants with a demanding job (Holzinger & Klösch, 2018). Cognitive components have the aim to change thoughts, attitudes and beliefs about sleep to reduce stress and mental pressure (Harvey et al., 2005). This change of thoughts can be achieved through sleep trackers and sleep diaries to inhibit a misperception of sleep, which is necessary to change long-term behavior (Holzinger & Klösch, 2018). Sleep hygiene is an important aspect to improve influencing behaviors, e.g. physical activity, nutrition, alcohol use and reduction of external disruptive factors, such as noise, light, etc. (National Sleep Foundation, 2019). CBT-I does not exclude pharmacological therapy (Somers et al., 2007). CBT-I components may vary between different approaches and models. The systematic review of CBT-I's effectiveness in this work includes RCTs with at least three components mentioned above.

For CBT-I some requirements need to be fulfilled: a) participants need to have a certain constraint, distress or impairment in case of sleep to enable the treatment to be effective, b) absence of an undiagnosed or unstable illness, c) there is no unstable disease, which could be worsened or distracted by CBT-I, or d) the participant does not show behavioral or psychological factors which maintain chronic insomnia (Smith & Perlis, 2006). High drop-out rates are associated with longer total sleep time (TST), severe depression and a lower insomnia

severity score before treatment (Yeung et al., 2015), which supports the requirement of a severe constraint or impairment.

CBT is transferable to many mental disorders, as it takes actions for the own behavior and dealing with the constraint. Besides, CBT can have positive side effects and gains, not just for the impairment it was meant for. For instance, a web-based CBT for *Anxiety Relief* is proven to be effective in reducing anxiety but also causes transfer effects in diminishing insomnia symptoms through improved sleep quality (Morris et al., 2016). Reversely, CBT for insomnia can have positive effects on: quality of life (Shao et al., 2010, Zeitlhofer et al., 2000, van Straten et al., 2014), anxiety (Horsch et al. 2017, Morris et al., 2016, Lancee et al., 2016, van Straten et al., 2014, Lancee et al., 2012, 2015), depressive symptoms (Blom et al., 2015, Horsch et al., 2017, Morris et al., 2016, Lancee et al., 2012, 2013, 2015), work and social impairment (Holmqvist et al., 2014), as well as worrying (Thiart et al., 2015).

Some of the offered web-based CBT approaches for insomnia are based on self-help therapy and therefore need no support from therapists. Berger and colleagues prove that guided online treatment achieves (non-significant) slightly larger effects than self-help approaches (2011). Somers notes that self-help CBT approaches for depression are most suitable for light disorders (2007), which applies to insomnia treatment as well.

CBT-I has several advantages such as an effectiveness after a short period of time, long-lasting success and possibility for group-based treatment (Penzel et al, 2005).

Exemplary web-based CBT-I Approaches

There are several different web-based approaches using CBT components for the treatment of insomnia. All programs mentioned in relevant articles of the systematic literature review are briefly described in the following.

The *Sleepio* website and the *Sleepio* application is a six-week approach using an interactive virtual therapist with well-visualized progress and analysis of sleep. Participants can ask questions via E-Mail or telephone and can receive SMS or E-Mail reminders (Bostock et al., 2016, Espie et al., 2012). Another approach is used by Lancee and colleagues. It is structured as a six-week internet application with explanations and different exercises for each module. Participants are able to ask technical questions only. Additional studies included an application, which integrated exercises into the context and tracked the progress. Each module needs to be completed before going on to the next module (2012, 2013, 2015, 2016). *SHUTI* (Sleep Healthy

Using the Internet) is a six to nine-week program using texts, graphs, animations and games, supported by E-Mail reminders, to implement learned content into everyday life (Ritterband et al., 2016). Van Straten's nameless six-week approach supports modules using examples of other participants executing the treatment, accompanied by practical exercises. Furthermore, participants can contact an expert who additionally provides individual feedback on the exercises (2013). *Return2sleep* is a six-week program using audio-visual content, graphs and audio files including homework exercises without any personal contact (Vincent et al., 2009, Holmqvist et al., 2014). The *Sleepcare* application by Horsch et al. is a fully automated program with a conversation screen (automated comments with content and multiple-choice questions to the participant) giving an overview of sleep behavior over time (2017). Blom and colleagues, as well as Kaldo and colleagues, use a nameless treatment with therapist support via texts, questions, exercises, worksheets and sleep diary consisting of eight modules. Therapists review homework exercises, give feedback and offer E-Mail contact as well as reminders for the completion of the modules (2015). *Insomnia Relief* is a seven-week approach using monitoring tools and feedback with standardized weekly E-Mails reminding about exercises and encouraging the participant (Morris et al., 2016). The six-week program *Get.On Recovery* includes a choice of exercises in each of the sections, monitoring tools to track the sleep, weekly motivational support, reminders and feedback by coaches (Thiart et al., 2015) but also a self-help option without external support (GET.ON Institut GmbH, 2018).

There are several German online programs, which are based on CBT as well. Just to introduce a few of them, *Selfapy* and *Mementor* are briefly described. *Selfapy* is based on the Letssleep program. It is an online-based self-help coaching using a combination of web-based lessons and therapist contact by telephone. The 12-week coaching is based on informing sessions, exercises, sleep diaries and individual coaching by sleep experts via phone calls (Selfapy GmbH, 2019). *Mementor Somnium* is a similar program based on a four- to six-week training including 12 modules, sleep diary, individual goals and the possibility to include a sleep tracker. The special feature of the Swiss treatment is the virtual sleep coach providing information and advice to improve sleep behavior (Mementor GmbH, 2019). Evidence shows high completion rates (93%) and medium to large effect sizes in sleep-related outcomes, sleep-related cognitions, safety behavior, depression and somatization in the treatment group compared to waitlist controls with long-term stability (Lorenz et al., 2018). Unfortunately, there cannot be found a face-to-face comparison for *Mementor* treatment.

Some of the approaches as *Get.On* (PRO MIND), *Selfapy* (letssleep) and *Mementor Somnium* can be financially supported by some health insurance companies (GET.ON Institut GmbH, 2018, Selfapy GmbH, 2019, Mementor GmbH, 2019).

Drop-out Rates

Different definitions of an adequate dose of participation complicate comparison of adherence rates in the different approaches. Therefore, this section compares full completion rates, either completion of all modules or completion of post-intervention measurements. Web-based CBT-I approaches show very different completion rates. The self-induced approach *Return2sleep* without expert support or reminders shows rates from 22.6% to 76.8% depending on the module (Vincent et al., 2009). Approaches using automated homework and diary reminders without support by experts achieve higher participation rates from 60.3% to 81.2% at post-treatment (Ritterband et al., 2016, Morris et al., 2016). An exception is the application by Horsch et al. which achieves completion of questionnaires of 61% only (2017). Another report by Horsch about application-based sleep interventions with a virtual coach reveals an average adherence of 52% (95% CI 43%-61%) combining ten studies (2015). Approaches using any kind of support (via phone or E-Mail), as well as reminders, yield rates from 73%, over 82%, to 92.2% at post-treatment (Bostock et al., 2016, Espie et al., 2012, Thiart et al., 2015). In contrast, in-person CBT-I adherence demonstrates rates of 70% (Lancee et al., 2016) and 60-86% in individual or group treatment in a clinical setting (Ong et al., 2008). Therefore, the statement of higher completion rates in face-to-face treatment (Holmqvist et al., 2014, Blom et al. 2015), may not be supported if the features of E-Mail support and automated reminders are given.

However, not only completion rates are influenced by support features but also the scope of treatment effect. Lancee et al. reveal better results in SE, sleep onset latency (SOL), waketime after sleep-onset (WASO), number of awakenings (NWAK), Insomnia Severity Index (ISI), depression and anxiety in the supported group (2013), which is supported by the study from Matthews and colleagues (2013). Contrary to the findings of Lancee et al., Berger and colleagues prove that self-help approaches can achieve similar results compared to guided online treatment (2011). Hence, the question arises what the reasons for drop-outs are. If we look at participants who did not finish treatment, high drop-out rates are associated with longer total sleep time (TST), severe depression and a lower ISI score at pre-treatment (Yeung et al., 2015). As high drop-out rates seem to be an issue in web-based CBT-I, it should be taken into account for the systematic literature research and SWOT-Analysis.

The subject of investigation in the following chapter will be the methodology of the systematic literature review and the SWOT-Analysis.

4. Methodology

The following chapters describe the methodological procedure in the systematic literature review to answer the research question on the effectiveness of web-based CBT-I in general (chapter 4.1) and methods for the SWOT-Analysis to assess the applicability of such approaches for the hospital setting (chapter 4.2).

4.1 Systematic Literature Review

Database search

A keyword-based search on the following databases was conducted: PubMed, Cochrane Library, Ebsco and Google Scholar. In addition, resources of previously published systematic reviews and meta-analyses of the past ten years were searched for relevant RCT's. If possible, Mesh-Terms were used to prevent missing studies with synonymous expressions. After several too precise searches using terms like *((("Sleep Wake Disorders"[Mesh]) OR "sleep* qualit*") AND "Personnel, Hospital"[Mesh]) AND ("Cognitive Behavioral Therapy"[Mesh] OR "Behavior Therapy"[Mesh] OR "sleep* intervention*" OR "self-induced intervention*" OR online intervention*)* with only a few records (none of relevant content), the search was adjusted to a wider term excluding the search term of hospital employees. The search term *((((„quality of sleep“) OR "Sleep"[Mesh]) OR "Sleep Wake Disorders"[Mesh]) OR "Sleep Hygiene"[Mesh]) AND ("Cognitive Behavioral Therapy"[Mesh] OR "Behavior Therapy"[Mesh]) AND (online OR web-based OR online-based OR digital)* resulted in a larger number of records. Filters, like language (English and German), target group (humans), date of publication (from 2009) and study design (RCTs) were used if possible. Further information about search terms used in each of the databases is given in Appendix 2.

Inclusion and exclusion criteria

PICO scheme was used to examine the inclusion and exclusion criteria for the screened studies (Table 1). Narrowing the population to hospital staff or similar professions did not lead to any relevant results. Thus, the population was changed to adults with any kind of sleeping problem or diagnosed insomnia from light to severe. The intervention was chosen to be web-based and covering at least three topics of typical CBT components for insomnia, which are described further in chapter 3.3. Treatments delivered via applications are included if they can be used on a computer as well. The intervention group should be compared to at least one other group:

either a control group, a waitlist control group, treatment as usual or a comparable treatment, which can be online or offline. Outcomes need to be sleep-related (preferably sleep quality, sleep efficiency or insomnia severity) with pre and post measurement in all groups. Only randomized controlled trials with a sample size above 40 were chosen. Studies should provide all data, preferably within-group and between-group comparison and effect sizes for at least one of those.

Table 1: PICO-Scheme for Search Strategy

Population	Intervention	Comparison	Outcome
Adults	Online sleep intervention with at least three CBT-I components	No intervention, other intervention, treatment as usual (online or offline)	Insomnia severity, sleep quality, sleep efficiency, other sleep-related outcomes

Studies were excluded if the primary or secondary outcomes were not sleep-related and if the intervention was not web-based or based on CBT components (less than three components). Studies looking at comorbidities were included if the outcome was sleep-related and if the intervention focused on sleep.

Selection procedure and quality assessment

The selection procedure can be found in Figure 1 as a flow-chart diagram. 260 reports were screened by title or abstract to check for inclusion and exclusion criteria. 155 studies were excluded due to different content as inclusion criteria. 105 reports were screened by full text of which 90 were excluded due to other dependent or independent variables (no focus on insomnia or web-based CBT), other target groups (e.g. children), organic cause for insomnia (e.g. cancer) or other study designs than RCT. Comorbidities were included if the outcome was mainly sleep-related and the comorbidity is stable and not the major cause for insomnia. 15 RCTs have been included in this report to assess the effectiveness of web-based CBT-I.

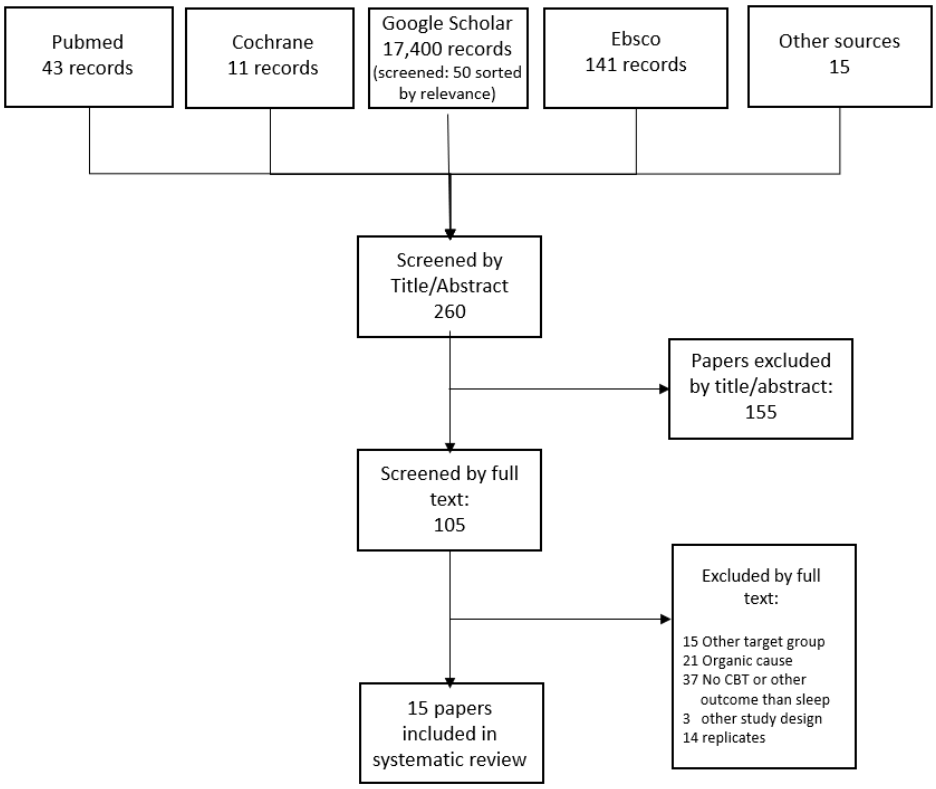

Figure 1: Flow-Chart of Study Inclusion Process

The methodological quality was rated using JBI Critical Appraisal Checklist for Randomized Controlled Trials (Tufanaru et al., 2017) using 13 criteria. The checklist includes randomization, allocation, blinding, completer analysis, intention-to-treat-analysis, reliability and statistical methods. An overview of the rated studies is found in Appendix 3. Scores were rated with 0 (not fulfilled), 1 (fulfilled) or n/a (not given) with a maximum of 13 points. Critical appraisal was used for discussion of limitations and evaluation of results.

4.2 SWOT-Analysis

To analyze the applicability of web-based CBT-I programs, a cross-sectional survey of an exemplary hospital analysis indicates circumstances of sleep disorders in hospital staff. Additionally, two interviews give information about requirements for the employees (nurse) and practical aspects regarding the implementation of such projects (Human Resource/HR Manager). After assessing the current state of the personnel‘s sleep quality and the needs of the setting, all information is included in a SWOT-Analysis to evaluate strengths, weaknesses, opportunities and threats of web-based CBT-I for the special target group of hospital staff. The

SWOT-Analysis is the basis for further strategy assessment to implement web-based CBT-I into the hospital setting.

Context and target group

To examine the setting of hospital personnel, an exemplary hospital is used. The hospital is based in a suburban region of a large German city and provides 850 beds. This general hospital has 2,333 employees of which 1,287 can be assigned to nursing personnel and medical professions, 433 are physicians, 58 are administrative professions and 555 are therapists, trainees and other professions. Thus, nursing and medical jobs are the majority profession in a hospital like the exemplary one and this might be the most difficult target group to address with CBT-I. Human resource management of the exemplary hospital provides occupational activities in the fields of physical activity, nutrition, addiction and stress.

The analysis of the hospital setting and the burden of sleep disorders in the employees is carried out through several statistical analyses. First of all, age and sex are analyzed in regard to its relation to the Pittsburgh Sleep Quality Index (PSQI) score and component scores. Age and total PSQI score, as metric variables, are analyzed with Pearson correlation. The analysis of age and PSQI components is executed with Spearman correlation due to the ordinal scale of each component of PSQI. Binary independent variables of shift work and sex are analyzed with point biserial correlation and independent sample t-Test for comparison of the total score and with Chi-square test and Mann-Whitney-U Test for the analysis of sub-components. The influence of the field of work (profession) on the PSQI score and component scores is examined by analysis of variance. All compared groups are checked for normality. If normality is not given, non-parametric tests are used.

The results of the analysis of influencing variables on sleep quality are included in the SWOT-Analysis to examine the applicability of web-based CBT-I to shift workers and different fields of work in a hospital.

SWOT-Analysis

This work applies a SWOT-Analysis as a prospective approach to examine the applicability of online CBT-I to hospital personnel. To ensure this, a description of the hospital setting is conducted, using a cross-sectional survey (n=58) of an exemplary hospital, followed by two expert interviews delivering information about requirements needed in the hospital setting.

Including both sources of information, a SWOT-Analysis is executed focusing on the web-based CBT-I respecting its variety of approaches. A SWOT-Analysis is primarily used for companies to analyze the internal company conditions towards external market conditions. But in this particular case, the strengths and weaknesses of CBT-I in general represent the internal view, whereas opportunities and threats of the hospital setting illustrate the external part.

Starting the analysis with the simple listing of strengths, weaknesses, opportunities and threats, a following classification into the matrix is conducted to identify internal/external as well as positive/negative aspects of web-based CBT-I. This classification is necessary to be able to derive strategies at a later stage. There are strength-opportunity strategies following the program‘s strengths to maximize its effectiveness. Strength-threat strategies use the strengths to overcome threats. Weakness-opportunity strategies take advantage of opportunities in the setting (e.g. hospital setting) to minimize weaknesses. Hence, weakness-threat strategies try to minimize the program‘s weaknesses to avoid threats of the setting. (Behrens, 2017, Wodetzki, 2019). Chermack and Kasshanna claim that SWOT-Analysis is “poorly used to justify courses of action that have already been decided and is often disconnected from other parts of the strategy process“ (2007, p. 396). This report has the aim to analyze web-based CBT-I and the hospital setting in order to choose and adapt a web-based CBT-I approach to the hospital personnel. On this basis, decisions about further occupational health actions can be derived.

Instruments

For the analysis of the hospital setting, the PSQI questionnaire is used to measure the quality of sleep of the last four weeks in the staff of the exemplary hospital. 18 Items can be assigned to one out of seven dimensions, such as sleeping time, quality, efficiency, daily tiredness, medications, sleep disorders and delay of falling asleep. Each item can have a value between 0 and 3 depending on the occurrence of symptoms during the last four weeks (from 0=no symptoms to 3= three times or more often). In the end, a total score between 0 and 21 can be calculated which assesses non-physiological sleep behavior with a score between six and 21, while a lower score represents “good sleep”. There are different reasons for using a well-known international questionnaire. First of all, the time investment for conducting a new questionnaire would exceed possibilities. Additionally, the quality criteria of an existing questionnaire would deliver more reliable results. Test-retest reliability using correlation analysis for the total score showed satisfying results between 0.86-0.9 for patients with primary insomnia in the German version (Backhaus et al., 2001). Cronbach‘s alpha shows 0.7 and 0.78 in two different studies for sleep disorders, which means a medium good up to good internal consistency for the

questions of the questionnaire (Carpenter et al. 1998, Doi et al. 2000 cited by dgsm, 2007). The validity of the PSQI showed a sensitivity between 80 and 100% and specificity between 83-87% (dgms, 2007). Standardization is only given through the cut-off value of the total score of five, set by the study from Buysse et al. (1989) using the English version. In the German version, 32.1% of the sample size of 1049 reaches scores above five and are assigned to “poor sleepers“ (Zeitlhofer et al., 2000). These findings fit into the results of Schlack et al. that nearly one third (27.6%) of the German population experiences problems falling asleep at least once a week (2013). As there are only a few studies given for the test quality criteria of the German version, the results should only be seen as an indication of sleep disorders. Nevertheless, enough quality criteria are given for the English version and studies using the German version tend to show similar results. PSQI results of the exemplary hospital are used to derive sleep-related information of hospital employees. In addition, two interviews with an HR Manager and a nurse provide further information about the applicability. The HR Manager provides insights into the planning, implementation and difficulties of such a project, while the nurse can give information about the practical use, requirements and preference representative for the profession. The results are used as a basis for the SWOT-Analysis of web-based CBT-I and its applicability to hospital personnel.

The SWOT-Analysis is a common instrument for the strategic alignment of a company or process. It is based on an internal analysis of strengths and weaknesses and on an analysis of external opportunities and threats. (Wodetzki, 2019). As it is used to adapt the internal strategy to external circumstances, thus it can be transferred to an intervention analyzed towards the fitness to a particular setting.

5. Results

The following chapter includes a brief overview of studies analyzed in the Literature Review (Chapter 5.1.1) and concisely summarizes the most important results (5.1.2), followed by an analysis of the applicability of web-based CBT-I in the hospital setting (chapter 5.2)

5.1 Systematic Literature Review

5.1.1 Study Overview

17,610 articles were found using the search terms given in Appendix 2, of which 260 were screened by title or abstract. As Google Scholar search ended in a number of 17,400 records, only the first 50 were screened by title and abstract ordered by most relevant records. After 20 records, no relevant articles could be found, therefore the search was set to 50. After screening for title and abstract, 105 articles were left, which were reviewed by full text. 90 studies were excluded due to another target group (n=15), organic cause for insomnia (n=21), another intervention or outcome than sleep-related (n=37), other study design than RCT (n=3) and duplicates (n=14). Therefore, 15 articles met inclusion criteria and were included in the review.

General study information is given in Table 2, further details are listed in Appendix 1. All articles are randomized controlled trials analyzing any kind of web-based CBT treatment group comparing it to a non-treated or other treated group. Sample sizes vary between 48 to 623 and include either no specified group or a certain target group (employees, university students, teachers). All participants report insomnia symptoms, either self-identified or diagnosed. Interventions vary between two-armed (n=11) and three-armed (n=4) study designs. Comparisons vary between web-based CBT-I compared to (waitlist) controls (n=9), face-to-face CBT (n=3), paper-and-pencil CBT-I (n=1), active control conditions such as treatment as usual/online patient education (OPE) (n=3) or similar treatment not including CBT components (placebo treatment or anxiety treatment) (n=2). Treatment as usual, online patient education and active control groups represent a more realistic view of comparison, as in reality persons being affected by insomnia, seek help at a physician or on the internet. Treatment as usual include treatment by a physician and prescription (Espie et al., 2012). Online patient education comprises basic information about insomnia without CBT components to ensure a more realistic comparison to CBT (Ritterband et al., 2016). Active controls involve basic information, as well as general treatment components of less empirical proven contents such as relaxation, sleep hygiene and mindfulness (Kaldo et al., 2015). One study compares web-based CBT-I with E-Mail support and without support (n=1). Long-term effect (≥3 months) is analyzed by eleven

articles of which only three carry out one-year (or 48 weeks) follow-up measurements. The sleep-related outcome is mainly measured with sleep diaries, ISI, SCI or PSQI resulting in details about sleep efficiency, sleep onset latency, waketime after sleep onset, number of awakenings, insomnia severity, sleep condition or sleep quality. The majority of secondary outcomes focus on quality of life, anxiety, depression, absenteeism/presenteeism, safety behavior and dysfunctional beliefs. All articles report significant differences in group comparisons in at least one of the outcomes measured.

The quality assessment ranged from 7 to 11 on a scale of 12 maximal points. The average score for the RCTs was 9.13 points. Further information on the critical appraisal is given in Appendix 3. The following table presents the main information about the articles used for the review. Additional characteristics of the articles (e.g. recruitment, name of the intervention, treatment duration, measurement tools, etc.) are given in Appendix 1.

Table 2: Study Synopsis

(m=month, y=year, w=week, IG=intervention group, CG=control group, aCG=active control group, WL=waitlist control group, OPE=online patient education TAU=treatment as usual, ES=effect size, SCI=Sleep Condition Indicator, ISI=Insomnia Severity Index, f2f=face-to-face therapy, oCBT-I= online Cognitive Behavioral Therapy for Insomnia; ppCBT=paper-and-pencil CBT; IRT=Image Relief Therapy; f-u=follow-up; QoL=quality of life, PSQI= Pittsburgh Sleep Quality Index, SE= sleep efficiency, SOL= sleep onset latency, WASO= waketime after sleep-onset, TST= total sleep time, NWAK= number of awakenings, TWAK= terminal wakefulness, SQ= sleep quality, TWT= total wake time, TIB= time in bed)

Reference	N	Target group	Intervention	f-u	Sleep outcome: Primary (& secondary)	Results about Effectiveness
Bostock, 2016	270	U.S. employees (mainly working in the office)	oCBT, WL	3m	SCI: sleep quality & nightime/daytime symptoms, (sleepiness, presenteeism, absenteeism, anxiety, patient health)	- oCBT: ES for SCI d=1.1 - WL: d=0.34 - Sign. interaction effect - presenteeism: 15.4% reduction (d=0.64 compared to WL d=0.09) - absenteeism: no effect
Lancee 2016	90	Netherlands	F2f CBT-I, oCBT-I, WL	3m, 6m	Insomnia severity (ISI), Anxiety, SE, TWT, SOL, WASO, TWAK, NWAK, SQ	- Online & f2f intervention: large effects in ISI (d=1.0 and 2.3), TWT, SE and anxiety compared to WL - F2f sign. more effective than oCBT: severity (d=0.9), depressive symptoms (d=0.7)
Espie 2012	164	UK	oCBT with virtual therapist, IRT/placebo, TAU	8w	SE (SOL, WASO, TST, TWT, SCI, SQ, daytime performance, daytime social functioning)	- Main effect of time and interaction effect for CBT compared to TAU and IRT (f-u: remained results) - SE: large ES for CBT compared to TAU & IRT - Sign. changes in: SE, SOL, WASO, TWT, TST, SQ, SCI, daytime performance, daytime social functioning - Placebo (IRT) achieves small to moderate effects, CBT achieves moderate to large

						effects - Large ES of comparison CBT-TAU - Large ES of CBT-IRT - Small ES of IRT-TAU
Ritterband 2016	303	USA	oCBT, OPE	6m & 1y	ISI, SOL, WASO, (SE, NWAK, SQ, TST)	- Sign. Interaction effect for ISI, SOL & WASO - Large time effect for IG - 1y-f-u: larger improvement on ISI (d=2.32), SOL (d=0.95) & WASO (d=1.41) in IG than in OPE (d=1.53, 0.64, 0.86) - SE, NWAK, SQ: larger effect in IG
vanStraten 2014	118	Netherlands	oCBT, WL	3m	SE, TST, SOL, NWAK (SQ, duration, medication, anxiety, depression, QoL)	- Large ES (d=0.57-1.06) on SQ, TST, SE, soundness & QoL - Medium ES for NWAK, feeling refreshed, anxiety & depression (d=0.4-0.54) - No effect on SOL
Vincent 2009	118	Canada	oCBT, WL	4w	ISI, MFI, SQ, TST, SOL, WASO, NWAK, medication (pre-sleep arousal, beliefs/attitudes about sleep)	- Sign. Interaction effect: SQ, MFI, ISI - SQ, ISI improved from pre to post and pre- to f-u - MFI improved from pre-post - Medium ES: TST, SQ, SOL, NWAK, SE, MFI, pre-sleep arousal - Large ES: ISI, beliefs/attitudes about sleep
Holmqvist 2014	73	Rural Canadian area	oCBT, telehealth CBT (group sessions)	8w	ISI (TST, SOL, SE, NWAK, WASO, SQ, daytime fatigue, dysfunctional beliefs about sleep, work and social impairment)	- Sign. more drop-outs in web-intervention - Sign. time effects for all variables: changes in both groups - Sign. group effect: better SQ in web-IG - No sign. diff. in treatments
Horsch 2017	151	Netherlands	CBT App, WL	3m	ISI, SQ, SOL, WASO, NWAK, SE, TST, beliefs/attitudes about sleep, depression, anxiety	- Sign. improvements of ISI (d=-0.66) and SE (d=0.71) at post-intervention - Sign. improvement: WASO, NWAK, PSQI, depression, anxiety & depressive symptoms - No improvement: SOL, wakefulness, TST, TIB, dysfunctional beliefs/attitudes
Thiart 2015	128	German teachers in Nordrhein-Westfalen	oCBT with mail support, WL	6m	ISI (work related rumination, SE, recuperation, absenteeism, presenteeism, recovery, user satisfaction	- High participation rate (92.2%) and satisfaction (91%) - Severity of IG decreased sign. more than CG (d=1.45) - Sign. improved SE (d=-0.47), recuperation in sleep (d=-0.77), work related rumination (d=0.73), worrying (d=0.75), recreational activities (d=-0.58), presenteeism (d=0.35 in f-u)
Blom 2015	N=48	Ostergötland County, Sweden	Group CBT, oCBT with mail support	6m	ISI (TIB, SOL, NWAK, waking up time, time standing up, SQ, SE, SOL, TST, SQ, depressive symptoms, medication)	- No interaction & group effect - Sign. effects for both groups in: SE, SOL, SQ, depression - improvements in CBT (not online): TST
Kaldo 2015	N=148	Sweden	oCBT, aCG	6m, 1y	ISI (SOL, WASO, SE, SQ, stress)	- oCBT-I sign. more effective than aCG - Sign. diff. in: ISI (d=0.85), medication, SE (d=0.59), SOL (d=0.35), SQ (d=0.45) - 12m f-u: no longer sign. diff. (active CG also decreased ISI)
Morris 2016	N=138	University students in UK	Anxiety CBT, insomnia CBT, CG	/	SQ, anxiety, depression	- Sign. increase in SQ (main effect of time) and interaction effect - Within-group ES d=1.04 - Between-group ES d=0.51

						- Anxiety program achieves similar results in SQ (d=0.87 & 0.55) - No improvement in CG
Lancee 2012	N=623	Netherlands	oCBT, ppCBT, WL	18w, 48w	TIB, time standing up, SOL, NWAK, WASO, medication, SE, TST, anxiety, depression	- Both IG equal effective - ES (d) for SLEEP-50: oCBT=-1.44, ppCBT=-1.32, WL=-0.47 - ES for SE: oCBT=-0.95, ppCBT=-0.93, WL=-0.37 - Large ES for: SE, WASO (both IG) - Moderate ES for: TST, SOL, NWAK, depression, anxiety (both IG) - 48w f-u: similar results
Lancee 2013	N=262	Netherlands	oCBT with mail support, oCBT without support	6m	TIB, time standing up, SOL, WASO, NWAK, SQ, preceding day, TST, SE (medication, ISI, depressive symptoms)	- Both IG improved outcomes: large ES in SE, WASO, SQ, ISI (d=0.41 – 1.55) - Larger effects in CBT with support: SE, SOL, WASO, ISI (d=0.3 - 0.49) - 6m f-u: effect remained for SE, SOL, ISI, depression (d=0.3-0.5)
Lancee 2015	N=63	Netherlands	oCBT, WL	3m, 6m	ISI, safety behavior, dysfunctional beliefs, anxiety, depression, SE, TST, SOL, WASO, wakefulness, NWAK, SQ	- Interaction effect for severity, SE, WASO, SQ, dysfunctional cognition, SE, safety behavior, depressive symptoms - Between-group comparison: moderate ES depression (d=-0.5), large ES ISI (d=-1.05), dysfunctional beliefs (-1.49), sleep safety behavior (-0.97), SE (1.0), WASO (-0.91), SQ (0.79) - no sign. interaction effect: TST, Anxiety, SOL, wakefulness, NWAK - sign. mediating factor: safety behavior - maintained/ improved effects at 6m f-u

Referring to the table given before, a brief study synopsis and a description of study procedures is given in the following.

Bostock and colleagues (2016) analyze digital CBT for insomnia by comparing the intervention group (n=135) with waitlist controls (n=135) in a large U.S. company with office jobs mainly. The intervention is called *Sleepio* including a website and an application. It comprises an animated therapist guiding through the six-week program in an interactive way, including individual sleep analysis and E-Mail or text message reminders. All participants have self-identified sleep problems with no significant difference in characteristics in the groups at baseline. 73% of participants in the treatment group completed the intervention. An interaction effect of SCI results is given ($F(1,485)=15.63$, $P<0.0001$]). Large effect size is given in the intervention group ($d=1.1$, $p < 0.0001$), while waitlist controls show small effects ($d=0.34$). Beside the main outcome, presenteeism shows improvements in the intervention group, while absenteeism indicates no differences. Follow-up data suggests maintained improvements in the uncontrolled intervention group after three months. Beside the lack of blinding, the lack of a comparable treatment condition and no long-term follow-up, critical appraisal reaches good quality assessments.

Lancee et al. (2016) examine a six- to eight-week web-based CBT-I compared to face-to-face CBT and waitlist controls (n=90). Included participants are diagnosed with insomnia with an ISI score of ten or higher, excluding psychiatric comorbidities, shift work, previous therapy and other conditions. Treatment conditions include similar content. Web-based CBT-I offers feedback on exercises and sleep diary via E-Mail. Both, web-based ($d=1.0$, $p < 0.001$) and face-to-face treatment ($d=2.3$, $p < 0.001$), result in large effect sizes for insomnia severity. Anxiety and depression measurements, as well as sleep diary outcomes, yield large effect sizes. Between-group comparison of the intervention groups shows a significantly larger effect in face-to-face treatment than the online condition regarding insomnia severity, except for sleep diary outcomes at post-treatment. Lack of blinding, small sample size and the influence of different time investments in treatment groups comprise bias, still showing an acceptable methodological appraisal.

Espie and colleagues (2012) assess the efficacy of web-based CBT-I, placebo treatment and treatment as usual with a number of participants of 164 adults in total. Online treatment is based on *Sleepio*, presented by a virtual therapist which is used by Bostock et al. as well. To minimize bias of presentation of content and expectation bias, placebo treatment and treatment as usual is used as a comparison. Placebo treatment comprises the same virtual presentation of content as the treatment group but includes only basic information about sleep and non-scientifically proven exercises. Treatment as usual allows access to medical treatment by physicians and prescription of medication to ensure a more realistic comparison to treatment groups. The main outcome of sleep efficiency and sleep-wake functioning shows better results in web-based CBT-I than in control conditions with SE improvements of 19.5% (95%CI, 15.3 to 23.7). In addition to a significant time effect and treatment x time interaction effect ($F4,304 = 15.97$, $P < 0.0001$), between-group comparison yields large effect sizes favoring CBT. In total, 82% of the participants in CBT condition completed all modules. Critical appraisal reaches a high score and good quality of the methods used.

The group of authors of Ritterband (2016) compares web-based CBT-I with online patient education by randomizing 303 adults into either the *SHUTI* group or into the group having access to online information about sleep and basic environmental and behavioral strategies improving sleep. Short-term analysis shows a significant interaction effect in insomnia severity ($F3,1063 = 20.65$, $P < .001$), SOL ($F3,1042 = 6.01$,$P < .001$) and WASO ($F3,1042 = 12.68$, $P < .001$) favoring *SHUTI* treatment, as well as remaining long-term effects. Limitation of different insomnia duration (on average ten years in IG, seven years in OPE group) and patient education group being disadvantaged by the poorly presented content may bias results.

Therefore, better results may not be associated with web-based CBT-I but with preparation and presentation of content.

Van Straten and colleagues (2014) analyze 114 participants by comparing a guided web-based CBT-I with waitlist controls resulting in large effect sizes for SQ, TST, SE, soundness of sleep and quality of life and medium effect size for NWAK, feeling refreshed, anxiety and depression. 14-week follow-up is measured in the intervention group only, which poses a limitation. Furthermore, groups are not similar in all characteristics at baseline, no power analysis is given and statistical analysis could include multilevel regression analysis and analysis of variance in addition to the t-Test and Chi-square test.

Lancee et al. (2012) observe that self-help online and paper-and-pencil approaches seem to have similar effects on sleep-related outcomes compared to a control group. For comparison of the online intervention and the paper-and-pencil version, a six-week online treatment is based on a simple website with the same content as the non-web-based approach. The results show similar improvements in both of the treatment conditions. The adherence rate is relatively low compared to other online treatments, though does not differ between online and paper-and-pencil condition. Long-term effects (48-week follow-up) are measured and show slightly better results for web-based treatment. The main limitation of this article is the simplicity of the web-based approach which decreases adherence.

Another RCT from Lancee as the first author (2013) sets the focus on E-Mail support in web-based CBT-I and compared two treatment groups (n=262). Weekly support leads to a higher completion rate and significantly higher effects on sleep-related measures ($d=0.3 - 0.5$, $p < 0.05 – p < 0.001$), as well as anxiety and depressive symptoms ($d=0.35 – 0.36$, $p < 0.01$), which stays significant for SE, SOL, insomnia symptoms and depressive symptoms ($d=0.3 - 0.5$, $p < 0.05 – p < 0.001$) at six-month follow-up. Due to the lack of a control condition in this study, the results should be interpreted with caution and in addition to the previously mentioned study.

Furthermore, Lancee and colleagues (2015) analyze mediating factors of the effectiveness of web-based CBT-I by comparing the treatment group with controls. Web-based treatment is based on the simple approach used by Lancee et al. (2013) and shows improved outcomes after treatment in terms of (interaction effects in) insomnia severity, SE, WASO, SQ, dysfunctional cognitions, safety behavior and depressive symptoms. These outcomes are maintained or improved at six-month follow-up, especially for insomnia severity, anxiety and depressive symptoms. In addition, they execute mediation analysis for variables showing an interaction effect, indicating that 94% of the effect of insomnia severity and sleep efficiency can be explained by dysfunctional beliefs and 92% by safety behaviors. Only 47.2% of the

participants completed all the modules. The main limitation is the small sample size of n=63 participants and the missing follow-up measurement in the control condition.

The RCT by Vincent et al. (2009) includes participants with chronic insomnia (n=118), randomizing them into web-based CBT-I treatment and waitlist controls. Insomnia severity, MFI and SQ show a significant interaction effect. Inclusion criteria are adults suffering from insomnia and daytime impairments for at least six months and more than three nights per week, not excluding comorbidities or psychiatric disorders if they are stable. Collected data is based on ISI, sleep diary, MFI and General Fatigue Scale. A limitation is the exclusion of internet use regarding sleep-related information in control participants, which fails to comply with reality. Furthermore, positive results are biased because the treatment is developed by the first author who wants to prove his treatment as effective. Besides, 67% of the participants have a medical or psychiatric diagnosis or take medication, which may influence results as well.

Holmqvist et al. (2014) include chronic insomnia patients as well. 73 adults living in a rural Canadian area, receive either telehealth treatment at a close clinic or web-based treatment at home. ISI as the main outcome as well as MFI, sleep diary measurements, dysfunctional beliefs, Work and Social Adjustment Scale (WSAS) are analyzed as secondary outcomes. The web-based treatment is the one developed by Vincent who is the second author in this study. Telehealth treatment is delivered in a separate room of a nearby clinic for each of the geographically separated 6-12 participants. Both groups participate in weekly 1.5-hour sessions in which group discussions and questions are a crucial aspect of the therapy. Results show significantly more drop-outs in the web-based intervention. Further outcomes show slightly larger improvements in SQ in the web-based group but in general, there is no significant difference in treatments. Small sample size, a different time investment in the groups, missing power analysis and a missing control group are the major limitations of this study.

The analysis of the *Sleepcare* program compared to a waitlist control group by Horsch et al (2017) includes 151 Dutch adults with mild insomnia. *Sleepcare* is delivered via an application on a mobile phone or computer comprising sleep progress, automated conversations and CBT components. ISI, dysfunctional beliefs, depression and anxiety are measured at post-treatment and three-month follow-up. The analysis shows medium effect sizes on interaction effects of insomnia severity and sleep efficiency as well as significant improvements in WASO, NWAK, PSQI, anxiety and depression. Although another treatment such as web-based or face-to-face treatment is not included, critical appraisal of this RCT states an appropriate methodological quality.

The RCT conducted by Thiart and colleagues (2015) focuses on work-related sleep impairments treated with web-based *Get.On Recovery* intervention. German teachers with diagnosed stress and insomnia (n=128) are analyzed on insomnia severity before and after treatment comparing online treatment with waitlist controls. The program achieves high participation and satisfaction rates and large effect size for ISI in the intervention group. SE, recuperation, work-related rumination, worrying, recreational activities and presenteeism changed as well. Beside the lack of statistical comparison of baseline characteristics in the groups and a missing treatment comparison, this RCT applies reasonable methods.

Another article (Blom et al., 2015) assesses the difference in insomnia severity for a guided online CBT-I compared to group-based CBT-I (n=48) through non-inferiority analysis using the confidence interval approach. Group treatment is executed by a therapist in two-hour sessions. In addition to CBT components, further aspects include questions, group discussions and a discussion of sleep diaries. The online treatment contains the same modules and offered therapist support via E-Mail. No interaction or group effect is found besides significant time effects for SE, SOL, SQ, depression in both groups. The main limitations of this article are the small sample size, the absence of a control group and the use of a large non-inferiority margin.

Kaldo and his colleagues (2015) evaluate an internet-delivered CBT for insomnia and compare it with an active control group. Participants (n=148) are randomized either to a control condition including therapy components with less empirical support and basic sleep information or to a guided web-based treatment, which is applied by Blom et al. The primary outcome of insomnia severity is measured at pre, post, 6- and 12-month follow-up. Results show the online treatment being more effective with significant differences in ISI, medication, SE, SOL and SQ. It should be noted that there cannot be seen differences towards active controls anymore at the 12-month follow-up. The limitations of this study include the lack of blinding and the lack of information about other treatments used by the active controls.

Another RCT (Morris et al., 2016) analyzes the difference in the effectiveness of insomnia and anxiety treatment. University students (n=138) are randomized into *Insomnia Relief, Anxiety Relief* or control condition. The main aim is to detect differences in the effectiveness, as well as side effects of the treatments on the other constraint. Outcomes are measured with PSQI and State-trait Anxiety Inventory, showing an increase in SQ and interaction effects in *Insomnia Relief* therapy. The anxiety program achieves an improvement of SQ as well. But *Insomnia Relief* does not achieve significant improvements in anxiety measurements. This study has been underpowered (power=0.68), only partly analyzed follow-up results and the main analysis is based on completer analysis, although intention-to-treat analysis (ITTA) is provided as well.

After introducing the analyzed studies, a closer look into the effectiveness of web-based CBT-I is given hereafter. Results are structured by outcomes.

5.1.2 Effectiveness of web-based CBT-I

Table 3 gives an overview of the given effect sizes found in the analyzed articles. Effect sizes are represented as no effect (-), small effect (+), medium effect (++) or large (+++) effect. Empty columns are based on missing effect sizes. Each of the outcomes is given as within-group effect sizes (effect from pre- to post-treatment within the intervention group) as well as between-group effect sizes (difference of effect comparing groups). Some articles are lacking for either within- or between-group comparisons. The between-group comparison must be interpreted with caution of control condition: Blom et al. and Holmqvist et al. used face-to-face or telehealth group CBT as a comparison (2015, 2014), while Lancee et al. compared web-based CBT with and without support (2013). The other articles refer to a waitlist control condition.

Table 3: Cohen's d Effect Sizes (ES) for Sleep-Related Outcomes in each of the Articles presented by Within-Group and Between-Group Comparison

Effect Sizes (ES): - no ES (d<0.2 or n.s.) // + small ES (d=0.2 - 0.49) // ++ medium ES (d=0.5 - 0.79) // +++ large ES (d≥0.8)

(wg= within-group effect size, bg= between-group effect size, WL= waitlist control group, ISI= Insomnia Severity Index, PSQI= Pittsburgh Sleep Quality Index, SCI= Sleep Condition Indicator, SE= sleep efficiency, SOL= sleep onset latency, WASO= waketime after sleep-onset, TST= total sleep time, NWAK= number of awakenings, TWAK= terminal wakefulness, SQ= sleep quality, TWT= total wake time, TIB= time in bed)

Outcome	**ISI**		**PSQI**		**SCI**		**SE**		**SOL**		**WASO**		**TST**		**NWAK**		**TWAK**		**SQ**		**TWT**		**TIB**	
Within-group / between-group effect (wg based on web-based CBT)	wg	bg	wg	bg	wg	bg	wg	bg	wg	bg	wg	bg	wg	bg	wg	bg	wg	bg	wg	bg	wg	bg	wg	bg
Bostock 2016					+++																			
Blom 2015*	+++						+++	-	+++	-			-	-	-	-			++	-	-	-		
Espie 2012**					+++	+++	+++	+++	++	+	+++	+++	++	-					++	++	+++	+++		
Holmqvist 2014*	+++	+					+++	-	++	-	++	-	+	-	+++	+			+++	+++				
Horsch 2017	+++	++	+++	++			+++	++	+++	+	+++	++	++	+	+	+	++	+	++	+			+	++
Kaldo 2015	+++	+++						++		+				-						+				
Lancee 2012							+++		++		++		+		+									
Lancee 2013***	+++	+					+++	+	++	+	+++	+	+	-	++	+			+++	-				
Lancee 2015	+++	+++					+++	+++	-	-	++	+++	++	-	-	-	++	-	++	++				
Lancee 2016 (bg comparison: WL)		+++					++	++	-	-	++	++	-	-	++	++	-	-	+++	++		+++		
Morris 2016			+++	++																				
Ritterband 2016	+++						+++						+		++				+++					
Van Straten 2014			+++	+++				+++		-				++		++								
Vincent 2009	+++																							
Thiart 2015	+++																							

* Comparison: face-to-face or group CBT

**Comparison: treatment as usual

***Comparison: support vs. no support (within-group effect sizes based on supported group)

Insomnia Severity

The ISI score is a commonly used tool to measure insomnia severity. In this review, most of the articles use ISI as one of the outcomes to assess sleep. Web-based CBT-I shows significant changes in insomnia severity compared to waitlist controls in all articles using ISI scores (Lancee et al., 2016, Ritterband et al., 2016, Vincent et al., 2009, Holmqvist et al., 2014, Horsch et al., 2017, Thiart et al., 2015, Kaldo et al., 2015). Effect sizes vary from d=1.08 ($p < 0.001$; Lancee et al., 2013), d=1.21 ($p < 0.001$; Lancee et al., 2015), d=1.33 ($p < 0.05$; Horsch et al., 2017), d=1.45 ($p < 0.001$; Thiart et al., 2015), d=1.56 ($p < 0.001$; Holmqvist et al., 2014), d=1.81 ($p < 0.05$; Blom et al., 2015), d=2.07 ($p < 0.05$; Kaldo et al., 2015), to d = 2.08 ($p < 0.05$; Ritterband et al., 2016). Effect sizes are referring to within-group effects of the treatment condition from pre to post-treatment. There is to say that the RCTs by Holmqvist (2014), Blom (2015) and Lancee (2015 & 2016) are based on small sample sizes. Nevertheless, articles with large sample sizes such as Ritterband (2016) and Lancee (2013) support large effects as well. For between-group comparisons, it should be mentioned that different control conditions are used in the articles. In general, between-group comparison yields small to large effect sizes. A small difference in effects can be found in an article with telehealth group CBT comparison (Holmqvist et al., 2014) and non-supported web-based CBT comparison (Lancee et al., 2013). All articles comparing web-based CBT-I with waitlist controls achieve medium (Horsch et al., 2017) to large effects (Kaldo et al., 2015, Lancee et al., 2015, Lancee et al., 2016). According to the conditions of comparison, non-CBT online education scores an effect size of d=1.37 ($p < 0.05$) for the ISI score (Ritterband et al., 2016), while comparison towards group-based face-to-face condition shows non-inferiority of the online treatment, although there is not given an effect size (Blom et al., 2015).

Comparing web-based CBT with telehealth CBT, including group-based online communication with a CBT therapist, there is no significant difference in insomnia severity (Holmqvist et al., 2014). Nevertheless, there is a significant difference towards face-to-face CBT (between-group comparison: d=0.9, $p < 0.001$) in favor of the in-person approach (Lancee et al., 2016). Whereas Blom et al. reveal similar changes of insomnia severity in both CBT groups: online and group CBT (2015). Comparing expert-supported with non-supported approaches, there can be seen a significant difference in ISI outcomes with a between-group effect size of d=0.44 ($p < 0.001$) as well as an improved SE, SOL and WASO (Lancee et al., 2013).

Looking at long-term effects on the severity of insomnia, the six-month follow-up shows better results in ISI change (≥8 points) for face-to-face CBT (73%) than for online treatment (48%) (Lancee et al., 2016). However, other articles observe no difference in severity index in face-to-face group CBT compared to online CBT (Blom et al., 2015). Kaldo et al. show realigned ISI

results for one-year follow-up comparing active controls and web-based CBT (2015), while Ritterband et al. find larger ISI changes in online CBT than in online patient education at one-year follow-up (2016).

Therefore, there is a clearly given effectiveness changing insomnia severity for intervention groups compared to controls. Though, contradictory results can be found with regard to the comparison towards face-to-face and group CBT, as well as about long-term changes.

SCI & SLEEP-50

Only a few studies analyze the Sleep Condition Indicator (SCI) or use the SLEEP-50 questionnaire for sleep assessment. While SCI detects all nighttime and daytime symptoms of insomnia based on the revision of classification to DSM-5 (Espie et al., 2014), SLEEP-50 measures not only insomnia symptoms but also sleep apnea and nightmares for instance (Spoormaker et al., 2005). Using SCI, Bostock and colleagues prove a large effect size for the treatment group compared to the control condition (2016). This result corresponds to Espie‘s measured large within-group effect size ($d=1.5$, $p < 0.05$), compared to an effect size of 1.0 ($p < 0.05$) in placebo treatment and 0.65 in the treatment as usual. The between-group comparison shows a large effect comparing CBT with placebo and treatment as usual (2012). Another study uses SLEEP-50 resulting in an effect size of $d=1.44$ ($p < 0.001$) for the web-based approach, compared to $d=1.32$ ($p < 0.001$) in the paper-and-pencil condition and $d=0.47$ ($p < 0.001$) in the control group (Lancee et al., 2012).

Summarizing this, these two tools measuring sleep and symptoms of sleep impairments reveal large effects in the treatment groups (Bostock et al., 2016, Espie et al., 2012, Lancee et al., 2012) but placebo treatment (Espie et al., 2012) and paper-and-pencil CBT-I achieve large changes in sleep outcomes as well.

Sleep Quality

Sleep quality is measured by PSQI and one section of the sleep diary. As it is mentioned in chapter 4.2, the Pittsburgh Sleep Quality Index represents 7 dimensions of sleep quality with a cut-off value for the identification of “poor sleepers”. Three of the analyzed articles use the questionnaire showing a significant change in sleep quality scores (van Straten et al., 2014, Horsch et al., 2017, Morris et al., 2016). Comparing pre and post-treatment (within-group) effect sizes, results vary from 1.04 (Morris et al., 2016) to 1.09 (Horsch et al., 2017), showing consistent

large effects. Between-group PSQI score differences of web-based CBT-I and (waitlist) controls vary from d=0.51 ($p < 0.05$; Morris et al., 2016), over d=0.77 ($p < 0.05$; Horsch et al., 2017) to 1.06 ($p < 0.01$; van Straten et al., 2014). From post-treatment to three-month follow-up, the effect size is 0.25 (van Straten et al., 2014).

In sleep diary measurements, sleep quality is measured as one of several aspects regarding sleep. Studies show different results regarding other sleep diary components, but all articles measure significantly improved sleep quality with medium to large effect sizes from pre to post-treatment in the intervention group (Espie et al., 2012, Ritterband et al., 2016, van Straten et al., 2014, Vincent et al., 2009, Holmqvist et al., 2014, Blom et al., 2015, Kaldo et al., 2015, Lancee et al., 2013, Lancee et al., 2015, Lancee et al., 2016). A comparison with the waitlist control group reveals a small (Horsch et al., 2017, Kaldo et al., 2015) to medium effect (Lancee et al., 2015, Lancee et al., 2016). Compared to face-to-face CBT (d=1.0; $p < 0.001$), online CBT (d=0.7; $p < 0.001$) demonstrates slightly less effectiveness in changing sleep quality being not significant (Lancee et al., 2016), consistent with non-significant differences in SQ observed by Blom et al. (2015). Treatment as usual, active controls or patient education are comparisons based on more realistic conditions, which show effect sizes from d=0.21 (p = n.a.; Espie et al., 2012) to d=0.53 ($p < 0.05$; Ritterband et al., 2016), compared to web-based CBT (d=0.77, $p < 0.05$; d=0.87, $p < 0.05$) still being significantly more effective. Placebo treatment using the same presentation of content but no inclusion of CBT components shows a moderate effect (d=0.47, $p < 0.05$) (Espie et al., 2012). Kaldo et al. do not provide effect sizes for the individual groups but only a small effect size (d=0.45, $p < 0.05$) for group differences (2015).

In conclusion, the above-mentioned results indicate unified effectiveness of web-based CBT-I on sleep quality. The odds ratio for control group participants scoring below the threshold of ≤8 at post-treatment is 16.5 higher than in the intervention group, whereas improved sleep quality (≥3) is 6.9 times higher in the intervention group (van Straten et al., 2014).

Sleep diary outcomes

The largest discrepancies can be observed in sleep diary measurements. Within-group comparisons in the intervention groups are consistent regarding sleep efficiency and sleep quality, which are represented by medium to large effect sizes (Blom et al., 2015, Espie et al., 2012, Holmqvist et al., 2014, Horsch et al., 2017, Lancee, 2013, 2015, 2016, Ritterband, 2016). In addition, between-group comparison reveals small to large effects for SQ and medium to large effects for SE in treatment groups compared to waitlist controls or treatment as usual (Espie et

al., 2012, Horsch et al., 2017, Kaldo et al., 2015, Lancee et al., 2015, Lancee et al., 2016). Studies using face-to-face CBT or telehealth group CBT for comparison reveal no significant difference for Sleep efficiency (SE) outcome comparing groups (Blom et al., 2015, Holmqvist et al., 2014, Lancee et al., 2016). Looking at web-based CBT with and without support, SE is higher in the supported intervention group with an effect size of $d=0.49$ ($p < 0.001$), as well as a decrease of insomnia severity and improved SOL and WASO (Lancee et al., 2013).

Sleep onset latency (SOL), measured in the treatment groups, achieves medium to large effect sizes in several articles (Blom et al., 2015, Espie et al., 2012, Horsch et al., 2017, Holmqvist et al., 2014, Lancee et al., 2012, Lancee et al., 2013), although no effect can be observed in two of Lancee's studies (2015, 2016). Lancee et al. state that web-based CBT has a medium effect of $d=0.6$-0.7 ($p < 0.05$) on WASO, NWAK and SQ compared to waitlist controls, while it has no significant effect on SOL and TWAK (2016). Between-group analysis indicates no (Lancee et al., 2015, 2016, van Straten et al., 2014) or small (Espie et al., 2012, Horsch et al., 2017, Kaldo et al., 2015) difference in effects on SOL comparing web-based CBT-I and waitlist controls or treatment as usual. There is no difference towards face-to-face CBT-I (Blom et al., 2015, Holmqvist et al., 2014).

Waketime after sleep onset (WASO) achieves medium to large effects for within-group measurements of the treatment groups (Espie et al., 2012, Holmqvist et al., 2014, Horsch et al., 2017, Lancee et al., 2012, 2013, 2015, 2016). Compared to waitlist controls, active controls or TAU, WASO shows larger effects in treatment groups (Espie et al., 2012, Horsch et al., 2017, Lancee et al., 2015, 2016). Furthermore, no different effect is found comparing a web-based and an in-person approach (Holmqvist et al., 2014) whereas a small effect is given comparing a supported and non-supported web-based approach (Lancee et al., 2013).

The number of awakenings (NWAK) decreases from pre- to post-treatment in most of the studies with small to large effects (Holmqvist et al., 2014, Horsch et al., 2017, Lancee et al., 2012, 2013, 2016, Ritterband et al., 2016). These results are contrary to non-existent within-group effects in Blom's and Lancee's articles (2015, 2015). Compared to control groups there are inconsistent results from no effect (Lancee et al., 2015), over small effect (Horsch et al., 2017) to medium effect (Lancee et al., 2016, van Straten et al., 2014). Comparison with in-person treatment shows discrepancies as well: no effect (Blom et al., 2015) as well as small effect (Holmqvist et al., 2014). Differences in supported and non-supported groups are small (Lancee et al. 2013).

Terminal wakefulness (TWAK) is only measured by three groups of authors, of which two result in no significant effect compared to the control group (Lancee te al., 2015, 2016) and one resulting

in a small effect (Horsch et al., 2017). Within the intervention groups, no effect (Lancee et al., 2016), as well as a medium effect (Horsch et al., 2017, Lancee et al., 2015) is described.

TST, TWT, TIB and TWAK are not examined in many studies because some CBT components are based on sleep restriction. Therefore, the effect regarding those variables is limited. Instead, these measurements are used to assess SE, which represents time sleeping in relation to time spent in bed. Nevertheless, TST, TWT and TIB are analyzed by some of the RCTs. TST is measured with no effect (Blom et al., 2015, Lancee et al., 2016) or small to medium effect (Espie et al., 2012, Holmqvist et al., 2014, Horsch et al., 2017, Ritterband et al., 2016, Lancee et al., 2012, 2013, 2015) from pre to post-treatment. In comparison of groups, TST shows no effect (Espie et al., 2012, Kaldo et al., 2015, Lancee et al., 2015, Lancee et al., 2016) or small and medium effect (Horsch et al., 2017, van Straten et al., 2014) comparing CBT to control group/TAU. Face-to-face and telehealth treatment demonstrate no difference towards web-based approaches (Blom et al., 2015, Holmqvist et al., 2014, Lancee et al., 2016). TWT does not change during treatment in one study (Blom et al., 2015) and reveals large effects in another (Espie et al., 2012). Further, no effect can be seen in comparison to group-based CBT (Blom et al., 2015) and large effect can be found compared to waitlist or treatment as usual (Lancee et al., 2016, Espie et al., 2012). TIB is analyzed by one article revealing a small effect of time and a medium effect of groups (Horsch et al., 2017).

Looking at eight weeks and six-month follow-up, all achievements remain similar to post-treatment (Horsch et al., 2017, Blom et al., 2015, Espie et al., 2012, Kaldo et al., 2015), but NWAK increases again in a study conducted by Horsch and colleagues (2017). Active controls no longer show significantly different results at one-year follow-up, which they do at six-month measurement (Kaldo et al., 2015). Other articles with one year follow-up support long-term effects (Lancee et al, 2012, Ritterband et al., 2016) with sustained large effects in Insomnia Severity Index ($d=2.32$, $p < 0.05$), SOL ($d=1.41$, $p < 0.05$) and WASO ($d=0.95$, $p < 0.05$) (Ritterband et al., 2016) and Insomnia SLEEP outcome and SE ($d=0.94$, $p < 0.01$) (Lancee et al., 2012).

Summing up the findings of sleep diary outcomes, SE and SQ achieve medium to large effect sizes within the groups of intervention and small to large effects in comparison with waitlist controls or treatment as usual. However, there can be seen no between-group difference towards face-to-face and group CBT for SE. SOL and WASO are found to be decreased after online treatment in the majority of studies, although SOL reveals no difference in three of the articles. TST, TWT and TIB appear to be contradictory outcomes ranging from no effect to large effects after CBT-I treatment.

Secondary Outcomes

Secondary outcomes differ between the analyzed articles but the majority of them include depressive symptoms and anxiety. Depressive symptoms significantly decrease during web-based CBT-I treatment with a medium effect (van Straten et al., 2014, Horsch et al., 2017, Blom et al., 2015, Lancee et al., 2012, Lancee et al., 2013, Lancee et al., 2015). Larger effectiveness is achieved through face-to-face treatment (Lancee et al., 2016), but equal effectiveness can be seen in group CBT (Blom et al., 2015). Depressive symptoms are influenced by *Insomnia Relief,* as well as *Anxiety Relief Therapy* (Morris et al., 2016).

With regard to anxiety scales, there are found medium to large effects (van Straten et al., 2014, Lancee et al., 2012, 2013, 2016, Horsch et al., 2017) with higher effect sizes in face-to-face CBT than web-based CBT (Lancee et al., 2016). Lancee et al. do not reveal a significant interaction effect for anxiety symptoms (2015), as well as Morris et al. (2016). Morris and colleagues compare an anxiety program with an insomnia program finding no effects of insomnia treatment on depressive symptoms, whereas there are positive sleep-related effects in anxiety treatment (2016). Besides, an E-Mail supported program achieves a significantly higher effect in anxiety measurements than a non-supported program (Lancee et al., 2013).

As already described in previous chapters, sleep disturbances can influence work-related performance. Some articles assess aspects like fatigue, presenteeism, absenteeism and daytime sleepiness as secondary outcomes. The Multi-Dimensional Fatigue Inventory (MFI) for instance, reveals improvements in daytime fatigue with medium within-group and large between-group effects and no improvement in control condition (Vincent et al., 2009), whereas Holmqvist reveals a large within intervention group effect (d=0.91, p = n.a.) and very small effect comparing groups (d=0.11, p = n.a.) (Holmqvist et al., 2014). In line with these results, daytime sleepiness improves with an effect size of d=0.4 compared to d=0.02 (p = n.a.) in the control condition (Bostock et al., 2016). Bostock et al. achieve a reduction of 15.4% of presenteeism (d=0.64 compared to d=0.09 of waitlist controls; p = 0.001;) (2016), consistent with slightly smaller effects in Thiart's article (2015). In addition to the sleep outcomes, web-based CBT significantly changes daytime performance and daytime social functioning with small effect sizes compared to placebo treatment (Espie et al., 2012). Referring to that, work and social impairment improves significantly in all groups but achieves the largest effect in telehealth treatment (Holmqvist et al., 2014). Rumination and recuperation of sleep, including restorative sleep, recreational activities and recovery experiences, benefits significantly from the treatment *Get.On Recovery* (Thiart et al., 2015). Safety behavior is also found to be influenced by web-based CBT-I as a significant mediating factor (Lancee et al., 2015).

As cognitive strategies are a major part of CBT for insomnia, cognitive outcomes are measured in some articles. Significant changes are observed in dysfunctional beliefs and attitudes about sleep in the intervention groups (Vincent et al., 2009, Lancee et al., 2015). No improvements are found in Horsch and colleagues' article, whose treatment does not include cognitive components (2017). Holmqvist describes an assessment of DBAS-10 as well but does not provide any results (2014). Pre-Sleep Arousal Scale, which is “an 8-item measure of cognitive hyperarousal associated with insomnia“, achieves medium effects (Vincent et al., 2009, p. 809).

The use of medication does not change during treatment and does not differ in comparison of groups in Vincent’s RCT (2009) but it is reduced in both groups of Holmqvist’s analysis (2014). Lancee and colleagues reveal a slight decrease in medication use until 48-week follow-up in both intervention groups (2012).

Stress is reduced from pre to post-treatment and to follow-up measurements, but it does not differ between web-based CBT and active controls (Kaldo et al., 2015). Furthermore, quality of life shows medium effect sizes in the comparison of groups ($d=0.58$, $p = 0.04$) with ongoing small improvements ($d=0.21$, p = n.s.) from post-test to follow-up measurements (van Straten et al., 2014).

In view of all non-sleep-related outcomes, especially depressive symptoms seem to benefit from web-based CBT-I with medium effects represented in the articles of this review. Most of the studies present medium to large effects in anxiety measurements with higher effect sizes in favor of face-to-face CBT. A tendency of positive effects on beliefs and attitudes about sleep or dysfunctional beliefs is found in the majority of the articles. Looking at outcomes such as fatigue, presenteeism, daytime sleepiness, daytime performance and social functioning, a mostly consistent tendency of positive effects can be seen.

Features and Completion Rate

The large variability of outcomes leads to the suspicion that the features and characteristics of the approaches influence the outcome tremendously. Referring to the sleep-related outcomes, face-to-face and in-person group CBT achieve similar (Blom et al., 2015, Holmqvist et al., 2014) or larger effects than web-based CBT (Lancee et al., 2016). Placebo treatment with a virtual therapist yields improved results, e.g. in WASO, but not as large effects as the web-based CBT approach (Espie et al., 2012). CBT-I, which is used as an application, achieves similar effect sizes compared to other studies using website-based treatments, although the completion rate is quite low for the application (61% completion of questionnaires) (Horsch et al., 2017). Website-

based programs achieve completion rates of 60.3% to 92.2% (Ritterband et a., 2016, Thiart et al., 2015).

Additional features maximizing the effect and completion rate could be supported by an expert or automated reminders. Comparing programs with and without E-Mail support from experts, the supported approach leads to significantly better results in SE, SOL, WASO, NWAK, insomnia severity, depression and anxiety (Lancee et al., 2013). Looking at all approaches used in the 15 articles analyzed, only the program *Return2sleep* is not covering any kind of support or reminders (Vincent et al., 2009, Holmqvist et al., 2014). Its analysis shows a much higher drop-out rate for *Return2sleep* compared to telehealth treatment (Holmqvist et al., 2014) with adherence rates from 22.6% to 76.8% in the different modules (Vincent et al., 2009). Approaches using automated homework and diary reminders but no other support, achieve high participation rates from 60.3% (Ritterband et al., 2016), over 61% (Horsch et al., 2017) to 81.2% (Morris et al., 2016). Approaches using any kind of support by experts, as well as reminders, yield rates from 73% (Bostock et al., 2016), over 82% (Espie et al., 2012) to 92.2% (Thiart et al., 2015) at post-treatment. Not only the different web-based programs differ regarding the completion rates but also in-person and web-based approaches. Adherence is lower in web-based CBT than in face-to-face treatment in two of the articles (Holmqvist et al., 2014, Blom et al. 2015) but the same in another (Lancee et al., 2016). Between web-based CBT and paper-and-pencil CBT, there is no difference in completion rates (Lancee et al., 2012). Homework completion is analyzed seldomly but reaches 66% in face-to-face telehealth CBT compared to 73.7% of web-based CBT in one of the studies (Holmqvist et al., 2014).

Before starting intervention, treatment preference is in favor of the face-to-face intervention (77.8%), compared to online treatment (52.2%), treatment by a general practitioner (43.3%) and medication use (15.6%) (Lancee et al., 2016). Satisfaction analysis shows no significant difference of web-based CBT and face-to-face CBT (Blom et al., 2015, Holmqvist et al., 2014), contrary to significantly different satisfaction rates in favor of face-to-face treatment in the study of Lancee and colleagues (2016). Satisfaction is very high in the treatment *Get.On Recovery* by Thiart et al., which achieves a participation rate of 92.2% (pre- to post-treatment) and a satisfaction rate of 91% (2015).

To sum it up, adherence is either the same or lower in web-based CBT than in face-to-face treatment. Support via messages or E-Mail has a large influence on completion rates and even on the sleep-related outcome. Approaches including expert support and automated reminders achieve the largest adherence rates. Satisfaction analysis shows contradictory results of either no

difference in web-based CBT compared to face-to-face CBT as well as a higher satisfaction in face-to-face.

5.2 Applicability to the Hospital Setting

A cross-sectional survey of the sleep quality among the employees of an exemplary hospital can indicate to what extent the staff is affected by sleep disorders in general. This survey includes 57 results of the Pittsburgh Sleep Quality Index (PSQI) questionnaire, which is used by some of the studies included in the review. Besides, the survey includes information about the field of work (profession), shift work, age and sex to examine possible associations between influencing factors and sleep disabilities. After assessing the sleep quality of the exemplary hospital, a SWOT-Analysis and derivation of strategies are executed.

5.2.1 Analysis of the Hospital Setting

Hospital Setting

Looking at the employees of this exemplary hospital, the mean age is 38,63 based on the cross-sectional survey made (n=59) with normality given in 1 of 2 tests for normality (see Appendix 5). 71.2% of the employees are female and 28.8% are male. 44.1% of the sample is working in shifts (52.5% no shift work, 3.4% n/a). The different fields of jobs are displayed in the following Figure 2, showing medical occupations as the largest proportion of the professions, followed by office workers. In total, 34% of the sample could be assigned to the field of nursing and medical jobs (including nursing, MFA/MTA, functional area profession), while hospital management states 55% working in that field. The underrepresentation of this group in the survey may be assigned to the limited time for breaks and thus for filling out the questionnaire. Distribution of shift work in the fields of work (Appendix 4) demonstrates that shift work is most common in nursing and medical jobs as well as GPA and service. Office jobs are mainly no subject to shifting schedules. Further descriptive information can be found in Appendix 4.

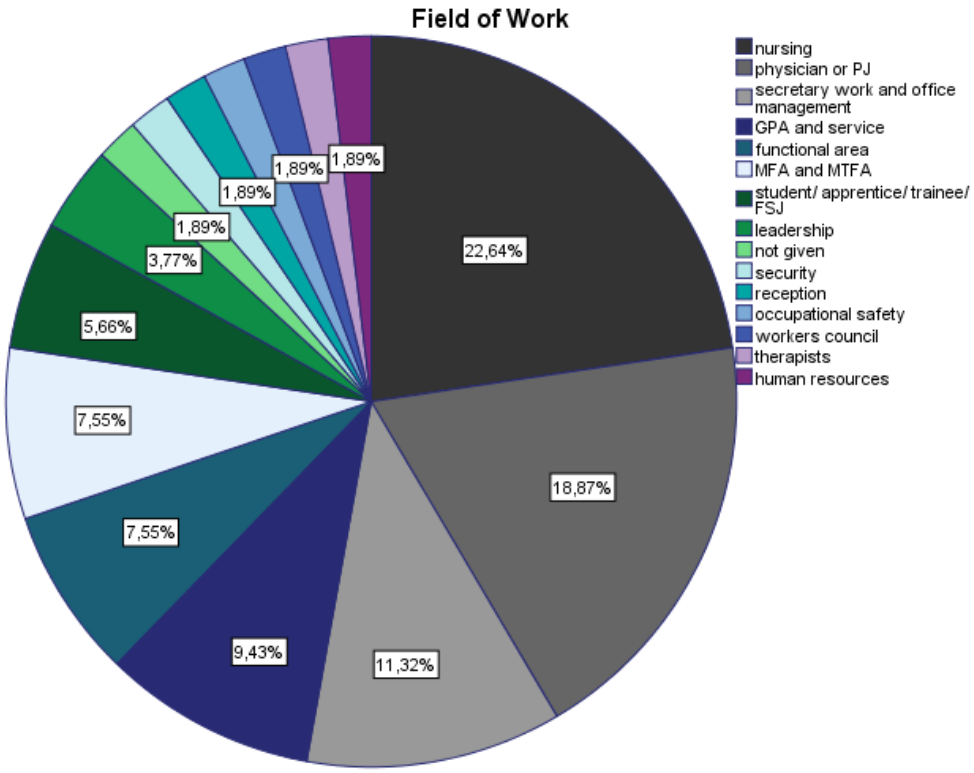

Figure 2: Relative Frequencies of the Field of Job in the Exemplary Hospital

Employee's Sleep Behavior and Influencing Variables

In this sample, 67.8% of the employees show a PSQI score above five, being a "poor sleeper". Only 32.2% can be classified as "healthy sleepers". The mean PSQI score is 7.034 (see Appendix 4). The variables sex, age, shift work and profession are analyzed towards its influence on the PSQI total score and PSQI components (sleep quality, sleep (onset) latency, duration of sleep, sleep efficiency, disorders, medication and tiredness).

The variable sex shows a small correlation ($r=0.317$) towards the total score of the PSQI questionnaire executing the Pearson correlation (Appendix 6.1). Looking at the Chi-square test, the PSQI component sleep efficiency and the total PSQI score show a significant association with sex ($p<0.05$), which fits into the results of the Mann-Whitney-U Test (Appendix 6.1).

Age is not correlating with the total score of PSQI and PSQI components (see Appendix 6.2). The components of the questionnaire are based on a non-parametric correlation analysis because of its ordinal scale (0 to 3). The total score correlation is analyzed with Spearman and Pearson correlation, neither being significant.

The point-biserial correlation and the t-Test are made on the basis of normal distribution in both of the shift groups (Appendix 5). Looking at the relationship between shift work and quality of sleep (PSQI total score ranging from 0 to 21), there is a small significant correlation of r=0.271 ($p<0.05$) executing the Pearson correlation (see Appendix 6.3). T-Test as well reveals a significant difference in the total PSQI score in the two shift groups (p=0.042, df=55, t=-2.084) (Appendix 6.3), illustrated in Figure 3. As the individual PSQI components have a smaller range (0 to 3), correlation analysis and t-Test could not be executed and non-parametric tests are used instead. As it is shown in the independent sample t-Test in Appendix 6.3, the components sleep latency, sleep duration and total score are significantly different in the shift groups. As the groups are slightly smaller than 30 and the subscales are only ordinal, non-parametric analysis (Mann-Whitney-U test) is executed additionally, showing significant differences in shift groups for sleep latency and duration of sleep but not for the total score (Appendix 6.3). The Chi-square test of shift work and PSQI components shows non-significant results (Appendix 6.3).

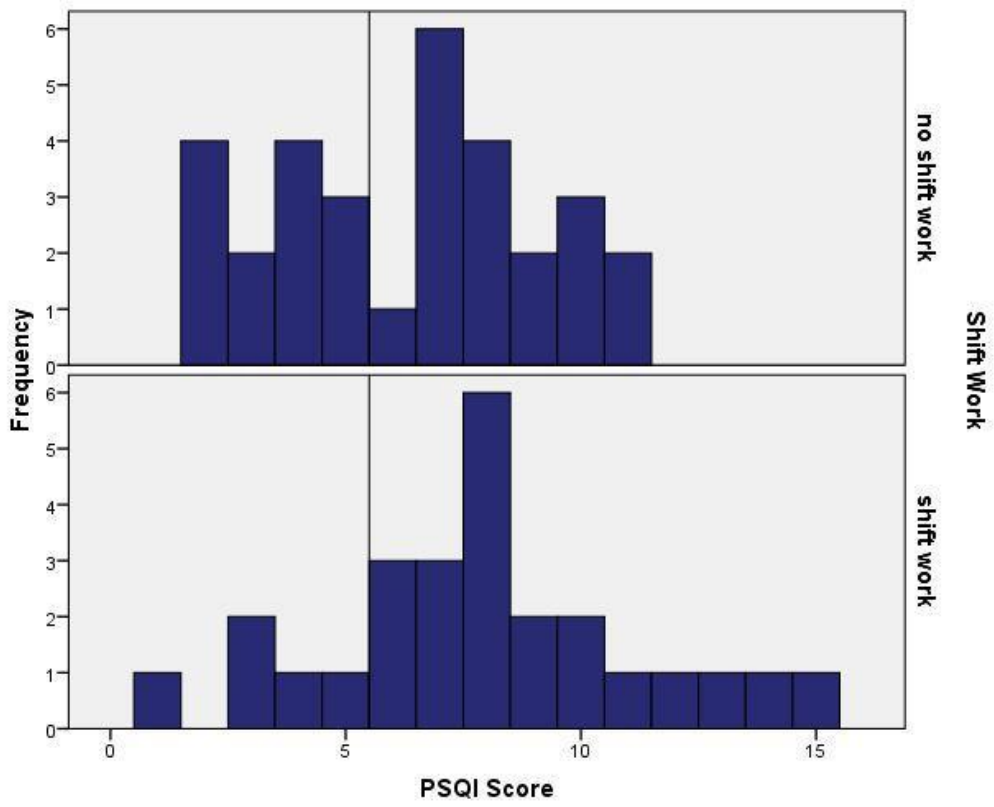

Figure 3: Frequency Distribution of the PSQI Total Score in Relation to Shift Work (cut-off value: 5, showing "poor sleepers" with a value above 5)

The variable field of work (profession) may be another factor influencing the quality of sleep and thus, is worth to be analyzed as well. Using analysis of variance, all 53 cases that provided information about the field of work are included in the one-way ANOVA. Analysis of the total score comparing job groups shows a non-significant difference (p=0.365) in the groups. Since some of the job fields include only one participant, broader groups were defined and analysis of variance is carried out again with a result of a non-significant difference (Appendix 6.4). Even if the result is not significant, differences in the average PSQI score can be observed in the job groups (comparison in Figure 4). The largest mean of PSQI scores can be found in safety and security work ($\bar{x}$ =9.25), followed by GPA and service personnel ($\bar{x}$ =8.5) (Figure 4 below). Means of office work ($\bar{x}$ =7.8), nursing jobs ($\bar{x}$ =7.5), juniors ($\bar{x}$ =6.2) and management jobs ($\bar{x}$ =5.33) are above the cut-off value of five and therefore have an unphysiological sleep quality as well. Physicians and physicians in their practical year (PJ) is the only group having a mean score below five ($\bar{x}$ =4.45). However, the standard deviations are partly very high (see Appendix 6.4).

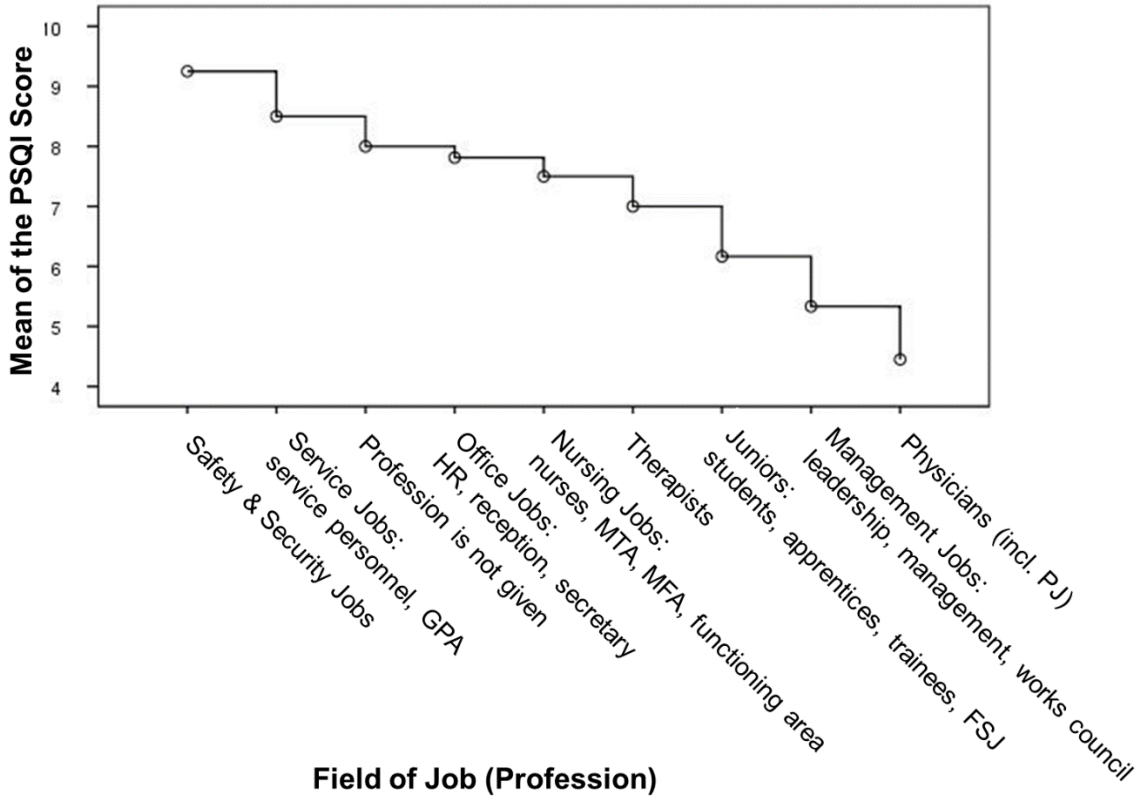

Figure 4: Mean PSQI Scores in the Field of Job

Examining the categories of the PSQI questionnaire, the group of therapists is excluded due to the small sample size. The analysis of variance (Appendix 6.4) shows significant differences in the groups for sleep quality only (F=2.377, df=6, p=0.045), but homogeneity of variances is not

given in case of this PSQI component. Post-hoc tests for sleep quality components (Appendix 6.4) reveal this significant difference only between the nursing group and physicians (mean difference 0.9, SE=0.276, p=0.045, CI= 0.01 – 1.79).

Analysis of variance including both variables, field of work and shift work, reveals significant results for shift work (F=4.9, df=1, p=0.033) with an explained variance of 11.8% but not for the variable field of job (Appendix 6.5). Interaction effects are not significant. But these results should be interpreted with caution due to a significant Levenes test and therefore violated assumptions.

Going through all the analyses, the variable age shows no correlation towards PSQI results and hence is not taken into account for the SWOT-Analysis. Profession (field of job) as well does not show any difference in PSQI results, except for the comparison of physicians and nurses. Only sex and shift work may have an influence on sleep quality and PSQI components. The variable of sex shows a small correlation with the PSQI score. Even though statistical tests reveal different results, an influence of shift work on sleep onset latency, duration of sleep and total PSQI score (sleep quality in general) can be observed in some of the tests. In total, 11.8% of the variance in the total score of PSQI can be explained by shift work. Therefore, web-based CBT-I will be analyzed with regard to its applicability to shift working personnel. Since the variable sex does only show a small influence and does not have a large influence on the adaptation of web-based CBT-I content, features and other requirements, it is not included in the SWOT-Analysis.

Requirements for CBT-I

In order to examine web-based CBT-I with the aim to analyze its applicability to hospital personnel, CBT-I needs to be described further. There is a wide range of different web-based CBT-I approaches described in the articles, which differ in their requirements. Most articles include only primary insomnia and exclude comorbidities. As insomnia rarely is an exclusive primary symptom (Ohayon et al., 2002b, Wu et al., 2015) and web-based CBT-I is highly effective in comorbid insomnia patients (Smith & Perlis, 2006, Wu et al., 2015), comorbidities can hardly be excluded for this therapy method. Nevertheless, CBT has some exclusion criteria that need to be followed in any kind of setting as well as in the hospital setting: circadian rhythm disorder, an unstable illness or maladaptive behaviors perpetuating insomnia (Smith & Perlis, 2006).

More important for the hospital setting to consider is the exclusion of shift workers from most of the studies (Espie et al., 2012, Vincent et al., 2009, Holmqvist et al., 2014, Horsch et al., 2017, Blom et al., 2015, Kaldo et al., 2015, Lancee et al., 2015, Lancee et al., 2016). Only a few studies analyze shift workers executing CBT-I. Group-based CBT yields significant effects on SOL, SE,

SQ, restedness, insomnia severity, sleep-related dysfunctional cognitions and psychiatric and somatic symptoms for media shift-workers (Järnefelt et al., 2012). Another non-randomized study from Järnefelt and colleagues with media shift-workers shows no difference in the effectiveness of daytime and shift workers (2014). Only one article is found for shift-working nurses. Kim and Kim reveal significant changes in irrational thoughts and beliefs as well as improvements in sleep, sleep quality and quality of life for rotating shift nurses using CBT-I based on the mobile social networking service (2005). No research is found on web-based approaches for shift workers.

5.2.2 SWOT-Analysis

Two interviews with stakeholders and the previously given analysis of an exemplary hospital provide information for a SWOT-Analysis. The SWOT-Analysis is the basis for further strategy assessment (chapter 5.23) to implement web-based CBT-I into the hospital setting. Table 4 provides information about all identified strengths, weaknesses, opportunities and threats. In table 5, the most important internal and external factors are transformed into strategies using the following information.

Table 4: SWOT Listing (* mentioned in the interviews)

Internal: Web-based CBT-I		External: Hospital Setting	
Strengths	**Weaknesses**	**Opportunities**	**Threats**
- Inhibition threshold is lower in online treatment* - Flexible use* - Reachability of every employee through online device* - Self-induced= intrinsic motivation & higher learning effect* - Similar cost-effectiveness compared to face-to-face CBT - Provide more people with intervention* - Possibility for support* (phone, Mail, reminder etc.) - Employees feel appreciated* (work satisfaction, less fluctuation) - Fewer accidents and higher productivity - CBT components cover a broad range of psychological issues	- Completion rate (50-92.2%) - Flexible use → procrastination* - Time-consuming* - Less effective than face-to-face therapy - Preference of face-to-face therapy - Self-induced = intrinsic motivation - Costs (68% of employees have a sleep disorder) - Disadvantage for people without internet/computer* - Perceived low value of online interventions*	- Clinical background & knowledge* - Scope of effect is high in this setting (large target group: 68% affected) - §20 SGB-V: cost-related support by health insurance companies - Image of the hospital* (e.g. for personnel recruitment)	- Different shifts* (reachability & feasibility) - Different professions* (difficult to reach everyone, different needs) - Large number of employees (resources to ensure supply) - Costs for the hospital (68% of 2,333) - Effort and organization (responsible person is needed) - Sleep restriction and sleep hygiene requires regular shifts* - Privacy issues due to introduction of CBT at workplace* - Skepticism of something new/web-based/self-induced* (especially older employees) - Perceived stress is high in this setting*

Internal Strengths

The opportunity to supply CBT online is a huge strength as it can reach more affected people, it can further be used flexibly and it causes lower costs than providing face-to-face therapy. The inhibition threshold to start intervention might even be lower in web-based treatment compared to face-to-face treatment, as an affected nurse points out in an interview (see Appendix 7). The flexible use at home is suitable for a wide range of occupations and shifts, as well as more people can be addressed due to lower costs compared to individual or group coachings. These aspects of online approaches are beneficial for the use of a large hospital, an HR manager reports.

Another benefit is that most approaches are self-induced to maximize intrinsic motivation and learning effect. “Intrinsic motivation needs to be existent to some point to start and continue the intervention, otherwise the best promotive events cannot help“ (citation from the interview with a nurse from the exemplary hospital, Appendix 7). Self-help and self-induced approaches generate the same effects as face-to-face treatments (Vernmark et al., 2010) but require fewer resources (e.g. therapists) to supply treatment for a high number of affected people. One of the main goals

of such coaching is to reach as many affected employees as possible. However, the effectiveness should be comparable to that of a personal or group-based treatment.

Thiart and colleagues execute a cost-effectiveness and cost-benefit analysis for web-based CBT in teachers, observing (non-significant) employer gains of 3.10€ for every euro investing in such treatment and savings of 1,162€ for each participant with significant ISI improvements after six months. The probability being more cost-effective than treatment as usual is 87% at 0€ willingness to pay (WTP) for one positive treatment response. At a WTP of 243€, the probability of being more cost-effective is 90% (2016). Unfortunately, no euro-based cost-effectiveness analysis is found for face-to-face CBT in comparison. A British analysis can deliver results for a community-based CBT-I workshop showing a 97% probability of being cost-effective at a WTP of £150 per point of ISI score (Bonin et al., 2014). Cost-effectiveness analysis of web-based treatment and in-person treatment (community-based in this case) are hardly comparable due to different measurements of effectiveness (any positive treatment response vs. one point of ISI). To sum it up, web-based CBT-I is more cost-effective than treatment as usual. Therefore, web-based CBT-I might be a cost-effective alternative to in-person or community-based treatments.

Further, an online intervention can provide the supply for a large number of people. Providing this intervention for a large number of affected employees does not mean that all participants finish treatment. High completion rates are another important aspect because the company wants to achieve better sleep quality for as many participants as they paid treatment for, as well as approaches with high adherence rates may achieve better sleep-related outcomes (Matthews et al., 2013, Lancee et al., 2013). Support from experts, either by telephone or E-Mail, have a supportive effect on completion, as adherence is comparably high in articles using support services (Thiart et al., 2015, Lancee et al., 2013) but smaller than in face-to-face treatment (Holmqvist et al., 2014, Blom et al. 2015). An expert-supported group shows a higher completion rate of 74.4%, compared to 39.8% without support (Lancee et al., 2013). Beside influencing completion rates, the supported group reveals better results in SE, SOL, WASO, NWAK, insomnia severity, depression and anxiety (Lancee et al., 2013). Contrary to that, Berger and colleagues prove that self-help approaches achieve similar results than guided online treatment (2011). Furthermore, reminders for the completion of homework could encourage completion of all sessions (Thiart et al., 2015, Horsch et al., 2017) and is requested by the employees and the HR department (interviews in Appendix 7).

Workplace health promotive actions, such as offering web-based CBT-I for the employees, have an impact on vitality, work performance, self-management (Hendriksen et al., 2016) and self-perceived health, sickness absence, productivity and workability (Rongen et al., 2013). This kind

of sleep interventions even show a relationship with quality of life (Shao et al., 2010, Zeitlhofer et al., 2000, van Straten et al., 2014). Therefore, health promotive actions can improve job satisfaction and would be highly appreciated by the nurses as well as it improves the image of the hospital (mentioned by the interviewed stakeholders, Appendix 7).

As it is mentioned in chapter 3.2, daytime sleepiness correlates with occupational accidents (Suzuki et al., 2005) and the error rate is much higher in rotating shifts or night shifts than in day and evening shifts (Gold et al., 1992, Niu et al., 2013). Additionally, web-based CBT-I can reduce presenteeism and improve productivity (Bostock et al., 2016).

In addition, CBT-I covers a broad range of psychological aspects ranging from changing cognitive thoughts to a reduction of rumination (Holzinger & Klösch, 2018). The inclusion of changing attitudes and beliefs as well as cognitive habits leads to a significant change in outcomes such as perceived stress (Kaldo et al., 2015), quality of life (Shao et al., 2010, Zeitlhofer et al., 2000, van Straten et al., 2014) and beliefs and attitudes about sleep or dysfunctional beliefs (Vincent et al., 2009, Lancee et al., 2015).

Internal Weaknesses

High attrition rates are a major disadvantage of online approaches. As high completion rates result in better sleep-related outcomes (Matthews et al., 2013, Lancee et al., 2013), it is beneficial to maximize participation through the selection of an approach and its features. As it is described in detail before (chapter 3.3), completion rates of web-based CBT-I vary between 50 and 92.2% (van Straten et al., 2014, Lancee et al., 2016, Ritterband et a., 2016, Morris et al., 2015, Thiart et al., 2015), while non-online CBT-I adherence is found to be 60-86% in the clinical setting (Ong et al., 2008) or around 70% in another study (Lancee et al., 2016). Therefore, hospital personnel will probably be subject to similar attrition rates and the hospital would have to bear the costs for non-used licenses. Further advice about the aim of high participation rates is given in chapter 5.2.3.

An interviewed nurse of the exemplary hospital mentions the flexible use as an advantage as well as a disadvantage: motivation and maintaining the attendance for changing shift workers would be difficult for the nurses. It could allow procrastination and people tend to postpone sessions and homework if there is no fixed appointment like it is given in face-to-face therapy. Moreover, time investment should not exceed 15-20 minutes per day, an interview with a nurse indicates.

The question of whether in-person or web-based CBT-I is more effective is discussed controversely. Face-to-face CBT is found to be more effective in reducing insomnia severity

compared to a web-based and self-induced method in one of the studies (Lancee et al., 2016), but Holmqvist and colleagues prove the opposite in regard of sleep quality (2014). Other articles show similar outcomes in both of the methods (Blom et al., 2015, Lancee et al., 2012). In regard to self-induced learning effects, both designs include self-help components and a high importance of willingness to change behavior in all-day-life, e.g. through homework exercises. Participant's preference was in favor of face-to-face intervention (77.8%), compared to online treatment (52.2%) (Lancee et al., 2016), which is not supported by the interview with a nurse (Appendix 7).

Costs can be another internal weakness of web-based CBT-I, as 68% of the employees have a sleep disorder, which would, in consequence, represent 1,586 employees. Online training varies between 79€ (GET.ON Institut GmbH, 2018) and 209.70€ (Selfapy, 2019) per person. This can cause a big financial burden for a hospital.

Furthermore, one of the requirements for such an online intervention is internet access at home. There are possibilities of telehealth solutions, as it is used in the study by Holmqvist and colleagues (2014), but home access facilitates the completion of weekly homework and exercises and is feasible for a large number of participants. The interviews (Appendix 7) revealed that some nurses might not be able to use online approaches. For ethical reasons treatment should be available for every employee.

Referring to the interviews given in Appendix 7, the value of web-based approaches might not be recognized and appreciated. As this can lead to low adherence rates, it needs to be considered by implementing this project.

External Opportunities

External opportunities of the hospital setting can be the clinical background and knowledge of the affected employees. Medical occupations comprise the largest group of professions, which can be a threat or an opportunity. Medical employees might question the effectiveness of the treatment. This supports the aim to choose a well-proven effective online treatment, which provides suitable content for medical professions and non-medical professions in a hospital. An interviewed nurse mentioned pre-existing knowledge covered in the apprenticeship such as progressive muscle relaxation, which supports the implementation of similar CBT components.

A huge advantage and aim of a sleep intervention is the scope of effect in this setting. As the majority of the personnel is affected by sleep disturbances, a large target group is addressed with

this health promotive action. The analysis of an exemplary hospital shows a prevalence of 68% classified as poor sleepers (PSQI>5), compared to a prevalence of 8.1% of depressive symptoms (Busch et al., 2013) for instance. Therefore, the provision of a sleep intervention would affect a high number of employees, which can be achieved with online approaches.

The cost related issue mentioned above can be minimized by referring to §20 SGB-V, which provides the opportunity for support by health insurance companies. Web-based CBT-I is classified within the scope of stress prevention and self-management competencies and therefore fulfills requirements of the “Präventionsleitfaden“ to get financial support. (GKV-Spitzenverband, 2018)

Prevention and health promotive actions are a crucial part of leadership and employee management nowadays. The image of the hospital is an essential aspect for the recruitment of personnel considering the current lack of specified personnel and nursing staff – especially in the clinical setting (Simon, 2012). Overall the number of nursing personnel is rising. Noteworthy is the closer look into the different locations of work. While the number of nurses increased by 22.3% in general (hospital nursing, preventive and rehabilitative nursing, ambulant nursing and geriatric nursing) from 1999 to 2009, hospital nurses even decreased by −0.6% (Simon, 2012). Recent numbers show an increase of 7% of demand in hospital nurses and an increase of 2% in geriatric nurses (Statistik der Bundesagentur für Arbeit, 2019). However, health promotion is still rarely implemented in German hospitals, which makes it a unique positive feature of the hospital as an employer.

External Threats

Looking at threats regarding the hospital setting, variability of professions, shift work, reachability and feasibility might be the major challenges in implementing web-based CBT-I. As it is shown in Figure 2, professions vary from office jobs, over medical professions to service personnel. A shift-working nurse might need different input compared to an HR secretary working in an office. The interviewed nurse mentioned shift-related input and advice as very important features to her. However, advice for shift workers should not be over-represented due to the other participating professions.

Another challenge is the reachability and supply of web-based CBT-I for every participant. As all professions are affected by sleep impairments, except for the physicians in this hospital, it needs to be guaranteed that all professions are informed about the offer. The high number of affected employees also causes a high financial burden, which is an internal weakness in terms of costs

of the web-based CBT-I for up to 1,586 (68% of 2,333) employees as well as a financial difficulty for the hospital. Besides, hospitals rarely have their own personnel to ensure health promotion and prevention. In the exemplary hospital, there is one HR manager who takes care of occupational health issues beside his main HR tasks.

Sleep restriction and sleep hygiene modules, which are major CBT components, may not be compatible with shift work. Most of the articles analyzing web-based CBT approaches for insomnia patients exclude shift working personnel from the study because of sleep restriction and sleep hygiene implementations of CBT-I. This is supported by a study by Schiller et al. showing a significant change in insomnia symptoms after workplace-based group CBT but not in shift working participants (n=11) (2018). In contrast, Järnefelt and colleagues reveal no difference of effectiveness in daytime and media shift workers (2014). Another article is supporting these findings showing that shift-working nurses reveal improvements regarding irrational thoughts and beliefs, general sleep, sleep quality and quality of life using CBT-I based on the mobile social networking service (Kim & Kim, 2005). This issue is further discussed in chapter 5.2.3.

Privacy might be another aspect, which should be taken into account. An introductory workshop for the web-based CBT-I would take place in the hospital and might lead to low participation rates due to privacy issues. In contrast, intervention at home could be advantageous.

Referring to the age structure in the exemplary hospital (Appendix 4), there is a large group of older employees who might be skeptical about web-based approaches and the value of such approaches. This is supported by the HR manager of the exemplary hospital. To overcome this skepticism, strategies are outlined in the following chapter.

Perceived stress at the job may also be a threat in the hospital setting. An interview reveals a permanent stress-level in the profession of nursing (Appendix 7).

5.2.3 Strategy Assessment

The present work derives strategies to implement web-based CBT-I for hospital employees to reduce previously mentioned burden in hospital settings. To address all strengths, weaknesses, opportunities and threats, a combination of these is used to develop strategies. Strength-opportunity strategies are based on the use of internal strengths and external market opportunities to evolve a concept to maximize success quickly. Weakness-opportunity strategies use opportunities of the setting to reduce or eliminate weaknesses, while strength-threat

strategies are used to reduce threats by using internal and external strengths. Reducing weaknesses and threats is the aim of the weakness-threat strategy. (Behrens, 2017)

The following table 5 presents the most essential strategies to implement web-based CBT-I in the hospital setting.

Table 5: SWOT-Analysis Strategies based on Definitions by Behrens, 2017

		Internal: Web-based CBT-I	
		Strengths	**Weaknesses**
External: Hospital Setting	**Opportunities**	SO-Strategies: - Flexible use for a large number of affected people with similar effectiveness as face-to-face CBT-I	WO-Strategies: - Completion rate is low → use clinical background to make clear the relevance, use of support & reminders, reward by employer - Costs and personnel resources → support from health insurance - Sleep restriction & sleep hygiene in shift work → sleep schedule for every shift & ensure enough time between shift change - Employees without internet → paper-and-pencil version
	Threats	ST-Strategies: - Shortage of time of hospital personnel → flexible use, transparency about higher effectiveness with fixed time slots - Marketing & image for recruitment to overcome the shortage of nursing professions - Variability of professions & suitability for broad target group → selection of a suitable CBT-I version (special requirements: shift work, easy use & access, time investment, reminders, overview of progress etc.) - Stress reduction is included in CBT and positively influences occupational stress caused by the setting/job	WT-Strategies: Reducing threats - Improve working conditions in the setting: e.g. shift work & stress - Ensure privacy (introductory event) & demonstrate support - Minimize skepticism & conception of low value: transparency about the program, motivative introduction, show scientific effectiveness Reducing weaknesses - Necessity of intrinsic motivation - Choose appropriate & effective approach

Strength-Opportunity Strategy

In the case of hospital settings, web-based CBT approaches can ensure flexible use, fast delivery and meet the high demand of the setting. Web-based CBT-I is as effective as face-to-face CBT-I (Blom et al., 2015, Lancee et al., 2012, Holmqvist et al., 2014) and can supply a large number of participants. It meets the current situation of a lack of therapists (Ärzteblatt, 2017) as well as a lower inhibition threshold to start treatment compared to face-to-face therapy and medical treatments (Interview with a nurse, Appendix 7).

Weakness-Opportunity Strategy

A low completion rate is one of the largest issues in web-based approaches. To overcome this issue, the clinical background in the setting can be used to report about the relevance and scientific effectiveness to maximize participation rates. Additionally, it has been proven that online support can be a useful strategy to overcome this challenge. Support (via phone or E-Mail) in combination with automated reminders yields rates from 73%, over 82%, to 92.2% (Bostock et al., 2016, Espie et al., 2012, Thiart et al., 2015) with a large satisfaction rate (Thiart et al., 2015). Lancee and colleagues even reveal larger effects in online CBT-I with support in outcomes such as SE, SOL, WASO and ISI (2013). In order to reach a large number of affected employees and to maximize completion rate, an introductory event needs to catch attention and arouse intrinsic motivation to select only motivated employees for the intervention. An interview with a nurse reveals some requirements to convince her to participate and complete treatment: generating curiosity and motivating content, constant reminders, easy use, an overview of the progress and a reward by the employer. Such a reward could be an extra day off, a free massage or gaining some of the compulsory training points they need to achieve every year. Those requests are mainly supported by the HR manager who describes difficulties with the implementation of time-consuming registration or handling in the past. Another idea for the implementation of such an approach is to start a test run with a small number of employees to test the intervention and let them act as multipliers afterwards. These multipliers can recommend the intervention and help others to register.

In Germany, the weakness of costs of such programs can be refuted by the opportunity to get financial and health management support from health insurance companies through §20 SGB-V. Support by the employer or insurance company is one major requirement for participating in such a program, the interviewed nurse reveals. Beside the burden of costs, there is a lack of personnel resources in the hospital to ensure health promotive actions, which can be overcome with support by a health insurance company and the CBT-I supplier. These two stakeholders can support the hospital in planning and executing the project including introductory workshops and advertisement.

As mentioned before, some CBT components (e.g. sleep restriction) interfere with shift work. One study reveals a significant decrease in insomnia symptoms after workplace-based group CBT but not for shift working participants (Schiller et al., 2018). Other articles prove the opposite (Wu et al., 2015, Järnefeld et al., 2012, 2014), which refutes the weakness of this approach not being applicable to hospital personnel. The weakness of the applicability of sleep restriction and regular sleep behavior can be overcome by an adaptation for shift workers: regular bedtime for each of

the shifts and sleep hygiene aspects (e.g. complete darkening of the bedroom, earplugs, etc.). Additionally, the hospital needs to ensure that there is enough time between changing shifts. This is supported by the articles described in chapter 3.2. Nurses gain approximately one hour more sleep in four hours on/eight hours off schedules compared to six hours on/six hours off and eight hours on/eight hours off schedules (Short et al., 2015) and they need at least 3 days off before changing to another shift (Niu et al., 2015). As a result, the hospital might need to consider shift schedules of the same shift for several weeks in a row, followed by at least three days off.

Due to ethical discussions caused by the discrimination of employees who have no internet access, the hospital might have to think of the provision of content on a non-web basis. Alternatives could be provided via a paper-and-pencil version or a workshop. Paper-and-pencil CBT-I can achieve similar improvements as web-based approaches (Lancee et al., 2012) and could be derived from the web-based version. A nurse being interviewed mentions a workshop as most suitable for her older colleagues to ensure equality. This would prevent an ethical debate in the workforce and workers‘ council.

Strength-Threat Strategy

Requirements for the threats of hospital personnel, e.g. lack of time and different shifts, are met by the flexible use of online-based interventions. The difficulty to make time for daily or weekly use may be overcome with fixed time slots to work on intervention’s exercises. Advice on how to ensure regular use can be provided through an introductory event. Reminders and E-Mail support influence the submission of homework and sleep diaries as well. An advertising and motivating event can ensure that every employee is informed about the opportunity to participate in the program. Asking a nurse, the lack of time during work and the lack of willingness to spend free time are the major problems implementing such an event. A so-called *Lunch & Learn*, as an interactive and informing break while consuming lunch (either financed by the employer or brought by the employees), may be an appropriate way to introduce the program and register participants.

A nurse working at the exemplary hospital complains about the lack of health promotive actions and support by the employer and would appreciate such support. The health promotive support at the hospital can also be used to enhance the image. This type of employee support can have a positive impact on the shortage of medical staff.

The strength of the variety of web-based CBT-I approaches can be used to combat the problem of variety of needs in the hospital setting. As there is a large variety of professions and medical

knowledge, content needs to be suitable for all participants. Approaches using too simple explanations might reduce the value for medical employees. Practical advice for shift workers might be advisable, as 44.1% of the exemplary hospital are working in shifts (Appendix 4) and an affected nurse confirms the need for that. Advice for particular professions should be added for these professions only (if technically feasible) or should not be overrepresented. In order to choose an appropriate approach, support and reminders during the intervention are notable features. On the one hand, support during treatment can improve effectiveness and completion rate (Thiart et al., 2015, Lancee et al., 2013). On the other hand, the opposite is proven by the study by Berger and colleagues (2011). Besides, the number of affected people in a hospital might exceed possibilities to ensure individual support by a therapist or expert. Therefore, automated support or the inclusion of an automated conversation screen might be the answer for a large hospital like the analyzed one. Reminders would be highly appreciated by the interviewed nurse, as she expects to forget about the exercises when the shifts are changing. Easy use and access is another important requirement, such as the use of an application on the mobile phone for quick access. The aim of such an approach is to achieve a low expenditure of time with a large impact. A nurse admitted that 15 to 20 minutes a day is the maximum of time she would spend for the intervention and its exercises. Moreover, an overview of the success and sleep behavior would be reasonable for her. All of those aspects could overcome threats of the variety of professions and low completion rates.

The interview with the nurse revealed a stressful occupational setting due to the lack of nurses. As cognitive elements and stress reduction is included in CBT components (Holzinger & Klösch, 2018), perceived stress can be positively influenced by web-based CBT-I (Kaldo et al., 2015). Beside perceived stress, quality of life (van Straten et al., 2014), daytime performance and daytime social functioning (Espie et al., 2012) can be influenced as well.

Weakness-Threat Strategy

Reducing threats of the setting and weaknesses of the web-based CBT-I approach is another way to maximize the effect of the project. Threats of the setting may be the working conditions particularly in the field of nursing. Fast rotating shifts, perceived stress and lack of time in the personnel should be minimized if possible. As mentioned before, the employer should ensure that the shift schedules do not rotate within a short period of time. Besides, stress and lack of time may be reduced by recruiting additional nursing personnel.

Another threat may be the lack of privacy of introductory workshops at the workplace. Transparency is a major aspect of managing participation. The employer and management need to state the support of participating in the intervention with releasing from work for the introductory events and workshops and may even use incentives such as the aforementioned. To clarify that data will not be used by the employer, the therapy supplier should organize and execute workshops and any support during the intervention.

Skepticism about web-based approaches poses another threat. This makes it necessary to inform about the value of the online intervention in a transparent way with the aim of maximizing completion rates. An introductory workshop, *Lunch & Learn* or presentation of the intervention may be appropriate to inform every employee about the intervention. The introductory event needs to be motivative and show scientific effectiveness to convince the employees of the program. The scientific background needs to be prepared to address medical professions as well as office personnel. Obviously, the event has to be offered to all shifts and professions. Therefore, it may be reasonable to execute several workshops at different times and enable participation from the morning to the night shift. It is advisable to exempt employees from work for the time of the workshop or even transforming it into official training by gaining training points.

CBT-I requires a high level of self-intrinsic motivation as it includes several self-induced exercises and sleep tracking. A lack of intrinsic motivation resulting in low completion rates may be overcome with the employer's support. By executing a well-organized and motivating event or workshop, the employee’s awareness is raised. Implementing a test run with multipliers recruiting participants may support such weaknesses.

The weakness of being less effective than face-to-face CBT-I is questionable. While some studies show significantly higher effectiveness in face-to-face CBT for insomnia severity and depressive symptoms (Lancee et al., 2016), no difference is found in comparison with face-to-face group CBT-I (Blom et al., 2015) and telehealth group CBT-I (Holmqvist et al., 2014).

Conclusions

On the basis of the SWOT-Analysis and strategies described above, the following requirements are derived:

- No regular feedback by therapists due to a large number of participants (advisable for smaller hospitals)

- Introductory workshops (e.g. Lunch & Learn at several times) or pilot phase with a few “multipliers”
- Reminders via E-Mail or text messages
- Proven effectiveness of the chosen approach
- High participation rate
- Flexible use
- Easy use and access (e.g. through an application)
- Effort of max. 15 to 20 minutes per day
- Overview of the progress
- Content suitable for medical professions and office staff (practical advice for shift workers)

Exemplary Approaches

Referring to the approaches described in chapter 3.3, *Sleepio, Get.On Recovery*, van Straten’s intervention and Blom and Kaldo’s intervention with individual communication and advice from a therapist may not be suitable for a hospital setting with a large number of employees. It would exceed the resources of therapists. Intervention by Lancee and Spoormaker provides advice for participant’s questions from one author only, which as well exceeds manageable demand. *Return2sleep* shows a significant interaction effect, e.g. in sleep quality and insomnia severity (Vincent et al., 2009) but shows no difference towards telehealth CBT-I (Holmqvist et al., 2014). Besides, it can be found a lower participation rate in the web-based treatment (Holmqvist et al., 2014), which could be assigned to the lack of supportive messages or reminders. *Sleepcare*, as an application by Horsch et al., provides automated messages and reminders as well as conversation-like questions about the sleep and progress. It shows improvements in insomnia severity and sleep efficiency but for instance not for SOL. Adherence data reveal a high number of conversations done (mean=83%), diaries filled in (mean=29 of 49) and deviation from agreed TIB (mean=59 min.). But only 61% completed questionnaires and only 41% completed diaries (2017), which is a lower completion rate compared to other treatments. *SHUTI* treatment shows significant interaction effects favoring intervention group, compared to online patient education and effect sizes from d=0.79 to d=1.9 ($p < 0.05$) for the intervention group (Ritterband et al., 2016). *Insomnia Relief* increases sleep quality with a large effect size with similar results in *Anxiety Relief* (Morris et al., 2016).

Referring to the requirements mentioned before, *Sleepio, SHUTI, Get.On* and *Insomnia Relief* may be possible intervention programs to implement in the hospital setting. All of the programs include a presentation of the progress of sleep behavior over treatment time and only a few hours

per week are necessary to complete the modules. *SHUTI*, for instance, is a well-proven program with a high rate of satisfaction and perceived effectiveness (approximately 90%) and a low attrition rate of 5% (Thorndike et al., 2008). It offers texts, graphs, animations and games and is supported by automated reminders to improve completion rates (Ritterband et al., 2016). This presentation and gamification of content fulfills the request for an interesting and curious making program by the nurse (Appendix 7). *Sleepio*, which can be used via website or application, comprises an animated therapist guiding through the 6-week program in an interactive way, including individual sleep analysis and reminders. In total, 73% of the treatment group completed the program and a large effect can be observed in the intervention group ($d=1.1$, $p < 0.0001$) compared to control condition (Bostock et al., 2016). Furthermore, offering an application fulfils the request of easy usage. *Get.On* as well has a high adherence rate, automated reminders, the opportunity to use the online program for one year and a large number of RCTs proving the effectiveness (GET.ON Institut GmbH, 2018). Depending on the number of participants, individual support might need to be reduced or canceled in the *Sleepio* and *Get.On* approach. About *Insomnia Relief* there cannot be found a lot of information, but it emerges large effects as well as inclusion of automated reminders. Beside these international approaches, *Selfapy* and Mementor can be mentioned as suitable German web-based programs to treat insomnia. Mementor Somnium with its high participation rate and virtual therapist support could be an applicable treatment for hospital staff. In this context, it should be examined whether the virtual “expert“ presents content in an appropriate way for medical personnel to be accepted by hospital professions. *Selfapy*, which established scientifically substantiated self-help courses for depression, offers a comparably new approach for insomnia lacking for research in the field of sleep so far. In all of these approaches special advice for shift workers would have to be added.

6. Discussion

The present study demonstrates that web-based CBT-I offers a comparable opportunity for face-to-face CBT-I treatment resulting in improvements for several sleep-related, social and work-related outcomes. The analysis of an exemplary hospital and its burden of sleep constraints in their employees provides a basis for the assessment of the applicability of such approaches in the hospital. The following chapter discusses the results within the current research and limitations of the present work.

Systematic Literature Review: Placement into the Context of Previous Research

In line with previous systematic reviews, the present study evaluates the effectiveness of web-based CBT-I in comparison with a control group or other treatment. Previous reviews and meta-analyses show that web-based CBT-I results in reduced severity of insomnia (Cheng, 2012, Seyffert, 2016, Ye, 2015), improved sleep efficiency (Cheng, 2012, Ho, 2014, Seyffert, 2016, Ye, 2015, Zachariae, 2015), sleep quality (Cheng, 2012, Ho, 2014, Zachariae, 2015) and other sleep-related outcomes. Aligned to that, results of the systematic review show significantly decreased **insomnia severity** for web-based CBT-I participants in all studies analyzing ISI scores (Lancee et al., 2016, Ritterband et al., 2016, Vincent et al., 2009, Holmqvist et al., 2014, Horsch et al., 2017, Thiart et al., 2015, Kaldo et al., 2015). The present review shows effect sizes from d=1.08 ($p < 0.001$; Lancee et al., 2013), to d = 2.08 ($p < 0.05$; Ritterband et al., 2016). The large to very large effect sizes fit to previous research results with standard mean differences ranging from -0.86 (CI -1.18, -0.53, I^2=0%) (Cheng et al., 2012) to -4.29 (CI -7.12, 1.46, I^2=86.7%) (Seyffert et al., 2016) and an effect size of 1.23 ($p < 0.001$; Sandlund et al., 2017) in a nurse-led group CBT. But there is to say that face-to-face therapy is more effective than web-based approaches in an article by Lancee et al. (2016), in contrast to no difference in another article (Blom et al., 2015) and in comparison to telehealth group CBT-I (Holmqvist et al., 2014). Previous meta-analyses support no significant difference towards face-to-face CBT (Seyffert et al., 2016, Zachariae et al., 2015). Comparing results for **sleep quality** changes, all articles measure significantly improved sleep quality with medium to large effect sizes from pre- to post-treatment in the web-based intervention group (Bostock et al., 2016, Horsch et al., 2017, Holmqvist et al., 2014, Espie et al., 2012, Ritterband et al., 2016, van Straten et al., 2014, Vincent et al., 2009, Blom et al., 2015, Kaldo et al., 2015, Morris et al., 2016, Lancee et al., 2013, Lancee et al., 2015, Lancee et al., 2016). Previous reviews support sleep quality improvements (Cheng, 2012, Ho, 2014, Zachariae, 2015) with a mean effect size of 0.41 (CI 0.16, 0.65, I^2=45%). The effect of web-based CBT-I appears to be smaller compared to this review. This could be attributed to different study

inclusion and to some limitations of this review resulting in an overestimation of effect. Limitations are described in the following paragraphs. The two articles using face-to-face treatment as a comparison reveal no difference in sleep quality (Blom et al., 2015, Lancee et al., 2016). **Sleep efficiency** shows significant improvement with mostly large effect sizes (Blom et al., 2015, Espie et al., 2012, Holmqvist et al., 2014, Horsch et al., 2017, Lancee, 2013, 2015, 2016, Ritterband, 2016) with no between-group difference towards face-to-face and group CBT (Holmqvist et al., 2014, Blom et al., 2015). This basically fits into the results of previous analyses (Cheng et al., 2012, Ye et al., 2015, Ho et al., 2014, Seyffert et al., 2016, Zachariae et al., 2015). These preceding meta-analyses show a comparably lower standard mean difference of 0.40 (CI 0.15, 0.64, I^2=63%) (Cheng, 2012) and a mean improvement of 9.58% (CI 7.3, 11.85, I^2=76%) (Ye et al., 2015). **SOL** (Blom et al., 2015, Espie et al., 2012, Horsch et al., 2017, Holmqvist et al., 2014, Lancee et al., 2012, Lancee et al., 2013) and **WASO** (Espie et al., 2012, Holmqvist et al., 2014, Horsch et al., 2017, Lancee et al., 2012, 2013, 2015, 2016) is found to be changed after online treatment in some studies of this work, but SOL shows no difference in three other articles (Lancee et al., 2015, 2016, Horsch et al., 2017). This is contradictory to the meta-analyses, in which SOL achieves an effect size of -0.55 standard mean difference (CI -0.3, -0.8, I^2=0%) (Cheng et al., 2012) and a change from -10.68% (CI -16, -5.37, I^2=4.3%) (Seyffert et al., 2016) to 18.41% (CI -23.2, -13.6, I^2=62%) (Ye et al., 2015). Meta-analysis of WASO shows non-significant changes (Cheng et al., 2012), which contradicts with medium to large effects in within-group comparison in this review (Espie et al., 2012, Holmqvist et al., 2014, Horsch et al., 2017, Lancee et al., 2012, 2013, 2015, 2016). Another review supports a medium effect size for WASO (Ho et al., 2014). **TST** shows non-significant effects (Cheng et al., 2012) as well as a small to medium effect (Ye et al., 2015, Ho et al., 2014, Zachariae et al., 2015) in previous reviews. In this review, the majority of studies show no effect on TST (Kaldo et al., 2015, Lancee et al., 2015, Lancee et al., 2016), which may be explained by CBT focusing on improvement of sleep efficiency instead of sleep time.

The focus of secondary outcomes vary between existing studies, but Ho and colleagues mention depressive symptoms, anxiety, dysfunctional beliefs and attitudes about insomnia as positively influenced outcomes, consistent with studies discussed in this literature review. Especially **depressive symptoms** seem to benefit from web-based CBT-I with a mean difference of -2.28 (CI -2.89, -1.67, I^2=0%) (Seyffert et al., 2016), which fits into medium effects represented in the articles of this review (van Straten et al., 2014, Horsch et al., 2017, Blom et al., 2015, Lancee et al., 2012, Lancee et al., 2013, Lancee et al., 2015). Medium to large effects are found in **anxiety** scales (van Straten et al., 2014, Lancee et al., 2016, Horsch et al., 2017, Lancee et al., 2012) with higher effect sizes in face-to-face CBT than web-based CBT (Lancee et al., 2016). Two

articles do not find any effect of web-based CBT-I on anxiety (Lancee et al., 2015, Morris et al., 2016). While accordance of positive effects on **beliefs and attitudes about sleep** or dysfunctional beliefs is found (Ho et al., 2014, Vincent et al., 2009, Lancee et al., 2015), one article does not find an effect (Horsch et al., 2017).

In web-based CBT-I, drop-out rates are a common problem. In some articles, adherence is lower in web-based CBT than in face-to-face treatment (Holmqvist et al., 2014, Blom et al. 2015) but the same in another (Lancee et al., 2016). Support via messages or E-Mail has a large influence on completion rates with a significant difference towards CBT without support (Lancee et al., 2013), though previous research found no significant difference (Berger et al., 2011). Satisfaction analysis shows contradictory results: there can be found no significant difference in web-based CBT and face-to-face CBT (Blom et al., 2015, Holmqvist et al., 2014) as well as there are significant different satisfaction rates in favor of face-to-face treatment in the study of Lancee and colleagues (2016). Satisfaction was very high in the treatment *Get.On Recovery* by Thiart et al., which achieved a participation rate of 92.2% and satisfaction of 91% (2015).

Placing the systematic literature review into current research available, there can be seen a consistency in results for the effectiveness of the main sleep-related outcomes. Only sleep diary outcomes and secondary non-sleep-related outcomes vary between articles and their different methodologies.

Limitations of the Systematic Literature Review

However there can be found a consistent effect of web-based CBT-I, some limitations need to be noted. First, it needs to be taken into account that literature research comprises the risk of publication bias, as grey literature search was not included. Secondly, within-group effects are mostly based on completer analysis, which involves selection bias and comprises an overestimation of effect. Thirdly, participants starting treatment might have more symptoms and suffer more causing an underrepresentation of light disorders. This is supported by Yeung's results of high drop-out rates associated with longer TST, depression and a lower ISI score (2015). Therefore, participants dropping out during the time of treatment may be the ones achieving no (big) changes in insomnia symptoms, which leads to a larger effect size in those finishing the treatment. Fourth, an overestimation of effect may also be compounded by the authors being the founder of the analyzed approach which is the case in some of the RCT's. Fifth, strict inclusion of primary insomnia in most of the studies limits the value of the results, as

comorbidities are likely to coexist with insomnia (Ohayon et al., 2002b, Wu et al., 2015) and may also benefit from CBT-I (Smith & Perlis, 2006, Wu et al., 2015).

Moreover, methodology of the articles needs to be considered as well. Difference of web-based CBT-I approaches conceals the limitation of limited comparability. Although treatment approaches are comparable contentwise, authors include different components of CBT, which leads to different outcome measures, such as Horsch et al. who exclude cognitive aspects and stimulus control (2017). Other web-based CBT approaches, for instance, do not include relaxation exercises (Thiart et al., 2015, Ritterband et al., 2016). Additionally, some outcome measurements are not aligned to CBT components, such as TST, TIB and TWT. As CBT aims to achieve less time awake and rising sleep efficiency, methods like sleep restriction, TIB and TST may not be appropriate measurements for CBT. A different focus of the approaches may also explain different results and makes it difficult to derive a clear statement about treatment effects. Beside the variety of treatment components, discrepancies in outcome measures impede interpretation of the systematic literature review. Effect sizes of some of the outcomes vary extremely in the articles, as it can be seen in table 3 in chapter 5.1.2. For instance, the variation of ISI scores from 1.08 to 2.08 indicates that other aspects may influence the outcome. Large effect sizes can be found in Ritterband's article but it should be mentioned a possible overestimation of between-group differences due to more severe insomnia in the intervention group and poorly presented content in the control condition. Sample size, treatment components, length of treatment, time investment, insomnia severity at baseline and support may be possible influencing factors. The impact of treatment length, support, presentation of content and insomnia duration are supported by Zachariae and colleagues (2015). Influence of support and reminders on adherence rates is represented previously in this review, while the length of treatment does not give a clear tendency comparing treatment effect. The presentation of the content may also play a role in influencing adherence and outcomes but there cannot be seen a clear influence of animated content (used in *Sleepio* and *SHUTI*), for instance. The results retrieved from articles with small sample sizes, such as Holmqvist et al. (2014), Blom et al. (2015) and Lancee et al. (2015 & 2016), need to be interpreted with caution due to overestimation. But referring to table 3 in chapter 5.1.2 and effect sizes given in the articles, a tendency of larger effect sizes in small-sample RCTs cannot be observed.

The different findings may also be explained by different group comparison and control conditions. Mostly, control groups are not blinded, hence expectation bias may play a role and results might be overrated. Some studies compare treatment to waitlist controls only, therefore results should be interpreted with caution. Similar articles using treatment as usual or active controls show equalized results after one-year follow-up (Kaldo et al., 2015). Only two studies

use placebo treatment as a comparison, which gives an indication for the treatment without CBT components. Nevertheless, these placebo treatments ended with smaller effects than web-based CBT-I (Espie et al., 2012, Ritterband et al., 2016). Critical appraisal reveals three studies with a score below 8 (out of 12) points. Lancee and colleagues do not include any control group, for instance (2013), while van Straten's article is missing on follow-up and power analysis (2014). Holmqvist and colleague's article also lacks a power analysis, follow-up analysis and control condition as well as the treatments are not comparable in time investment (2014). Other articles achieve appropriate scores in critical appraisal.

SWOT-Analysis: Placement into the Context of Previous Research

There is evidence about accidents and errors occurring more often in rotating shift workers (Gold et al., 1992) and night shift workers (Niu et al., 2013). Beside the issue of errors, the economical burden of sleep disorders needs to be considered as well. As sick leave days are more frequent in rotating shift workers (Ohayon et al., 2002b) causing indirect costs and several direct costs coming on top, a poor sleeper causes 5,010$ annual costs, while a good sleeper causes only 420$ (Daley et al., 2009). These, among many others, are the reasons why hospital personnel should get special attention in the field of sleep as well as for the practical implementation of sleep interventions.

As there is no research about the applicability of web-based CBT-I for hospital personnel, there can hardly be drawn comparisons with the current state of research. The cross-sectional survey, analyzed in chapter 5.2.1, supports the findings that hospital personnel is likely to be affected by insomnia. In the small sample of the exemplary hospital, it can be seen that 67.8% of the employees show poor sleep quality. Chien and colleagues admit a comparable rate of 75.8% of poor sleepers in hospital nurses, of which other professions are not included (2013). Although there can be found several articles about the sleep quality of nurses and shift workers, there cannot be found any articles on web-based CBT approaches for insomnia patients working in the hospital setting. Despite medical professions and especially shift workers, rotating shift workers and night shift workers are proven to be a vulnerable group being affected by insomnia or bad quality of sleep (Escribá et al., 1992, Ferri et al., 2016, Gold et al., 1992, Short et al., 2015, Ohayon et al., 2002b, Zhang et al., 2016), this target group is lacking for research about requirements for a web-based sleep intervention.

Referring to chapter 5.2, the program should fulfill several requirements: limiting effort for individual feedback by therapists due to large number of participants, an appropriate motivative

introduction, easy usage and access (e.g. through an application), time investment of 15 to 20 minutes per day, overview of the progress, reminders via Mail or text message, proven effectiveness, high participation rate, flexible use and suitable content for medical professions and office staff. Based on those requirements, which are described in chapter 5.2.3, *SHUTI* treatment, *Get.On* and *Insomnia Relief* may be possible intervention programs to implement in the hospital setting. However, German approaches, such as *Selfapy* and *Mementor* may also meet requirements and are supported by health insurance as prevention courses. Despite a potential suitability of mentioned programs, the affected hospital should execute an in-depth analysis before deciding for one particular app.

Limitations of the SWOT-Analysis

There have to be admitted several limitations regarding the analysis of applicability to the hospital setting. Analyzing the hospital setting with the survey executed, a selection bias cannot be excluded. The poll was placed at the main entrance where the majority of employees walk past before and after work and during the breaks. Because of the understaffing of nurses and lack of time, some employees refused to take part in the survey. This may lead to an underrepresentation of nursing professions and medical staff. Besides, the sample size is small and other influencing factors could have been included in the questionnaire. Hinz et al. give the advice to assess information about sex, psychological factors and obesity (2016). Due to the reason of only providing information as a basis for the SWOT-Analysis, it was decided to limit the sample size and include only variables that may be relevant for the analysis. Therefore, sex, shift work and hospital profession were included. Interviews with two stakeholders of the exemplary hospital provide information for the SWOT-Analysis. More interviews representing other recurrent professions, such as a physician and an office worker, would have supplemented information for the applicability of such web-based implementation.

Furthermore, the SWOT-Analysis itself entails some further limitations. A SWOT-Analysis is not fully transferable to the evaluation of an intervention, as it is usually used to analyze the current situation of a company by evaluating competitors and the market situation. As there is not chosen a certain web-based CBT-I program to be used in the setting, an analysis of external factors for the range of existing web-based CBT-I approaches is difficult to apply. In this analysis, external aspects refer to the hospital setting and its challenges for the implementation of web-based CBT-I. Therefore, internal aspects focus on advantages, disadvantages, variations and features of web-based CBT-I approaches to meet (external) hospital requirements. Pickton and Wright describe three main limitations of the SWOT-Analysis: inadequate inclusion of factors, lack of

prioritization and compiler bias/subjectivity (1998). To overcome broad and subjective formulations, the present analysis uses current research, the literature review executed before and stakeholder interviews. The lack of a predefined way of classification into strengths, weaknesses, opportunities and threats is a limitation but in contrast to that, enables adaptation for analysis of applicability.

Despite the limitations, the present work complements previous findings of the effectiveness of web-based CBT-I approaches. It provides a broad overview of web-based CBT-I approaches and its aspects influencing effectiveness, which is lacking in other reviews. This thesis further provides important guidance for the implementation of web-based CBT for insomnia in medium to large scale hospitals. The lack of knowledge about the implementation of web-based CBT-I in hospital personnel is still prominent but this work provides practical advice for the choice of intervention and implementation. Conclusions towards the objectives and further recommendations are given in the following chapter.

7. Conclusion and Outlook

Relevance of Results

Sleep disturbances and disorders are an underrepresented and underestimated problem in German society, although the number of people being affected is increasing (Marschall et al., 2017). The lack of psychotherapists and long waiting lists (Ärzteblatt, 2017) can be compensated with web-based and self-induced programs such as the ones analyzed in this review. Web-based CBT-I provides a flexible and unassisted way to adapt cognitive beliefs and behaviors at home. Previous research provides consistent derivations to some extent and partly contradictory results about some of the sleep-related and secondary outcomes. The inconsistent results of some studies and outdated RCTs which are used in previous analyses made further review necessary. The present work describes the current range of web-based CBT-I approaches, its effectiveness and generates practical information about its applicability to hospital employees. Next to the systematic review, a closer look into hospital professions reduces the current gap of research about this target group and gives practical advice to choose a web-based CBT-I approach to meet requirements for the setting. Since hospital employees are a vulnerable group with 67.8% being affected by sleep disturbances (PSQI>5), this target group deserves further attention in research.

Research Question and Objectives

The research questions “What effect does web-based Cognitive Behavioral Therapy for insomnia have on the severity of insomnia, sleep quality and other sleep-related variables? To what extent is web-based CBT-I applicable to hospital personnel?” are mainly answered. The effectiveness of web-based CBT-I is given, except for some articles claiming a lower effect size compared to face-to-face CBT-I. Although some sleep-related and secondary outcomes, such as SOL, SE, NWAK, TWAK, TIB, depressive symptoms, anxiety, dysfunctional beliefs, daytime functioning and presenteeism or absenteeism, did not achieve the same results in all of the articles, a clear tendency of main sleep-related outcomes can be observed. Primarily focused variables, which should be addressed by CBT-I components, changed significantly compared to a control condition: insomnia severity, sleep quality, sleep efficiency and WASO. Although in some of the articles certain outcomes are significantly better in face-to-face compared to web-based CBT-I, web-based CBT can be seen as a comparable effective alternative with a large scope of treated people. Therefore, the objectives of determining the effectiveness of web-based CBT-I

interventions and of assessing the influence on insomnia severity, sleep quality, sleep efficiency and other sleep-related variables, are answered.

The objective to analyze strengths, weaknesses, opportunities and threats of web-based CBT-I for the use in hospital personnel is executed in chapter 5.2.2. To assess the applicability of web-based CBT-I to hospital personnel, strategies are derived. The research question, to what extent web-based CBT-I is applicable to hospital personnel, can be answered with a few requirements of a possible approach to fit into the hospital setting. Requirements to make web-based CBT-I applicable to hospital employees are: the introduction into the program with an event or workshop, reminders for homework and sleep diaries, proven effectiveness of this approach, a high completion rate of this program, flexible use and suitable content for all professions. Regular individual feedback by therapists, which is used by some approaches, may need too many resources for a large number of participants such as it is given in the exemplary hospital. Looking at the approaches covered in the analyzed articles, *SHUTI* treatment and *Insomnia Relief* may be possible intervention programs to implement in the hospital setting. Beside those, several comparable online treatments are available on the market, which are not mentioned in the analyzed articles and need to be considered if a certain hospital is looking for appropriate treatments.

Recommendations

Taking into consideration the size of this big assignment and the time that will be involved, the project should be put out to a public tendering process before jumping into a decision on what program/approach to use. To make sure every possible view is taken into account, relevant stakeholders should be involved in the decisional process, hence, before starting the tender, during the planning process and during and after the intervention. These meetings should be held by all stakeholders that contribute to the planning and execution of the project. Recommended stakeholders are: a supportive health insurance company (functioning as a potential financier), employees representing several professions, the management, human resource management, works council and web-based CBT-I providers. For the implementation, support by the works council needs to be ensured in advance. Quality management should accompany the whole process and evaluate the acquisition of participants, introductory activities, participation rates and effectiveness of the intervention for constant adaptation if needed.

Beside the practical recommendations, research recommendations can be derived from this analysis. Overall, the effectiveness of web-based CBT for insomnia for some of the outcomes can

be confirmed by the literature. Nevertheless, heterogeneity of the articles and the variety of CBT programs itself makes further research reasonable. First of all, the influence of features and types of web-based programs needs to be analyzed further. As there is a large variety of different approaches, mostly one study examining one particular program, more RCTs evaluating characteristics and features of the interventions need to be executed. Support, homework reminders, visual and audio-based features could be of interest for further research, especially with regard to completion rates. Second, there is a lack of research about secondary insomnia, which deserves further attention, as insomnia is rarely found to be an exclusive symptom. Third, long-term effects of web-based CBT-I are required to be investigated further. Only two of the investigated articles include a one-year follow-up, of which one indicated similar results for insomnia severity in controls after such a long period of time. Fourth, a profession-related analysis of effectiveness and applicability to particular work settings is reasonable. Most of the analyzed studies are region-based and participation offers are broadly spread via the internet. Only two articles focus on a particular group (teachers and university students). Especially medical staff and hospital personnel need further attention due to previously described vulnerability for insomnia. Fifth, participant's characteristics should be analyzed further regarding their influence on insomnia and the CBT-I treatment. Most study participants are middle-aged with a majority of females. Only a few studies include other social or work-related aspects which makes it difficult to get reliable results. Social status, job profession, job satisfaction, stress, social support and quality of life are only a few aspects that could be taken into account for analysis. All in all, further high-quality RCTs with comparable control conditions (e.g. placebo, treatment as usual or comparable non-web-based designs) would be valuable to understand how to ensure a high participation rate and satisfaction to achieve the highest possible reduction of insomnia symptoms. Particularly German programs and applications are rarely evaluated and need further attention as well as its unexplored cost-effectiveness.

In summary, this thesis supports previous findings of web-based CBT-I as an effective treatment alternative to face-to-face CBT-I with short and long-term improvements in sleep-related outcomes. Web-based CBT-I is a flexible self-help intervention applicable to hospital employees with regard to several requirements to maximize the effect and adherence rate.

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Appendix 1: Study Overview

Abbreviations:

MA=Meta-Analysis; SR=Systematic Review; IG=intervention group; CG=control group; aCG=active control group; WL=waiting list; SCI=Sleep Condition Indicator; ISI=Insomnia Severity Index; f2f=face-to-face therapy; oCBT-I= online Cognitive Behavioral Therapy for Insomnia; ppCBT=paper-and-pencil CBT; SE=sleep efficiency; TWT=total sleep time; SOL=sleep onset latency; WASO=wake time after sleep; TWAK=terminal wakefulness; NWAK=no. of awakenings; SQ=sleep quality; IRT= imagery relief therapy; DASS=Depression Anxiety Stress Scale; ES=effect size; TAU=treatment as usual; SHUTI=Sleep Healthy Using the Internet; OPE=online patient education; PSQI=Pittsburgh Sleep Quality Index; HADS=Hospital Anxiety and Depression Scale; CES-D=Center for Epidemiologic Studies – Depression Scale; MFI=Multi-Dimensional Fatigue Inventory; DBAS-10=Dysfunctional Beliefs and Attitudes about Sleep Scale; WSAS=Work and Social Adjustment Scale; CGI=Client Satisfaction Questionnaire; IS=Irritation Scale; PSWQ=Penn State Worry Questionnaire; REAQ=Recreation Experience and Activity Questionnaire; RoB=Risk of Bias; MADRS=Montgomery-Asberg Depression Scale; AUDIT= Alcohol Use Disorders Identification Test, DUDIT=Drug Use Disorders Identification Test; PSS=Perceived Stress Scale; CSQ-8=Client Satisfaction Questionnaire; STAIS=State-Trait Anxiety Inventory-State; BDI-2=Beck Depression Inventory, SRBQ=Sleep-related Behaviors Questionnaire

Reference	Design	N	Target group	Insomnia	Recruitment	Measurement/ Tools	Comparison	Intervention	Duration of intervention	f-u	Sleep outcome: Primary (& secondary)	Results about Effectiveness
Bostock, 2016	RCT	270 (98 IG, 116 CG)	U.S. employees (mainly office)	self-identified sleep problem	Mail	SCI (sleepiness, presenteeism, absenteeism, anxiety)	oCBT, WL	Sleepio	8w	3m	SCI: sleep quality & nightime/daytime symptoms, (sleepiness, presenteeism, absenteeism, anxiety, patient health)	- oCBT: ES for SCI d=1.1 - WL: d=0.34 - Sign. Interaction effect - presenteeism: 15.4% reduction (d=0.64 compared to WL d=0.09) - absenteeism: no effect
Lancee 2016	RCT	90 (30 each)	Netherlands	ISI≥10, awake 30 mins min. 3 nights/week	Scientific website and facebook	ISI, sleep diary	F2f CBT-I, oCBT-I, WL	Intervention by Lancee & Spoormaker	6w	3m, 6m	Severity/ISI, Anxiety, SE, TWT, SOL, WASO, TWAK, NWAK, SQ	- Online & f2f intervention: large effects in ISI (d=1.0 and 2.3), TWT, SE and anxiety compared to WL - F2f sign. more effective than oCBT: severity (d=0.9), depressive symptoms (d=0.7)
Espie 2012	RCT	164 (CBT 55, IRT: 55, TAU: 54)	UK	diagnosed insomnia (DSM-5)	Diagnosed by GBSS (survey)	Sleep diary, SCI, DASS	oCBT w virtual therapist, IRT/placebo, TAU	Sleepio	6w	8w	SE (SOL, WASO, TST, TWT, CI, SQ, daytime performance, daytime social functioning)	- Main effect of time and interaction effect for CBT compared to TAU and IRT (f-u: remained results) - SE: large ES for CBT compared to TAU & IRT - Sign. changes in: SE, SOL, WASO, TWT, TST, SQ, SCI, daytime performance, daytime social functioning - Placebo (IRT) achieved small to moderate effects, CBT achieved moderate to large effects - Large ES of comparison CBT-TAU - Large ES of CBT-IRT - Small ES of IRT-TAU
Ritterband 2016	RT	303		Chronic insomnia (self-referred)	Online (no further information given)	ISI, sleep diary	oCBT, OPE	SHUTI	6w	6m & 1y	Severity/ISI, SOL, WASO, (SE, NWAK, SQ, TST)	- Sign. Interaction effect for ISI, SOL & WASO - Large time effect for IG - 1y-f-u: bigger Improvement on ISI (d=2.32), SOL (d=0.95) & WASO (d=1.41) in IG than in OPE (d=1.53, 0.64, 0.86) - SE, NWAK, SQ: larger effect in IG
vanStraten 2014	RT	118 (IG 59, WL 59)		Diagnosed Insomnia (DSM-4)	Scientific website: first 1500 requests	Sleep diary (PSQI, HADS, CES-D)	oCBT (6w), WL	Treatment by van Straten	6w	3m	SE, TST, SOL, NWAK (SQ, duration, medication, anxiety, depression, QoL)	- Large ES (d=0.57-1.06) on SQ, TST, SE, soundness & QoL - Medium ES for NWAK, refreshed, anxiety & depression (d=0.4-0.54) - No effect on SOL

Vincent 2009	RCT	118 (IG 59, WL 59)		Chronic insomnia with duration of at least 6 month and symptoms more than 3 nights/week	Sleep clinic or newspaper advertisement	Sleep diary, ISI, MFI, PSAS, DBAS-10	oCBT, WL	Return2sleep by Vincent	5w	4w	ISI, MFI, SQ, TST, SOL, WASO, NWAK, medication (pre-sleep arousal, beliefs/attitudes about sleep)	- Sign. Interaction effect: SQ, MFI, ISI - SQ, ISI improved from pre-post and pre-f-u - MFI improved from pre-post - Medium ES: TST, SQ, SOL, NWAK, SE, MFI, pre-sleep arousal - Large ES: ISI, beliefs/attitudes about sleep
Holmqvist 2014	RCT	73 (web 39, tele 34)	Rural Canadian area	Diagnosed insomnia	Sleep clinic or newspaper advertisement	ISI, sleep diary, MFI, DBAS-10, WSAS, CGI	oCBT, telehealth CBT (group sessions)	Return2sleep by Vincent	6w	8w	ISI/severity (TST, SOL, SE, NWAK, WASO, SQ, daytime fatigue, dysfunctional beliefs about sleep, work and social impairment)	- Sign. More drop-outs in web-intervention - Sign. Time effects for all variables: changes in both groups - Sign. Group effect: better SQ in web-IG - No sign. diff. In treatments
Horsch 2017	RCT	151 (IG 74, WL 77)	Netherlands	Diagnosed mild insomnia (DSM-5)	Web, social media, advertisement, flyers, press	ISI, sleep diary (PSQI, DBAS-16, HADS, CES-D	CBT App, WL	Sleepcare	6-7w	3m	ISI/severity, SQ, SOL, WASO, NWAK, SE, TST, beliefs/attitudes about sleep, depression, anxiety	- Sign. Improvements of ISI/severity (d=-0.66) and SE (d=0.71) at post-intervention - Sign. Improvement: WASO, NWAK, PSQI, CES-D, HADS - No Improvement: SOL, wakefulness, TST, TIB, DBAS-16
Thiart 2015	RCT	128 (IG 64, WL 64)	German teachers in Nordrhein-Westphalen	ISI ≥15	Mailing from Ministry of Education (Nordrhein-Westfalen)	ISI, IS, sleep diary, SIS-D, PSWQ, REAQ	oCBT with mail support, WL	GET.ON	8w	6m	ISI/severity (work related rumination, SE, recuperation, Absenteeism, Presenteeism, recovery, user satisfaction	- High participation rate (92.2%) and satisfaction (91%) - Severity of IG decreased sign. more than CG (d=1.45) - Sign. Improved SE (d=-0.47), recuperation in sleep (d=-0.77), work related rumination (d=0.73), worrying (d=0.75), recreational activities (d=-0.58), presenteeism (d=0.35 in f-u)
Blom 2015	RCT	N=48 (CBT: 24, oCBT: 24)	Ostergötland County, Sweden	Diagnosed insomnia, ISI>10	Website, radio, newspaper	ISI (sleep diary, MADRS-S)	Group CBT, oCBT with mail support	Treatment based on Jernelöv	8w	6m	ISI/severity (TIB, SOL, NWAK, waking up time, time standing up, SQ, SE, SOL, TST, SQ, depressive symptoms, medication)	- No interaction & group effect - Sign. Effects for both groups in: SE, SOL, SQ, depression - improvements in CBT (not online): TST
Kaldo 2015	RT	N=148 (oCBT: 73, aCG: 75)	Sweden	Diagnosed insomnia, ISI>10	Website, newspaper, website of psychiatry clinic	ISI (MADRS, AUDIT, DUBIT, sleep diary, PSS-4, medications, CSQ-8)	oCBT, aCG	Treatment based on Jernelöv	8w	6m, 1y	ISI/severity (SOL, WASO, SE, SQ, stress)	- oCBT-I sign. More effective than aCG - Sign. Diff. In: ISI (d=0.85), medication, SE (d=0.59), SOL (d=0.35), SQ (d=0.45) - 12m f-u: no longer sign. diff. (active CG also decreased ISI)
Morris 2016	RCT	Students at University of Bristol N=138 (anxiety: 43, Insomnia: 48, CG: 47)	University students in UK	experienced stress	Mailing, posters, flyers at University	STAIS, PSQI, BDI-2	Anxiety CBT, insomnia CBT, CG	Insomnia Relief	6w	/	SQ, anxiety, depression	- Sign. Increase in SQ (main effect of time) and interaction effect - Within-group ES d=1.04 - Between-group ES d=0.51 - Anxiety program achieved similar results in SQ (d=0.87 & 0.55) - No improvement in CG
Lancee 2012	RCT	N=623 (oCBT: 216, ppCBT: 205, WL: 202)	Netherlands	Diagnosed insomnia (DSM4), SE<85%	website	Sleep diary, SLEEP-50 (HADS, CES-D)	oCBT, ppCBT, WL	Intervention by Lancee & Spoormaker	6w	18w, 48w	TIB, time standing up, SOL, NWAK, WASO, medication, SE, TST, anxiety, depression	- Both IG equal effective - ES (d) for SLEEP-50: oCBT=-1.44, ppCBT=-1.32, WL=-0.47 - ES for SE: oCBT=-0.95, ppCBT=-0.93, WL=-0.37 - Big ES for: SE, WASO (both IG) - Moderate ES for: TST, SOL, NWAK, depression, anxiety (both IG) - 48w f-u: similar results

Lancee 2013	RCT	N=262 (support: 129, no support: 133)	Netherlands	Diagnosed insomnia (DSM-4) in SLEEP-50 and ISI	website	Sleep diary (ISI, CES-D, HADS, SLEEP-50)	oCBT with mail support, oCBT without support	Intervention by Lancee & Spoormaker	6w	6m	TIB, time standing up, SOL, WASO, NWAK, SQ, preceding day, TST, SE (medication, ISI, depressive symptoms)	- Both IG improved insomnia outcomes: large ES in SE, WASO, SQ, ISI (d=0.41 – 1.55) - Higher effects in CBT with support: SE, SOL, WASO, ISI (d=0.3 - 0.49) - 6m f-u: effect remained for SE, SOL, ISI, depression (d=0.3-0.5)
Lancee 2015	RCT	N=63 (oCBT: 36, WL: 27)	Netherlands	Diagnosed insomnia (DSM-5), ISI>9	Website, facebook	ISI, DBAS, SRBQ, CES-D, HADS, SLEEP-50, sleep diary	oCBT, WL	Intervention by Lancee & Spoormaker	6w	3m, 6m	Severity, safety behavior, dysfunctional beliefs, anxiety, depression, diary: SE, TST, SOL, WASO, wakefulness, NWAK, SQ	- Interaction effect for severity, SE, WASO, SQ, dysfunctional cognition, SE, safety behavior, depressive symptoms - Moderate ES comparing groups: depression (d=-0.5) - Large ES comparing groups: Severity (d=-1.05), dysfunctional beliefs (-1.49), sleep safety behavior (-0.97), SE (1.0), WASO (-0.91), SQ (0.79) - not sign. Interaction effect: TST, Anxiety, SOL, wakefulness, NWAK - sign. mediating factor: safety behavior - maintained/improved effects at 6m f-u
Cheng 2012	MA & SR	6 RCTs (1999-2011)		With and without diagnosis, primary or Secondary or comorbid insomnia	/	CASP Score>60%						
Ho 2014	SR & MA	20 RCTs (n=2411) 1979-2012		General complaint/dissatisfaction with sleep	4 databases	Chochranes RoB Assessment						
Seyffert 2016	SR & MA	15 RCTs (13 for MA) (n=2392)		n/a (averaged: medium severity)	6 databases	RoB						
Ye2015	MA	15 RCTs (n=1013)		Diagnosed insomnia (DSM-5, DSM-4 or ICD-2) or sleep difficulty	4 databases	RoB						
Zachariae 2015	SR & MA	11 RCTs (n=1460) (2004-2015)		Diagnosed or self-reported insomnia	6 databases	12 criteria (collaboration of 3 diff. Tools)						

Appendix 2: Search Strategy

Population/problem	Intervention	Comparison	Outcome
Hospital staff	online sleep intervention OR Cognitive Behavioral Therapy OR self-induced sleep intervention	No intervention, other intervention, treatment as usual	Insomnia severity, Sleep quality, other sleep related outcomes
Database hits including RCTs:			
Database	**Search Term**	**Number of Records (using filters*)**	**Articles left after screened by title and abstract**
Pubmed	**Hospital personnel** 188 hits ((("Sleep Wake Disorders"[Mesh]) OR "sleep* qualit*") AND "Personnel, Hospital"[Mesh]) AND ("Cognitive Behavioral Therapy"[Mesh] OR "Behavior Therapy"[Mesh] OR "sleep* intervention*" OR "self-induced intervention*" OR online intervention*)	9	0
	Hospital personnel 305 hits "Personnel, Hospital"[Mesh]) AND ("Cognitive Behavioral Therapy"[Mesh] OR "Behavior Therapy"[Mesh] OR "sleep* intervention*" OR "self-induced intervention*" OR online intervention*)	25	0
	Hospital personnel 313 hits sleep* AND "Personnel, Hospital"[Mesh]) AND ("Therapeutics/education"[Mesh] OR "Therapeutics/prevention and control"[Mesh] OR "Therapeutics/psychology"[Mesh] OR "Therapeutics/rehabilitation"[Mesh] OR "Therapeutics/therapeutic use"[Mesh] OR "Therapeutics/therapy"[Mesh] OR "Cognitive Behavioral Therapy"[Mesh] OR "Behavior Therapy"[Mesh] OR online*	9	0

	intervention OR sleep* intervention)		
	No limitation of profession 82 hits ((((„quality of sleep“) OR "Sleep"[Mesh]) OR "Sleep Wake Disorders"[Mesh]) OR "Sleep Hygiene"[Mesh]) AND ("Cognitive Behavioral Therapy"[Mesh] OR "Behavior Therapy"[Mesh]) AND (online OR web-based OR online-based OR digital)	43	9 Excluded by title or abstract: 6 special group (youth, teachers) 9 organic/psychiatric cause 14 Other IV (no CBT) or DV (no sleep quality) 1 qualitative 1 double
Cochrane	11 hits MeSH descriptor: [sleep] explode all trees AND MeSH descriptor: [cognitive behavioral therapy] explode all trees AND (online* intervention*):ti,ab,kw	11	1 (same on pubmed) Excluded: 2 group 3 Other cause 4 other DV or IV
Google Scholar	163,000 hits quality of sleep OR Sleep OR Sleep Wake Disorders OR Sleep Hygiene AND (cognitive behavioral therapy OR cbt OR cognitive behavioural therapy) AND (online OR web-based OR online-based OR digital)	17,400 (screened first 50, sorted by highest relevance)	4 (same on pubmed) Excluded: 4 group 17 Different IV or DV 5 organic/psychiatric cause 1 evidence level low
Ebsco	141 hits (quality of sleep or Sleep or Sleep Wake Disorders or Sleep Hygiene AND (cognitive behavioral therapy or cbt or cognitive behavioural therapy) AND (online OR web-based OR online-based OR digital)	141 Exclusion of organic/psychiatric causes: 18	3 (same on pubmed) Excluded: 4 Different group 5 organic/other cause 3 Other DV and IV 1 qualitative
Sources used in other studies		15	6 Excluded: Older than 10y, not web-based, small sample, other IV or DV

*Filters used: date of release 2009-2019; German or English, RCTs, humans

Appendix 3: Critical Appraisal

Randomized Controlled Trials

1= fulfilled, 0.5= partly fulfilled, 0= not fulfilled

	Bostock 2016	Blom 2015	Kaldo 2015	Lancee 2012	Lancee 2013	Lancee 2015	Lancee 2016	Morris 2016	Espie 2012	Ritterband 2016	Van Straten 2014	Vincent 2009	Holmqvist 2014	Horsch 2017	Thiart 2015
Randomization	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Concealed allocation	1	1	1	1	1	n/a	1	1	1	1	1	1	1	1	1
Treatment groups similar at the baseline	1	0.5 (educational level)	1	1	0.5 (physical cause)	1	1	1	1	0.5 (duration of disorder)	0 (sex, SOL, NWAK)	1	1	1	0 (no statistical comparison)
Blind participants	1	n/a	0 (aCG not blinded)	0	0	0	0	0	1	1	0	0	0	0	0
Blind treatment performer (computerized: 1)	1	0	0	1	0	1	0	1	1	1	1	1	0	1	1
Blind outcomes assessors	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Treatment groups treated identically (other exposures/ confounder)	1	1	0 (confounder: other treatment until f-u, no CG/WL)	1	1 (comorbidities)	0 (CG: no f-u)	0.5 (confounder: time investment & depression)	1	0	0 (not controlled: OPE)	1	0.5 (medication, CG: internet use)	0 (diff. time investment)	1	1
Follow-up completed and/or well analyzed	0	n/a	1	1	0	1	1	0 (partly analyzed)	1	1	0	1	0	1	1

Analysis in initial groups (ITTA)	1	1	1	1	1	1	1	0 (separate ITTA)	1	1	1	1	1	1	1
Same outcome measures	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Reliability (power)	1	1	1	1	1	0 (small sample size)	1	0 (under-powered)	1	1	0	n/a	0	1	1
Appropriate statistical analysis	1	1	1	1	1	1	1	1	1	1	0 (better: multilevel regres-sion and analysis of variance?)	1	1	1	1
Apprpriate trial design	0.5	1 (but big non-inferiority margin)	1	0 (web-based approach: very plain)	0 (no CG)	1	1	1	1	0 (OPE hardly compara-ble)	1	1	0 (no CG)	1	1
Score	10.5	9.5	9	10	7.5	8	9.5	8	11	9.5	7	9.5	6	11	10

Systematic Reviews and Meta-Analyses

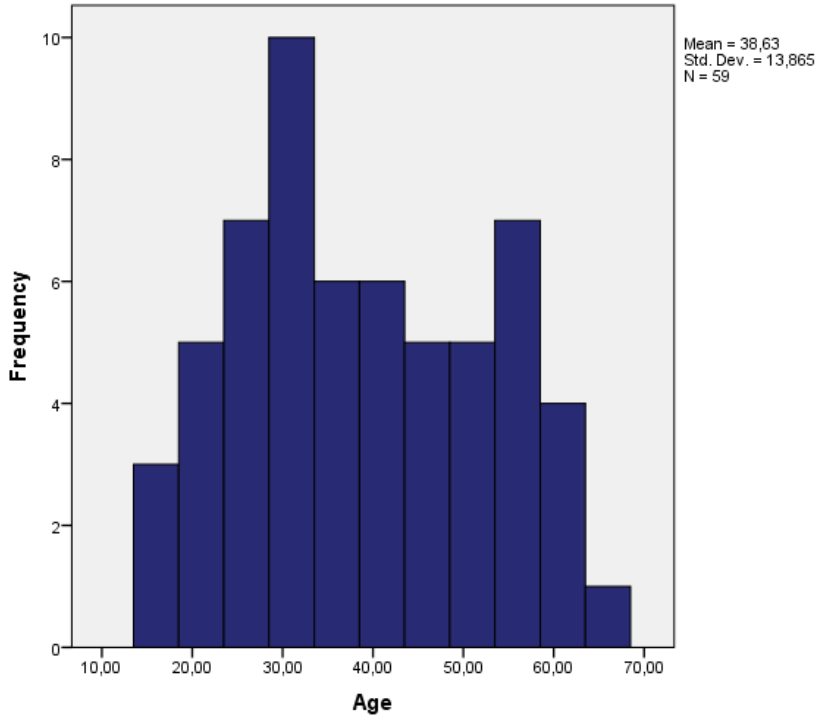
1= fulfilled, 0.5= partly fulfilled, 0= not fulfilled

	Cheng 2012	Ho 2014	Seyffert 2016	Ye 2016	Zachariae 2015
Did the study address a clearly focused question?	0 (only objective)	0 (only objective)	0 (only objective)	0	0 (only objective)
Was a comprehensive literature search conducted using relevant research databases?	1	1	1	1	1
Is the search systematic and reproducible (e.g. were searched information sources listed, were search terms provided)?	1	1	1	1	1
Has publication bias been prevented as far as possible (e.g. were attempts made at collecting unpublished data)?	0.5 (contacting CBT-I experts)	0	0	0	0
Are the inclusion and exclusion criteria clearly defined (e.g. population, outcomes of interest, study design)	1	1	1	1	1
Was the methodological quality of each study assessed using predetermined quality criteria?	1	1	1	1	1
Are the key features (population, sample size, study design, outcome measures, effect sizes, limitations) of the included studies described?	0 (online table cannot be found)	1	0.5 (no limitations of the analyzed studies given)	0.5 (no limitations of the analyzed studies given)	0.5 (no limitations of the analyzed studies given)
Has the meta-analysis been conducted correctly?	1	1	1	1	1
Were the results similar from study to study?	0.5 (ES very small – large)	1	1	1	1
Is the effect size practical relevant?	1	1	1	1	1
How precise is the estimate of the effect? Were confidence intervals given?	1	1	0.5 (only improvements/ no ES)	0.5 (only improvements/ no ES)	1

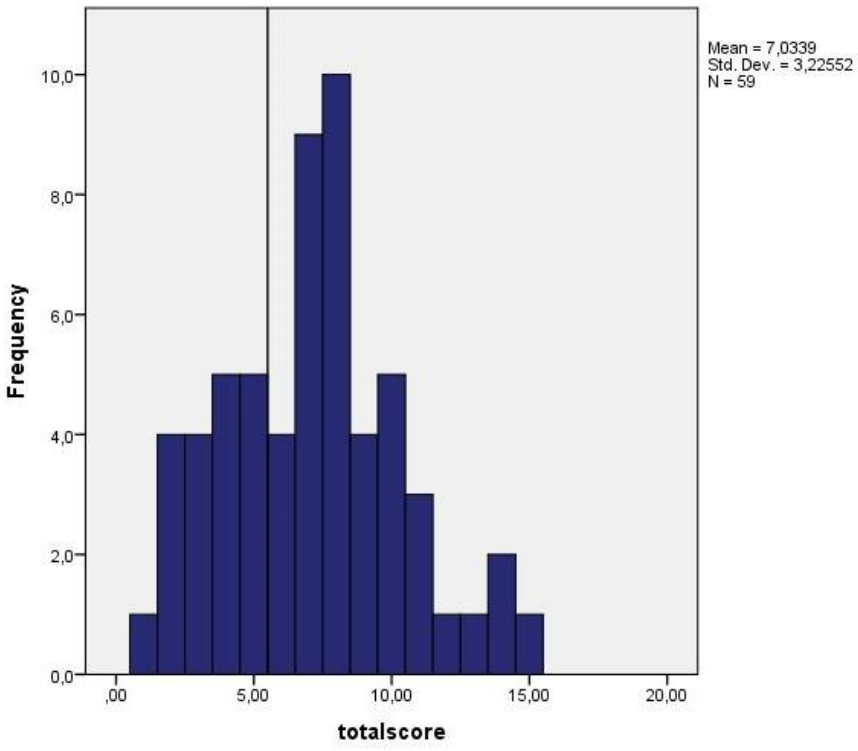
Can the results be applied to your organization?	1	1	1	0 (limited discussion & outlook)	1
Score (max. 12)	9	10	9	8	9.5

Appendix 4: Descriptives

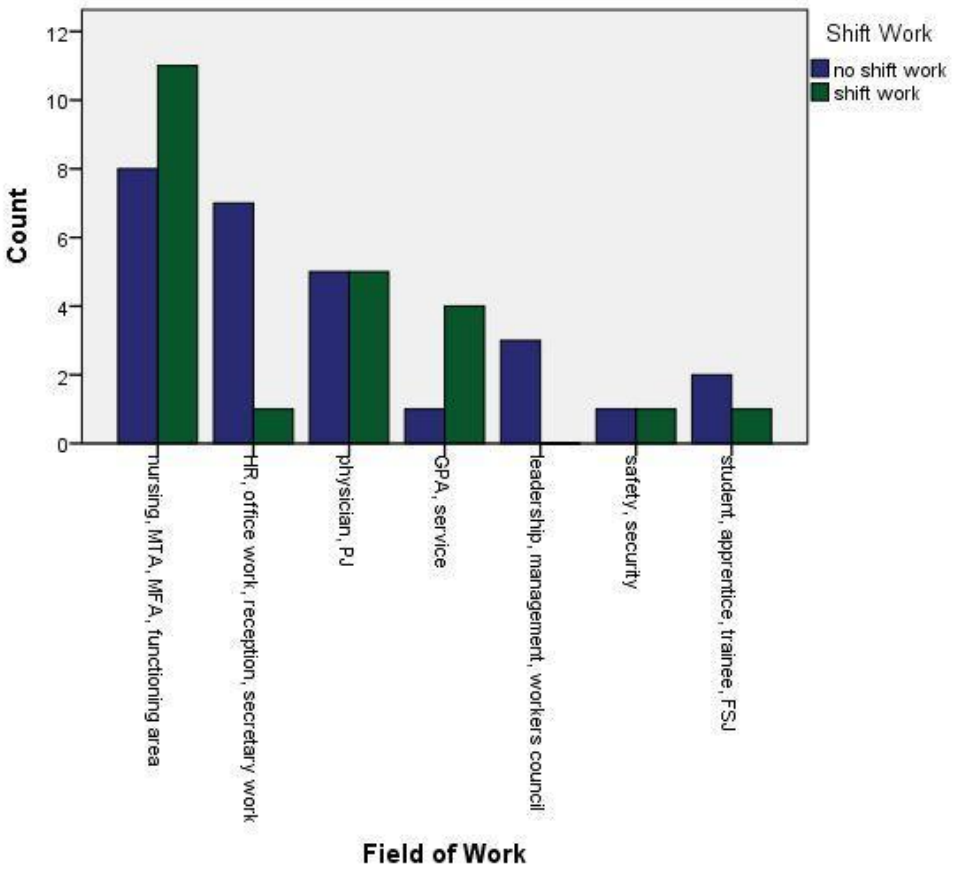
Distribution of Age Groups:



Distribution of PSQI Scores:



Distribution of Professions:



Descritives for Professions:

job

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	nursing, MTA, MFA, functioning area	20	33,9	37,7	37,7
	HR, office work, reception, secretary work	8	13,6	15,1	52,8
	physician, PJ	10	16,9	18,9	71,7
	GPA, service	5	8,5	9,4	81,1
	leadership, management, workers council	3	5,1	5,7	86,8
	safety, security	2	3,4	3,8	90,6
	therapists	1	1,7	1,9	92,5
	student, apprentice, trainee, FSJ	3	5,1	5,7	98,1
	not given	1	1,7	1,9	100,0
	Total	53	89,8	100,0	
Missing	System	6	10,2		
Total		59	100,0		

Descritives of Shift Work & Sex:

shift

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no shift work	31	52,5	54,4	54,4
	shift work	26	44,1	45,6	100,0
	Total	57	96,6	100,0	
Missing	System	2	3,4		
Total		59	100,0		

sex

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	male	17	28,8	28,8	28,8
	female	42	71,2	71,2	100,0
	Total	59	100,0	100,0	

Statistics

		shift	sex	job
N	Valid	57	59	53
	Missing	2	0	6
Mean		,4561	1,7119	4,5849
Std. Deviation		,50250	,45678	13,37109
Variance		,253	,209	178,786
Sum		26,00	101,00	243,00

Appendix 5: Tests for Normality

Normality tests for variable: sex

Tests of Normality

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	sex	Statistic	df	Sig.	Statistic	df	Sig.
totalscore	male	,137	15	,200*	,945	15	,450
	female	,091	37	,200*	,980	37	,724

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Normality tests for variable: age

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
age	,105	59	,163	,952	59	,022

a. Lilliefors Significance Correction

Normality tests for variable: Field of Work/Profession

Tests of Normality[c,d,e,f,g,h,i]

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	job	Statistic	df	Sig.	Statistic	df	Sig.
totalscore	nursing	,166	12	,200*	,949	12	,625
	secretary work and office management	,212	6	,200*	,948	6	,726
	physician or PJ	,179	10	,200*	,898	10	,208
	MFA and MTFA	,185	4	.	,993	4	,971
	functional area	,253	3	.	,964	3	,637
	student/ apprentice/ trainee/ FSJ	,308	3	.	,902	3	,391
	GPA and service	,216	5	,200*	,930	5	,595
	leadership	,260	2	.			

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

c. totalscore is constant when job = human resources. It has been omitted.

d. totalscore is constant when job = therapists. It has been omitted.

e. totalscore is constant when job = workers council. It has been omitted.

f. totalscore is constant when job = occupational safety. It has been omitted.

g. totalscore is constant when job = reception. It has been omitted.

h. totalscore is constant when job = security. It has been omitted.

i. totalscore is constant when job = not given. It has been omitted.

Normality tests for variable: Shift Work

Tests of Normality

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	shift	Statistic	df	Sig.	Statistic	df	Sig.
totalscore	no shift work	,107	31	,200*	,951	31	,169
	shift work	,138	26	,200*	,981	26	,899

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Appendix 6: Statistical Analyses of an Exemplary Hospital

6.1 Sex and PSQI Results

Chi-square test of sex and PSQI components (due to violated assumptions: Likelihood Ratio is used):

PSQI Component (achievable score: 0-3)	Value of l kelihood ratio	df of likelihood ratio	Sign. of l kelihood ratio
Sleep quality	5.867	4	0.209
Sleep (onset) latency	7.639	4	0.106
Duration of sleep	7.539	4	0.110
Sleep efficiency	12.720	5	**0.026**
Disorders	0.058	2	0.971
Medication	2.582	2	0.275
Tiredness	5.238	3	0.155
Total Score	32.465	20	**0.039**

Pearson Correlation of sex and PSQI total score:

Correlations

Descriptive Statistics

	Mean	Std. Deviation	N
totalscore	7,0339	3,22552	59
sex	1,7119	,45678	59

Correlations

		totalscore	sex
totalscore	Pearson Correlation	1	,317*
	Sig. (2-tailed)		,014
	N	59	59
sex	Pearson Correlation	,317*	1
	Sig. (2-tailed)	,014	
	N	59	59

*. Correlation is significant at the 0.05 level (2-tailed).

Mann-Whitney-U Test of sex and PSQI components:

Test Statistics[a]

	quality	latency	duration	efficiency	disorders	medication	tiredness	totalscore
Mann-Whitney U	248,000	266,000	300,000	189,000	349,000	331,000	250,000	214,000
Wilcoxon W	401,000	419,000	453,000	325,000	502,000	1234,000	403,000	367,000
Z	-1,964	-1,581	-,980	-2,874	-,239	-,999	-1,926	-2,400
Asymp. Sig. (2-tailed)	,050	,114	,327	,004	,811	,318	,054	,016

a. Grouping Variable: sex

6.2 Age and PSQI Results

Pearson and Spearman Correlation for age and PSQ total score:

Descriptive Statistics

	Mean	Std. Deviation	N
totalscore	7,0339	3,22552	59
age	38,6271	13,86499	59

Correlations

		totalscore	age
totalscore	Pearson Correlation	1	-,173
	Sig. (2-tailed)		,191
	N	59	59
age	Pearson Correlation	-,173	1
	Sig. (2-tailed)	,191	
	N	59	59

Correlations

			totalscore	age
Spearman's rho	totalscore	Correlation Coefficient	1,000	-,208
		Sig. (2-tailed)	.	,115
		N	59	59
	age	Correlation Coefficient	-,208	1,000
		Sig. (2-tailed)	,115	.
		N	59	59

Spearman Correlation for age and PSQI components:

Correlations

			age	quality	latency	duration	efficiency	disorders	medication	tiredness
Spearman's rho	age	Correlation Coefficient	1,000	-,064	-,114	-,060	-,175	-,070	-,167	-,202
		Sig. (2-tailed)	.	,632	,389	,651	,188	,598	,207	,125
		N	59	59	59	59	58	59	59	59
	quality	Correlation Coefficient	-,064	1,000	,518**	,483**	,401**	,252	,093	,434**
		Sig. (2-tailed)	,632	.	,000	,000	,002	,055	,482	,001
		N	59	59	59	59	58	59	59	59
	latency	Correlation Coefficient	-,114	,518**	1,000	,392**	,300*	,088	,103	,172
		Sig. (2-tailed)	,389	,000	.	,002	,022	,509	,435	,192
		N	59	59	59	59	58	59	59	59
	duration	Correlation Coefficient	-,060	,483**	,392**	1,000	,287*	,015	-,096	,254
		Sig. (2-tailed)	,651	,000	,002	.	,029	,910	,472	,052
		N	59	59	59	59	58	59	59	59
	efficiency	Correlation Coefficient	-,175	,401**	,300*	,287*	1,000	,068	,084	,133
		Sig. (2-tailed)	,188	,002	,022	,029	.	,610	,532	,319
		N	58	58	58	58	58	58	58	58
	disorders	Correlation Coefficient	-,070	,252	,088	,015	,068	1,000	-,014	,233
		Sig. (2-tailed)	,598	,055	,509	,910	,610	.	,916	,076
		N	59	59	59	59	58	59	59	59
	medication	Correlation Coefficient	-,167	,093	,103	-,096	,084	-,014	1,000	,011
		Sig. (2-tailed)	,207	,482	,435	,472	,532	,916	.	,933
		N	59	59	59	59	58	59	59	59
	tiredness	Correlation Coefficient	-,202	,434**	,172	,254	,133	,233	,011	1,000
		Sig. (2-tailed)	,125	,001	,192	,052	,319	,076	,933	.
		N	59	59	59	59	58	59	59	59

6.3 Shift Work and PSQI Results

Chi-square of shift work and PSQI components (due to violated assumptions: Likelihood Ratio ist used):

PSQI Component	Value	Df	Sign.
Sleep quality	6.947	4	0.139
Sleep (onset) latency	7.097	4	0.131
Duration of sleep	8.930	4	0.063
Sleep efficiency	2.690	5	0.748
Disorders	0.221	2	0.895
Medication	1.759	2	0.415
Tiredness	3.050	3	0.384
Total Score	25.279	20	0.191

Pearson Correlation of shift work and PSQI total score:

Correlations

Descriptive Statistics

	Mean	Std. Deviation	N
shift	,4561	,50250	57
totalscore	7,0339	3,22552	59

Correlations

		shift	totalscore
shift	Pearson Correlation	1	,271*
	Sig. (2-tailed)		,042
	N	57	57
totalscore	Pearson Correlation	,271*	1
	Sig. (2-tailed)	,042	
	N	57	59

*. Correlation is significant at the 0.05 level (2-tailed).

Mann-Whitney-U Test of shift work and PSQI components:

Test Statistics[a]

	quality	latency	duration	efficiency	disorders	medication	tiredness	totalscore
Mann-Whitney U	334,500	283,000	278,500	352,500	388,500	399,000	338,500	285,000
Wilcoxon W	830,500	779,000	774,500	848,500	884,500	895,000	834,500	781,000
Z	-1,179	-2,000	-2,050	-,650	-,408	-,145	-1,110	-1,896
Asymp. Sig. (2-tailed)	,238	,046	,040	,516	,683	,885	,267	,058

a. Grouping Variable: shift

Independent sample t-Test for PSQI total score comparing shift workers and non-shift workers:

T-Test

Group Statistics

	shift	N	Mean	Std. Deviation	Std. Error Mean
totalscore	no shift work	31	6,1774	2,76149	,49598
	shift work	26	7,8654	3,35427	,65783

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
totalscore	Equal variances assumed	,123	,727	-2,084	55	,042	-1,68797	,80983	-3,31091	-,06502
	Equal variances not assumed			-2,049	48,454	,046	-1,68797	,82385	-3,34403	-,03190

Independent sample t-Test for PSQI components comparing shift workers and non-shift workers:

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
quality	Equal variances assumed	1,665	0,202	-1,284	55	0,205	-0,26117	0,20340	-0,66879	0,14646
	Equal variances not assumed			-1,259	47,533	0,214	-0,26117	0,20748	-0,67843	0,15610
latency	Equal variances assumed	3,458	0,068	-2,090	55	0,041	-0,53784	0,25730	-1,05349	-0,02220
	Equal variances not assumed			-2,052	48,011	0,046	-0,53784	0,26210	-1,06482	-0,01087
duration	Equal variances assumed	2,017	0,161	-2,173	55	0,034	-0,59615	0,27429	-1,14583	-0,04647
	Equal variances not assumed			-2,138	48,711	0,038	-0,59615	0,27882	-1,15655	-0,03576
efficiency	Equal variances assumed	0,123	0,727	-0,361	54	0,720	-0,09097	0,25218	-0,59655	0,41461
	Equal variances not assumed			-0,363	52,787	0,718	-0,09097	0,25031	-0,59308	0,41114
disorders	Equal variances assumed	0,047	0,829	-0,407	55	0,686	-0,03846	0,09461	-0,22807	0,15114
	Equal variances not assumed			-0,409	54,217	0,684	-0,03846	0,09411	-0,22713	0,15021
medication	Equal variances assumed	0,854	0,359	0,432	55	0,668	0,05211	0,12070	-0,18978	0,29400
	Equal variances not assumed			0,456	44,862	0,650	0,05211	0,11418	-0,17789	0,28211
tiredness	Equal variances assumed	2,190	0,145	-1,005	55	0,319	-0,21092	0,20985	-0,63147	0,20963
	Equal variances not assumed			-0,995	50,660	0,325	-0,21092	0,21201	-0,63662	0,21479
totalscore	Equal variances assumed	0,123	0,727	-2,084	55	0,042	-1,68797	0,80983	-3,31091	-0,06502
	Equal variances not assumed			-2,049	48,454	0,046	-1,68797	0,82385	-3,34403	-0,03190

6.4 Field of work and PSQI results

One-way ANOVA for PSQI total score and field of work (profession):

Descriptives

totalscore

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
nursing, MTA, MFA, functioning area	20	7,5000	2,49737	,55843	6,3312	8,6688	2,00	11,00
HR, office work, reception, secretary work	8	7,8125	2,08631	,73762	6,0683	9,5567	4,00	10,00
physician, PJ	10	4,4500	2,60821	,82479	2,5842	6,3158	1,00	8,00
GPA, service	5	8,5000	5,07445	2,26936	2,1992	14,8008	3,00	15,00
leadership, management, workers council	3	5,3333	2,51661	1,45297	-,9183	11,5849	3,00	8,00
safety, security	2	9,2500	3,88909	2,75000	-25,6921	44,1921	6,50	12,00
therapists	1	7,0000	.	.	.	.	7,00	7,00
student, apprentice, trainee, FSJ	3	6,1667	3,68556	2,12786	-2,9888	15,3221	2,00	9,00
not given	1	8,0000	.	.	.	.	8,00	8,00
Total	53	6,9340	3,02559	,41560	6,1000	7,7679	1,00	15,00

Test of Homogeneity of Variances

totalscore

Levene Statistic	df1	df2	Sig.
2,185[a]	6	44	,062

a. Groups with only one case are ignored in computing the test of homogeneity of variance for totalscore.

ANOVA

totalscore

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	107,867	8	13,483	1,611	,149
Within Groups	368,152	44	8,367		
Total	476,019	52			

One-way ANOVA for PSQI components and field of work:

		Sum of Squares	df	Mean Square	F	Sig.
totalscore	Between Groups	106,701	6	17,783	2,125	,069
	Within Groups	368,152	44	8,367		
	Total	474,853	50			
quality	Between Groups	7,231	6	1,205	2,377	,045
	Within Groups	22,308	44	,507		
	Total	29,539	50			
latency	Between Groups	9,206	6	1,534	1,628	,162
	Within Groups	41,471	44	,943		
	Total	50,676	50			
duration	Between Groups	5,613	6	,936	,783	,588
	Within Groups	52,573	44	1,195		
	Total	58,186	50			
efficiency	Between Groups	4,602	6	,767	,823	,559
	Within Groups	41,025	44	,932		
	Total	45,627	50			
disorders	Between Groups	,824	6	,137	1,510	,197
	Within Groups	4,000	44	,091		
	Total	4,824	50			
medication	Between Groups	1,610	6	,268	1,326	,266
	Within Groups	8,900	44	,202		
	Total	10,510	50			
tiredness	Between Groups	4,187	6	,698	1,128	,362
	Within Groups	27,225	44	,619		
	Total	31,412	50			

Post-hoc Test for significant PSQI component "sleep quality":

Bonferroni	nursing, MTA, MFA, functioning area	HR, office work, reception, secretary work	-,02500	,29787	1,000	-,9855	,9355
		physician, PJ	,90000*	,27577	,045	,0108	1,7892
		GPA, service	,00000	,35602	1,000	-1,1480	1,1480
		leadership, management, workers council	,26667	,44085	1,000	-1,1549	1,6882
		safety, security	,10000	,52807	1,000	-1,6027	1,8027
		student, apprentice, trainee, FSJ	,76667	,44085	1,000	-,6549	2,1882
	HR, office work	nursing, MTA, MFA	,02500	,29787	1,000	-,9355	,9855

6.5 Field of work and shift work with PSQI total score outcome

Two-way ANOVA for field of work and shift work with the outcome of total PSQI score:

Levene's Test of Equality of Error Variances[a]

Dependent Variable: totalscore

F	df1	df2	Sig.
2,695	12	37	,010

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + shift + jobs_new + shift * jobs_new

Tests of Between-Subjects Effects

Dependent Variable: totalscore

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	158,645[a]	12	13,220	1,565	,145	,337
Intercept	1289,576	1	1289,576	152,696	,000	,805
shift	41,627	1	41,627	4,929	,033	,118
jobs_new	92,908	6	15,485	1,834	,119	,229
shift * jobs_new	35,663	5	7,133	,845	,527	,102
Error	312,480	37	8,445			
Total	2886,250	50				
Corrected Total	471,125	49				

a. R Squared = ,337 (Adjusted R Squared = ,122)

Appendix 7: Interviews with Stakeholders

Interviews of two hospital stakeholders provide information for the SWOT-Analysis. Interviews are conducted anonymous and in German.

Interview Pflegekraft (Alter: 28, arbeitet im 3-Schicht-System):

Einführung: Beschreibung der Intervention inkl. Möglichkeiten und verschiedener Ausführungen.

Was für Vor- und Nachteile sehen Sie an einem online Schlaf-Coaching als möglicher Teilnehmer?

- Vorteile: zu Hause, flexibel, vom AG bezahlt, geringe Hemmschwelle (einfach und privat)
- Nachteile: Schichtwechsel, Nachtdienst, Motivation, Regelmäßigkeit, online könnte als nicht so „wertig“ wahrgenommen werden (v.a. bei älteren Mitarbeitern)

Welche Anforderungen muss ein online Schlaf-Coaching erfüllen, damit Sie mitmachen?

- Kostenübernahme („endlich auch mal mehr Unterstützung und Aktionen für Krankenhauspersonal, nicht nur in Wirtschaftsunternehmen“)
- Zeitlicher Aufwand (15-20 Min./Tag)
- Flexible Nutzung (z.B. auf dem Handy abrufbar)
- Automatische Erinnerung
- Einfache Handhabung
- An Beruf angepasst
- Statistik über Verlauf und Fortschritt
- Praktische Tipps und direkte Umsetzung („Selbst-Hilfe“)
- Stressbezogene Inhalte, da dauerhaftes Stress-Level auf der Arbeit vorhanden ist

Ist ein online Coaching für Pflegekräfte und Schichtarbeit geeignet? Was könnten Vor-/Nachteile sein?

- Vorteile: Flexible Nutzung, med. Hintergrundwissen, Tipps für Schichtdienste, z.B. zum schnellen Runterkommen nach Spätschicht, Wissen über PME in Ausbildung gehabt
- Nachteile: Inhalt muss für alle Berufsgruppen aufbereitet sein

Was wären Komponenten des Programms, die Sie motivieren das Programm anzufangen und bis zum Ende mitzumachen?

- Intrinsische Motivation besser zu schlafen („auch die besten Aktionen zur Bewerbung der Intervention bringt nichts, wenn man keine intrinsische Motivation zum Anfangen und Weitermachen hat“)
- Erinnerungsnachrichten
- Neugierde wecken: Module aufeinander aufbauend: 1 Modul abschließen bevor es weiter geht

Welche Anreize kann die Klinik geben, um Ihre Teilnahme zu gewinnen und Sie bis zum Ende zu motivieren?

- 1-2 Urlaubstage mehr
- Vergünstigung für Massage

- Fortbildungspunkte
- Alternative für die älteren Mitarbeiter: Seminare/Workshops

Was wünschen Sie sich als Einführung und Bekanntgabe des Programms?

- Begleitung beim Anmelden und erste Übungen
- Kein Frontalvortrag
- Aktion zur Einführung: in der Freizeit: geringe Teilnahme, während der Arbeitszeit: nicht umsetzbar
- Besser: Lunch and Learn (während der Pause gut umsetzbar) oder als Fortbildung (Mitarbeiter müssen ohnehin Fortbildungspunkte sammeln)

Würden Sie lieber zu einem Therapeuten/Schlaf-Experten gehen oder eine Online-Möglichkeit nutzen?

- „Ich würde lieber ein Online-Programm oder eine App nutzen. Um zum Therapeuten zu gehen müssten die Schlafstörungen schon sehr schlimm sein."

Würden Sie so ein Programm nutzen?

- Ja („Wenn Mein Arbeitgeber die Kosten übernimmt, würde ich auf jeden Fall daran teilnehmen")

Interview Personalmanager und Beauftragter für betriebliches Gesundheitsmanagement:

Einführung: Beschreibung der Intervention inkl. Möglichkeiten und verschiedener Ausführungen

Was für Vor- und Nachteile sehen Sie an einem online Schlaf-Coaching als Personalmanager?

- Vorteile: Erreichbarkeit (online: mehr Mitarbeiter abdeckbar), Flexibilität (Schichtdienst), kostengünstiger & weniger aufwendig als persönliche Coachings durch Therapeuten, genereller Vorteil von BGM Aktionen: Imagesteigerung, um neue Mitarbeiter zu gewinnen
- Nachteile: Technik (ältere Mitarbeiter), Akzeptanz & Wertigkeit von online Kursen

Welche Anforderungen muss ein online Schlaf-Coaching erfüllen, damit die Mitarbeiter mitmachen?

- Externer Anbieter (keine Überwachung des AG), aber transparente Unterstützung
- Einfache Handhabung und Registrierung (schlechte Erfahrung mit aufwendiger Registrierung)
- Interaktiver Einführungsworkshop

Was für Schwierigkeiten könnte es bei der Einführung des Programms bei einer großen Klinik wie Ihrer geben?

- Mundpropaganda ist sehr wichtig (vorheriger Testlauf mit wenigen Mitarbeitern sinnvoll)
- Genug Vorlaufzeit für die Bewerbung

Ist ein online Coaching für alle Berufsgruppen und auch für Schichtarbeiter geeignet?

- Ärzte, Büroangestellte und jüngere Mitarbeiter sind zugänglicher für online Aktionen
- Pflegemitarbeiter erreicht man damit schwieriger

Was wären Komponenten des Programms, die die Mitarbeiter motivieren das Programm bis zum Ende mitzumachen?

- Einfache Handhabung
- Erinnerungen & Motivationsnachrichten

Welche Anreize kann die Klinik geben, um die Teilnahmequote zu erhöhen?

- Geld, Fortbildungspunkte, Gutscheine, kleinere „Goodies“

Wie könnte man das Coaching bekannt zu machen und einführen?

- Multiplikatoren (Testlauf, Mundpropaganda)
- Bewerbung
- Interaktiver Workshop