Sleep and insomnia symptoms in adolescence

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GITA HEDIN has a background in Public Health and Education, with a special interest in adolescents' sleep and insomnia symptoms. Gita is employee at Kristianstad University and did her doctoral studies at Lunds University.

This doctoral thesis contributes with knowledge about sleep and insomnia symptoms among adolescents. From the result that emerged, adolescents express a wish for arenas to discuss and reflect on sleep and sleep habits with adults and peers, both at home and in school.

This thesis shows the importance of listening to adolescents' thoughts and reflections about sleep and sleep problems, and to create a society that promotes good sleep for all, as the 24-hour society is here to stay, and we must find ways to live in it.

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Sleep and insomnia symptoms in adolescence

Gita Hedin

LUND UNIVERSITY

DOCTORAL DISSERTATION

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Abstract

Insufficient sleep, sleep problems and insomnia are common in adolescents, and insomnia and insufficient sleep are public health concerns that can impact adolescents' mental and physical health. There are several different treatments for sleep problems and insomnia, and there is a great focus on the problem when it has already arisen. However, since this is a public health problem, it is important to shed light on it at an early stage, and to inform about adolescents' sleep problems and insomnia symptoms. This, in hope to help the adolescents', adults in their environment and professionals in school health care.

Aim and methods: The overall aim of this doctoral thesis was to contribute with knowledge about possible factors influencing sleep and insomnia symptoms among adolescents. Paper **I** investigated adolescents' experiences regarding what they perceived as facilitators and barriers for a good night´s sleep. This study has a qualitative design, focus groups interviews were performed and analysed with qualitative content analysis. Paper **II** investigated the associations between insomnia symptoms, academic performance, self-reported health, physical activity, school start time, and substance use in adolescents. This paper was a cross-sectional survey and analysed with descriptive and analytic statistics. Paper **III** aimed to test the measurement properties of the Minimal Insomnia Symptom Scale (MISS) together with an additional item focusing on daytime functioning, Minimal Insomnia Symptom Scale-Revised (MISS-R) among adolescents. This study has cross-sectional design and data was analysed with Rash measurement model. Paper **IV** aimed to investigate whether sleep duration, difficulties waking up, tiredness in school, and family financial situation among school-aged girls and boys (aged 6-10 years) can predict insomnia symptoms among female and male adolescents (aged 14-16 years). This was a longitudinal design and was analysed with descriptive and analytic statistics.

Results: From paper **I** emerge that the adolescents were aware of the importance of sleep for managing during the day. However, there were both facilitators and barriers for achieving a good night sleep. Three categories were identified: striving for a sense of well-being, tiring yourself out and regulating electronic media. Paper **II** highlights that insomnia was associated with poor self-reported health, failed school courses, and use of alcohol and/or cigarettes. When the combined effect of self-reported health and physical activity were investigated, a combination of low physical activity and poor self-reported health was strongly associated with insomnia. Paper **III** showed that both MISS and MISS-R had good measurement properties, regarding targeting, items tended to represent more severe levels of insomnia symptoms than reported by the adolescents. Older adolescents were more likely to score higher than younger adolescents in the items concerning "problems with not being rested by sleep", and "problems with daytime disturbance". Paper **IV** showed different factors in childhood that predicted insomnia symptoms in adolescence. These factors differed between sex. Perceived quite bad/very bad family financial situation, and short sleep duration at baseline was associated with insomnia symptoms among female adolescents. However, problems waking up at baseline was associated with insomnia symptoms among male adolescents.

Conclusions: This thesis shows that the adolescents want to talk about sleep problems and insomnia symptoms with adults in their environment. One instrument that professionals in school health care can have benefit of in the conversation with the adolescents, are MISS-R. MISS-R seem to be a reliable screening instrument for insomnia symptoms among adolescents. The adolescents need support from adults to facilitate a good night sleep.

Key words:
Adolescents, Insomnia symptoms, Minimal insomnia symptom scale, Public Health, Qualitative content analyse, Rasch measurement, Sex, Sleep, Sleep duration

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To my beloved daughters

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Abbreviations

AIQ	Adolescent Insomnia Questionnaire
APA	American Psychological Association
CI	Confidence Interval
CTT	Classical Test Theory
DIF	Differential Item Functioning
DSM-5	Diagnostic and Statistical Manual of Mental Disorders
EMU	Electronic Media Use
ESS	Epworth Sleepiness Scale
ICCs	Item Characteristic Curves
ICD-10	International Classification of Diseases 10th revision
ICI	Sleep Condition Indicator
ICSD-3	International Classification of Sleep Disorders - 3rd Edition
IF	Information Function
ISI	Insomnia Severity Index
MISS	Minimal Insomnia Symptom Scale
MISS-R	Minimal Insomnia Symptom Scale – Revised
OR	Odds Ratio
PSI	Person Separation Index
SCI	Sleep Condition Indicator
SD	Standard Deviation
SE	Standard Error

List of papers

This thesis is based on the following papers. In the text they will be referred to by their respective Roman numerals. The original versions of the papers are appended at the end of the thesis.

I. Hedin, G., Norell-Clarke, A., Hagell, P., Tønnesen, H., Westergren, A., & Garmy, P. (2020). Facilitators and Barriers for a Good Night´s Sleep Among Adolescents. Frontiers in Neuroscience. doi: 10.3389/fnins.2020.00092.

II. Hedin, G., Norell-Clarke, A., Hagell, P., Tønnesen, H., Westergren, A., & Garmy, P. (2020). Insomnia in Relation to Academic Performance, Self-Reported Health, Physical Activity, and Substance Use Among Adolescents. International Journal of Environmental Research and Public Health. doi: 10.3390/ijerph17176433.

III. Hedin, G., Garmy, P., Norell-Clarke, A., Tønnesen, Hagell, P., & Westergren, A. Measurement properties of the Minimal Insomnia Symptom Scale (MISS) in Adolescents. Accepted.

IV. Hedin, G., Norell-Clarke, A., Hanne Tønnesen., Westergren, A., & Garmy, P. Contributory factors for teen insomnia symptoms. Submitted.

Paper I, II and paper III were published with permission from the publishers.

Preface

My first contact with the subject of public health came when I started studying at Kristianstad University. I have always been interested in what makes us humans feel good; therefore, public health was a natural choice as a research area. In 2005, I graduated in public health and education and felt that I was ready to enter working life. I was passionate about my interest in adolescents' health.

Immediately after graduation, I gained employment as a project leader for a public health integration project and as a leader of discussion groups among female adolescents within the organization Save the Children. Through this work, I met adolescents, and they taught me a lot about how they viewed health and what they felt they needed to feel good. Several of these adolescents were growing up in areas and homes that lacked a calm environment, which, in turn, disrupted their lives. For example, they could be awakened frequently during the night for various reasons, resulting in tiredness during the school day.

For five years, I worked as a research assistant within a research environment at Kristianstad University. This work allowed me to learn and develop my knowledge about quantitative methods and questionnaires, data collection, analysis, and results. Through this work, I developed a desire to continue with research in some way, thought at that time, I was not yet ready to do so.

I started teaching in public health at Kristianstad University and continued for a few years. I wanted to be involved and influence the education of students who, in the future, would work with public health in different ways. During my time as a lecturer, I encountered research on various topics, mainly concerning adolescents.

To develop my skills, I began PhD studies in public health science, including the project "Sleep and Lifestyle among children and adolescents". When I met the participating adolescents, the first thing I noticed was their willingness to take part and their appreciation of the fact that someone wanted to take the time to talk and listen to them. In particular, I noticed this in the first study in this thesis. Here, my pre-understanding, including my interest in adolescents and public health, might have played a role. I have sought to maintain awareness of my pre-understanding throughout the whole process.

Being an adolescent in our modern society is a complex experience, as several factors that might have an impact on health are out of adolescents' control. Sleep is

important for feeling good and leading a healthy life. For me, it has always been important to listen to adolescents' voices.

Now my journey as a PhD student is almost done, and I hope that this thesis has made the adolescents' voices heard. Through this thesis, I have gained knowledge and insights regarding adolescents' sleep and insomnia symptoms, and my view on this topic has expanded. My vision is that this thesis will increase knowledge about adolescents' sleep and insomnia symptoms and lead to sleep-promoting interventions in the future.

"Just stop thinking and shut everything out and imagine that you´re sinking into the bed like into a cloud and relax. Then it is much easier to fall asleep."

(Female adolescent from study I)

Introduction

"Sleep is the best meditation"

Dalai Lama

We spend one-third of our lives sleeping, and sleep is essential for good health and well-being. However, factors in our environment can disturb our sleep (WHO, 2004). Insufficient sleep among adolescents is a public health problem (Bruni et al., 2019; Johnson et al., 2018). In adolescence, sleep problems can depend partly on biological and psychosocial changes that are natural parts of an adolescent's life and development. The prevalence of insomnia among adolescents in Sweden is approximately 7-24% (Bauducco, 2017). Insufficient sleep in adolescence is associated with depression, anxiety, poor academic achievement, and poor physical health (Gregory & Sadeh, 2012). Therefore, sleep problems and insufficient sleep should be taken seriously.

Furthermore, it is important to acknowledge the complexity of sleep, as several factors may affect adolescents' sleep, such as biological factors, contextual factors, and psychosocial factors. These factors are included in the Biopsychosocial and Contextual Model of Sleep (Becker et al., 2015). To capture the complexity of adolescents' sleep, a variety of different methods was chosen in the four papers in this thesis. The four papers include a qualitative study (**I**), cross-sectional studies (**II-III**), psychometric tests (**III**), and a longitudinal study (**IV**).

This thesis is written in the subject of public health. Therefore, the background begins with a section regarding the public health perspective on adolescent sleep. Then, the background will focus on sleep and adolescent development and, later, borrow its structure from the three concepts of the Biopsychosocial and Contextual Model of Sleep according to (Becker et al., 2015) – the biological, contextual, and psychosocial factors (Fig. 1) (Becker et al., 2015). These factors interactively affect sleep during adolescent development.

Public health perspective

Public health is an expression of the population's state of health. It includes not only the principle that health should be as good as possible but also the principle that it should be evenly distributed among the population. Over the years, public health has been defined in several ways, but the definition most used is that it is the science and art of preventing disease, prolonging life, and promoting health through the organized effort of society (Committee of Inquiry into the Future Development of the Public Health Function, 1988). Public health requires flexibility to develop appropriate strategies reflecting the needs and interests of communities.

Sleep is an area of interest in public health because insufficient sleep is a public health challenge associated with morbidity and mortality (Institute of Medicine Committee on Sleep & Research, 2006). Sleep is an essential function that allows the body and mind to recharge (Kreuger & Obal, 2002). Adolescent sleep is receiving more attention because many changes – including physical, mental, and emotional development – take place when the transition from childhood to adulthood occurs (Association of Maternal & Child Health Programs, 2021). Sleep changes dramatically during adolescence. We have grounds to believe that adolescents' habits are continued in adulthood. Thus, problems and healthy behaviours in adolescence might further affect one's adulthood (Frech, 2012).

Biopsychosocial and Contextual Model of Sleep in Adolescence

This thesis explores the context and complexity of adolescents sleep through a wide perspective on factors and research methods. One way of trying to understand this is through the Biopsychosocial and Contextual Model of Sleep in Adolescence (Becker et al., 2015). This model says that the preference for a later bedtime among adolescents has biological, contextual, and psychosocial reasons (Figure 1); these three factors affect adolescents' sleep during their development. Biological factors include the circadian rhythm, which is an internal mechanism regulating sleep-wake behaviour during the 24-hour period. It is controlled by the suprachiasmatic nucleus in the hypothalamus, which is sensitive to environmental cues such as daylight. When it comes to biological factors, puberty also plays a central role. Furthermore, contextual, and psychosocial factors include relationships with parents and peers and experimenting with new social interactions (friendship and romantic relationships). They also include electronic media use, homework, extracurricular activities, school start times, neighbourhoods, and community factors (Becker et al., 2015).

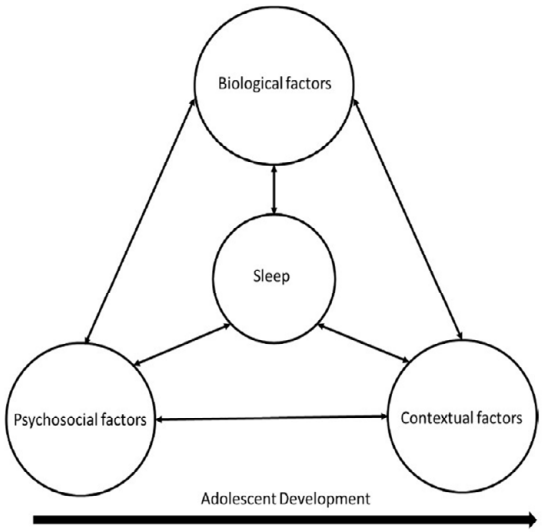

Figure 1. Interpretation of the Biopsychosocial and Contextual Model of Seep in Adolescence.

Sleep

Sleep is considered a positive resource in life (Buysse, 2014). It is a recurring, reversible neurobehavioral state of relative perceptual disengagement from and unresponsiveness to the environment (Kryger, 2005). It is also typically accompanied by lying down, being behaviourally calm, closing one's eyes. Sleep is a physiological state and is necessary for human well-being. It is a complex process, and wakefulness and sleep interact with each other. Sleep quality influences the next day´s emotional experiences, which in turn may have an impact on sleep in the coming night (Bódizs, 2021). Sleep includes a vital bodily maintenance activity that lets the brain recover, process information, and absorb what was learned during the day. It is a state of behavioural quiescence associated with intense neuronal activity and functional increases in the brain regions necessary for emotional and memory processing (Payne, 2010). Also, it seems that sleep relieves aggression, tension, and anxiety (Baker, 2017). Clearly, sleep is more than just rest (Bódizs, 2021); it is a mixture of physiological and behavioural processes (Baker, 2017) and is important to all areas of human functioning.

There are many theories about the functions of sleep. One theory focuses on timing. Humans sleep to improve the timing and effectiveness of their activities during the day; the best time for studies and work is during the day, when it is bright. Staying awake during the day is a way to facilitate good sleep during the night (Bódizs,

2021). Sleep is also important for conservation. We sleep to save energy, and the needs of the brain for energy and oxygen decreases during sleep. Sleep in general is associated with body cooling (the temperature decreases), and lack of sleep is associated with increased energy waste. Thus, energy conservation is one of the potential functions of sleep, and temperature and other energy-intensive activities decrease during sleep (Bódizs, 2021). Sleep helps with the removal of metabolic waste and the restoration of our neurocognitive and emotional functions; also, we sleep to strengthen our memories and adaptive immunity. Sleep helps us maintain neural networks (Bódizs, 2021).

The effect of sleep on learning and memory

Sleep appears to promote the creation of novel associations between information to create a solution to a problem (Cai et al., 2009). Working memory is the ability to actively uphold and manipulate information for up to 10 seconds (e.g., keeping different numbers in mind while performing something else). The working memory is a vital component of numerous executive and attentional functions and can be modulated by sleep restrictions (Krause et al., 2017). For example, individuals reveal reduced frontoparietal activity after only 30 hours of sleep deprivation. However, difficult tasks may be less vulnerable to sleep deprivation, as there is a great risk of falling asleep when performing repetitive and monotonous tasks (Simor, 2021). For adolescents, learning and memory are important when it comes to school performance, and there are associations between disturbed sleep and lower academic performance (Evers et al., 2020).

When a sequence of cognitive abilities is included, the executive functions are affected. These include flexibility, planning, and coordinating goal-directed actions. Executive function insufficiencies can also lead to reduced memory recollection when strategies must be planned (Simor, 2021). When it comes to sleep deprivation, the ability to link different tasks is negatively affected (e.g., due to the response speed and the need to be flexible between different tasks); however, after a post-lunch nap, the ability to link different tasks improves (Simor, 2021).

Sleep and daytime function

Sleep quality seems to affect the next day´s emotional experiences (Simor, 2021). There are also associations between impaired sleep and emotional processing (Simor, 2021). A single sleep-deprived night applies a negative bias to the processing of emotional stimuli, and disturbed sleep contributes to the risk and maintenance of psychiatric conditions (Harvey, 2011). Subjective symptoms of sleep deprivation are irritability and mood disturbance (Simor, 2021). Changes in emotional responsiveness after sleep deprivation may also lead to impaired

processing of complex emotional stimuli, such as recognition of human emotions (Cote et al., 2014; van der Helm et al., 2010).

Sleep duration

Adequate sleep duration is associated with improved attention, behaviour, cognitive functioning, emotional regulation, and physical health among children and adolescents (Paruthi et al., 2016). Sleep duration differs throughout life because of biological and social changes connected to growing and aging, and therefore the recommendations for sleep duration vary according to age. Sleeping six hours or less each night is often considered a short sleep duration, while sleeping nine hours or more is considered a long sleep duration among adults (Holst, 2021). Recommendations for sleep duration for children and adolescents in Sweden are 11-14 hours for pre-school children (1-5 years), 10-11 hours for school children (6-12 years), and 8-9 hours for adolescents (13-18 years) (Andrée. et al., 2015). These recommendations are close to the guidelines from the US, which are 10-13 hours for pre-school children (3-5 years), 9-11 hours for school children (6-13 years), and 8-10 hours for adolescents (14-17 years) (Hirshkowitz et al., 2015).

In a longitudinal study, children and adolescents aged 10-18 years were followed over time, and it was found that when the adolescents were allowed to sleep for 10 hours, they slept, on average, 9.25 hours no matter their age (Leach, 2021). Children and adolescents in the 20th century slept, on average, 71 minutes less per night than adolescents 100 years ago (Matricciani et al., 2012).

A measure of daytime sleepiness is one way to detect insufficient sleep (Holst, 2021). Adults who had shorter sleep (<6.5 hours) had more daytime sleepiness compared to those who slept longer (Holst, 2021), but we must consider that insufficient sleep can be an individual matter, and that we have difference preferences. During adolescence, development problems with short sleep have been found in different areas (Shochat et al., 2014); these negative health outcomes include weight gain, obesity, diabetes type 2, and cardiovascular disease (Cappuccio et al., 2010). Sleep deprivation has also been associated with increased mortality and a higher risk of accidents (Holst, 2021). Sufficient sleep is a prerequisite for human well-being and the ability to perform optimally (Holst, 2021).

Insomnia

A commonly used term to describe subjectively insufficient sleep is insomnia; however, the definition of insomnia has changed over time, based on increased knowledge (Ellis, 2021). Generally, insomnia is defined as difficulties in either initiating or maintaining sleep or waking earlier than necessary with an inability to get back to sleep. These problems should have existed for one to three months and occur at least three or more nights per week before the condition is classified as chronic. The individual must also experience these problems despite having sufficient opportunity for sleep and being negatively affected during the daytime (Ellis, 2021). Approximately 30-48% of the general population has insomnia at a symptom level; however, approximately, 6-20% meets the diagnostic criteria (Ellis, 2021). Insomnia may be the most commonly reported mental health complaint (Robotham, 2011). Mental health influences insomnia, and insomnia can lead to mental health problems (Robotham, 2011).

Diagnosis systems

Insomnia as a diagnosis is included in three different diagnostic systems: the International Statistical Classification of Diseases and Related Health Problems (ICD-10), the International Classification of Sleep Disorders, 3rd Edition (ICSD-3), and the Diagnostic and Statistical Manual of Mental Disorders, 5th edition (DSM-5). The diagnostic criteria according to ICD-10 include difficulties initiating or maintaining sleep; non-refreshing sleep; the sleep disorder occurring three times per week for at least one month; and the sleep disorder causing obvious discomfort for the person or disrupting her/his daily life. The ICD-10 (World Health Organization, 2010) is a standard diagnostic tool for epidemiology, health management, and clinical practice. It is based on the World Health Organization (2010) and appeared in its first version in 1994, then was revised in 2010. The diagnostic criteria for insomnia were revised to some extent in the DSM-5 (American Psychiatric Association, 2013), with a stronger emphasis on daytime functioning.

Measuring insomnia

The diagnosis of insomnia is made after a clinical interview, physical investigation and the use of sleep diaries and other questionnaires. Other investigation methods, such as the actigraph and polysomnography, are more rarely used. It is important to exclude other medical or psychiatric disorders that could cause insomnia symptoms (Riemann, 2021). However, regardless of its cause, insomnia has the same negative effects on a person's well-being. In research and screening, insomnia is commonly measured through brief questionnaires.

When it comes to screening for and measuring insomnia, different instruments have been validated; see Table 1. The Insomnia Severity Index determines the severity of insomnia (Bastien et al., 2001). The Sleep Condition Indicator can be used to screen for symptoms of insomnia (Espie et al., 2014). Beyond screening instruments, several scales measure insomnia-specific aspects and other sleep symptoms, such as the Epworth Sleepiness Scale, which evaluates daytime sleepiness (Johns, 1991). However, one instrument, the Minimal Insomnia Symptoms Scale (MISS), is set apart from the others in terms of brevity. The MISS is a screening instrument for insomnia symptoms (Broman et al., 2008; Westergren et al., 2015). The brevity of MISS with only three questions increases the probability of getting complete answers in comparison to longer instruments and could thus be beneficial for an adolescent population (Appendix 1).

Table 1. Questionnaires screening for and measuring insomnia symptoms.

Questionnaire	Items	References
Insomnia Severity Index (ISI)	7	Bastien et al. (2001)
Sleep Condition Indicator (ICI)	8	Espie et al. (2014)
Epworth Sleepiness Scale (ESS)	8	Johns (1991)
Minimal Insomnia Symptom Scale (MISS)	3	Broman et al. (2008); Westergren et al. 2(015)

Insomnia among adolescents

Approximately 10% of adolescents in the US (13-16 years old) in a study fulfilled the diagnostic criteria for insomnia. Furthermore, 33% had insomnia symptoms and were frustrated with their sleep (Johnson. et al., 2006). However, when it comes to insomnia among adolescents, many preventive factors have been reported to have a positive impact on sleep duration and sleep quality (Kredlow et al., 2015). The most common sleep recommendations are sleep hygiene factors that, together with other treatments for insomnia, are effective (Bruni, 2021). When it comes to sleep hygiene, this includes a combination of factors to create an environment that promotes healthy sleep (Bruni, 2021). Sleep hygiene includes a consistent sleep schedule (going to bed and getting up at the same time every day), avoiding stimulating activities before bedtime (watching TV, playing videogames), abstaining from food or drink intake before bedtime (limiting caffeinated soft drinks, chocolate, and caffeine) and having a regular bedtime routine (taking a calming bath, reading a book). It also includes avoiding spending lots of non-sleep time in bed; electronic media should be kept outside the bedroom (Bruni, 2021) (Figure 2).

Figure 2. Different aspects included in sleep hygiene to promote a good night's sleep.

It is important to identify insomnia at an early stage among adolescents because their bodies are growing and there is evidence indicating an association between insomnia and physical, cognitive, emotional, and social development (Bruni et al., 2019).

Adolescents' development

In the Biopsychosocial and Contextual Model of Sleep, it is highlighted that during adolescents' development, many changes take place when the transition from childhood to adulthood occurs (Becker et al., 2015), including physical, mental, and emotional development (Association of Maternal & Child Health Programs, 2021). Sleep changes during adolescence. Youths go to bed later, have evening activities, and sleep less than they did during childhood (Colrain & Baker, 2011). The development from childhood to adulthood assumes three primary stages of adolescence: early adolescence (10-14 years), middle adolescence (15-17 years), and late adolescence (18-24 years) (Association of Maternal & Child Health Programs, 2021).

In the early adolescence stage (10-14 years), puberty begins. Both girls and boys experience physical growth and increased sexual interest. In early adolescence, the abstract thinking capacity is limited, and the adolescent lives mainly in the present, though intellectual interests are expanding and becoming more important (Association of Maternal & Child Health Programs, 2021).

In the middle adolescence stage (15-17 years), puberty is completed for both girls and boys; physical growth is decreasing for girls but continues for boys. Adolescents start to set long-term goals and become more interested in the meaning of life and moral reasoning (Association of Maternal & Child Health Programs, 2021).

In the late adolescence stage (18-24 years), physical development is decreasing, and cognitive ability is increasing. Adolescents gain an increased ability to think about ideas rationally, delay gratification, plan for the future, and gain an identity. Adolescents in this stage also develop increased emotional stability and independence (Association of Maternal & Child Health Programs, 2021).

Biological factors and sex differences

Biological development affects sleep and sleep patterns among adolescents (Carskadon, 2011). In particular, brain development seems to be associated with changes in sleep patterns during adolescence (Carskadon., 1982; Sisk & Foster, 2004). When children reach adolescence, different biological changes occur (Colrain & Baker, 2011). From being alert in the morning, adolescents become alert in the evening; this is linked to puberty. It is a normal part of development, but many adolescents get insufficient sleep in this phase (Colrain & Baker, 2011). Adolescents go through dramatic biological and social changes, which can affect their health, behaviour, and sleep (Colrain & Baker, 2011).

Furthermore, women are 1.3-1.6 times more likely than men to report sleep disturbance, but there is also a socioeconomic influence when it comes to sex differences. This is an important factor when it comes to explaining sleep problems between the sexes; low income also affects sleep duration and quality (Porkka-Heiskanen, 2021).

Psychosocial factors

Psychosocial factors in relation to the social context – for instance, family, peers, academic achievement, and mental health concerning the individual – can affect adolescents' sleep patterns. Across the lifespan, the family context is of great importance when it comes to sleep (Dahl & El-Sheikh, 2007). Different factors within a family can affect adolescents. These factors can be divided into groups (Dahl & El-Sheikh, 2007):

- Other family members: Infants who are awake and crying at night, which can lead to daytime tiredness.
- Family context: Stress, attitudes, rules, and emotions.

- Sleep and family: Among those who are against parents' control and rules, these factors seem to have a connection with sleep problems in adolescence being linked to behavioural problems.
- Academic achievement: Problems with sleep have a negative impact on academic achievement. Adolescents with good sleep have greater school competence compared to adolescents with poorer sleep.
- Sleep and mental health: Disturbed sleep is a symptom of several psychiatric disorders. Sleep functioning is relevant to most, if not all, domains of mental health (e.g., anxiety, depression, and substance use).

Family also has an important effect on an adolescent's sleep, and the relationship between parents and adolescents is important for sleep duration and quality (Dahl & El-Sheikh, 2007). A good relationship with one's parents is associated with better sleep (Meijer et al., 2016), while a poor relationship seems to have a negative effect on sleep (Brand et al., 2009). Adolescents whose parents set their bedtimes had a longer sleep duration compared to those whose parents did not set bedtime rules (Biggs et al., 2010).

Another factor in the psychosocial aspect is peers and how they influence adolescents' sleep patterns. Adolescents with sleep problems more often have problems with peer relationships (Roberts et al., 2002). Also, short sleep duration has been associated with peer problems (such as usually being on their own, generally play alone, and they get on better with adults than with people in their own age) (Sarchiapone et al., 2014).

Contextual factors

In different ways, contextual factors – such as electronic media use, homework, school start time, activities, neighbourhood, community, and cultural aspects – affect adolescents' sleep patterns (Becker et al., 2015).

Regarding sleep and electronic media use among adolescents, research shows contradicting results. Many studies show the negative effects of electronic media use and sleep duration and quality. The use of electronic media late at night has a negative impact on sleep duration among adolescents (Bruni, 2021). Moreover, a longitudinal study describes associations between electronic media use and sleep problems among adolescents (Nuutinen et al., 2013). Sleep disturbance includes nighttime-specific behaviours related to social media, such as waking to check messages or incoming notifications and having a later bedtime because of social media activities (Evers et al., 2020). Furthermore, a systematic review among youth (aged 16-25) shows significant associations between social media use and poor

sleep quality and negative mental health (Alonzo et al., 2021). Moreover, Bartel et al. (2019) found that adolescents who reduced their electronic media use by one hour each day experienced a notable reduction in later sleep problems. Meanwhile, other studies show no or minor negative effects on sleep duration and sleep quality (Combertaldi et al., 2021). Orben and Przybylski (2020) highlight that one must take into account that there are great individual differences in how adolescents react after using electronic media at bedtime.

When it comes to sleep duration and time spent on homework, several studies show a negative association. More time spent on homework is significantly associated with shorter sleep (Zhou et al., 2012). One could argue that homework is linked to school stress. However, few studies have examined stress and sleep problems among adolescents (Chung & Cheung, 2008). It is not uncommon for adolescents to take a long time on homework; therefore, more longitudinal studies are needed to investigate the factors that affect sleep duration (Becker et al., 2015).

One factor that can affect sleep duration is the school start time; it is recognized as an important factor for understanding sleep among adolescents (Kirby, 2011). In a study in Australia, where the school start time was around 8:30 a.m., the adolescents slept about 47 minutes more each night than those in the US, where the schools started at 7:45 a.m. (Short et al., 2013). However, even here, it is difficult to say that the school start time influences sleep, as sleep timing is culturally determined and depends on the bedtime set by parents (Short et al., 2013). When it comes to improving adolescents' sleep, it is important to examine school start time but also other contexts in the adolescents' environments.

In addition to school, the neighbourhood and wider community are important when investigating whether adolescents have sufficient or insufficient sleep. However, there is a gap in knowledge about the benefits of napping in the daytime for functioning among adolescents; therefore, more studies are needed, comparing nappers and non-nappers, and considering cultural factors (Fukuda & Ishihara, 2002; Lemos et al., 2014). In conclusion, sleep duration can vary across continents with different cultural norms (Do et al., 2013).

When it comes to neighbourhood, Troxel et al. (2020) found that on an individual level, low socioeconomic status is associated with insufficient sleep. They also reported that housing distress (such as plumbing that does not work, rats or mice, broken locks or no looks on doors, or heating systems that do not work) was associated with shorter sleep duration and poor self-reported sleep quality (Troxel et al., 2020). There is clear evidence that environmental factors are associated with insufficient sleep and sleep disorders (Johnson et al., 2018).

In addition to neighbourhood, it is important to consider the cultural context in a broader way when it comes to adolescents' sleep. For example, in some countries, afternoon napping is common and may help adolescents in those cultures obtain more sleep over a 24-hour period; the benefits or detrimental effects of napping on

adolescents' daytime functioning and nighttime sleep remain unclear (Fukuda & Ishihara, 2002).

To sum up, adolescents' sleep is complex, and it is important to take into account biological, contextual, and psychosocial factors when talking about adolescents and their sleep, and in research.

Rationale

Sleep problems comprise a significant public health concern among adolescents worldwide and could lead to both physical and mental health issues. There is a biological drive for adolescents to go to bed later and to wake up late. However, during the school weeks, many adolescents get to bed later but still have to get up early. This leads them to constantly miss out on crucial sleep during the week.

There is a growing need for knowledge about adolescent sleep and sleep problems. One way to increase knowledge is to listen to the voices of the adolescents themselves. Screening for and identifying predictors of insomnia symptoms at an early stage could be a step toward preventing other negative health factors and habits among adolescents, such as poor self-reported health, infrequent physical activity, and the use of alcohol and/or cigarettes. Easily accessible and short screening instruments are in demand, especially among health professionals in primary health care, such as school nurses and public health nurses.

Another path for predicting insomnia is to investigate the factors in childhood that can lead to insomnia among female and male adolescents, such as sleep habits and family financial situation. Therefore, this thesis strives to contribute knowledge about possible factors influencing sleep and insomnia symptoms among adolescents.

Aim

The overall aim of this doctoral thesis was to contribute with knowledge about possible factors influencing sleep and insomnia symptoms among adolescents.

The specific aims were:

I. To investigate adolescents' experiences regarding what they perceived as facilitatiors and barriers for a good night's sleep.

II. To investigate the association between insomnia, failed grades, self-reported health, physical activity, school start time, and substance use among adolescents.

III. To test the measurement properties of the Minimal Insomnia Symptom Scale together with an additional item focusing on daytime funcioning among adolescents using modern test theory.

IV. To investigate whether sleep habits, sleep duration and family financial situation at childhood (aged 6-10 years) can predict insomnia in female and male adolescents (aged 14-16 years).

Methods

Design

This doctoral thesis includes both qualitative and quantitative research designs to contribute knowledge about factors influencing sleep and insomnia symptoms among adolescents. The first paper (**I**) used focus group interviews, while the second paper (**II**) was a cross-sectional study. Paper **III** was a cross-sectional psychometric testing of an insomnia screening instrument, while the last paper (**IV**) was a longitudinal quantitative study. The various designs of the four studies were chosen based on the overall aim of the thesis. In paper **I**, we asked the adolescents what they experienced as facilitators and barriers for a good night's sleep. This was the basis for the choice of variables in paper **II**. Further, in paper **III**, we wanted to psychometrically test the instrument, which led to the choice of instrument in paper **IV** (Table 2).

Table 2. Overview of studies included in this thesis.

Paper	Aim	Design, sample, and year of data collection	Data collection	Analysis
I.	To investigate adolescents' experiences regarding what they perceived as facilitators and barriers for a good night's sleep.	Qualitative design. Adolescents aged 16-18 years (n=45). 2018-2019.	Focus groups.	Qualitative content analysis.
II.	To investigate the association between insomnia, academic performance, self-reported health, physical activity, school start time, and substance use among 15 – 17-year old Swedish adolescents.	Quantitative design. Cross-sectional study. Adolescents aged 15-17 years (n= 1504). 2017-2019.	Questionnaire.	Bivariate and logistic regression analyses.
III.	To test the measurement properties of the MISS together with an additional item focusing on daytime functioning among adolescents using the Rasch measurement model.	Quantitative design. Cross-sectional study, psychometric testing of instrument. Adolescents aged 13-17 years (n= 3022). 2015-2019.	Questionnaire.	Rasch measurement model.
IV.	To investigate whether sleep duration, difficulties waking up, tiredness in school, and family financial situation among school-aged girls and boys (aged 6-10 years) can predict insomnia symptoms among female and male adolescents (aged 14-16 years).	Quantitative design. Longitudinal study. Children and adolescents aged 6-16 years (n=522). 2008-2019.	Questionnaire.	Bivariate and logistic regression analyses.

Context

The studies were carried out in southern and middle Sweden. Seven municipalities were included in this project. The population of the smaller municipalities was less than 15,000 inhabitants, while in the medium to large municipalities, it was 40,000-130,000 inhabitants (Statistics Sweden, 2019).

The studies were carried out within the school environment. The schools were both private and public and were in rural and urban areas. The number of students in the different schools was in the range of 315-2595 (Skolkollen, 2019).

Sample, procedure, and data collection

The data collection for the four papers was both qualitative and quantitative. Paper **I** contained focus group interviews with adolescents in upper secondary school (n = 45). Paper **II** contained a questionnaire that was distributed to adolescents aged 15-17 years (n=1504). Paper **III** contained a questionnaire and was distributed to adolescents aged 13-17 years (n=3022). For paper **IV**, the questionnaire was distributed at two different times. The first time was when the children were 6-10 years old, and the second time was when they were 14-16 years old (n=522).

Qualitative design

Sample and data collection

Focus group interviews were used as a data collection method in paper **I**. The focus groups were conducted during school days between October 2018 and May 2019; there were seven focus groups held in both private and public schools. The schools were in southern and central Sweden. All focus groups were with adolescents in upper secondary school and were held in a school environment well known to the adolescents. Focus groups are useful when one seeks to understand how a target group perceives a phenomenon and why (Krueger & Casey, 2015). In this thesis, the studied phenomenon was sleep. The choice of data collection method was based on interest in using data with a variety of perspectives, ideas, and experiences (Patton, 2002). The advantage of focus group interviews is that the participants can listen to each other's answers and, thus, develop their own reflections on, and discussions about, the questions (Krueger & Casey, 2015). Focus groups were chosen to capture the adolescents' experiences of facilitators and barriers for a good night's sleep. Distributions of the number of participants, sex, and age are described in Table 3.

Table 3. Distribution of the number of participants, sex, and age in the focus group interviews.

Focus group, number	Number of participants and sex	Age
1	3 females, 4 males	16 years
2	6 females, 2 males	16–17 years
3	5 females, 2 males	16 years
4	3 females, 4 males	16 years
5	4 females, 4 males	16-18 years
6	4 females, 1 male	16 years
7	3 females	16 years

Interview guide

Before data collection started, 10 researchers with expertise in adolescents' health reviewed and provided input on the semi-structured interview guide. This was done to validate that the interview guide covered the purpose being investigated (Krueger & Casey, 2015). These questions were used to guide the dialogue in the focus groups (Krueger & Casey, 2015). Examples of questions were: "Could you please give examples of a good night's sleep?", "What are the challenges for a good night's sleep?", "How do you handle these challenges?" and "What resources do you think exist in your everyday life to meet your challenges regarding sleep?". The semi-structured interview guide is presented in appendix 2.

Procedure

Recruitment of participants for the focus groups was done by purposive sampling (Patton, 2015). The participants were informed about the study and invited to participate, on a volunteer basis, by their teacher or school health professionals. Nine schools were asked to participate; two of them declined because of time constraints. Forty-five adolescents in the age range 16-18 years old were included in the study; 28 of them were females and 17 of them were males. Most focus group contained a mix of females and males, and the participants were acquainted with each other in some way. There were three to eight adolescents in each group (n=7 groups); the school health professionals or teachers arranged places for each interview and informed the adolescents about the voluntary participation.

Before the focus groups started, the participants were once again informed about the study and its voluntary nature. They filled in a written informed consent to participate. After this, the focus groups started. First, the moderator welcomed the participants. Then the moderator introduced the purpose of the focus groups and informed the participants to talk one at a time, put their mobile phones on silent, and not take photos or record anything themselves. Also, before the start of the focus groups, the researchers explained the procedure, indicated that the real experts on the topic were the participants, and said that the moderator and the observers' roles were to guide the discussion.

For most of the focus groups (n=5), I was the moderator (GH). However, in two of the groups, my supervisors (PG, ANC) moderated the focus groups. The duration of the focus groups was between 70 and 90 minutes, except for one of the interviews, which lasted 45 minutes. The interviews were audio-recorded after permission was obtained from the participants. A semi-structured interview guide about sleep, school start time, and physical activity was discussed during the interviews. The same semi-structured interview guide was used for all focus groups. The intention was to have a moderator and an observer in every focus group, and this was the case in four of the focus groups. In the last three focus groups, due to time constraints, there was one moderator but no observer. The moderator´s role was to lead the groups forward and to ensure that everyone was allowed to speak. The observer informed the participants from the beginning of the observers' role to sit quietly during the whole conversation, but to interact in the end with additional questions if there was a need for that. In all seven groups, the atmosphere was positive. Furthermore, in all the focus groups, we used visual tools in the form of A4 papers with keywords linked with the open questions. All focus group interviews were transcribed verbatim by GH.

Quantitative design

Paper **II** and paper **III** had cross-sectional designs. Furthermore, in paper **III**, psychometric testing of a screening instrument of insomnia symptoms was conducted. In paper **IV**, a longitudinal design was used.

Instrument

The screening instrument, the Minimal Insomnia Symptom Scale (MISS), was included. The MISS consists of three items representing symptoms of insomnia: difficulties falling asleep, night awakenings, and unrefreshing sleep (Broman et al., 2008; Westergren et al., 2015) (Appendix 1). Every item has five response categories: no, minor, moderate, severe, and very severe problems, which are scored from 0-4. The total score ranges from 0-12, with higher scores indicating more severe insomnia symptoms. A cut-off score of ≥6 for identifying insomnia is recommended among adults (Broman et al., 2008) and was used for identifying insomnia symptoms in this paper. The MISS was originally developed and tested for adults and the elderly (Broman et al., 2008). Westergren et al. (2015) provide general support for the measurement properties of the MISS; however, they also highlight that caution should be observed when comparing raw MISS scores between age groups. They also indicate that additional studies are needed to determine the clinically ideal cut-off score for the identification of insomnia symptoms (Westergren et al., 2015). Because the diagnostic criteria for insomnia have been revised to some extent in the DSM-5 (American Psychiatric Association, 2013), with a stronger emphasis on daytime functioning compared to when the

MISS was developed, a fourth question in paper **III** was added to the instrument, about daytime disturbance (Appendix 1). The original MISS item "not rested by sleep" was replaced, with the item "daytime disturbance", we label this new scale MISS-Revised (MISS-R). The new item had the same response categories as the three other questions.

In addition to the MISS, items from the Sleep and Media Habits Questionnaire (Garmy, 2018; Garmy et al., 2012) and Sollerhed (2006) were used in papers **II** and **IV**. The surveys included questions about sex, family financial situation (five-point Likert scale ranging from "very well" to very bad"), self-reported health (five-point Likert scale ranging from "very well" to very bad"), school start time, physical activity (seven-point Likert scale ranging from "never" to "≥4 times/week"), failed school courses ("none" to "≥5 courses"), alcohol and cigarette use (six-point Likert scale ranging from "never" to " ≥1 time/day"), time spent on social media/gaming (hours/minutes), time spent watching TV/films (hours/minutes), being tired in school (four-point Likert scale ranging from "never" to "each day"), difficulties waking up (four-point Likert scale ranging from "never" to "each day"), and sleep duration (hours/minutes). Before data collection, the questionnaires were distributed to school classes in the target age group to check face validity. The feedback from students was that the questionnaires were easy to understand and fill out.

Procedure

The questionnaires distributed in compulsory school (students aged 6-15 years) were collected by the school nurses, in conjunction with the optional health visits in school. In the upper secondary school (students aged 16-17), the questionnaire was distributed by teachers as a web survey. For children aged 6-10, the questionnaires were filled in by the guardians together with the children. For adolescents, the questionnaire was filled in by the students themselves at school, and the guardians were given written information in advance about the study. These questionnaires formed the basis for the data material for papers **II**, **III**, and **IV**. Characteristics of the sample in papers **II**, **III**, and **IV** are described in Table 4, Table 5, and Table 6.

Table 4. Characteristics of study sample in paper II.

Characteristics	Study sample (n=1504)
Age, range	15-17 years
Female, n (%)	816 (56.6)
Male, n (%)	636 (43.4)

Table 5. Characteristics of study sample in paper III.

Characteristics	Study sample n=3022)	
	The MISS scale	The MISS-R scale
Total sample, n (%)	2968 (98)	2980 (99)
Female, n (%)	1566 (53)	1570 (51)
Male, n (%)	1364 (46)	1372 (45)
Younger sample, n (%)	1491 (49)	1507 (50)
Older sample, n (%)	1477 (49)	1473 (49)

Table6. Characteristics of study sample in paper IV.

Characteristics	Study sample, baseline (n=522)	Study sample, follow up (n=522)
Age, range, mean	6-10 years, 9.43	14-16 years, 14.28
Female, n (%)	260 (49.8)	260 (49.8)
Male, n (%)	262 (50.2)	262 (50.2)

Analysis

Qualitative analysis

Paper I

In paper **I**, qualitative content analysis (Graneheim & Lundman, 2004) was used to analyse a large amount of data with a focus on variation. Nvivo Plus software, version 12, was used to sort and organize the data material. First, I read and listened to the material several times. Furthermore, two of the supervisors analysed the material. In the next step, two more supervisors were included in the analysis by reading a random sample of interview extracts. To establish consistency, which in turn increases credibility and trustworthiness (Guba, 1981), the supervisors and I independently read transcriptions of the interviews. In addition, two of the supervisors and I separately identified content areas and the facilitators of, and barriers to, a good night's sleep, according to the adolescents. Hereafter, we identified meaning units, codes, sub-categories, and categories. The supervisors and I discussed this several times. All authors agreed upon the final findings in the analysis.

Quantitative analysis

Papers II and IV

In papers **II** and **IV**, due to the low frequency of responses in some answers, certain items were dichotomized (see appendix 3 for item description and dichotomized variables). The descriptive and analytic statistics in papers **II** and **IV** were calculated

using SPSS software version 26. Bivariate analyses were used of the description of characteristics of the sample, between the independent and dependent items. Chi-square tests were used to compare the categorial items between the groups, and in study **IV**, Mann-Whitney U tests were used to compare ordinal data between independent groups. The significance level was set to a p-value of <0.05, and items with a p-value of < 0.2 from the bivariate analyses were included in the multiple logistic regression. Odds Ratios (ORs) were calculated to quantify the associations between the independent and dependent items (Norman & Streiner, 2014). In both studies, we used an OR with a 95% confidence interval to define significance.

Items in the logistic regression models were tested for multicollinearity with linear regression (**II**, **IV**). Problems with multicollinearity occur if tolerance < 0.4 (Norman & Streiner, 2014). To determine model fit in the logistic regression analyses, Nagelkerke's R^2 was used, which explains the model's proportion of variance in the dependent item, and Hosmer and Lemeshow's goodness-of-fit, which compares actual and predicted values; non-significant or small chi-square values indicate good model fit (Hair, 2019).

Paper III

In paper **III**, the measurement properties of the MISS (Broman et al., 2008) were tested according to modern test theory, i.e., Rasch measurement model (RMT) (Hobart, 2009; Rasch, 1960). In contrast to classical test theory, which is based on correlational analyses, RMT is based on fundamental measurement principles from the physical sciences (Andrich & Marais, 2019; Rasch, 1960).

The RUMM2030 software (Andrich, 2012) was used to analyse the measurement properties of the MISS (Broman et al., 2008). The significance level was set to a two-tailed p-value of <0.05, and Bonferroni adjustment was carried out due to the increased risk of type I error when conducting a large number of statistical tests (Armstrong, 2014). The MISS score is calculated as a total score and cut-off application for the identification of cases with insomnia symptoms needs complete item responses. Thus, the analyses were conducted on respondents without missing item response data. The analyses were conducted stepwise focusing on targeting, reliability, model fit, response category functioning, and differential item functioning (DIF) (Table 7).

Table 7. Rash measurement analyses focused on the following aspects (in paper III).

Different analyses	Description
Targeting	Good targeting between the relative locations of the persons and items is elemental for good measurement.
Reliability	Estimated by the person separation index (PSI), which is conceptually analogous to the coefficient alpha and should be ≥0.7.
Model fit	The meaning of the extent to which the observed item responses accord with what is expected from the Rasch measurement model; generally expected to range between −2.5 and +2.5.
Respone category functioning	Whether ordered response categories work as expected by representing increasing levels from less to more was assessed by exploring the ordering of response-category thresholds.
Differential Item Functioning (DIF)	An additional aspect of model fit, DIF occurs when an item does not function in the same way for different groups of persons (e.g., age and sex).

For methodological details, see Andrich (1988); Hobart (2009); Andrich (2012); Wright B (1982).

Ethical considerations

Through the research process of the four papers in this thesis, ethical considerations have been made and discussed. The four papers (**I**-**IV**) have been approved by the Ethical Review Boards (VEN 34-09, EPN 2011/333, EPN 2015/113 and EPN 2017/600). All procedures were also performed following the Declaration of Helsinki (World Medical Association Declaration, 2018).

Informed consent

To respect the persons taking part in the research, and to protect their rights to self-determination, informed consent was considered (World Medical Association Declaration, 2018). In papers **I**-**IV**, both oral and written consent were obtained. In paper **IV**, guardians, and children (6-10 years old) filled out the questionnaire together. The adolescents in paper **II**, **III** and **IV** (13-17 years old) filled in the questionnaire themselves, but information about the study was sent to the guardians as well. In paper **I**, oral and written information about the study was given to the participants before the focus group started, and if the person agreed to take part, they signed the informed consent. Moreover, we informed participants about the voluntary nature of participating in the studies and said that they could withdraw whenever they wanted without saying why. However, there might always be a risk that the participants would feel forced to take part because they already agreed to take part. To minimize the risk of this, we sought to ensure that the participants understood the oral and written information about the study and the meaning of taking part. They received oral information some time before the actual data collection took place. This allowed them to reflect on the information and whether they really wanted to participate. We also gave the participants the opportunity, before the focus groups, to ask questions about the study.

Moreover, when it came to the focus groups with adolescents (**I**), we, as the moderator and the observer, let the adolescents discuss and be open with their thoughts, without interruption from us. Further, we took into account the power differences that exist in all relationships with people (Tew, 2006). We were clear, from the beginning of the focus groups, that it was the adolescents themselves who were the experts about this subject; therefore, we were there to listen to them. This was done to equalise any possible power balance between the adolescents and us as researchers.

The principle of autonomy

The principle of autonomy (Beauchamp & Childress, 2009) means that participants have the right to refrain from participating in the research without being questioned or facing consequences. This is particularly important because the data collection took place within the school frameworks, where other activities are mandatory. We, as researchers, have an important task to inform the participants that this research and participation in it are voluntary.

When it comes to research among children, guardians also need to be involved, as the children/adolescents are in a dependent position. In paper **IV**, which includes students aged 6-10 years old, a questionnaire was used. We provided letters in advance to students, guardians, and the school, with information about the study, its voluntary nature, and the research group contact details. When the guardians and students answered the questionnaires, they gave written informed consent. The questionnaire was distributed by teachers or the school nurse at each school.

In papers **I-III**, written informed consent was obtained from the students, while the guardians received written information about the study. The research project obtained ethical approval for letting the adolescents themselves sign their voluntary participation. It is important to ensure that consent is really informed, as there might be a risk that the students would feel obliged to participate, especially if those asking about the participation are people with authority. In these studies, this is particularly relevant for the students. Those who asked the students if they wanted to participate were teachers or school health care personnel – in other words, people with authority in the school world. To deal with this, we informed the teachers and the school health staff, before the start of the studies, about this risk and emphasized the volunteer nature of the study for the students.

The principle of justice

The principle of justice (Beauchamp & Childress, 2009) means that individuals with equal needs should be treated equally. This principle was considered such that all who wanted to participate were allowed to do so. The studies included those who voluntarily reported their participation. Both public and private schools were included, from both urban and rural areas in different municipalities, and students from both vocational and university preparatory programmes were included.

The do-good and not harm principle

The do-good and not harm principle (Beauchamp & Childress, 2009) means that the students must be offered help by meeting their medical and human needs and that harm to the individual must be avoided. The questionnaire that the students filled out was about sleep habits and lifestyle. Answering such questions could lead to emotional reactions; readiness to face this is found in school health care. The guardians of the youngest children answered the questionnaires together with the children, and the adolescents answered the questionnaires in the classroom in the presence of an adult. No negative aspects of answering the questionnaires were reported. Through the questionnaires, the children's and adolescents' experiences are taken into account. Also, knowledge of adolescents' sleep habits increases, which may lead to better support in the future.

When it comes to focus groups and paper **I**, a risk can be that participants in the group become too dominant. It is the moderator´s role to evenly distribute the time between those who want to speak. The focus groups were led by researchers (GH, PG, and ANC), who were used to moderate groups. There was also a readiness to refer the participants to school health care if necessary.

The data is handled in such a way that no unauthorized people have access to it or can identify the individuals or the schools participating in the papers (**I-IV**). We also stored the audio files and transcribed interviews so that no unauthorized person had access to them.

The ethical principles are taken into account throughout the thesis. We within the research group attached great importance to these principles and had an ongoing dialogue about them during all the studies.

Result

Adolescents' experience of facilitators and barriers for a good night´s sleep (paper I).

Seven focus group interviews with in total 45 adolescents participated. Through the focus groups interviews, it emerged that the adolescents were aware of the importance of sleep for managing during the day. However, there were different aspects that the adolescents considered as facilitators and barriers for good night's sleep. Some of these aspects were within their control, but some were beyond their control. Overall, the adolescents were knowledgeable about commonly recommended strategies for improving sleep, but they had trouble striking a balance between sleep and other activities. The adolescents thought that sleep was important to being able to cope with everyday life and to allowing for physical recovery.

Three categories were identified in the analysis regarding facilitators and barriers for achieving a good night´s sleep: (1) Striving for a sense of well-being, (2) Tiring yourself out, and (3) Regulating electronic media. These categories interact with each other and influence the adolescent's sleep; each category includes both barriers to, and facilitators of, a good night's sleep (Figure 3). The sub-categories of the result were: engagement in relaxing activities, dealing with strains, exhausting oneself physically, being mentally wound up but sedentary, having a sense of relief, and a feeling of losing control.

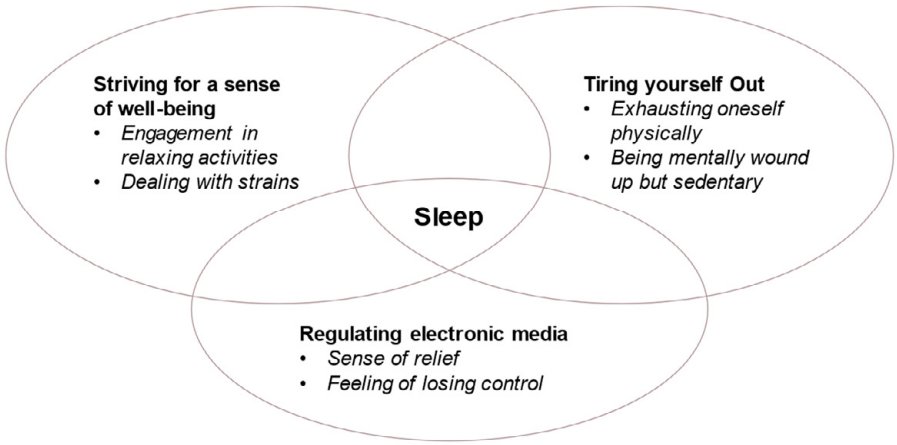

Figure 3. Three categories that interactively affect sleep according to the adolescents.

Striving for a sense of well-being

The adolescents described striving for a sense of well-being and talked about relaxing activities and dealing with strains. The adolescents felt relaxed with family and friends, experiencing togetherness, which was a facilitator of sleep. Lastly, some adolescents said that going outside to smoke was a strategy for relaxation. They were fully aware that smoking was not good for their health, but it felt good and relaxing in the moment.

Dealing with strains was an expression of school stress, worries, and pain. The adolescents said that during school terms, they had a lot of homework to finish, as well as other leisure activities. Overall, stress, anxiety, and thoughts about school, friends, and family all had negative impacts on sleep. The results demonstrated that both boys and girls considered negative thoughts, stress, and anxiety as barriers to a good night's sleep.

Tiring yourself out

The adolescents described "tiring yourself out" as exhausting oneself physically and being mentally wound up. Exhausting oneself physically was described as having a positive impact on sleep. The adolescents said that, after physical activity, they felt an inner calm and an absence of anxiety and that they slept better. The adolescents also reported that they appreciated physical education during school.

Regulating electronic media availability

The adolescents described regulating electronic media as important to ensuring they were inaccessible during the night, as interruptions could prevent a good night's sleep. They also stated that they had different strategies to make themselves inaccessible at night, which helped them feel in control. For example, they switched off the sound on their smartphones or left their smartphones outside the bedroom, and instead engaged in activities such as reading books, which could create a sense of relief. Some of the adolescents said that their guardians had no idea of their activities on social media and how frequently they engaged in these during the night. The adolescents also mentioned that they sometimes wished that their guardians had more rules about media use, as this would facilitate putting away their smartphones; it was a struggle to make that decision on their own.

Insomnia among adolescents is related to academic performance, self-reported health, physical activity, and substance use (paper II).

A total of 1504 participants answered the questionnaires, and the median age was 16 years (range 15-17 years). Insomnia symptoms (MISS ≥ 6) were reported in 22% of the study group. In the bivariate analysis, insomnia was associated with being male, having a poorer perceived family financial situation, having poor self-reported health, infrequently engaging in physical activity (≤1 time/week), having failed at least one school course, and using alcohol and/or cigarettes monthly ($p < 0.05$). However, some factors were not associated with insomnia symptoms, such as school start time before or after 8:30 a.m. and time spent on social media and/or gaming ≥4 h/day.

Furthermore, in the multiple logistic regression analysis, insomnia symptoms (MISS ≥ 6) were associated with poor self-reported health (OR: 4.35), failed school courses (OR: 1.47), and the use of alcohol and/or cigarettes (OR: 1.43). However, there were no significant associations between insomnia symptoms and school start time, perceived family financial situation, physical activity, or spending ≥4 h/day on social media and/or gaming. However, when the possible combined effect between self-reported health and physical activity was investigated, a combination of low physical activity (≤1 time/week) and poor self-reported health was found to be strongly associated with insomnia symptoms (OR: 18.87).

Measurement properties of the Minimal Insomnia Symptom Scale in adolescents (paper III)

A total of 3022 participants answered the questionnaires; a total score could be computed for 2968 (98.2%) for the MISS and for 2980 (98.6%) for the MISS-R. The MISS had good measurement properties. Regarding targeting, items tended to represent more severe levels of insomnia symptoms than that reported by the sample. However, this can be considered acceptable from the perspective of using the questionnaire as a screening instrument rather than a diagnostic tool. Reliability was significantly better for the MISS-R (PSI=0.55) than the MISS (PSI=0.50). Overall model fit was acceptable for both the MISS and MISS-R, and there was no local dependency between any items. Response categories functioned as intended in all items. There were DIF by age in the MISS, item "problems with not being rested by sleep", and the MISS-R item "problems with daytime disturbance". Older adolescents were more likely to score higher (i.e., reporting more problems) than younger adolescents in these items. The identified DIF limits the validity of the MISS and MISS-R for invariant comparisons between younger and older adolescents. This DIF by age can be reduced by avoiding a total score comparison and using only the insomnia cut-off. A raw score cut-off of ≥6 according to the smallest difference in logits between the age groups appears to be preferable.

Contributory factors for teen insomnia symptoms (paper IV).

A total of 522 participants answered the questionnaire and could be followed over time. Insomnia symptoms were measured with the MISS-R, and insomnia symptoms were more common among adolescent females (16.5 %) than adolescent males (6.5 %). The mean age at baseline was 9.43, and the mean age at follow-up was 14.28. The mean time from baseline to follow-up was 4.85 years. In the bivariate analysis, perceived quite bad/very bad family financial situation and short sleep duration (<10 hours during the school week) among girls (6-10 years) were significantly associated with insomnia symptoms among female adolescents ($p < 0.05$). Among boys (6-10 years), insomnia symptoms were significantly associated with difficulty waking up ($p < 0.05$). When it comes to tiredness in school, there were no significant associations with insomnia symptoms among either female adolescents or male adolescents.

In the logistic regression, the item concerning the perceived quite bad/very bad family financial situation at baseline was associated with insomnia among female adolescents at follow-up (OR:3.30). Furthermore, the item about short sleep duration (less than 10 hours) at baseline was associated with insomnia symptoms

among female adolescents (OR: 2.20), but not among male adolescents (OR: 0.90). However, problems waking up were associated with insomnia among male adolescents (OR: 3.64), but not among female adolescents (OR: 0.40) (Table 8).

Table 8. Associations between insomnia (MISS-R ≥ 6) in adolescence (14-16 years) and family financial situation, sleep habits and sleep duration in childhood (6-10 years), n=522, (results from paper IV).

	Adolescent females (14-16y)[1]		Adolescent males (14-16y)[2]	
Factors at baseline	**OR**	**95% CI for OR**	**OR**	**95% CI for OR**
Poor family financial situation	3.30	1.57-6.95	2.21	.76-6.43
Often tired at school	1.45	.47-4.44	1.81	.35-9.32
Often having difficulties waking up	.40	.67-2.83	3.64	1.32-10.03
Less than 10h sleep[3]	2.20	1.02-4.73	.90	.33-2.48

CI=confidence interval; OR=odds ratio. 1: Naglekerke´s pseudo-R^2=.05. 2: Naglekerke´s pseudo-R^2=.09; there were no signs of multicollinearity (tolerance: 0.7-0.8). 3: Less than 10 hours of sleep during school week.

Discussion

General discussion

The four papers included in this thesis contribute with knowledge about possible factors influencing sleep and insomnia symptoms among adolescents. Three main findings in this thesis will be discussed. The main findings in the four studies are *first*, contextual factors outside the control of the adolescents are a challenge to achieving sufficient sleep. *Second*, there are sex differences when it comes to insomnia symptoms. *Third*, a revised screening instrument for insomnia symptoms has been developed for use among adolescents.

Contextual factors

The adolescents in our study are well aware of the importance of sufficient sleep, but they have a hard time achieving it. Contextual factors beyond the adolescents' control affect the adolescents' sleep. Furthermore, the Biopsychosocial and Contextual Model of Sleep (Becker et al., 2015) highlights that family and peer factors affect the adolescent's sleep. Failed school courses and infrequent physical activity are also associated with insomnia symptoms (**II**). Our findings are in line with those of Wolfson and Carskadon (2003), which strongly indicates that short sleep duration and poor sleep quality are negatively associated with poor academic performance for adolescents from middle school through the college years. Furthermore, significant associations have been shown when it comes to physical activity and insomnia symptoms (Hartescu & Morgan, 2019). However, it has been seen that both very low and very high levels of physical activity are associated with insomnia symptoms (Hartescu & Morgan, 2019). On the one hand, one may say that school performance and physical activity are within the adolescent's control, but on the other hand, other factors might play a role here as well. Physical inactivity is a serious public health concern among adolescents from low- and middle-income areas (Vancampfort et al., 2019). Physical activity among adolescents is a complex and multi-dimensional behaviour determined by socio-economic status (Vancampfort et al., 2019). A systematic review reports associations between socioeconomic status and level of physical activity among adolescents (Stalsberg & Pedersen, 2010). It was found that adolescents with higher socioeconomic status are

more physically active than those with lower socioeconomic status (Stalsberg & Pedersen, 2010).

Furthermore, failed school courses were associated with insomnia symptoms (**II**). We do not know if worries about failed school courses lead to sleep problems, or if the sleep problems cause failed school courses.

A systematic review (Felden et al., 2015) showed a negative association between socioeconomic level and sleep in adolescents. Among female adolescents (**IV**), there were higher odds of insomnia symptoms in quite bad/very bad family financial situations. That girls are more sensitive to the family financial situation may have to do with norms, behaviours, and roles (World Health Organization, 2022). If the family has a low financial situation, this is reflected in adolescents' worse subjective perception of sleep quality, sleep problems/disturbances (such as insomnia), short sleep duration, and greater daytime sleepiness (Felden et al., 2015).

When it comes to adolescents, it seems that peer influences have an impact on sleep, as does the decrease of guardian involvement in bedtime routines (Logan et al., 2018). Furthermore, even if the adolescents in this theses are at an age at which it is natural to free themselves from guardians, and at which peers gain a more central role according to the Biopsychosocial and Contextual Model of Sleep (Becker et al., 2015), several of the adolescents wanted their guardians or other adults in their environment to set more rules about bedtime, especially when it came to putting away mobile phones before nightfall (**I**). Some of the adolescents in this thesis (**I**) stated that they felt disturbed during sleep at night, and some requested help from adults when it came to limiting electronic media during the night. One way of helping adolescents is a guardian-set bedtime, which offers a simple way for adolescents to improve their sleep and daytime functioning (Short et al., 2011). It has been shown that adolescents whose guardians set their bedtimes had earlier bedtimes than those who did not, and that they obtained longer sleep duration and experienced less daytime sleepiness (Short et al., 2011). Thus, guardians who set bedtimes seem to act in a preventive way, promoting good sleep among adolescents, which might facilitate an easy intervention at home. It is therefore important to inform guardians about sleeping difficulties among adolescents, as this could give them a better understanding of the need to support adolescents in getting to bed on time. However, it is important for guardians to set bedtime in early adolescence, as later in adolescence it might be more difficult to renegotiate bedtime if the adolescents already have bedtime autonomy (Wolfson et al., 2015).

Peers play an important role and influence the adolescents' everyday life (Becker et al., 2015). This is in line with the result in paper **I**, where peers were found to be essential. Moreover, Mednick et al. (2010) report that sleep behaviours are influenced by peer norms and that peers seem to have similar sleep duration. To conclude, it seems that support from guardians and peer influences might be beneficial for adolescents' sleep routines.

Furthermore, physical activity is beneficial when it comes to an earlier bedtime and good sleep, while electronic media use is related to a later bedtime (Bartel et al., 2015). The adolescents in this thesis (**I**) reported results that support this, as they stated that they felt relaxed and experienced inner calm after physical activity. Various forms of physical activity were mentioned for better sleep, which is in concordance with other studies demonstrating that physical activity has beneficial effects on sleep duration (Kredlow et al., 2015). Another benefit of physical activity that the adolescents mentioned was that it allowed them to get together with their peers.

When it comes to a later bedtime, both female and male adolescents experienced different barriers to a good night´s sleep. Most guardians are unaware that their adolescents are not sleeping enough (National Sleep Foundation, 2006).

One of the major reasons for insufficient sleep that the adolescents themselves mentioned (**I**) was that they got stuck during the night with their smartphones. However, the adolescents did not think it was the screen itself that was the trouble; they admitted that they got stuck, became sedentary, and the hours flew by, meaning they got inadequate sleep during the night. However, in study **II**, we did not find any associations between insomnia symptoms and electronic media use. Also, some studies report minor associations between screen time and adolescents' sleep on both weekdays and weekends days (Orben & Przybylski, 2020). Also, Troxel et al. (2020) address that where one lives and one's neighbourhood disadvantages are associated with poor sleep. Electronic media has also been shown to have little or no negative effect on an adolescent's sleep and sleep duration (Combertaldi et al., 2021). There is an ongoing discussion in society regarding the possible link between the use of electronic media and sleep among adolescents. Thus, future research is needed.

Sex differences

There are sex differences when it comes to sleep (Zhang & Wing, 2006). Although several studies have shown that females report consistently worse sleep quality than males in all age groups (Porkka-Heiskanen, 2021), the result in one of our studies (**II**) showed that adolescent males had more insomnia symptoms than adolescent females. However, when the effects of self-reported health and physical activity were taken together, the sex differences disappeared (**II**). Could it be that the level of physical activity, rather than the participants' sex, is most influential of whether or not adolescents experience insomnia symptoms? In other words, inactive adolescents with poor self-reported health are more likely to have insomnia symptoms relative to physically active adolescents with good self-reported health.

Sex differences become more visible during puberty and many adolescents get insufficient sleep in this phase (Colrain & Baker, 2011). Female adolescents and

male adolescents are affected by different hormones during puberty, which in turn affects their sleep (Porkka-Heiskanen, 2021). Epidemiological studies show that females have more sleep problems around times when sex hormones change, such as puberty (Morssinkhof et al., 2020). Female adolescents reported a higher rate of insomnia symptoms than male adolescents (Hysing et al., 2013). This result is confirmed in paper **IV**, in which insomnia symptoms were more present among adolescent females (16.5%) than among adolescent males (6.5%), but not in paper **II**, where more adolescent males had insomnia symptoms (27%) than adolescent females (18%).

Additionally, factors other than puberty may influence sex differences, such as social factors. When it comes to adults, it has been seen that social factor such as the number of children in the household, responsibility for household chores, marital status, and employment conditions affect females' sleep quality (Chen et al., 2005). We do not know if some of these social factors also apply to adolescents, but in paper **IV** there was an association between insomnia symptoms and family financial situation among females. However, when Chen et al. (2005) adjusted for social factors, such as home chores, the level of insomnia symptoms decreased among females.

The result from paper **IV** showed that shorter sleep than recommended (<10 hours) was common among both girls (57%) and boys (53%) aged 6-10. However, only for the girls did short sleep duration predict insomnia symptoms later in adolescence. However, male adolescents seem to have later bedtimes and greater weekday/weekend discrepancies (Hysing et al., 2013). This might have to do with different societal expectations regarding morning and evening behaviour. If this is the case, it might explain why short sleep duration (less than 10 hours) at baseline was associated with insomnia symptoms among female adolescents, but not among male adolescents, and this predicts insomnia symptoms only for females. Furthermore, problems waking up in boys aged 6-10 years old predicted insomnia symptoms in adolescent males at follow-up, though not among female adolescents.

Screening instrument

Sleep problems among adolescents are increasing in Sweden and worldwide (Norell-Clarke & Hagquist, 2017; Twenge et al., 2017). Lack of or altered sleep might disrupt daytime functioning, resulting in decreased cognitive abilities to regulate and express our emotions. A meta-analytic evaluation found that adolescents with past insomnia have an increased risk of reporting depressive symptoms later in life (Baglioni et al., 2011). Also, daytime cognitive and emotional functioning has an impact on sleep (Baglioni et al., 2011). Due to the update of the diagnostic criteria for insomnia, with a stronger emphasis on daytime functioning (American Psychiatric Association, 2013), there is a need for a psychometrically tested screening instrument with this focus. As far as we are aware, no brief

screening instrument has been psychometrically tested among adolescents, aligned with the updated diagnostic criteria. Therefore, we revised the MISS (paper **III**) (Broman et al., 2008). The revised screening instrument (MISS-R) showed slightly better reliability than the MISS.

Furthermore, according to the result (**III**), older adolescents were more likely to score higher (i.e., reporting more problems) on the scale than younger adolescents in some of the items. This was in both the MISS and MISS-R. What this depends on needs further investigation; however, one can consider whether this might have to do with more and higher expectations among older adolescents, due to school achievement and thoughts about the future. According to Ungdomsbarometern (2022), adolescents have high expectations of themselves (50%) compared to expectations from their families (19%).

To prevent adolescents' sleep problems and insomnia symptoms as early as possible, it is important to use reliable and tested screening instruments. It is also important to ask about insomnia symptoms. The MISS-R can be an important instrument for questions about insomnia symptoms (paper **III**). Therefore, we advocate the use of the MISS-R among adolescents.

Methodological consideration

I will now discuss the methodological aspects that I have considered in this thesis. A methodological strength of the thesis is its use of both qualitative and quantitative research designs, which gives broader perspectives on the phenomenon under study (Verhoef & Casebeer, 1997). The aim of the research guided the choice of its design. By using different designs (qualitative and quantitative) in different papers, it was possible to investigate adolescents' sleep and insomnia symptoms. Paper **I** used focus group methodology and was analysed with qualitative content analyses, paper **II** was a cross-sectional study applying bivariate and multivariate analyses, paper **III** was a cross-sectional study with psychometric testing according to the Rasch measurement model, and paper **IV** was a longitudinal study applying bivariate and multivariate analyses. In this way, the area of sleep and insomnia among the participants was investigated in a wide way. Using both qualitative and quantitative methods is a forceful attempt to strengthen the validity of the study, as the weaknesses of one method are contrasted with the strengths of another (Patton, 2002). The strongest research findings are achieved by combining quantitative and qualitative methods (Morse, 1995).

I will now more explicitly discuss the strengths and limitations. First, methodological considerations in qualitative research (**I**) will be discussed with the help of the concept of trustworthiness in relation to the concept of credibility, transferability, dependability, and confirmability. Thereafter, I will discuss internal

and external validity and reliability with the help of these concepts in quantitative research (**II-IV**).

Trustworthiness

Essential for qualitative studies' trustworthiness are credibility, transferability, dependability, and confirmability (Graneheim & Lundman, 2004; Lincoln & Guba, 1986). I will now discuss a few points linked to paper **I** according to trustworthiness.

Credibility regarding the result of qualitative studies depends on the extent to which the reader can trust the research and its results and is the overall goal of qualitative research (Lincoln & Guba, 1986). To check the open questions in paper **I**, we asked researchers with expertise in adolescent health to give feedback to the semi-structured interview guide about sleep. According to Krueger & Casey (2015), this is a way to test the instrument in a subjective view to see if the questions covered the purpose that we wanted to investigate. A minor adjustment was made to the semi-structured interview guide following input from the researchers. The semi-structured interview guide used in paper **I** was considered to work among this age group and to cover the purpose of the study. Therefore, we continued using the interview guide in all the focus group interviews.

The strengths of focus group interviews are that the participants can reflect on different opinions and views and that this can lead the discussion forward and promote thoughts and ideas (Krueger & Casey, 2015). This was obvious in the focus groups with the adolescents. In those groups in which the participants knew each other better, the discussion flowed more easily. In one of the focus groups, it was more difficult to get the participant to talk freely and spontaneously. We do not know the reason for this. Maybe the adolescents did not want to open up to some of the group members because they were worried about what the others would say or think. The target is not on gaining consensus in the focus groups, as we wanted a variety of experiences. However, for adolescents at this age, it is very important and crucial to feel accepted in the group (Kelly, 2014). It can be difficult to identify a variety within the groups in these ages, as the participants strive to be equal. One option could have been to conduct individual interviews instead to increase the credibility. However, my supervisors and I have experience conducting focus groups interviews and placed a great emphasis on creating a safe and permissive climate within the groups. We found that most of the participants in the focus groups spoke freely and felt allowed to share their opinions. The adolescents reflected and listened to each other throughout the conversations. There was a good atmosphere in all the focus groups, and the adolescents openly shared their experiences about sleep and health-related factors.

When it comes to group size, Krueger & Casey (2015) advocate five to eight participants. In most focus groups, the number was within this framework, but one

group consisted of only three participants (paper **I**). However, the limitations from the lower number may to some degree be balanced by the open climate, and all the participants were included in the discussion. We had sought a higher number of participants, but this was the number who voluntarily signed up at this school. Also, in the other focus groups, everyone had the opportunity to speak when they wanted. The discussion went well, but on some occasions, in the larger groups, I had to ask them to talk one at a time and to not chat with the person sitting next to them. I felt that all participants and the moderator/observer were respectful of each other and that the participants repeatedly pointed out that they wanted to share their experiences within this topic.

Member check is another way to improve credibility, which includes going back to the participants and asking them about the preliminary interpretation of the result, as well as if they perceived them correctly (Karnieli-Miller et al., 2009). However, this was not done with the adolescents in paper **I** because the member check comprised some ethical considerations and challenges (Karnieli-Miller et al., 2009) such as the possibility of requiring permission to save contact information so that the researcher could reach the participants again.

Paper **I** was carried out within the school environment and could have affected the result, as the adolescents may have felt compelled to participate because many activities in school are mandatory. We handle this by being clear in explaining that it was voluntary to participate. When it comes to the analysis of paper **I**, qualitative content analysis was used to analyse the focus groups interviews (Graneheim & Lundman, 2004). First, I carried out the analysis. The next step was that different supervisors were introduced stepwise into the analysis. This approach made it possible for me and the supervisors to confirm or disagree with the interpretations and to ensure that they were not biased by interest or preunderstanding. In the last step, all authors discussed the analyses. To assess the interpretations, I used the software programme Nvivo Plus Software version 12, which facilitated going back and forth from the raw data to the codes or discussion content. This meant that the interpretations remained close to the data all the time.

Dependability

The semi-structured interview guide (Appendix 2) was used for all focus groups to achieve stability and increase dependability (Wibeck., 2010). This meant that the same focus remained within the different groups, but because the interview guide included open questions, there was room for variation in the discussion. In all the focus groups, we used visual tools in the form of A4 papers with keywords linked with the open questions. I think this was a great help in keeping the discussions on topic. I also found that the participants saw this as a help, as they reminded each other to stick to the topic by referring to the keywords on the A4 paper.

Confirmability

Confirmability deals with the objectivity of the data interpretation (Lincoln & Guba, 1986). According to Lincoln and Guba (1986), objectivity is a key concept in the analysis. However, Lundman & Graneheim (2008) state that the result of interviews cannot be seen as independent of the researchers, as the researchers' pre-understanding is important in the interpretation process. They write that it is an advantage that the analysis is carried out by more than one person. The analysis of paper **I** was carried out by researchers with varied pre-understanding and educational backgrounds in public health, nursing, medicine, and psychology. This strengthens the confirmability, as it provides different perspectives on the analysis. It is also a strength that we discussed and reflected on the process of analysis and the interpretation of the results.

Transferability

Transferability includes the extent to which the results of the studies can be applied in other contexts and similar groups (Lincoln & Guba, 1986). When it comes to paper **I**, this could be other schools and municipalities. There was a roughly even distribution between participating females and males in the focus groups, except from one school, where one of the focus groups consisted of only females. The participating schools in the studies were recruited from both urban and rural areas, larger and smaller municipalities, and university preparatory and vocational programs.

Information about the study was spread by the teacher or school health professional to the students, and only those who volunteered to participate took part in the study. We did not ask non-participating students why they did not want to participate, which is one of the reasons why we do not know the reasons. In any case, the adolescents expressed a great variety of opinions and views regarding facilitators of, and barriers to, a good night's sleep. Because the schools were of different sizes and in different municipalities, and also given the different opinions that emerged, these results could be reliable in other contexts among other adolescents.

Reliability

Reliability concerns whether the same measurement result emerges regardless of time and who distributes/asks the questions (Norman & Streiner, 2014). Norman & Streiner (2014) emphasise that reliable, stable instruments are required.

The instruments MISS (**II-III**) and MISS-R (**III-IV**) have been psychometrically tested according to the Rasch measurement model in paper **III.** Analyses according to the Rasch measurement model (Andrich & Marais, 2019) indicate internal consistency, among other aspects. Reliability was slightly and significantly better for the MISS-R compared to the MISS. According to the Rasch measurement model,

reliability is reflected through the Person Separation Index (PSI), which is similar to coefficient alpha. Reliability (PSI) for the MISS scale was 0.50, while for the MISS-R scale it was 0.55. This indicates that the MISS and MISS-R can separate a sample into two distinct groups, i.e., persons possibly without (or with a low level of) insomnia, and persons with a higher level of insomnia. An ability to separate two strata can be considered sufficient for a screening tool.

It is important to emphasize that the MISS and MISS-R are screening tools. This means that if insomnia is indicated, it should be followed up with more comprehensive questionnaires, interviews, and/or examinations. The choice of the MISS was due to its brevity, which may be both a strength and a limitation. A clear strength is that the instrument is easy to use. This emphasises that it is not time-consuming for the participants or that they are exposed to unnecessary questions.

Internal validity

Internal validity is defined as the ability to draw accurate conclusions about the data, which is dependent on events or decisions within the design of the study, sample, items, and analyses (Creswell & Creswell, 2018). It includes how reliable the results are, i.e., if the study investigates what was intended to be measured (Creswell & Creswell, 2018).

Design in paper **II** and paper **III** were cross-sectional. There are both strengths and limitations when it comes to this design. One of the benefits is that it provides an overview of the items' frequencies. It also gives an overview of the relationship between the items and makes the associations between the dependent items and independent items clearer (Björk, 2019). The cross-sectional design gives a snapshot of subjective experiences from a person – in our studies, from the adolescents. When it comes to limitations of cross-sectional designs, one example is that no causal relationship could be determined between the dependent and independent items, as the items are measured at the same time. Thus, it is difficult to say anything about the direction of the relationships (Altman, 1991). Therefore, no casual relations can be established between insomnia symptoms and other health factors in paper **II**. However, the cross-sectional design was valuable because it allowed us to identify some potential factors for adolescents' insomnia symptoms. Bias could have occurred in that adolescents could have interpreted the questions differently. However, the questionnaires were distributed to two school classes before data collection started, to check for face validity. None of the adolescents expressed concerns about the questions.

In study **IV**, a longitudinal design was used. The longitudinal design provides several advantages over cross-sectional studies when it comes to estimating changes over time and identifying predictors of changes, including a greater ability to distinguish between and within-individual and group variations (Madhyastha et al.,

2018). In paper **IV**, we could follow the children and detect predictors of insomnia symptoms later in adolescence. However, there are also limitations. Limitations with longitudinal studies may be that society changes over time, and some of the questions (**IV**) may no longer be relevant at follow-up. For example, a limitation of study **IV** was that we did not include questions about the use of smartphones at the baseline. However, this was not possible because smartphones were not common among children and adolescents at the start of data collection (2008). Smartphones did not become common until 2012 (Statens medieråd, 2021).

Also, our perspective changes over time. Children see things in a certain way, while adolescents might see them in a different way. However, it is a strength to be able to follow individuals over time (Madhyastha et al., 2018). This can lead to deeper knowledge and seeing changes that may occur. The large sample size is also a strength, although the relatively high attrition due to difficulties identifying the students from baseline to follow-up is a limitation.

Sample size in paper **II-IV** were relatively high (**II-IV**, n=1504; n=3022; and n=522, respectively) which is a strength. For a regression model, 20 persons are recommended per item to get a valid result (Norman & Streiner, 2014). Therefore, in papers **II-IV**, the sample seems to be adequate. Conclusions from statistical tests can be incorrect as a result of type I and type II errors (García-Pérez, 2012). If the sample size is too small, there is a risk of type-II errors, i.e., one might conclude that there is no difference/association even though there is, in fact, a difference/association (Norman & Streiner, 2014). Type II errors can occur when multiple significance tests are conducted. What happens then is that one might conclude that there is a difference/association even though there is no difference/association in reality. In our papers (**II-IV**), there were no concerns of either type I error or type II error, as we used a two-tailed p-value of <0.05, and Bonferroni adjustment was carried out (**III**) due to the increased risk of type I error when conducting a large number of statistical tests (Armstrong, 2014).

Items in the papers (**II**, **IV**) were guided by the findings from paper **I**, in which we asked the adolescents what they experienced as facilitators of, and barriers to, a good night's sleep. This was the basis for the choice of variables in papers **II** and **IV**. Further, in paper **III**, we wanted to psychometrically test the instrument, which led to the choice of instrument in paper **IV**. The questionnaire was developed through qualitative, theoretical, and clinical considerations. It is a strength that the items that were asked to the participants were validated. According to the psychometric testing (paper **III**), the MISS and MISS-R had a good fit with the Rasch measurement model and reliability. Furthermore, the items in the MISS and MISS-R function well with respect to items response category functioning. It may be considered a limitation that we did not have the insomnia symptom measurement at baseline (**IV**), rendering it impossible to control for effects from childhood insomnia symptoms on adolescents' insomnia symptoms. Furthermore, single items were used (**II-III**) (Garmy et al., 2012). Previous research has shown that single items could make

answering questions easier for the respondent, as fewer questions have to be asked (Bowling, 2005). Single items may raise concerns about whether a single item can capture the intended phenomena. However, asking one question at a time, instead of a whole battery of questions, to assess one phenomenon may reduce the burden for the person answering (Bowling, 2005).

Analyses were used with Hosmer and Lemeshow´s test and Nagelkerke R^2 to test the fit of the model, according to Norman & Streiner (2014). In paper **II**, Nagelkerke R^2 indicated .27 among the adolescents. In paper **IV**, Nagelkerke R^2 varied between .05-.09. This can be seen as a limitation; however, a possible explanation for this might be the complexity according to the adolescent's sleep, and that other factors not included in the model could explain the variation. Furthermore, in the logistic regression (**II** and **IV**), some items were dichotomised due to the low response rate for some options. This provides a clear response picture. Nevertheless, when dichotomizing the items, there is always a risk of missing nuances in the results (Manor et al., 2000). To avoid missing important items in the logistic regression model, Chowdhury and Turin (2020) suggest including items with a p-value larger than 0.05. Due to this, all items with a p-value of <0.2 from the bivariate analyses were included in the multivariate analyses to minimize the number of items without losing anything. Items included in the papers (**II** and **IV**) were based on paper **I** and discussions among the authors of the papers. An adequate analysis of the data (**III**) included that we tested for type I error, due to repeated tests, i.e., Bonferroni correction. We had a large sample, which is in line with avoiding type II errors (**II** and **IV**).

When it comes to papers **II**-**IV**, there could be a potential limitation in that the questionnaires were self-reported, which might have resulted in response bias and inaccuracy.

External validity

External validity is defined as the extent to which the results apply to the intended population, other contexts, and future situations (Creswell & Creswell, 2018). For this thesis, the question about external validity concerns whether the results could be generalizable to other contexts, for example, other regions in Sweden, and also other countries.

We used different designs in our papers, which is an advantage and strength of this thesis. Paper **II** and **III** were cross-sectional in design, where we also used a validated instrument, which we also psychometrically tested. Finally, in the last study (**IV**), we chose a longitudinal design. The findings from the papers (**II**-**IV)** can probably be generalised in other schools and municipalities – for example, due to the relatively large sample and the fact that we use validated instruments (MISS and MISS-R), and also due to the fact that we have some control over the dropout,

i.e., sex and age did not differ among participants and non-participants. However, there may always be a risk of selection bias, due to a systematic difference between those who participated and those who did not (Björk, 2019).

The relatively high participation rate in papers **II-IV** gives strength to the external validity. However, how far the results may be generalisable to other groups like this, and in other regions or outside Sweden, can be discussed. The schools that participated (**II** and **IV**) had more university preparatory courses than the schools that declined to participate. The included municipality has a higher socio-economic status and education level than average in Sweden (Statistics Sweden, 2019). However, in paper **III**, there was more equality between university preparatory and vocational programs, and more municipalities were included, thus increasing the generalizability.

Construct validity

Construct validity concerns the accuracy of measuring the phenomenon under study (Polit & Beck, 2016). The instruments chosen in papers **II-IV** were the MISS and MISS-R. The MISS and MISS-R are validated instruments that have good psychometric standards. The MISS has mostly been used in various contexts among adults and older persons (Broman et al., 2008; Westergren et al., 2015), but now (**III)** also among adolescents, which strengthens the construct validity of the studies. Because the MISS-R is a recently developed screening instrument, it has only been used in our papers (**III** and **IV**); however, the MISS-R had slightly better reliability than the MISS among adolescents. Nevertheless, although instruments are well-validated, they may lose construct validity over time. Therefore, instruments should be used with caution, and interpretation of the results should be carried out in light of this consideration.

Conclusion

The intention of this thesis was to contribute with knowledge about possible factors influencing sleep and insomnia symptoms among adolescents. From the result that emerged, adolescents express a wish for arenas to discuss and reflect on sleep and sleep habits with adults and peers, both at home and in school. Furthermore, to prevent adolescents' sleep problems and insomnia symptoms, reliable screening instruments are important. The MISS-R can be used as a tool for school health professionals and public health workers to initiate discussions about sleep and sleep problems with adolescents.

Also, different factors in childhood were associated with adolescents' insomnia symptoms. These associations differed between boys and girls.

This thesis shows the importance of listening to adolescents' thoughts and reflections about sleep and sleep problems. It is also important to facilitate good sleep for adolescents.

Implications for practice

In practice, the results from the present thesis provide knowledge to adolescents, school health professionals, public health workers, guardians, and professionals who work with and meet adolescents in everyday life. It can also contribute with knowledge for persons in leading positions.

Our studies reveal that adolescents want to discuss sleep and sleep problems. Therefore, it is of great importance to create opportunities for these conversations. These conversations can occur in the school environment, as basically all adolescents go to school, and school is a great area for preventive work. Furthermore, within the schools, professionals with the competence to talk about sleep are available. Some ways to work with adolescents' sleep are with a sleep diary and sleep education at school (information about sleep and facilitators of, and barriers to, good sleep). This work could, for example, be done by school nurses, school social workers or public health workers. In combination with sleep diaries, questionnaires such as the MISS and MISS-R can be used as a basis for conversation. There are several good examples of schools whose health professionals have included sleep education in school (Bauducco, 2017).

Another important aspect is that guardians have an influence on adolescents' sleep, especially when it comes to sleep time, home environment, and good sleep hygiene. Through the results of this thesis, guardians may become aware of adolescents' sleep and sleep problems and get insight into how adolescent sleep problems affect other health factors. It also highlights the complexity according to contextual factors both within and out of the adolescent's control. Nonetheless, there are challenges to finding attractive solutions to work with adolescents' sleep and sleep problems. One way to meet these challenges is the importance of enabling time for school nurses, public health workers, and other professionals within the school. When it comes to society at large, it is important to take adolescents' sleep problems seriously and create resources for sleep promotion – perhaps even creating a society that promotes good sleep for all, as the 24-hour society is here to stay, and we must find ways to live in it.

Future research

This thesis indicated that contextual factors affect adolescents' sleep and that adolescents want to talk about sleep and sleep problems. This generates a need for further research:

- Adolescents want to talk about sleep; therefore, it is important to investigate how forums for discussions about sleep can be designed and implemented.
- In previous studies, a variety of questionnaires have been used; therefore, future research needs to use psychometrically tested instruments.
- The MISS-R is well suited for adolescents; future research could investigate the feasibility of using the MISS-R in school healthcare services.
- The results of the studies in this thesis highlighted that insomnia symptoms among adolescents are common and associated with negative health. Therefore, a suggestion for future research is to develop and implement school-based interventions to promote healthy sleep habits among adolescents.
- The challenges with previous interventions have been to create interventions that are attractive and have an effect in the long term for adolescents. Therefore, future research must involve co-creating the interventions with the adolescents themselves, as well as their guardians, to increase the likelihood of achieving changed behaviour among the adolescents.
- According to our results, guardians play an important role when it comes to adolescents' sleep. Therefore, future research should investigate guardians' experiences of how to support adolescents' sleep.

Svensk sammanfattning (Summary in Swedish)

Vi spenderar en tredjedel av våra liv sovandes och sömn är en avgörande faktor för god hälsa och välbefinnande. Men det är även viktigt att erkänna sömnens komplexitet, eftersom det är flera faktorer som kan påverka sömnen. Både biologiska, kontextuella och psykosociala faktorer har inverkan på ungdomarnas sömn. Otillräcklig sömn, sömnproblem och symptom på insomni är vanligt hos ungdomar. Sömnlöshet och otillräcklig sömn är folkhälsoproblem som kan påverka ungdomarnas fysiska och psykiska hälsa. Det är viktigt att belysa sömnproblem i ett tidigt skede och att sprida kunskap om ungdomars sömn och symptom på insomni. I avhandlingen har faktorer som påverkas vid otillräcklig sömn samt bidragande faktorer för symptom på insomni belysts.

För att fånga upp ungdomars sömn och symptom på insomni användes olika metoder i respektive delstudie (**I-IV**), vilket även är en av styrkorna i denna avhandling. Syftet med delstudie **I** var att undersöka ungdomarnas upplevelser av möjligheter och hinder för en god natts sömn. Delstudien genomfördes med fokusgruppsintervjuer och analyserades med kvalitativ innehållsanalys. I fokusgrupperna inkluderades skolungdomar i åldern 16–18 år. I delstudie **II** var syftet att undersöka associationer mellan symptom på insomni, skolprestationer, självskattad hälsa, fysisk aktivitet, skolstarttid och substansanvändning. Skolungdomarna var i åldern 15–17 år. Delstudien var en tvärsnittsstudie och analyserades med deskriptiv och analytisk statistik. I delstudie **III** var syftet att testa mätegenskaperna hos MISS tillsammans med ytterligare en fråga som fokuserade på dagtidsfunktionen bland ungdomar i åldern 13–17 år. Delstudien var en tvärsnittsstudie och analyserades med Raschanalysmodellen. I delstudie **IV** var syftet att undersöka om sömnlängd, svårigheter att vakna på morgonen och familjens ekonomiska situation hos skolbarn i åldern 6–10 år kan predicera för symptom på insomni hos flickor och pojkar i åldern 14–16 år. Delstudien var en longitudinell studie och analyserades med deskriptiv och analytisk statistik.

Resultaten visar att ungdomarna själva vill prata om sömn och sömnproblem och det är av stor vikt att skapa utrymme för dessa samtal. Resultaten visar även på att ungdomars sömn är komplext och vårdnadshavare har en viktig betydelse för ungdomarnas sömn. Resultaten från delstudierna (**I-IV**) visade att symptom på insomni hos ungdomar är vanligt och att symptom på insomni är associerat med

negativa hälsokonsekvenser. Vidare visar resultaten på att MISS-R är väl lämpad som screeninginstrument gällande symptom på insomni hos ungdomar.

Sammantaget är det viktigt att skapa utrymme för ungdomar att prata om sömn och det är viktigt att i ett tidigt skede arbeta med sömnfrämjande interventioner för att förebygga insomni senare i tonåren. Men, man ska ha i åtanke att det finns utmaningar med att hitta attraktiva lösningar för att arbeta med ungdomars sömn- och sömnproblem. Ett sätt kan var att utöka tid för skolsjuksköterskor, folkhälsopedagoger och andra yrkesverksamma inom skolan. På det stora hela är det viktigt att ta ungdomars sömnproblem på allvar och att skapa ett samhälle som främjar god sömn för alla, för 24-timmarssamhället är här för att stanna och vi måste finna ett sätt att leva i det.

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Appendix

Appendix 1

Minimal Insomnia Symptom Scale and Minimal Insomnia Symptom Scale-Revised

Problems with… item#	None	Minor	Moderate	Severe	Very Severe
How big problems do you have with difficulties falling asleep (1)	☐	☐	☐	☐	☐
How big problems do you have with night awakenings (2)	☐	☐	☐	☐	☐
How big problems do you have with not being rested by sleep (3)	☐	☐	☐	☐	☐
How big problems do you have with daytime disturbance (eg. fatigue, schoolwork, leisure, cencentration, memory and mood?) (4)	☐	☐	☐	☐	☐

Item 1-3 are included in the original MISS (Broman et al., 2008).
Item 1, 2 and 4 are included in MISS-Revised (Hedin et al., 2022).

Appendix 2

Semi-structured interview guide

Could you please give examples of a good night's sleep.

What are the challenges for a good night's sleep?

How do you handle these challenges?

What resources do you think exist in your everyday life to meet your challenges regarding sleep?

Is there something we have not asked about that you would like to add?

Appendix 3

Descriptions of the items in study II and IV.

Items	Question	Answer	Dichotomised
Sex	Male, Female, Other	Male = 1 Female = 2 Other = 3	
Family financial situation	How well financial situation do you think your family have?	Very well = 1 Good = 2 Average = 3 Quite bad = 4 Very bad = 5 Do not know = 6	Very good/quite good/average = 0 Quite bad/very bad = 1
Self-reported health	How well are you most of the time?	Very well = 1 Good = 2 Neither good or bad = 3 Quite bad = 4 Very bad = 5	Very well/good = 0 Neither good nor bad/quite bad/very bad = 1
School start time	School usually starts around the clock	Hours/minutes	08:00–08:15 = 0 08.30 or later = 1
Physical activity	How often do you exercise in your spare time for at least half an hour	Never = 1 Once a year = 2 Once a month = 3 Regularly once a week = 4 Regularly twice a week = 5 Regularly three times a week = 6 Regularly four or more times a week = 7	≥2 times/week = 0 ≤1 time/week = 1
Failed school courses	Have you failed a course the last year?	No = 1 1-2 courses = 2 3-4 courses = 3 5 or more = 4	None = 0 ≥1 =1
Alcohole use	In the last year how often have you drunk alcohol	Never = 1 Seldom = 2 Once or several times a year = 3 Once or several times a month = 4 Once or several time a week = 5 Once or several times a day = 6	<1 time/month = 0 ≥1 time/month = 1
Cigarette use	In the last year how often have you used cigarettes?	Never = 1 Seldom = 2 Once or several times a year = 3 Once or several times a month = 4 Once or several time a week = 5 Once or several times a day = 6	<1 time/month = 0 ≤1 time/month =1
Screen time	Time spent on social media and/or gaming/TV/film on schooldays	Hours/minutes	Screen time <4 h/day = 0 Screen time ≥4 h/day = 1
Tired in school	I am tired in school	Never = 1 Seldom =2 Often = 3 Every day = 4	Never/seldom = 0 Often/every day = 1
Dificulties waking up	It is difficult to wake up in the morning	Never = 1 Seldom = 2 Often =3 Every morning = 4	Never/seldom = 0 Often/every day = 1
Sleep duration	When it's school the next day, I usually sleep	Hours/minutes	≥10h sleep = 0 < 10h sleep = 1