

Sleep problems associated with trauma and posttraumatic stress in children and adolescents

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1. Abstract

Objective: The aim of this thesis was to review recent research literature and make a systematic summary on the prevalence of sleep problems in trauma exposed populations of children, adolescents and young adults, and to explore to which degree trauma type, sleep problems and PTSD are associated in the selected studies.

Method: We conducted a search for studies on sleep problems in trauma exposed children and/or adolescents in PudMed. This search resulted in 276 articles, which were screened for relevance by reading the abstracts. 16 articles were found relevant according to the inclusion and exclusion criteria.

Results: The prevalence of sleep problems in trauma-exposed children and adolescents ranged from 15.7% to 68.4%. The studies differed in selection of age groups, study design, selection of exposed groups and sleep measurements. The results suggest that trauma exposed children and young adults show a higher prevalence of sleep problems than non-exposed populations of the same age. Interpersonal trauma seemed to be the trauma type most often associated with sleep problems according to these studies. The prevalence of sleep problems were higher in trauma exposed populations with PTSD than in non-PTSD-groups.

Conclusion: Trauma exposure and PTSD seems to be linked to higher prevalence of sleep problems.

2. Introduction

Background

For our project thesis, which is a mandatory part of the medical studies at the University of Oslo, we chose to investigate sleep problems associated with trauma and posttraumatic stress in children and adolescents. Our interest in the field of psychiatry led us to contact one of the leading psychiatrists in Norway, Grete Dyb, at the Norwegian Centre for Violence and Traumatic Stress Studies (NKVTS). Her previous research and dedication to the field of trauma and sleep problems in children and adolescents contributed to our increasing interest in this area of psychiatry. As Dyb and her colleagues, Synne Stensland and Kate Porcheret, pointed out to us, there is a lot of research lacking in this field. To improve our knowledge in sleep problems in this age group, we therefore chose to conduct a literature study reviewing recent research in the field. Throughout this process, they provided us with much needed guidance.

2.1 Sleep

“Sleep is a vital process linked to neural restoration and physiological maintenance across multiple systems. For example, healthy sleep is linked to clearance of metabolic waste from the brain and enhancement of cognitive function, including the consolidation of memory” (Cox & Olatunji, 2016, p.105). The need for sleep varies between individuals. Some adults only need 6 hours of sleep to feel rested in daytime, while others need 9 hours. On the other hand, children and adolescents need more sleep than adults. According to the American Academy of Sleep Medicine (AASM), children from 6-12 years are in need of 9 to 12 hours of sleep every night, while adolescents from 13-18 years are in need of 8 to 10 hours nightly (Paruthi et al., 2016). As the need for sleep varies individually, it is difficult to measure if the need is fulfilled from a common norm. Most studies use questionnaires to subjectively measure whether the participants are satisfied with their sleep, while also measuring the level of daytime sleepiness (Gjerstad, Helseth & Rootwelt, 2014, p.417).

Gjerstad et al. (2014) provides an introduction to different types and stages of sleep. There are two types of sleep; Rapid Eye Movement (REM) sleep and non-REM sleep. Non-REM sleep has four stages; stage one (S1), stage two (S2), stage three (S3) and stage

four sleep (S4). S1 is the changeover from wakefulness to sleep, while S2 is a period of light sleep before one moves over to S3/4, which is called slow wave sleep (SWS). SWS is the deepest sleep stage, and the most important one for feeling refreshed and awake in the morning. REM sleep is the stage where most of our dreaming occurs, but luckily, the muscles are paralysed so that one cannot act out one's dreams. The brain and body-activity also comes closer to wakefulness, as the blood pressure, heartbeat and respiratory rate varies more. These periods of REM sleep appear about every 90 minutes throughout the night (Gjerstad et al., 2014, p.417-419).

2.2 Insomnia

“Insomnia disorder” is defined by the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) as a predominant complaint of dissatisfaction with sleep quantity or quality, associated with one (or more) of the following symptoms: Difficulty initiating sleep, difficulty maintaining sleep (characterized by frequent awakenings or problems returning to sleep after awakenings), or early-morning awakening with inability to return to sleep (American Psychiatric Association, 2013). There are also multiple additional criteria: The sleep difficulty has to be present for at least 3 months, it has to cause clinically significant distress or impairment in social, occupational, educational, academic, behavioral, or other important areas of functioning. Furthermore, the sleep difficulty needs to occur at least 3 nights per week, and it has to occur despite adequate opportunity for sleep (American Psychiatric Association, 2013). The insomnia should also not be better explained by, and should not occur exclusively during, the course of another sleep-wake disorder (e.g., narcolepsy; a breathing-related sleep disorder; a circadian rhythm sleep-wake disorder; a parasomnia). Finally, coexisting mental disorders and medical conditions should not adequately explain the predominant complaint of insomnia, and the insomnia cannot be attributable to the physiological effects of a substance (e.g., a drug of abuse, or a medication), (American Psychiatric Association, 2013).

This separates insomnia disorder from a more acute type of insomnia, which is often related to specific circumstances, such as bad sleep before an exam, which does not last for such a long period of time, and does not typically fulfill several of the other diagnostic criteria (Gjerstad et al., 2014, p.420).

Throughout our thesis we used the term “sleep problems”, unless studies specified that they diagnosed insomnia according to the above criteria. By using the term “sleep problems”, we provided a broader definition, that is not dependent on fulfilling all of the specific criteria related to insomnia disorder. For the term sleep problems, it could be either problems falling or staying asleep, waking up too early, waking up multiple times in the night, experiencing more nightmares, or having excessive daytime sleepiness/problems with daily functioning.

2.3 Consequences of sleep problems

Sleep disturbance is highly prevalent in psychopathology, and sleep impairments are found in almost every major psychiatric disorder (Cox & Olatunji, 2016, p.105). Sleep loss is linked to a diverse range of adverse effects, including deficits in cognitive function, and dysregulation of circadian processes, such as cortisol secretion (Cox & Olatunji, 2016, p.105). Without sleep, our emotional abilities will also become disrupted (Krause et al., 2017, p.404). Sleep deprivation has also been found to have negative effects on our attention, and hippocampal learning (Krause et al., 2017, p.404). This was shown by performing selective deprivation of slow-wave sleep (using auditory stimulation), which lowered encoding-related activity in the hippocampus and associated learning (Krause et al., 2017, p.404). Hence, this supports a causal role for SWS in hippocampal memory encoding (Krause et al., 2017, p.413). Grønli et al. (2017) also addresses the effect on attention and learning, as they state that sleep problems in youths have been linked to impaired attention and poor school performance, as well as adolescent problem behaviour, such as substance use, accidents and injuries (Grønli et al., 2017, p.220).

2.4 Sleep measurements

According to Cox & Olatunji (2016), the measurements of sleep can be put into two categories; objective and subjective. The objective method utilizes technical devices for determining sleep parameters, and it consists of either polysomnography (PSG) or actigraphy (Cox & Olatunji, 2016, p.105). PSG is the most comprehensive choice, where the brain activity, eye movements and muscle tone are measured, often in a laboratory setting. Actigraphy uses an accelerometer, often worn by the wrist, and by measuring rest-activity it can be used to determine whether the participant is asleep or awake (Cox & Olatunji, 2016,

p.105). Studies have indicated that actigraphy is highly correlated to PSG, but the actigraphy recordings have been shown to be less reliable in detecting wakefulness. Therefore it is recommended to use actigraphy together with a sleep diary, which is one of the subjective methods. A sleep diary is a sampling of the subjective perception of the previous night's sleep, typically measured for one week or more. The diary typically includes self-reported total sleep time (TST), sleep onset latency (SOL), sleep efficiency, time in bed, wake after sleep onset (WASO) and a rating of perceived sleep quality. This is the golden standard for the subjective methods (Cox & Olatunji, 2016, p.105). Other subjective methods are questionnaires. The most common ones are the Pittsburgh Sleep Quality Index (PSQI) and the Insomnia Severity Index (ISI), which are frequently used by researchers (Cox & Olatunji, 2016, p.105-106). In the case of examining children, parents are often asked to complete the questionnaires on behalf of their children (Cox & Olatunji, 2016, p.105-106). This adds another layer of complexity to the understanding of the results from such studies.

2.5 Trauma

Noel et al. (2018) states that “approximately 25% of youth experience at least 1 traumatic event by age 16, and more than 60% have experienced a traumatic event in adolescence” (p.67). As exposure to trauma is such a frequent event in childhood and adolescence, we need to describe what this term includes. According to the American Psychiatric Association (2021), trauma is defined as a deeply distressing or disturbing experience. Examples of such experiences could be accidents, physical violence, emotional or sexual abuse, war, and natural disasters. Researchers therefore often classify traumatic events in wide categories that describe the intent of the event and, to some degree, the risk of psychopathology e.g. posttraumatic stress. In this thesis we describe the categories violence, natural disasters and war/shootings. Below, we discuss what information previous research has provided on the consequences of these different trauma types on sleep problems and posttraumatic stress.

One type of trauma often subject to research in this field is violence. Violence is defined by WHO (2021) as “the intentional use of physical force or power, threatened or actual, against oneself, another person, or against a group or community, that either results in or has a high likelihood of resulting in injury, death, psychological harm, maldevelopment, or deprivation”. Interpersonal violence refers to violence between individuals, and is subdivided into family/intimate partner violence and community violence (WHO, 2021). Exposure to

interpersonal violence are traumatic events that are prevalent and that have been associated with a poorer mental health and behavioral outcomes (Brown, Belcher, Accardo, Minhas & Briggs, 2016, p.123-124). Youths exposed to such trauma have previously been found to have poorer sleep outcomes compared to their peers (Brown et al., 2016, p.123-124).

Another traumatic event is natural disasters. They affect many people globally every year, and have a great impact on their everyday life through the damage of private property, infrastructure and the function of the local society, as well as being a threat to the lives of themselves and their family. This kind of trauma commonly causes post traumatic stress disorder (PTSD) (Brown, Mellman, Alfano & Weems, 2011, p. 575). Furthermore, there is research suggesting that natural disasters predict mild to severe insomnia in young adults (Brown, Akeeb & Mellman, 2015).

Armed conflict, as that of war, is another event known to cause significant trauma worldwide. For people living in a war zone, everyday life is deeply affected by the overhanging threat of the life of oneself and people in close proximity (Llabre & Hadi, 2009). Little research has been done on the case of children living in war zones, as war, traditionally, has been performed by adults (Llabre & Hadi, 2009). In modern times, however, combat has evolved to affect entire societies through technological development and attack of civilians. Hence, more research is needed in this area.

The final traumatic event we will investigate in this thesis is mass shootings. There is not yet a universally accepted definition of the term “mass shootings”, but some researchers define them as incidents involving multiple victims of firearm-violence (Rand Corporation, 2018). The lack of a clear definition makes it difficult to detect whether these types of events have statistically increased over time (Rand Corporation, 2018). Some shootings are executed on religious or political grounds, and some shootings happen in schools, often performed by adolescents (Rand Corporation, 2018). This type of event is known to cause significant trauma for those exposed, and research from the past thirty years shows that in youth directly exposed to a mass shooting, rates of posttraumatic stress were consistently higher compared to control populations (Ranney et al., 2019, p.735). It also seems to have an effect on parents of the exposed children, as studies report high rates of anxiety and sadness in both youth and parents in the community of the shooting (Ranney et al., 2019, p.735). The parents of survivors in the Utøya mass-shooting in Norway had five times higher posttraumatic stress and two times higher depressive symptoms than parents of the general population (Thoresen,

Jensen, Wentzel-Larsen & Dyb, 2016). It would be interesting to investigate how this again affects their children.

There are several possible consequences of trauma exposure. Immediately after the traumatic event most experience an acute emotional or cognitive reaction that is powerful and unexpected (Shalev, 2002, p.539). This reaction could also take control of a person's behavior, even in ways they would not expect (Shalev, 2002, p.539). After such an event, some also experience posttraumatic stress symptoms, such as distress, concentration problems, problems with emotional regulation, flash backs, sleep problems, or nightmares Zhou, Wu, An & Fu, 2014). Following traumatic experiences, sleep disturbances are frequently reported (Mysliwiec et al., 2018). The most common symptoms are insomnia and trauma related nightmares. The nightmares that trauma survivors develop are noted to be distinctly different from the nightmares which characterize idiopathic nightmare disorder (Mysliwiec et al., 2018). Trauma related nightmares tend to be more severe and distressing to the individual, and in many (but not all) cases, associated with PTSD (Mysliwiec et al., 2018).

After such an event, some experience long term reactions in the form of PTSD. A meta analysis by Alisic et al. (2014) collected information from studies examining trauma exposed 2-18 year olds. This analysis revealed that after being exposed to non-interpersonal trauma 15,2% developed PTSD, and for interpersonal trauma the rates were as much as 35.8% (Alisic et al., 2014, p.335).

PTSD is a psychiatric disorder, where not only symptoms, but also the type of trauma causing it is essential for correct diagnosis (Malt U.F., Andreassen., Malt E.A., Melle & Årslund, 2018). Hence, an individual who exhibits the same symptoms as those associated with PTSD, does not fulfill the clinical criteria for this diagnosis without a traumatic event triggering these symptoms. The disorder is characterized by 3 categories of symptoms, all of which appear at the same time (World Health Organization, 2019). These three categories include:

1. Intrusion: Re-experience of the traumatic event through flashbacks, nightmares and unwanted thoughts about the event.

2. Avoidance: Avoiding of thoughts about the event, or places, activities, people etc. that triggers memories of the event.
3. Arousal: A persisting perception of an ongoing threat, manifesting in an increased reaction to stimuli, such as easily being startled by an unexpected noise.

(Malt et al., 2018)

According to ICD-11 (WHO, 2019), to fulfill the diagnostic criteria, the symptoms have to cause an impairment of personal life and daily life functioning. This may include both interpersonal relations and work performance. The description of the disorder further emphasizes that the symptoms persist for several weeks at a minimum.

2.6 Established knowledge about the relationship between sleep problems, trauma and PTSD

Part of our aim is to explore to which degree trauma type, sleep problems and PTSD are associated. We will therefore give a short introduction to established knowledge in change in sleep parameters in trauma exposed children, in PTSD individuals and the relationship between sleep problems and PTSD, respectively.

Early-life trauma exposure and REM sleep in adulthood

Insana, Kolko & Germain (2012) identified associations between early-life trauma exposure and REM sleep fragmentation during adulthood in veterans. Earlier-life trauma was associated with REM sleep fragmentation, whereas later-life trauma was not found to be so. This particular finding provides insight into the interaction between early-development and early-life experiences, which may have an effect on the development of healthy sleep physiology into adulthood (Insana et al., 2012, p.574-575).

Changes in sleep parameters in adult PTSD individuals

Previously there has been limited research upon changes in sleep in children with PTSD. However, there are some interesting results in research upon adults that could be of interest. Cox & Olatunji (2016) performed a meta analysis upon studies examining how sleep disturbance may contribute to PTSD. From these studies, the most consistent results from objective measurements that compare individuals with PTSD to healthy controls, is decreased

sleep efficiency (the percentage of time a person sleeps, in relation to the amount of time a person spends in bed) (Cox & Olatunji, 2016, p.114). The individuals with PTSD also exhibit decreased TST, and increased SOL, number of awakenings, and sleep fragmentation (Cox & Olatunji, 2016, p.114).

Studies with objective methods that compare trauma-exposed individuals with and without PTSD have presented mixed findings. Some studies have found various differences between the groups, such as decreased sleep efficiency, increased sleep onset latency, and an increased number of awakenings in the PTSD group (Cox & Olatunji, 2016, p.116).

Studies with subjective methods have found consistent subjective sleep impairment in individuals with PTSD (Cox & Olatunji, 2016, p.121). Compared to healthy controls, they report increased sleep disturbances, and they report similar results as found in the objective studies (Cox & Olatunji, 2016, p.121-122). Subjective studies comparing trauma-exposed individuals with and without PTSD also have similar results. They have found that individuals with PTSD report more sleep impairment than the controls (Cox & Olatunji, 2016, p.122).

The relationship between sleep disturbances and PTSD

Several of the studies assessing the role of sleep disturbances in PTSD suggest that subjective sleep impairment may exacerbate the disorder, and this is confirmed by an association between increased objective sleep disturbance with increased PTSD symptom severity (Cox & Olatunji, 2016, p.122). Some studies have also found that pre-trauma sleep problems may contribute to the development of PTSD (Cox & Olatunji, 2016, p.122). The findings suggest that sleep disturbance may amplify the effects of factors that increase the likelihood of developing PTSD (Cox & Olatunji, 2016, p.122). Also, some studies have found that individuals who perceive their sleep as more disturbed are more likely to develop PTSD compared to trauma-exposed individuals who do not perceive a disturbance in sleep (Cox & Olatunji, 2016, p.122).

2.7 Why is this theme interesting, and what research is missing?

Our knowledge about sleep disturbances in youths exposed to a traumatic event is limited, and has often been based upon studies of adults (Kovacy et al., 2013). There seems to be a

need for more research on children and their reactions after trauma exposure (Noel et al., 2018, p.67).

Traditionally, insomnia was treated as a symptom of other psychiatric diseases, including PTSD. Thus, one would expect that the sleeping problems would resolve with treatment of the causative condition. However, this was not always the case (Gjerstad et al., 2014, p.420). As insomnia got acknowledged as an independent disease, it became a greater focus on also treating this alongside the causative condition (Gjerstad et al., 2014, p.420). Today, there are some treatment strategies, such as sleep-specific cognitive behavioural therapy (CBT). This is often included as a part of treating PTSD in adults (Ho, Chan & Tang, 2016). Ho et al. (2016) revealed that this sleep-specific CBT gave significant reductions of both insomnia and self-report PTSD (Ho et al., 2016, p.1). They do however stress that this field needs further study, especially when comparing trauma specific treatments. More research on the relationship between insomnia and other psychiatric diseases will therefore be important, so that there can be developed even better treatment strategies (Gjerstad et al., 2014, p.420).

As previously mentioned when describing the consequences of sleep disturbances, there are great personal costs of living with these problems. Furthermore, from a societal cost point of view, there are also benefits from gaining knowledge about this issue, and even more beneficially, how to prevent the problems from developing. A recent study from 2018, found that the total cost of inadequate sleep in Australia in the period of 2016-2017 was as high as 45.21 billion Australian dollars (Hillman et al., 2018, p.7). This includes both direct health system costs and productivity losses, as well as cost of reduced well-being (Hillman et al., 2018, p.1). In other words, there are huge benefits to gain from research that could be used to reduce the impact of sleep problems, both on a personal and societal level.

2.8 Aim and objectives

The aim of this thesis was to review recent research literature and make a systematic summary on the prevalence of sleep problems in trauma exposed populations of children, adolescents and young adults. Specifically, we aimed to explore to which degree trauma type, sleep problems and PTSD are associated in the selected studies.

More specifically the objectives were:

1. Explore the prevalence of sleep problems, and factors affecting this prevalence, in the studies on sleep problems in populations of children, adolescents and young adults exposed to different traumatic events.
3. Compare the results between different trauma types.
3. Identify whether PTSD affects sleep problems in trauma exposed youths.

3. Method

3.1 Search and selection of studies

A literature search in PubMed was done on March 13th, 2019. The search applied the following terms: (sleep wake disorders OR insomnia OR sleep problems OR sleep disturb* OR sleep deprivation OR sleep disturbanc*) AND (post traumatic stress disorders OR "post traumatic stress" OR trauma*[title]) AND (youth OR adolescence OR adolescent OR adolescents OR "young people" OR "young adults" OR teens OR teenagers OR teenager OR children OR child OR childhood). There was also set a time frame for up to 10-year-old articles.

3.2 Inclusion and exclusion criteria

The following inclusion criteria were used: 1) examining sleep problems as a consequence of trauma and/or PTSD, 2) age from 6-35.

The relevant articles included only young people, from childhood to 30 years old. The reason for including age up to 35 was because the term “youths” could include ages from 15 to the late twenties, and as we are interested in this lower age group of the term, we decided it was best to include this age group. It also needs to be mentioned that if the participants' age was older than 18 years, the studies still have a relation to trauma exposure in childhood and not in adult life.

Studies were excluded if: 1) the study was a case report, a qualitative study, or a clinical study, 2) they were not written in English, 3) they investigated possible somatic causes, 4) they were older than 10 years.

3.3 Study procedures

The search resulted in 276 articles. Titles and abstracts were imported into EndNote where they were screened for relevance, half by K.S.K and half by J.H. After reading through the abstracts, 16 of them were found to be relevant for exploring the aim. These 16 articles were divided equally between K.S.K and J.H for further examination.

The full text of the relevant articles was read through, and the information was sorted into a table. This table included the following categories; authors and year of publication, type of study, method (incl. recruitment process, type of measurements, and if there were control groups), sample size, age groups, gender, type of trauma, prevalence of sleep problems, and specific sleep problems. The studies were ordered alphabetically by the surname of the first author. For the full table, see Table 1.

After the table was finished, the results were sorted according to the aims. Firstly, the results on the prevalence in trauma exposed children and youths were sorted out. Thereafter we explored factors that could explain these prevalence, such as differences between studies, the effect of different trauma types, or PTSD.

4. Results

All 16 studies explored sleep problems related to traumatic events that can be categorized as violence, natural disasters or war/mass shootings. Some of the studies have performed objective measurements of sleep with an actigraph, but most studies used subjective methods with different questionnaires, such as ISI and PSQI. The age of the participants ranges from 6 to 35 years, and most of them were adolescents. Most studies were performed in the USA, and some were made in China or elsewhere. For detailed information about each study we refer to Table 1.

As our aim was to investigate the prevalence of sleep problems in trauma exposed children, adolescents and youths, we will first discuss the prevalence found in the studies we selected. Thereafter we will provide information about possible factors contributing to variations in prevalence.

4.1 Prevalence of sleep problems

All studies, excluding Hamilton, Brindle, Alloy & Liu (2018), addressed the prevalence of sleep problems in trauma exposed children and youths, with the prevalence ranging from 15.7% to 68.4%. This big span, however, is not a result of a few odd one outs, but is evenly distributed within these ranges. Total sample size from all studies was 20.485 participants.

As the prevalence ranges a lot from study to study, we had to explore factors that could be causing this. Factors we had a deeper look into include differences in age groups, sample sizes, study types, populations, sleep measurements and diagnostic criterias. Other factors we also included was the type of trauma that participants were exposed to or having a diagnosis of PTSD.

4.2 Factors that may affect the prevalence

Age range

Five studies, Brown et al. (2015), Hamilton et al. (2018), Swanson, Hamilton & Muzik (2014), Grønli et al. (2017) and Sami & Hallaq (2018), had an older age group than the others, where the group ranged from 16 to 35 years old. The remaining studies had an age range from 6 to 19 years. This could possibly provide an explanation for the differences in prevalence between the studies.

In the younger age groups prevalence ranges from 15.7% to 58.4% (18.816 participants). In the older group it ranges from 56% to 68.4% (1669 participants). It might therefore seem that the studies with younger participants tend to have lower prevalence, however the range of prevalence in the younger group remains wide.

Trauma exposure of population

As you can see from Table 1, seven studies only included trauma exposed children and youths, while five studies also included non-exposed controls. The prevalence in studies with non-exposed controls ranges from 21% to 56.3%, while in studies with only trauma exposed participants it ranges from 15.7% to 68.4%.

Four of the studies, Hamilton et al. (2018), Geng, Fan, Mo, Simandl & Liu (2013), Zhou et al. (2014), and Zhang et al. (2015), were unclear whether all of the participants were trauma exposed or not. As for Geng et al. (2013), Zhou et al. (2014) and Zhang et al. (2015), they recruited adolescents attending schools in the area of the earthquake, however it is a bit

unclear whether all participants were actually exposed. Therefore, they were not included in the prevalence range included in the last paragraph.

The studies that compared trauma exposed groups to non-exposed groups was Swanson et al. (2014), Grønli et al. (2017), Thordardottir et al. (2016), and Wang et al. (2016). Swanson et al. (2014) studied sleep complaints in postpartum women with a history of childhood trauma, compared to postpartum women who were not exposed to childhood trauma, using a questionnaire (PDSS). They found that the prevalence of troubles falling asleep was higher in the exposed group (18.8% vs. 7.8% in non-exposed), as well as troubles staying asleep (15.6% vs. 10.9% in non-exposed). Grønli et al. (2017) studied sleep problems that occurred after a mass shooting at a political youth summer camp in Norway in 18-25 year olds. They used the Bergen Insomnia Scale (BIS) criteria for the diagnosis of insomnia, and found that insomnia was more frequent in survivors (56.3% vs. 11.0% in non-exposed). Also self-reported sleep problems were found to be higher in survivors (52.4% vs. 13.6% in non-exposed). Thordardottir et al. (2016), studied the event of an avalanche experienced in childhood, and the effect on sleep across different developmental stages. For the age group 13-19 years they found a higher prevalence of sleep problems among exposed than non-exposed (39% vs. 16% in non-exposed). Wang et al. (2016) conducted a study upon 9582 adolescents (13-18y) from the National Comorbidity Survey Replication Adolescent Supplement (NCS-A). They found that adolescents exposed to childhood adversity had 1.93 times the risk of insomnia relative to those who were unexposed.

Summarized, there seems to be a higher prevalence of sleep problems in trauma-exposed groups compared to non-exposed groups in all of these studies.

Study design

Nine studies, Brown et al. (2015), Brown et al. (2016), Wang, Raffeld, Slopen, Hale & Dunn (2016), Wamser-Nanney & Chesher (2018), Hamilton et al. (2018), Grønli et al. (2017), Thordardottir et al. (2016), Sami & Hallaq (2018) and Bronstein & Montgomery (2013), are cross sectional studies in which participants were evaluated only once. The prevalence in these studies was from 15.7% to 68.4%. Even though they are the same study type, the studies differ in other measurements, as we are going to discuss further below.

The remaining seven studies are longitudinal studies where participants were re-evaluated one or multiple times following the first evaluation. Prevalence ranged from

27% to 58.4%. These studies provide a long-term perspective on the prevalence of sleep problems, as we can see how it changes with time. Among the studies reviewed, most longitudinal studies were exploring sleep problems following natural disasters. Geng, Fan, Mo, Simandl & Liu (2013) examined sleep problems in adolescent survivors of the Wenchuan earthquake that occurred in 2008. They did three follow-ups, and found that the prevalence ranged from 29.2% (at 18 months), to 30.2% (at 24 months), and lastly to 28.8% (at 30 months) after the earthquake. Zhou, Wu, An & Fu (2014) also studied survivors of the Wenchuan earthquake. They scored sleep problems on a scale from 0-2 extracted from the Child Behaviour Problems Questionnaire (CBPQ). This provided scores ranging from 1.76 at 1 year, 1.58 at 1.5 year, and 1.78 at 2 years after the earthquake. Zhang, Zhu, Du & Zhang (2015) studied 8-19 year olds after the 2013 Lushan Earthquake that happened in the same area as the 2008 Wenchuan earthquake. They found that the prevalence changed from 58.4% to 48.4% with a time range from 3 to 6 months after the earthquake. Brown et al. (2011) also performed a longitudinal study upon survivors of a hurricane. They found that prevalence went from 46% at 24 months, to 50% at 30 months after the hurricane.

Summarized, the prevalence in the cross sectional studies ranged from 15.7% to 68.4%. The prevalence in most of the longitudinal studies did not change a lot, however when comparing the different longitudinal studies, the prevalence ranged from 27% to 58.4%.

Sleep measurement method

Objective measurements provide information about specific symptoms related to sleep problems, such as sleep duration, mean bed time and rise time. This gives an opportunity to explore the development of these symptoms over time, and to objectively confirm or challenge the subjective results. Only two studies, Grønli et al. (2017) and Spilsbury et al. (2014), utilized an objective method for measuring sleep problems using an actigraph.

Spilsbury et al. (2014) explored the effects of a known community- or family-violence incident (police reported) on actigraphy-derived sleep outcomes. Objectively measured, 54% were obtaining <8 hours of nightly sleep, which is less than recommended for children and adolescents. They also discovered that children physically assaulted during the event (others only witnessed) showed lower sleep duration (35min less) and sleep efficiency (6% less), and a 2.8 times greater WASO compared to those not physically assaulted. The

main finding from this study therefore was that the children and adolescents directly assaulted had more objectively measured sleep problems than those who only witnessed the event. Grønli et al. (2017) found a similar increase for survivors of a mass shooting compared to non-exposed controls. Their actigraphy measurements revealed delayed bedtime (39min later), sleep onset (48 min later), and rise time (44 min later) in the survivors compared to controls.

Only one study, Brown et al. (2016), performed clinical assessments of the sleep problems. This study collected data from 4043 trauma exposed participants from the National Child Traumatic Stress Network Core. Trauma types included violence, natural disasters, illness, accidents, death and fire. This provided a prevalence of 15.7% in the total sample of participants ranging 7-18 years. Divided into age groups they found a prevalence of 12.3% for 7-12 year olds, and 19.7% for the age group 13-18.

The remainder of studies used different questionnaires as a part of subjective measurements of sleep. These studies have a prevalence that ranges from 21% to 68.4%. Even those using the same measurement have different prevalence, eg. PSQI prevalence in Llabre et al. (2009), Thordardottir et al. (2016), and Sami & Hallaq (2018) is 27%, 39% and 68.4%, respectively.

Summarized, children and adolescents being directly exposed to trauma seem to have an increase in objectively measured sleep problems compared to non-exposed individuals. As for the studies utilizing subjective measurements, the prevalence range was from 21% to 68.4%. For the studies that used the same questionnaire, PSQI, the prevalence still ranged from 27% to 68.4%.

Criteria: Insomnia vs. sleep problems

Among the studies reviewed, only one, Hamilton et al. (2018), did not mention the prevalence of sleep problems or insomnia. One, Grønli et al. (2017), examined the prevalence of both insomnia and of sleep problems, which was 56.3% and 52.4%, respectively. One, Brown et al. (2015), examined only the prevalence of insomnia disorder, while the remaining thirteen examined the prevalence of sleep problems.. The studies that examined sleep problems found prevalence between 15.7% and 68.4%. For insomnia disorder it was 56% and 56.3%. Two of the studies of sleep problems looked at only one specific symptom of sleep problems; one nightmares, Bronstein et al. (2013), and one poor sleep quality, Llabre et al.

(2009). From these results, it seems that there is a wider range of prevalence in the studies examining sleep problems, while the studies examining insomnia have more consistent prevalence.

Trauma types

The trauma types examined in the studies we reviewed were either related to natural disasters, violence, or war/shootings specifically, or a mix of these. The studies examining only natural disasters had a prevalence of sleep problems between 28.8% and 58.4%, while the mixed studies had a prevalence between 15.7% and 56%. The studies on war and shootings were Grønli et al. (2017), Bronstein & Montgomery (2013) and Llabre (2009), with a prevalence of 56.3%, 64% and 27% respectively. Studies examining only violence did not provide prevalence of sleep problems, but they did compare the severity of sleep problems after specific violence types using odds ratio.

In the studies exploring violence specifically, Hamilton et al. (2018) studied sleep in young adults (18-22y) with a history of depression. A significant association was found only between childhood emotional neglect with insomnia symptoms, even when correcting for other forms of childhood maltreatments, e.g. sexual or physical abuse/neglect. Swanson et al. (2014) discovered that postpartum women who had experienced physical abuse/neglect in childhood had higher rates of sleep problems than those who had experienced sexual abuse or other types of neglect. Additionally, women who only had experienced sexual abuse were not more likely to report difficulties with sleep than non-exposed. Spilsbury et al. (2014) found that physically assaulted children had less sleep duration, increased WASO, and lower sleep efficiency, compared to non-assaulted children. They also discovered that children who witnessed a homicide had a twofold increase in WASO, but this difference was not found at the 3-month follow-up.

For the mixed studies, Wang et al. (2016) found that exposure to interpersonal violence made the largest risk for insomnia symptoms relative to the other categories, which was accidents and injuries, social network or witnessing events, and other unspecified adversities. Within the category of interpersonal violence, exposure to rape/sexual assault made the largest risk relative to all other adversities. Brown et al. (2016) discovered that for ages 7-12y, only sexual assault was associated with sleep problems. For the older age group (13-18y), sexual abuse/assault, physical assault, emotional abuse, injury/accident, extreme

interpersonal violence, community violence, and school violence was all found to be associated with sleep problems. Brown et al. (2015) recruited a sample of nonclinical young adults (18-35y, mean 22y) African Americans to complete self-report measures. They found that sexual trauma, physical assault, accidents, natural disasters and sudden violent death predicted insomnia. Wamser-Nanney & Chesher (2018) studied a group of 6-18 years seeking trauma-focused treatment after being exposed to either community violence, interpersonal violence, or removal from home. In this study interpersonal trauma was found to be associated with some higher levels of child-reported trouble sleeping (45.5%) and caregiver-reported nightmares (20-30%).

Altogether, interpersonal trauma seems to be the trauma type most associated with sleep problems according to these studies. Within the category of interpersonal violence, Hamilton et al. (2018) found that only emotional neglect was associated, while sexual or physical abuse was not. Swanson et al. (2014) found that physical abuse was associated with sleep problems, while sexual or emotional abuse was not. Spilsbury et al. (2014) found that physical abuse was more associated with sleep problems than only witnessing violence. Wang et al. (2016) and Brown et al. (2016) found that sexual abuse made the largest risk of experiencing sleep problems.

PTSD

Out of the studies we reviewed, 12 also explored the relationship between sleep problems and PTSS or PTSD.

Sami & Hallaq (2018) found that exposure to war-related trauma is associated with both PTSD symptoms (43.1%) and with sleep difficulties in young people. Llabre et al. (2009) found that trauma exposure also predicted poor sleep quality through its association with concurrent posttraumatic stress. Swanson et al. (2014) found that PTSD was associated with trouble staying asleep. Grønli et al. (2017) found that the survivors that fulfilled the criteria for PTSD showed greater prolonged sleep latency compared to the survivors without PTSD. They also reported more sleep problems, insomnia, frequent nightmares, and excessive daytime sleepiness than those without PTSD. Another study supporting this is Bronstein & Montgomery (2013), who saw significantly greater SOL (20min), increased nightmares and less TST in the PTSD-group compared to the non-PTSD group. This is supported by the findings of Brown et al. (2016), who found that among those who met full

criteria for PTSD, 20.6% also met criteria for sleep problems, compared to 15% for those meeting partial criteria, and 8.4% for those reporting mild or no PTSD. In the case of insomnia, Brown et al. (2015) found that out of the 33% who met criteria for probable PTSD, 70% of these also met criteria for insomnia.

Some of the studies also investigated how the possible relationship between PTSD and sleep problems developed over time. Zhang et al. (2015) saw that the prevalence of all somatic symptoms was higher in the PTSD group than in the non-PTSD group. Trouble sleeping, among other somatic symptoms, predicted overall PTSD symptoms. The prevalence of somatic symptoms decreased over time for the non-PTSD group, whereas in the PTSD group it increased over time (Zhang et al., 2015). Zhou et al. (2014) found that PTSD symptoms (intrusion, avoidance and hyperarousal) predicted sleep problems from T1 to T2. However, only the symptom of avoidance predicted sleep problems from T2 to T3. Brown et al. (2011) found relationships of sleep problems and fear of sleeping alone with posttraumatic stress symptom severity. Young age and female gender were associated with greater PTSD symptom severity. There was a significant association between sleep problems at T1 and PTSD symptoms at T2, suggesting that sleep problems amplify PTSD symptoms rather than PTSD symptoms causing sleep problems (Brown et al., 2011).

While all of the above found associations between PTSD and sleep problems, Geng et al. (2013) did not find that PTSD symptoms increased the risk of later sleep problems in adolescents. Furthermore, Thordardottir et al. (2016) found increased sleep problems in the exposed group, but there was no difference in PTSD symptoms between the exposed and non-exposed group.

As we have seen in this section, most of the studies did find possible associations between PTSD and sleep problems, however two of them did not. Prevalence of sleep problems or insomnia were higher in PTSD groups than non-PTSD groups in Swanson et al. (2014), Grønli et al. (2017), Bronstein & Montgomery (2013), Brown et al. (2016) and Zhang et al. (2015). However, Geng et al. (2013) and Thordardottir et al. (2016) did not find such association.

4.3 Nightmares and daytime sleepiness

Several studies did not only mention prevalence of general sleep problems, they also provided extended information about specific sleep problems found in the populations.

In several studies, nightmares are frequently mentioned. In the study performed by Grønli et al. (2017), frequent nightmares were reported from 37.5% of trauma exposed adolescents vs. only 2.3% in non-exposed controls. In the study by Bronstein & Montgomery (2013), as much as 64% reported having nightmares weekly. Wamser-Nanney & Chesher (2018) also discovered that nightmares was the most commonly parent reported symptom on the Child Behavior Checklist (13.8%) and Trauma Symptom Checklist for Young Children (19.9%), and nightmares were also the most common sleep complaint among children (20%).

Other complaints were daytime sleepiness and reduced daily function. In Wang et al. (2016), 38% of 9582 participants reported daytime sleepiness. Grønli et al. (2017) found that 34.4% of survivors experienced excessive daytime sleepiness, compared to 13.6% in non-exposed controls. In Geng et al. (2013), as much as 40% reported difficulty functioning during daytime. Similarly, 46.7% of the participants in Llabre et al. (2009) reported that sleep difficulties interfered with daily function.

Summarized, several studies reported frequent complaints among trauma-exposed groups, such as nightmares, as well as daytime sleepiness and reduced daily function. Especially nightmares had increased prevalence compared to non-exposed controls.

5. Discussion

The aim of this paper was to investigate literature and make a systematic review on knowledge about the prevalence of sleep problems in populations of trauma exposed children and adolescents, and to which degree trauma type, sleep problems and PTSD are associated. The results suggest that trauma exposed children and young adults show a higher prevalence of sleep problems than non-exposed populations of the same age. Interpersonal trauma seemed to be the trauma type most often associated with sleep problems according to some studies. Furthermore, a majority of the studies we reviewed found that trauma exposed populations with PTSD had higher prevalence of sleep problems than non-PTSD trauma exposed populations.

Understanding our prevalence

When reviewing the results, we found that the prevalence of sleep problems varied a lot, from 15.7% to 68.4% in trauma exposed groups. There might be several things causing this wide range, and we therefore tried to look deeper into the biological factors (age range and trauma exposure of population) and the methodology (study type, sleep measurement and sleep problem criteria) of the studies. We also compared studies investigating different trauma types, and studies exploring possible associations between sleep problems and PTSD.

Biological factors

Looking at studies based on the age of the population, studies suggest that the younger group experience less sleep problems than the older group. There might be several possible explanations for this. One could be that the timing of the circadian clock changes and gets later with age. The circadian clock is a biological clock that regulates the timing of processes, such as sleep (Zerbini & Mellow, 2017, p.264). Variations in the timing of the clock determine an individual's chronotype, with an earlier chronotype being 'morning types', getting up earlier and going to bed earlier in the case of sleep (Zerbini & Mellow, 2017, p.264). Chronotype is getting later and later with age, and compared to a child, an adolescent naturally wants to go to bed late, and wake up late, which can cause problems when having to get up for school (Zerbini & Mellow, 2017, p.264). This might therefore explain why the older group had a higher prevalence of sleep problems than the younger group, as their chronotype might conflict with the societal expectations, and the result is that they get less sleep and therefore more sleep problems compared to younger children. Another explanation could be that the age groups are in different developmental stages. With age, children get more independent and take control of their own routines, and parents get less influence on e.g. bed time and nightly routines. Less parental control and more self control could cause bad sleep habits. This might explain that there are more sleep problems in the older age groups. A third explanation might also apply to the study methods. As for the smaller children, parents may be the ones reporting the sleep problems, while adolescents are reporting for themselves. In some cases, the parents might not be aware of their children experiencing sleep problems, and this may cause under-reporting of sleep problems in the younger age group.

Looking at the population selection from the studies, the results suggest that trauma exposed children/youths have higher prevalence of sleep problems than non-exposed controls. This would be expected, as we mentioned in the introduction that high prevalence rates of sleep problems have been reported among trauma exposed children and youth (Mysliwiec et al., 2017), and sleep problems are also defined as a symptom of PTSD (American Psychiatric Association, DSM-5, 2013). Another factor to take into consideration is whether the trauma exposure itself is causing the sleep problems, or if it is caused by the consequences of the traumatic event, such as changes in structural, physical or social environments. For example, a child that has been exposed to physical violence and placed into foster care, may have sleep disturbances both from the physical violence and from being placed in a new home.

Methodology

Differences in study methods could also partly explain the wide range in prevalence across the studies. Reviewing our results, even within each group of study designs, we identified considerable differences in selection of population and sleep measurements.

One of the biggest challenges in comparing the data, was the differences in sleep measurement methods. The objective methods did not produce prevalences of overall sleep problems, but did measurements of sleep related factors such as bed time and TST. The subjective methods produced wide ranges of prevalence, even in studies using the same questionnaire, e.g. PSQI prevalence in Llabre et al. (2009), Thordardottir et al. (2016), and Sami & Hallaq (2018). However, in these studies the populations and trauma types were very different, and this might be more plausible explanations for the different findings than the measurement methods.

When we look deeper into what criteria for sleep problems the scientists were investigating, the results suggested that there was a wider range of prevalence in the studies examining sleep problems, while the studies examining insomnia had more consistent prevalence. As mentioned in the introduction, insomnia disorder has more strict and specific criteria than the term sleep problems. While insomnia disorder is consistent with the criteria of DSM-5, the term “sleep problems” seemed to vary between the different studies, and only the presence of one sleep related symptom could in some cases be determined as “sleep problems”. This variation might therefore be a possible explanation to the wide range of

prevalence. However, even though the studies evaluating insomnia disorder seemed to have a more consistent prevalence, there were only two studies providing this.

Trauma type

Interpersonal trauma seemed to be the trauma type most often associated with sleep problems. There might be multiple reasons for this.

Different types of trauma might have different psychological impacts and therefore cause a variation in sleep problems and reactions, such as posttraumatic stress symptoms in those exposed. Whether or not the traumatic event was intentional or not, e.g. violence vs natural disaster, could for example create different reactions and triggers of symptoms. Interpersonal violence is intentional and often performed by a person in close relations. One might therefore think that this could cause more distress than other traumatic events, as found by Wang et al. (2016), Wamser-Nanney & Chesher (2018), and Brown et al. (2016). Additionally, interpersonal violence at home creates an experience of an unsafe home environment and possibly creates a difficult relationship with caregivers, and thereby produce a lot of potential triggers of symptoms and sleep problems. Falling asleep and obtaining sleep under these unsafe conditions might be difficult for a child. Furthermore, this might be an explanation to why sleep problems seem to be more associated with interpersonal violence than the other categories.

Another interesting point in trauma research on children, is that traumatic events do not only affect the children, but could also affect their parents. Parents of children exposed to the mass shooting in Norway showed five times higher posttraumatic stress and two times higher depressive symptoms than parents of the general population (Thoresen et al., 2016). One might think that the parent's reactions, emotional availability and support could potentially affect their children and their interpretations and reactions to the event in an unfortunate matter.

PTSD

Longitudinal studies have linked early life trauma and PTSD to poorer health in adulthood, including sleep disturbances (Noel et al., 2018, p. 67). The results in our thesis seem to correlate with this, as the results suggest that there is a higher prevalence of sleep problems in those having high levels of PTSS or a PTSD diagnosis compared to those who do not.

There are multiple theories on why PTSD and sleep problems are related in many studies. Zhou et al. (2014) mention some of these theories in their article. Some of the studies they present suggest that PTSD symptoms, such as intrusive symptoms or hyperarousal, result in sleep problems as they can either make trauma exposed persons avoid going to sleep in fear of intrusion, or to break the sleep because of a higher level of awareness and reaction to the external environment during sleep (Zhou et al., 2014). Other studies suggest that the posttraumatic stress symptoms are a consequence of the sleep problems, with two possible explanations. The first is that the daytime consequences (elevations in daytime fatigue, confusion, tension and anxiety) of sleep problems can generate a context in which trauma survivors are more sensitive and reactive to trauma reminders. For this reason, individuals are more likely to avoid these reminders and react with greater anxiety to trauma reminders when they cannot be avoided. The other explanation is that sleep problems can reduce sleep quality and/or quantity, result in poor concentration, agitation/irritability, and impair emotional coping, which may lead to more frequent and intense negative emotions (e.g. anger, sadness, and anxiety) in the short term and more frequent emotional complaints (depression and anxiety) in the long term (Zhou et al. 2014). Nevertheless, there seems to be a strong correlation between PTSD and sleep problems following a trauma.

What is interesting, is that two of the studies didn't find any difference in sleep problems between the PTSD group and the non-PTSD group. For Thordardottir et al. (2016), a possible explanation for this might be that both the trauma type (avalanche) and population (Icelandic) is different from the studies that did find a correlation. Furthermore, the measurements were performed sixteen years post-trauma, significantly later than the other studies on natural disasters. Geng et al. (2013), however, had both a similar population (adolescent students) and the same trauma type (earthquake) as Zhou et al. (2014) and Zhang et al. (2015). Zhou et al. (2014), who examined the same earthquake as Geng et al. (2013), did the measurements at different times, and this might be one possible explanation for the different findings. They concluded that PTSD symptoms predicted sleep problems from 1,5 years to 2 years post-trauma, which is before the first measurement in Geng et al. (2013). Furthermore, this relationship weakened over time, and one might therefore think that Geng et al. (2013) might have missed out on this due to the different periods of time covered. As for Zhang et al. (2015) the matter gets more complicated, as they investigated the impact of another earthquake that took place in the same area as the one studied by Geng, but 5 years

later. One might therefore think that the accumulation of trauma might have caused different findings.

Limitations

The generalizability of the results in our study is limited by the differences between the reviewed studies. Furthermore, the methodological choices on our part might also have contributed as a limitation, as our choice of search words might have excluded relevant results in the search. We only included research in English in this review, and the fact that relevant data may also exist in other languages, which we do not speak, leaves us missing out on important information that could have contributed to our understanding of the topic.

What might be the biggest limitation in our study is the differences in method and population among the studies we reviewed. The different studies utilized a vast number of measurement methods, see Table 1 for an overview. As our aim for this study was to compare prevalence between the studies, these differences have a big impact on the reliability of the results. Another factor is the difference in populations across the studies. Some have participants from the USA, while others have from China or the Middle East, inarguably significantly different cultural backgrounds and possibly also different socioeconomic status. Furthermore, even though our aim was to investigate children and adolescents, there is a big age range stretching over multiple development stages, making it hard to pinpoint the exact impact on minors at a given age.

Implications and recommendations

The results confirm that trauma not only affects sleep in adults, but also in children and adolescents. The ongoing research on trauma and sleep problems in young people is important, as it puts the mental health of young people in the spotlight, after years of being neglected in this particular research field.

Sleep problems are subject to huge health system costs and productivity losses, as well as cost of reduced well-being (Hillman et al., 2018, p.1). Getting a better knowledge of what causes sleep problems and how to prevent them would therefore have multiple benefits in these areas. Previous studies have linked trauma exposure and sleep problems in children and adolescents to poor school performance, as well as adolescent problem behaviour, such as substance use (Grønli et al., 2017). Furthermore, the societal costs of sleep loss are great

(Hillman et al., 2018). In order to solve this, there should be further investigations of the consequences of sleep problems in trauma exposed children and adolescents, and how to prevent it.

Education of health personnel about trauma associated sleep problems could be beneficial in relation to this. In a clinical setting, this could mean considering screening for sleep problems in trauma exposed children and adolescents.

Our recommendations for future research is that the research society agrees on measurement methods to more easily compare results across studies. This would make it easier to draw plausible conclusions from research data.

There should also be conducted more longitudinal studies to provide more information about how the sleep problems change over time, and to discover factors that could provide better outcomes on sleep. Longitudinal studies could also provide information about the relationship between PTSD symptoms and sleep problems over time, so that this is better understood.

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