Investigating sleep interactions in parent-child dyads: a multimethod approach

A thesis submitted in fulfilment of the requirements for the degree of Doctor of Philosophy

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Declaration

I certify that except where due acknowledgment has been made, the work is that of the author alone; the work has not been submitted previously, in whole or in part, to qualify for any other academic award; the content of the thesis is the result of work which has been carried out since the official commencement date of the approved research program; any editorial work, paid or unpaid, carried out by a third party is acknowledged; and, ethics procedures and guidelines have been followed. I acknowledge the support I have received for my research from School of Health and Biomedical Sciences, RMIT University.

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Preface

This thesis contains three study chapters written as papers for publication and one chapter on a pilot intervention. Accordingly, each study chapter has its own abstract, introduction, methods, results and discussion. Some content may overlap. The chapters are preceded by an introduction to the research project and followed by a general discussion that summarises the key findings of this collective research.

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List of abbreviations

ADHD	Attention Deficit Hyperactivity Disorder
ASD	Autism Spectrum Disorder
CBT-I	Cognitive Behaviour Therapy for Insomnia
CBCL	Child Behaviour Checklist
CSHQ	Children's Sleep Habits Questionnaire
DSM-V	Diagnostic and Statistical Manual of Mental Disorders *fifth edition*
ECG	Electrocardiography
EEG	Electroencephalogram
EOG	Electrooculography
ESS	Epworth Sleepiness Scale
IFS	Iowa Fatigue Scale
ISI	Insomnia Severity Index
GSES	Glasgow Sleep Effort Scale
JSS	Jenkins' Sleep Scale
MBSR	Mindfulness Based Stress Reduction
MCBT	Mindfulness Cognitive Behaviour Therapy
MBT-I	Mindfulness Based Therapy for Insomnia
NDD	Neurodevelopment Disorders (children)
PSG	Polysomnography
PSHQ	Parents' Sleep Habits Questionnaire
POMS	Profile of Mood States
PSAS	Pre-sleep Arousal Scale
PSAS-C	Pre-sleep Arousal Scale for Children
PSQI	Pittsburgh Sleep Quality Index
SDSC	Sleep Disturbance Scale for Children
SDQ	Strengths and Difficulties Questionnaire
SOL	Sleep onset latency
SPI	Sleep Patterns' Inventory
TD	Typically Developing (children)
TST	Total sleep time
WASO	Wake after sleep onset

Abstract

Sleep is a fundamental biological process with far-ranging consequences for mood, cognition, physical and mental health. It is also a social process that plays a pivotal role in family functioning. Despite this, we do not fully understand the dynamics between a parent and their child's sleep. Hence, this thesis investigated the links between children's sleep disturbances and parents' sleep by systematically reviewing previous literature, using parent-reports and collecting actigraphy derived sleep profiles. Feasibility of a self-help sleep intervention tool for parents was also examined.

The **first study** involved a systematic review of sleep associations in parents-child dyads. Results from 29 studies revealed significant associations between parent-child sleep quality, sleep duration and sleep efficiency. Parents of children with neurodevelopmental disorders reported poor sleep and high stress. Family characteristics affecting sleep in this dyad and directions for future research were examined.

The **second study** examined multiple sleep outcomes in parents of children with sleep disturbances. A total of 293 parents completed an online questionnaire assessing sleep in parents and their children. Results from the self-reporting study revealed that parents of children with sleep disturbances had poor sleep, poor mood and increased arousal before sleep, which indicated chronic insomnia. Children's sleep mediated the relationship between parents' sleep and mood.

The **third study** employed actigraphy to explore temporal associations between sleep and wake in parent-child dyads. It also assessed whether parent-reports of their child's sleep was corroborated by actigraphy. Parents were three times more likely to wake up when their children experienced sustained night-waking in comparison to children waking up when their parents experienced a sustained night-waking. Parent-report of their child's sleep disturbance was also confirmed by actigraphy. Parents of children with sleep disturbances had increased duration of night-wakings as measured by actigraphy and greater sleep variability than parents of children with no sleep disturbances.

Finally **study four** pilot-tested the feasibility of a self-help mindfulness tool on sleep and mood in parents. Parents of children with sleep difficulties used a mindfulness app for six-weeks with a baseline and follow-up. The study indicated improvements in parents' self-reported sleep quality, insomnia symptoms, pre-sleep arousal and sleep onset latency. These results should be validated further in larger samples using more rigorous methods.

This thesis presents compelling evidence for considering sleep disturbances at a family level, rather than the parent or child alone. Using novel analysis, it illustrates how children's sleep disturbances are associated with increased night-wakings and poorer sleep in their parents. Targeting sleep at a family level can, therefore, improve broader family outcomes. It also demonstrates the potential utility of self-help interventions for parents with sleep difficulties and recommends further testing of self-help sleep interventions.

Chapter 1

General introduction

Sleep within the family

Humans spend one-third of their life sleeping, which impacts every facet of their wakefulness. Sleep is linked to mood, behaviour, functioning, cognition, attention, reactions and interactions in both children and adults (Bubu et al., 2017; Chaput et al., 2016; Itani, Jike, Watanabe, & Kaneita, 2017; Shochat, Cohen-Zion, & Tzischinsky, 2014). Hence, individuals with disrupted sleep may experience stress, poor mood and impaired functioning upon waking (Konjarski, Murray, Lee, & Jackson, 2018; Ustinov et al., 2010), eventually affecting their sleep further (Kahn, Sheppes, & Sadeh, 2013; Konjarski et al., 2018). However, this impact of sleep extends beyond the individual, affecting other family members. This complex interplay of sleep-wake patterns within families is particularly observable in parent-child dyads.

Family factors such as bedtime interactions, parenting practices and parents' sleep habits predict sleep patterns in their children (El-Sheikh, Kelly, & Philbrook, 2017; Fuligni, Tsai, Krull, & Gonzales, 2015; Komada et al., 2009). In turn, paediatric sleep problems play a role in parents' sleep and family processes (Allen, Howlett, Coulombe, & Corkum, 2016). For instance, night-awakenings in younger children are associated with sleep disruptions in the parents, poor mood (Meltzer & Mindell, 2007), subsequent negative perceptions of co-parenting quality (McDaniel & Teti, 2012), poor daytime functioning in mothers (Meltzer & Mindell, 2006) and marital disruption (Peltz, Rogge, Sturge-Apple, O'Connor, & Pigeon, 2016). Hence, sleep in both parents and children play a crucial role in family functioning. Considering the nature of these sleep interactions further can foster our understanding of how parents and children influence each other's sleep. This could lead to better treatments for improved sleep and functioning within families.

There is robust evidence documenting the negative associations between children's sleep disturbances, their socio-emotional functioning, self-regulation and cognitive deficits (El-Sheikh et al., 2017; Sonney et al., 2017; Taras & Potts-Datema, 2005). The vital role of child's sleep is also acknowledged in chronic sleep issues in childhood and behavioural or anxiety disorders in adulthood (Armstrong, O'donnell, McCallum, & Dadds, 1998; Gregory et al., 2005; Ong, Wickramaratne, Tang, & Weissman, 2006). Sleep problems are also

identified as one of the three lifestyle factors that predispose children to development of non-communicable diseases (Wu et al., 2016), including metabolic diseases (Doane et al., 2019; Schmid, Hallschmid, & Schultes, 2015). Furthermore, good sleep in children enhances their emotional regulation (Baum et al., 2014), academic achievement (El-Sheikh, Buckhalt, Keller, Cummings, & Acebo, 2007) and improves their quality of life (Magee, Robinson & Keane, 2017). In contrast, poor sleep in children is associated with a host of negative outcomes related to physical and mental health. Adequate sleep duration, regular sleep time and overall good sleep quality are essential elements for a child's optimal development (Caldwell, Ordway, Sadler, & Redeker, 2020).

Hence, childhood sleep difficulties pose a significant public health concern (Barrios, Jay, Smith, Alfano, & Dougherty, 2018; Meltzer & Moore, 2008). Different estimates suggest that behavioural insomnia, characterised by difficulty initiating and/or maintaining sleep, affects up to 40% of general paediatric populations (Meltzer & McLaughlin Crabtree, 2015; Owens, 2005). Other factors like poor sleep quality, night-wakings and erratic sleep schedules also contribute to inconsistent sleep in children (Owens, 2005). Sleep problems tend to be worse in typically developing (TD) children with clinical conditions like anxiety, asthma, eczema or diabetes (Jaser et al., 2017; Moore, David, Murray, Child, & Arkwright, 2006; Sonney, Segrin, & Ward, 2017). Additionally, sleep disturbances are a hallmark feature in children with neurodevelopmental disorders (NDD). It is reported that up to 80% of children with Autism spectrum disorder (ASD) and Attention deficit hyperactivity disorder (ADHD) have sleep difficulties (Lunsford-Avery, Krystal, & Kollins, 2016; Sanberg, Kuhn, & Kennedy, 2018). As such, it is critical to examine sleep difficulties in children.

Apart from the effects on children, childhood sleep disruptions can also keep parents' awake (Lopez-Wagner, Hoffman, Sweeney, Hodge, & Gilliam, 2008) as family members have co-regulated sleeping patterns (Gunn & Eberhardt, 2019). Hence, disturbances in children's sleep are often linked to inadequate sleep, reduced functioning and psychological distress in their parents (Lopez-Wagner et al., 2008; Martin, Hiscock, Hardy, Davey, & Wake, 2007; Meltzer & Moore, 2008). Ultimately, this highlights that children do not exist in isolation and the impact of their sleep disturbances extends beyond their individual level, affecting the parents. Given these links, researchers are now advocating for the need to investigate these associations between children and their parents' sleep further (El-Sheikh & Sadeh, 2015; Kouros & El-Sheikh, 2017; Meltzer & Montgomery-Downs, 2011).

Accordingly, this chapter reviews sleep in parent-child dyads across different stages of development. It also examines sleep in parents of children diagnosed with neurodevelopmental disorders (NDD), followed by a brief overview of the structure and organisation of this thesis. The term 'parents' has been used for brevity and includes both parents and other primary caregivers (such as grandparents). The terms, 'sleep disturbances,' and 'sleep problems' have been used interchangeably throughout the thesis. These terms may encompass a variety of sleep-related difficulties including but not limited to insomnia (difficulty initiating or maintaining sleep, early awakening), hypersomnia (characterised by excessive time spent sleeping), excessive daytime sleepiness (Alvaro, Roberts, & Harris, 2013), reduced sleep duration and self-reported poor sleep quality.

Parent-child sleep

The links between parent-child sleep (or more specifically) sleep difficulties have been studied across the major stages of child development. These interdependent relations are largely assessed using subjective or objective sleep measures. Subjective sleep measures involve the use of self-report or parent-report of a child's sleep and commonly assesses for issues like bedtime resistance, nightmares, sleepiness, sleep disorders and perceived sleep quality, among others. As parents are the primary caregivers for their children, these parent-reports are considered vital in clinical settings. Parent-reports often allow caregivers to reflect on the child's sleep behaviour in the past few weeks/months. In contrast, objective measures usually employ actigraphy or polysomnography (PSG). Actigraphy uses a motion detector (and sometimes light sensors) to ascertain sleep and wake conditions, whereas PSG uses electrical activity in the brain, muscles and eye-movements, and sometimes heart-rate and respiration, to record sleep patterns and examine sleep stages. The latter is generally used to examine sleep disorders that have a biological cause (e.g., sleep apnoea, restless leg syndrome). Objective measures provide indications for real-time fluctuations in a child's sleep-wake patterns and help reduce any biases from subjective reports. However, objective measures may not record pre-sleep behaviours, such as daily interactions or bedtime resistance. Hence, a multi-modal approach combining retrospective, self/parent-reports and objective assessment of sleep may be most beneficial when assessing sleep in parents and children. Here, we elaborate on parent-child sleep across different developmental stages examined using subjective or objective sleep measures.

Sleep in infancy

Sleep plays a predominant role in infant development as newborns sleep up to 18 hours a day (Waters, Suresh, & Nixon, 2013). Newborns do not experience a circadian rhythm. Instead, they have a 'flip-flop' switch which controls rapid transitions between sleep and wakefulness (Blumberg, Gall, & Todd, 2014). Strengthening of bidirectional interactions between the brainstem and the forebrain leads to the consolidation of sleep (Blumberg et al., 2014). Development of circadian rhythms and entrainment follows. This usually happens after two to four months of age (McGraw, Hoffmann, Harker, & Herman, 1999). By the age of six months, most infants begin to have more consolidated sleep, developing a more consistent sleep pattern by two years of age (El-Sheikh, 2011).

Sleep quality, which is highly variable during the first year of life, also starts to improve by the second year (Paavonen et al., 2020). A steady decrease in night-time awakenings is observed after two and a half years of age, while sleep efficiency continues to increase between the ages of two to four years (Dubois-Comtois, Pennestri, Bernier, Cyr, & Godbout, 2019). While parents do report getting less sleep after the birth of their child (Meltzer & Westin, 2011), they usually experience better sleep once the infant develops a better routine.

However, a sub-set of parents may continue to experience difficulties with their child's sleep, wherein children may not develop normative sleep patterns. While sleep problems during infancy are not associated with cognition or mood impairment in children (Wake et al., 2006), sleep disruptions in mothers can increase their psychological distress (Rowland, 2017; Shimizu, 2013) and serve as a precursor or risk factor for the development of postpartum depression (Kempler, Sharpe, Miller, & Bartlett, 2016). Therefore, infants with non-normative sleep patterns may benefit from clinical assessments (Paavonen et al., 2020). Their parents can also benefit from sleep interventions, like psychoeducation, which has been shown to improve both mothers' sleep and mood (e.g., Werner et al., 2016).

Sleep in pre-schoolers, school-age children and their parents

About 30% of children continue to have sleep difficulties as they transition from infancy to childhood (Meltzer & Mindell, 2008). These sleep disruptions include behavioural sleep difficulties, such as bedtime resistance, difficulties in maintaining or initiating sleep and early morning awakening (Galland, Taylor, Elder, & Herbison, 2012; Krakowiak, Goodlin-Jones, Hertz-Picciotto, Croen, & Hansen, 2008). Children may also exhibit enuresis or bedwetting

(Sarici et al., 2016), which can also cause sleep disturbances. Parasomnias and nightmares are common in these age groups (Proserpio & Nobili, 2017). Furthermore, many children do not meet recommended 9-11 hours of sleep (National Sleep Foundation, 2014; Gradisar, Gardner, & Dohnt, 2011), often due to issues like bedtime resistance and night-awakenings. Parents of these children are likely to experience disrupted sleep as well, as they assist the child in going back to sleep during the night.

Most studies on sleep in pre-schoolers and school-age children examine parent sleep associations more broadly, lacking comparisons between children with and without sleep disturbances. Regardless, sleep interactions are observed in the parent-child dyads. For instance, studies on pre-school children, school-age and their parents have revealed that while children's sleep-wake timing is independent of their parents, children's overall sleep is related to parents' sleepiness and sleep quality (Gau & Merikangas, 2004; Iwata, Iwata, & Matsuishi, 2013). Sleep-wake patterns in parent-child dyads differ due to biological differences in sleep.

While sleep-wake characteristics may be dissimilar, a more recent study by Staples and colleagues (Staples, Bates, Petersen, McQuillan, & Hoyniak, 2019) have reported that mother-child sleep outcomes are related. The authors conducted a longitudinal study of mothers and their children. Mothers and children wore actigraphy at three time-points when their children were 30, 36 and 42 months old. Consistent sleep associations were reported for sleep activity, variability and timing across all three time-points, indicating that sleep is stable between children and mothers throughout the pre-school period. Similar results have been reported for school-age children aged 7-12 years and their parents, wherein actigraphy recorded sleep duration, sleep efficiency and waketimes which were all correlated between parent-child dyads (Kouros & El-Sheikh, 2017). Using multi-level modelling, the authors reported that a child's sleep duration (in minutes), sleep efficiency and amount of time awake (in minutes, referred to as wake after sleep onset or WASO) on a single night predicted fluctuation in their mothers' sleep but not their fathers' sleep on the same night. Matricciani and colleagues (2019) also employed actigraphy and reported associations between sleep duration, sleep onset and offset in parents and school children aged 11-12 years. This highlights that children and their parents, particularly mothers, share general sleep characteristics. Most of the studies that include both father and mothers report that mothers are more likely to share daily sleep variations with their children. However, it is unclear

whether this because they are the primary caregiver for their children, and if that is the case, whether fathers that are primary carers share similar sleep characteristics. It is also unclear whether these relationships are modelled at a behavioural level or if children share their parents' physiological sleep characteristics.

There have been a small number of studies that have investigated children with sleep disturbances and the role it plays in parents' sleep or functioning. Most of these studies are correlational and do not employ causation analysis. For instance, an Australian cross-sectional survey involving close to 5,000 pre-schoolers reported psychological distress in mothers of children with sleep problems. The study also indicated that sleep problems in children were linked to poor health in mothers and fathers (Martin et al., 2007). Another pilot study involving 47 mothers reported that mothers of children with regular sleep disruptions experienced more fatigue, increased parenting stress and more daytime sleepiness in comparison to mothers of children with no sleep disruptions (Meltzer & Mindell, 2007). Furthermore, sleep disorders in otherwise typically developing children (i.e., with no developmental disabilities) were found to be related with increased daytime sleepiness in parents (Boergers, Hart, Owens, Streisand, & Spirito, 2007). While these results provide preliminary evidence of links between children's sleep disturbances and parent sleep, they need to be validated using objective measures. These results broadly illustrate that as primary caregivers, parents must be awake and available in case the child needs assistance. This can potentially result in frequent awakening during the night and difficulties returning back to sleep among these parents.

While the direct impact of parents' sleep difficulties on children's sleep disturbances is relatively unknown, parents' sleep difficulties and psychological functioning can have an indirect impact on their children's sleep and development. For instance, parents play a crucial role in the development of regular nocturnal sleep by providing cues preceding their child's sleep during the first few years of their life (Bacaro et al., 2019). Poor sleep in parents is linked to a disruptive family environment, which can play a significant role in sleep difficulties among children (Brown & Low, 2008). However, parents' sleep difficulties are less likely to impact a child's sleep than a child's sleep impacting their parents' sleep and functioning. Cross-sectional studies on familial aspects of sleep indicate that parents of children with sleeping problems have more profound experiences in terms of their mood, stress or overall functioning (Meltzer & Westin, 2011). At the same time, poor sleep quality

in parents did not affect the sleep behaviour of their children (Iwata et al., 2013). This suggests the possibility that children's sleep disruptions may impair family functioning, which in turn could impact children's sleep further. While parents may impact a child's sleep by influencing their environment, their sleep difficulties may not necessarily directly affect the child's sleep.

Sleep in adolescents and parents

Research on parent-child sleep largely focuses on infants or younger children, and the links between parent-adolescent sleep are relatively understudied. This is possibly due to the assumption that parental interactions wane during teenage years as children experience increased behavioural autonomy (Fuligni et al., 2015). Adolescents experience a change in circadian timing, leading to delayed sleep phase, as opposed to younger children who sleep early (Carskadon, 2012), which may mean that their sleep-wake rhythms may be similar to their parents. Further, 17.5% of adolescents report parent-set bedtimes on school nights (Short et al., 2011). Hence, some similarities between adolescent and parent sleep may be observed. However, it appears that adolescents' display more autonomy in their sleep-wake routines than younger children (Carskadon, 2012) and consequently, their sleep is more likely to be influenced by psychosocial factors rather than parents' sleep patterns. For instance, adolescents' sleep is primarily influenced by factors such as screen usage and school start-times (Hale & Guan, 2015) with Cain and Gradisar's review (2010) reporting more disrupted sleep for adolescents who use more technology before bedtime.

Accordingly, interactions between parent-adolescent sleep may be indirect. For instance, Brand and colleagues (Brand, Gerber, Hatzinger, Beck, & Holsboer-Trachsler, 2009) recruited 239 adolescents that completed questionnaires on their sleep, parents' sleep, parenting styles and their psychological well-being. The authors reported that poor sleep in mothers had a direct impact on their parenting style, which in turn influenced sleep and functioning in their adolescents. Similarly, a more extensive study of 421 adolescents and their parents reported that family routines are linked to sleep in adolescents (Fuligni et al., 2015). Fuligni and colleagues used multi-level modelling to assess sleep, bedtime, and waketime concordance between parents and adolescents. They observed that parents and children shared similar sleep habits, possibility due to similar sleep-wake characteristics between parents and older children. This may be possible when parents set bedtimes for their adolescent children. Studies show that adolescents with parent-set bedtimes report lower

levels of depression and lesser suicidal tendencies (Gangwisch et al., 2010). However, a neural concordance study observed that sleep habits in parents did not predict sleep in their adolescents (Lee, Miernicki, & Telzer, 2017). The results from this study suggest the need for replication of results as well as further research on sleep characteristics in adolescent and parents.

Sleep in children with chronic conditions

TD children with diagnosed sleep disorders or other medical conditions may experience an increased level of sleep disturbances. This includes sleep difficulties related to conditions like asthma, diabetes, and sleep disturbances associated with sleep disorders other than insomnia such as sleep apnoea, parasomnias and restless leg syndrome. The impact of sleep problems in these children is related to parental sleep. For instance, breathing difficulties or monitoring of blood sugar levels in children with asthma or Type-I diabetes respectively can require nocturnal caregiving (Feeley et al., 2019; Herbert, Ghan, Cogen, & Streisand, 2015; Jaser et al., 2017; Macaulay, Boucher, Yogarajah, Galland, & Wheeler, 2019; Sonney et al., 2017). A comprehensive literature review of nineteen articles related to parent-child sleep (Meltzer & Moore, 2008) concluded that parents of children and adolescents with chronic illnesses experience sleep disruptions, which reduces their daytime functioning. These caregiving requirements on parents of children with medical conditions also increase the risk of depression and poor health, which in turn can lead to poor sleep in this parent population (Johnson, Meltzer, et al., 2018).

Sleep in children with Neurodevelopmental disorders (NDDs)

The Diagnostic and Statistical Manual of Mental Disorders – *fifth edition* (DSM V) categorises NDDs as ASD, intellectual disabilities, communication disorders, attention-deficit/hyperactivity disorder, learning disorders, motor disorders and neurodevelopmental disorders (American Psychological Association, 2013). Down's syndrome, epilepsy and cerebral palsy may also be considered NDDs. Unlike TD children, the aetiology of sleep disturbances in children with NDDs is usually a consequence of their disease-related factors. This includes circadian rhythm abnormalities, developmental delays and health problems in children with neurodevelopmental disorders (Owens & Weiss 2019). Hence, children with NDDs tend to have more profound sleep conditions, with rates ranging anywhere from 40% to over 80% in children with ASD and ADHD.

Sleep in neurodevelopmental conditions, such as ASD are most widely studied and attributed mainly to factors like circadian rhythm abnormalities and low plasma melatonin concentration, while environmental factors like noise, room family composition and lifestyle issues like parental work status and socioeconomic status may also play a role (Owens & Weiss, 2019). This often leads to exaggerated sleep difficulties that may influence sleep in parents. Previous studies that have compared TD children and children with ASD or ADHD have found that parents of the children with NDD have worse outcomes for sleep and mood (Bar, Efron, Gothelf, & Kushnir, 2016; Lopez-Wagner et al., 2008). This is observed for both self-reported and objectively measured sleep. These parents may experience disturbed sleep due to nocturnal caregiving requirements as well as the stress and challenges of caregiving (Cheezum et al., 2013; Horner, 1997). Parents of these children may also experience increased hyperarousal and night-time worry because of the need to check up on their child.

Potential mechanisms behind poor sleep in parents

Individuals or subsystems within a family are influenced by each other (Steinglass, 1987). Therefore, family systems view the family as a complex social system where members interact in various subsystems, such as marital or the parent-child subsystem (Nelson, O'Brien, Blankson, Calkins, & Keane, 2009). These interactions may lead to spillover or crossover effects. While the spillover model suggests that well-being can transmit from one domain to another (e.g., from work to family life), the crossover model postulates that states of well-being can transmit between closely related persons in a dyadic process (Bakker & Demerouti, 2013). The transmission can be both negative and positive. Considering the crossover model, it is possible that sleep disturbances or associated adverse effects can transmit from children to their parents, resulting in disturbed parental sleep. The associated stress or mood problems in parents may then transmit to the child, affecting their sleep or development. However, it is still unclear whether sleep states can actually crossover between parent-child dyad. Other alternative models are explored below.

Apart from general sleep disruption and sleep deprivation in parents, different mechanistic models of insomnia can be used to explain poor sleep quality in parents. This includes Spielman's 3-P model of insomnia, which posits that predisposing, precipitating and perpetuating factors are involved in the development or maintenance of insomnia (Spielman, Caruso, & Glovinsky, 1987). Predisposing factors include psychological or biological characteristics, such as heredity, gender, and anxiety, which can increase an individual's risk

of developing insomnia (Miller, Espie & Kyle, 2014). Precipitating factors can be medical, environmental or family-related that can trigger insomnia. Perpetuating factors are elements that maintain or exacerbate these sleep difficulties. This may include factors like spending more time in bed, taking more naps due to sleep loss or worrying about daytime consequences. Learned behaviours and maladaptive cognitions, such as parental accommodation behaviours (e.g., letting children sleep in parents' bedroom) can also be perpetuating actors. If Spielman's model for insomnia is considered (1987), children's sleep behaviour can be a precipitating factor for sleep problems in parents (Figure 1). Regular night-wakings in an unwell child may disrupt parent sleep in the short-term, leading to increased stress. While not all parents may develop insomnia in response to their child's sleep disturbances, recurrent sleep disturbances in the child, linked to parental stress, can become another precipitating factor, increasing parent's likelihood of experiencing insomnia. This stress, coupled with sleep deprivation and acute insomnia in parents (Palagini et al., 2016) may result in a vicious cycle where sleep loss can aggravate parent stress and worries around daytime functioning, which can perpetuate their insomnia. Eventually, even on the nights when the child does not wake up, parents may find themselves waking up in the middle of the night with difficulty going back to sleep. This inconsistency in sleep schedules may result in chronic insomnia in parents. Both birth of a child and caregiving demands related to children can precipitate or perpetuate insomnia (Swanson, Pickett, Flynn, & Armitage, 2011).

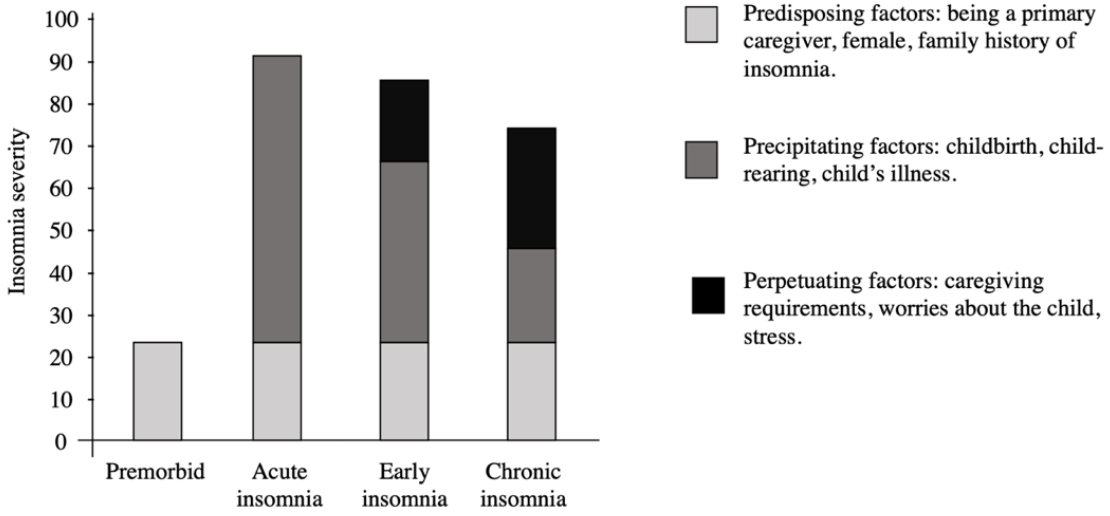

Figure 1. A theoretical representation of how sleep problems may manifest in parents of children with sleep disturbances. Image adapted from Miller and colleagues, 2014 (Miller, Espie, & Kyle, 2014).

The cognitive model of insomnia (Harvey, 2002) can also explain sleep disturbances in parents. This cognitive model notes that individuals with insomnia or recurrent sleep disturbances suffer from intrusive thoughts and uncontrollable worry during the pre-sleep period. This cognitive activity leads to sympathetic nervous system activation that may result in sleep problems. Worrying about their children's sleep disturbances or night-waking due to caregiving demands could potentially increase parents' pre-sleep cognitive activity, which is a classic characteristic of insomnia (Harvey, 2000). Resulting sleep difficulties in parents can cause 'hyperarousal' in parents. Hyperarousal refers to a state of elevated cognitive and physiological activation (Altena et al., 2017). This activation prior to sleep plays a role in insomnia symptoms. Furthermore, a child's sleep difficulties may also result in erratic sleep schedules for parents, which causes sleep continuity disturbances and difficulties in initiating or maintaining sleep (Riemann et al., 2010). Sleep fragmentation in mothers of newborn children is often related to how many times a mother wakes up to attend to their child (Gradisar et al., 2016; Meijer & van den Wittenboer, 2007; Shimizu, 2013). Whether this is true for mothers of older children is unclear, but it can be assumed that both hyperarousal and erratic sleep schedules can decrease a parent's ability to sleep well.

Child-related stress dysregulation or sleep reactivity can also result in parent's sleep difficulties. Sleep reactivity is a concept that defines the degree of sleep disruption in response to stressful events (Palagini et al., 2016). Stress-related sleep reactivity can result in both hyperarousal and persistence of sleep-related insomnia (Drake, Richardson, Roehrs, Scofield, & Roth, 2004), which may be present in parents of children with sleep disturbances. Based on an evolutionary perspective, one of the primary sources of insomnia in adults is child-rearing, including caregiving of infants, separation anxiety in children and insecure parent-child attachment (Perogamvros, Castelnovo, Samson, & Dang-Vu, 2020). Parents of children with sleep difficulties may experience excessive hyperarousal or sleep reactivity that can result in recurrent sleep disturbances in these parents.

Interventions for improving sleep in children and parents

Current treatments for paediatric sleep disturbances include behavioural interventions, use of melatonin and pharmacological approaches. Most of the treatments involve parents, who are provided with primary information around treating and managing their child's sleep. Parents also play a significant role in implementing sleep treatments or strategies. Apart from these treatments, recent research now focuses on extending sleep opportunities in children as a way

to improve sleep (Sadeh, Gruber, & Raviv, 2003; Van Dyk et al., 2017) as studies suggest that sleep duration,(i.e. the number of hours an individual spends sleeping) in children have steadily declined over the years (Allen et al., 2016; Dollman, Ridley, Olds, & Lowe, 2007; Owens & Mindell, 2011). Preliminary evidence suggests benefits of extending sleep opportunities for children, particularly adolescents, but the area needs more research to establish concrete evidence. Major sleep interventions for children and parents are discussed below.

Behavioural interventions

Behavioural sleep interventions usually have a multi-component structure, including caregiver psychoeducation for consistent bedtime routines, positive reinforcement and gradual extinction procedures (Mindell & Williamson, 2018), which can address children's maladaptive sleep behaviours (e.g. bedtime resistance, difficulties falling asleep etc.). The structures and protocol can differ based on the age of participating children, type of sleep problem and kind of delivery. For instance, brief residential programs may be used for reducing infant settling difficulties and improve daytime sleepiness, sleep disturbance and fatigue in mothers (Wilson et al., 2019), whereas school-based psychoeducation may be used for parents of older children (Quach, Hiscock, Ukoumunne, & Wake, 2011).

Psychosocial and behavioural interventions for mothers of infants have mixed results. Reviews indicate improvements in infants' nocturnal sleep time, but not their night-wakings (Kempler et al., 2016). However, a systematic review once highlighted that behavioural sleep interventions did not improve outcomes for both mothers and infants and suggested that current studies do not consider covariates and methodological issues like neurodevelopmental differences during different stages of development, feeding difficulties, and crying (Douglas & Hill, 2013). Furthermore, factors such as difficulties implementing interventions, such as time, presence of co-morbidities or lack of awareness may hinder the efficacy of treatments for children sleep. For instance, attachment to the child may prevent a parent from employing extinction procedures. However, mothers may still experience mood or depression related benefit from these interventions, suggesting the prospective utility of these interventions (Hiscock & Wake, 2002; Kempler et al., 2016).

A more recent meta-analysis examining the efficacy of behavioural sleep treatments for children (Meltzer & Mindell, 2014) concluded that while behavioural interventions

significantly improved sleep onset latency and night-waking frequency, more data was needed to confirm whether these interventions were beneficial for infants or older children, adolescents, and children with clinical conditions. This was supported by another systematic review that assessed the effectiveness of cognitive-behavioural sleep interventions for adolescents (Blake, Sheeber, Youssef, Raniti, & Allen, 2017). Authors highlighted that there was a moderate level of evidence to support behavioural treatments for insomnia in younger children, demonstrating the need for further studies in this area, as well as exploring other interventions and treatments for children and their families (Blake et al., 2017; Meltzer & Mindell, 2014). Most of the studies do not assess changes in parents' sleep due to the intervention. This reinforces the need for further studies that examine the effect of children's sleep disturbances and its treatment on parents' sleep.

Behavioural interventions for improving sleep in children with neurodevelopmental conditions, particularly ASD, have some systematic evidence as well. A meta-analysis of eight systematic reviews highlighted that behavioural interventions have a substantial effect ranking in terms of improving co-sleeping behaviours, morning wakings and self-settling in children with ASD (Cuomo et al., 2017). Further, a recent systematic review demonstrated that including parent training within behavioural sleep interventions for children with neurodevelopmental disorders led to reductions in parent-reported sleep problems (Kirkpatrick, Louw, & Leader, 2019).

Melatonin use

Melatonin is a neurohormone secreted from pineal gland which helps in regulating circadian sleep-wake cycles. It is available as a controlled and uncontrolled medication in several countries. In adult populations with delayed sleep phase disorder, it can help advance the sleep onset (Kennaway, 2015). Supplementation with melatonin has shown some benefits in improving sleep onset latency, duration and quality in children (Alvaro et al., 2013).

A meta-analysis of thirteen randomised controlled trials observed that use of melatonin significantly improved total sleep time in children with neurodevelopmental conditions. No adverse effects were reported (Abdelgadir, Gordon, & Akobeng, 2018). Whether the efficacy of melatonin can be improved by providing parents psychoeducation around their child's behavioural sleep difficulties is understudied. It is also unclear whether melatonin supplementation in children can have indirect, positive effects on parents' sleep. However,

the guidelines on the amount of supplementation are vague, and its potential safety risks are unaddressed. For instance, the Therapeutic Goods Administration in Australia stated that there is a lack of nonclinical studies in young animals to support the use of melatonin in children. Hence, it does not support the use of melatonin in paediatric populations (Kennaway, 2015). Similarly, the National Institutes of Health in the United States recommends not using melatonin in children because it is possibly unsafe (Kennaway, 2015). There is a lack of longitudinal data to establish melatonin's efficacy, side effects, and other drug interactions. It is also unclear how long-term use of melatonin in children can impact their overall development.

Other pharmacological treatments

Pharmacological treatments are not considered first in line for the treatment of sleep disturbances in children. However, they may be used as a therapy for children with ASD and other NDDs. For instance, Porcine secretin and the a_2 adrenergic agonist clonidine are used for improving sleep duration in children with autism and provide moderately effective results (Cuomo et al., 2017). However, there is a lack of evidence on the use of pharmacological treatments for children with ADHD. According to a systematic review, both Zolpidem and L-theanine provide a poor response in reducing sleep latency, with the former producing high levels of side effects (Barrett, Tracy, & Giaroli, 2013). Clonidine may provide some benefits for children with insomnia, but more research is needed to establish how pharmacological treatments can be safely and effectively used for children. Moreover, controlled trials are required to determine whether a combination of pharmacological treatments or parent administered behavioural intervention has a better impact on child's sleep or whether it can have a positive flow-on effect on family's sleep.

Currently, research focuses on treating sleep in children without addressing sleep within the family, despite the evidence suggesting interplay between parent-child sleep. While some studies have looked at altering the child's environment to improve their sleep (Jin, Hanley, & Beaulieu, 2013), they do not necessarily aim to improve sleep in parents. However, there is a suggestion that parent outcomes may not improve following these interventions (e.g., Stremler et al., 2013), potentially due to the development of chronic insomnia in these parents. Hence, concurrent treatments should be considered for parents. Some treatment options and avenues for parent sleep are suggested below.

Treatments for parents

While the evidence demonstrates the benefits of sleep interventions for children, there is a paucity of literature on sleep interventions targeting parents' sleep. Considering that parents modify their child's environment and their cognitions can influence sleep in children, it may be important to target sleep in parents. As indicated throughout this literature review, poor sleep and symptoms of insomnia are common in parents and linked to impairments in mood, cognition and daytime functioning. Treatments such as Cognitive Behavioural Therapy for Insomnia (CBT-I) and Mindfulness-based treatments that are considered beneficial for adults (Cincotta, Gehrman, Gooneratne, & Baime, 2011; Gong et al., 2016; Mitchell, Bisdounis, Ballesio, Omlin, & Kyle, 2019; Trauer, Qian, Doyle, Rajaratnam, & Cunnington, 2015; Winbush, Gross, & Kreitzer, 2007), may be applicable for treating sleep in parents. While these programs are currently being adapted for women in pregnancy and postpartum periods, they are untested for parents of children beyond infancy. At the same time, there is a possibility that parents of children with sleep disturbances might find these programs difficult to commit to due to caregiving demands, busy lifestyles and work schedules. Whether usual sleep interventions for adults can be adapted for parents, and if they are feasible for this population could only be determined by further testing.

Bei and colleagues (2019) recently published a scalable protocol for a CBT-I intervention for first-time mothers, where mothers were either randomised into a treatment or an active control (healthy diet) condition. The protocol included tests on maternal sleep quality, mood and quality of life, among other well-being indicators. The therapist-assisted intervention involved evidence-based therapeutic practices, along with mindfulness-based strategies for targeting physical discomfort, pain, and cognitive arousal. The intervention was reportedly delivered through a combination of a 50-minute standardised telephone session, a series of emails, and an option for mothers to contact a psychologist using email or telephone if they experience difficulty applying the intervention material.

In time, such treatments have the potential to improve sleep in parents and have crossover effects on children. Since children may learn their sleep habits from parents (Zhang, Li, Fok, & Wing, 2010), modifying parents' cognitions and behaviours around sleep may benefit the child as well. However, it must be noted that the protocol proposed by Bei and colleagues

was designed for first-time mothers and some of its aspects may not be feasible for parents who have older children with sleep difficulties, or those who have more than one child. It may be difficult for parents to attend any face-to-face sessions, especially for interventions like CBT-I that usually run for an hour, the same as any psychotherapy session. Given the feasibility issues, there may be benefits to exploring self-help tools that can help improve sleep in parents. This includes options like psychoeducation tools, such as sleep hygiene practices available online, or government-aided websites (e.g., sleepio.com, thiswayup.org.au.) that offer management of sleep and concurrent mental health conditions.

Given that sleep disturbances in children may be a precipitating/perpetuation factor for insomnia, and it may lead to cognitive or physiological arousal in parents, there may be some benefit to exploring the utility of sleep interventions that reduce hyperarousal in parents. While parents can improve their child's sleep through psychoeducation and implementation of behavioural sleep treatments for paediatric populations, the perpetuation of their own sleep problems may require a separate, more dedicated response. Since sleep reactivity and related stresses may be higher in this population, research may consider employing tools that can improve both sleep and arousal aspects while reducing stress dysregulation. A proposed tool can be mindfulness training. Mindfulness refers to receptive attention to and awareness of present events and experiences (Brown & Ryan, 2003). Cultivated through meditation, mindfulness encourages humans to be present-centred and non-judgmental (Dreyfus, 2011), allowing a shift of cognitive sets and decentring, which can allow for alternate appraisals of life events (Garland et al., 2014). Mindfulness training is easily available through mobile phone apps and may be feasible for parents who may find it challenging to commit to face-to-face treatment sessions for sleep difficulties.

Mindfulness training can modulate negative emotions and reduce arousal (Garland et al., 2014). This can help reduce pre-sleep arousal in parents of children with sleep disturbances. Hypothetically, mindfulness targets stress that arises from the inability to fall asleep (Ong & Smith, 2017). Ong and colleagues (2017) suggest that mindfulness principles can increase awareness of states when experiencing insomnia symptoms, reduce sleep-related arousal and promote a mindfulness stance when symptoms of insomnia arise. By changing relationship with thoughts related to sleep-related arousal, mindfulness can theoretically help in cases of sleep deprivation and insomnia. Previous studies report that mindfulness is associated with positive outcomes in adults, such as lower levels of depression and anxiety, greater emotional

regulation, and better sleep (Blanck et al., 2018; Hill & Updegraff, 2012; Ong, Xia, Smith-Mason, & Manber, 2018; Winbush et al., 2007). Mindfulness-based interventions also promote sleep and reduce pre-sleep arousal (Cincotta et al., 2011; Ong, Shapiro, & Manber, 2009). Hence, it may be particularly beneficial for parents that experience hypervigilance or worries about the child or have high cognitive arousal before sleep. The efficacy of mindfulness-based mobile phone applications for sleep is relatively underexamined (Low, Conduit, Varma, Meaklim & Jackson, 2020), but it is a growing of area of interest. Preliminary evidence suggests a positive uptake of mobile mindfulness applications with benefits noted for stress, clinical conditions like cancer and in cases of psychopathology (Cavanagh et al., 2013; Mistler, Ben-Zeev, Carpenter-Song, Brunette, & Friedman, 2017). Given that mindfulness applications offered via phone are inexpensive, accessible and time-friendly, they can be considered as a self-help support option for parents with sleep disturbances. However, it is unclear whether these digital health options and apps could be useful for people with chronic insomnia or occasional sleep disturbances (Ong & Moore, 2020). Hence, the feasibility of these self-help digital interventions should be examined further.

While mindfulness has not been studied in the context of parental sleep, it has been studied for a variety of other factors within the family realm. Mindfulness training in parents is associated with increased parent-child interaction in mothers of anxious pre-school children (Fereydooni, Heidari, Eftekhar Saadi, Ehteshamzadeh, & Pasha, 2020). Maternal mindfulness is associated with positive parenting practices (Ren, Han, Ahemaitijiang, & Zhang, 2020). In the context of family, research indicates positive effects of parental mindfulness on parent and child relationship quality (Coatsworth, Duncan, Greenberg, & Nix, 2010) and parenting practices (Van der Oord, Bögels, & Peijnenburg, 2012). The positive effects of mindfulness within families emphasise its potential utility in improving parents' sleep.

The case for investigating sleep characteristics in parent-child dyads

Sleep within the family unit is associated in complex ways. Given that sleep problems in children are highly prevalent, it is possible that their parents are sleeping poorly as well. As noted in the sections above, there is a small yet growing body of research that addresses the relationships between parent-child sleep (Kouros & El-Sheikh, 2017). However, the causal links between parent-child need to be explored further. While mothers commonly note their caregiving demands to be a cause of their insomnia (Arber, Hislop, Bote, & Meadows, 2007),

it is unclear if the child's sleep only relates to parental sleep disruption, or if it may play a role in parental insomnia.

Hence, observations from the current literature necessitate the need to explore parent-child sleep by adopting a family perspective. Parents of children with sleep difficulties may experience stress and anxiety, relationship or financial troubles, and may also have decreased ability to drive (Elphick et al., 2019), placing strain on parent health and the healthcare systems. Addressing parent sleep ensures better health outcomes while reducing the burden of sleep deprivation on society. Apart from informing researchers about the effect of a child's sleep on the parent, adopting a family perspective can foster our understanding of how a parent may influence their child's sleep. For instance, there is a 30% to 40% heritability component for sleep duration and quality (Grima, Bei, & Mansfield, 2019), which suggests that there are biopsychosocial mechanisms that predict sleep from childhood to adulthood and must be explored further. Also, parents shape the family environment and affect family functioning. An abundance of literature has documented that parent-related factors, such as mental health, behaviours and mood-related to children's ability to initiate and maintain sleep (Dubois-Comtois et al., 2019; Roberts, Harper, Bistricky, & Short, 2020). Since these family dynamics around sleep are modifiable, addressing and managing parent sleep can mediate the relationships between parents' health, family functioning, and children's sleep. Since parents and children share reciprocal sleep relationships, one of the most effective ways to improve sleep in children is to simultaneously treat children's sleep disturbances and address sleep in other members of the family (Fuligni et al., 2015), thus adopting a family perspective on sleep.

Objective and organisation of this thesis

The current thesis presents links between children's sleep disturbances and parents' sleep using a series of studies. This thesis examined sleep at dyadic levels, this being a child and their primary caregiver. We employed a robust, multi-modal approach to examine these relationships. This included a systematic review of literature and the use of retrospective reports to explore sleep outcomes in parents of children with sleep difficulties. To validate retrospective reports, actigraphy derived objective sleep profiles in parent-child dyads was collected and analysed using a novel measure. Following this, a pilot study of a self-help sleep intervention was conducted. Sections below discuss the organisation of this thesis.

Chapter Two

Chapter two describes the investigation of the relationship between parent and child sleep through the lens of past research. The systematic review identified sleep interactions in this dyad and highlighted areas of future interest. The aim was to assess sleep associations in parent-child dyads across a) TD children, and b) children with NDD.

Chapter Three

The objective of the second study was to extend the current literature. The primary objective was to explore pre-sleep arousal and sleep efforts in parents of children with sleep disturbances. Therefore, the study aimed to: a) examine sleep associations in parent-child dyads, b) if child's sleep mediated parent's sleep and mood, b) differences in parent's sleep and mood based on the extent and nature of children's sleep disturbance.

Chapter Four

The third study expanded the scope of the previous study by documenting parent-child sleep using objective measures. Sleep-wake concordance in parent-child dyads was examined. Parents and children wore actigraphy for 14 nights and parents completed sleep diaries for themselves and their children. Temporal links in parent-child night-waking were explored using sleep concordance analyses. Further, parent-reports of children's sleep disturbance were validated against actigraphy.

Chapter Five

Finally, study four assessed the feasibility of a self-help mindfulness tool on sleep and mood in parents. No previous studies have investigated the effectiveness of sleep interventions, specifically targeting parents. Hence, parents used a mindfulness-based mobile phone application for six weeks and reported their sleep and mood at baseline and follow-up.

Chapter Six

Chapter six provides a general discussion of the findings, along with an overall conclusion of the thesis.

Chapter 2

A systematic review of sleep in parent-child dyads: Implications for future research

Preamble

This chapter presents results from a systematic review that consolidated past literature on parent and child sleep. It includes both typically developing children and paediatric population with neurodevelopmental disorders. Previous research suggests that parent-child sleep is related, but it is unclear which specific sleep characteristics are linked. It is also reported that parents of children with neurodevelopmental disorders have poorer sleep and mood outcomes in comparison to parents of typically developing children, but never been systematically examined. Accordingly, this study used previous literature to explore the characteristics of sleep associations in parent-child dyads. Sleep outcomes were compared across objective-subjective measures and between different paediatric populations. Following this, the review identified gaps in the current literature and provided an agenda for future research.

Candidate's contribution

The candidate systematically searched, compiled and reported the literature. They conducted the review procedure, resolved discrepancies and wrote the chapter.

Publication

Varma, P., Conduit R., Junge M., Lee, V.V., Jackson, M.L. (under review). A systematic review of sleep in parent-child dyads: Implications for future research. *Journal of Child and Family Studies*.

Abstract

Background: There is a general consensus that parent-child sleep is related. However, no systematic reviews have consolidated the empirical evidence on these links This review aimed to examine sleep associations in parents and typically developing children, and parents of children with neurodevelopmental conditions aged two years and above.

Methods: A systematic literature search was conducted on PubMed, PsycINFO, EMBASE and Scopus databases for articles examining parent and child sleep. Twenty-nine studies were included in the final review.

Results: Parent-child sleep associations were found for sleep quality, sleep duration and sleep efficiency in TD children. Limited evidence was available sleepiness and night-wakings. Contradictory findings were reported for sleep-wake in this dyad. Typically developing children with clinical diagnosis experienced more sleep disturbances, and their parents had poorer sleep outcomes. Similarly, parents and children with neurodevelopmental disorders reported poor sleep. More recent studies observed bidirectional associations in parent-child sleep.

Conclusion: Parent-child sleep is associated with the general paediatric population. Children's sleep disturbances may play a role in poor sleep quality or insomnia symptoms in parents. In contrast, parents may influence a child's sleep through their own sleep habits. Future studies should consider longer follow-ups, assessment of bio-psychosocial elements in the context of sleep and use better dyadic models for assessing cause and effect. This review presents a case for considering sleep issues at a broader, family level rather than individually.

Keywords: parent, child, sleep, bedtime, waketime, parenting

Introduction

Epidemiological studies report that sleep disturbances are common in children, affecting 25%-40% of the general paediatric population and up to 80% of children with neurodevelopmental disorders (NDD) (Blader, Koplewicz, Abikoff, & Foley, 1997; Krakowiak, Goodlin-Jones, Hertz-Picciotto, Croen, & Hansen, 2008; Lopez-Wagner, Hoffman, Sweeney, Hodge, & Gilliam, 2008; Mihaila & Hartley, 2018; Owens, 2005, 2008; Owens & Mindell, 2011; Sung, Hiscock, Sciberras, & Efron, 2008). In typically developing (TD) or general paediatric populations, sleep disturbances include issues with bedtime resistance, and difficulties initiating or maintaining sleep (Galland, Taylor, Elder, & Herbison, 2012; Krakowiak et al., 2008). These sleep issues may be exacerbated by chronic health conditions such as asthma or diabetes (Jaser et al., 2017; Moore, David, Murray, Child, & Arkwright, 2006). Sleep disturbances in children with NDDs may also include behavioural difficulties, but they usually stem from a variety of biological, disease-related causes (Owens & Weiss, 2019). Regardless, primary caregivers of these children (hereon referred to as 'parents') experience sleep loss as they tend to their child (Meltzer & Montgomery-Downs, 2011) or worry about the child's well-being. On the other hand, parents' own insomnia symptoms can disrupt children's sleep (Zhang, Wang, & Huang, 2010), or their irregular sleep practices may be linked to increased dozing in children (Komada et al., 2009). This suggests elements of reciprocity in parent-child sleep. A systematic consolidation of the literature on parent-child sleep can, therefore, help promote the understanding of family links in sleep and highlight areas for further investigation. Given that family systems are interdependent, shedding light on sleep in parent-child dyads can enable prevention, diagnosis, treatment and management sleep difficulties within families.

Considering sleep at the level of the dyad, rather than looking at parent and child sleep separately, is crucial. Firstly, inadequate sleep in children is linked to significant sleep and mood impairment in parents (Goldberger-Raskin, Gothelf, Bachner-Melman, Lang, & Kushnir, 2018; Goldman, Bichell, Surdyka, & Malow, 2012; Goldman, Wang, & Fawkes, 2014; Hodge, Hoffman, Sweeney, & Riggs, 2013; Meltzer & Mindell, 2007). Secondly, children may learn or adapt sleep habits from their parents, particularly mothers (Kouros & El-Sheikh, 2017). Parents also exert a considerable influence on their child's environment, which may result in the development of a cyclic pattern between parent-child sleep difficulties. For instance, poorly sleeping children may play a role in disrupting parent sleep,

resulting in increased parental stress (Meltzer & Mindell, 2007) or altered parenting behaviours that are otherwise linked to sleep in children (Bordeleau, Bernier, & Carrier, 2012). These reciprocal relationships in sleep warrant further investigation in a family context; a recommendation made in several studies (El-Sheikh, Kelly, & Philbrook, 2017; El-Sheikh & Sadeh, 2015; Kouros & El-Sheikh, 2017; Meltzer & Montgomery-Downs, 2011). It is also crucial to explore how parent-child sleep interactions may differ based on whether the child is TD or has NDD.

Notably, no systematic reviews have discussed the links between parent-child sleep, and the nature of sleep relationships within this dyad is ambiguous. Narrative reviews on family sleep and sleep in parents of children with different medical conditions exist (e.g. Keilty, Cohen, Ho, Spalding, & Stremler, 2015; Meltzer & Montgomery-Downs, 2011), but they consider parents' sleep problems in the context of the child's diagnosis rather than their sleep difficulties. Therefore, the aim of this review was to examine sleep associations in parent-child dyads across TD paediatric populations and in children with NDD.

This review included children aged two years or above and excluded reports on parent-infant sleep for two reasons. Firstly, consistency in children's sleep pattern starts developing around two years of age (El-Sheikh et al., 2017), and sleep problems during infancy are transient, not necessarily related to later adverse outcomes (Wake et al., 2006). In contrast, far-reaching consequences are reported for childhood sleep disturbances beyond infancy, impacting their physical and mental health, behaviours, mood, cognition and school performance (Fallone, Owens, & Deane, 2002; Meltzer & Mindell, 2007; Smaldone, Honig, & Byrne, 2007). Secondly, the average age of diagnosis for major developmental conditions is usually after the age of two years when the child exhibits difficulties in attaining developmental milestones. For instance, the average age of diagnosis for autism is around three years (Daniels & Mandell, 2014; Mandell, Ittenbach, Levy, & Pinto-Martin, 2007). Including infant-related studies can make it difficult to discriminate sleep problems between TD and NDD populations. Hence, the review population included children aged 2-18 years and also considered the impact of age on parent-child sleep associations.

Methods

The PRISMA (Preferred Reporting for Systematic Reviews and Meta-Analysis) guidelines were used to identify studies for this review. A literature search was conducted on PubMed, PsycINFO, EMBASE and Scopus databases. A combination of free-text terms was used to generate high sensitivity research. The original search was restricted from January 2000 to April 2020, limited to peer review, human subjects, and articles written or translated in English. Figure 1 includes a list of keywords. In addition, we utilised the ancestry approach.

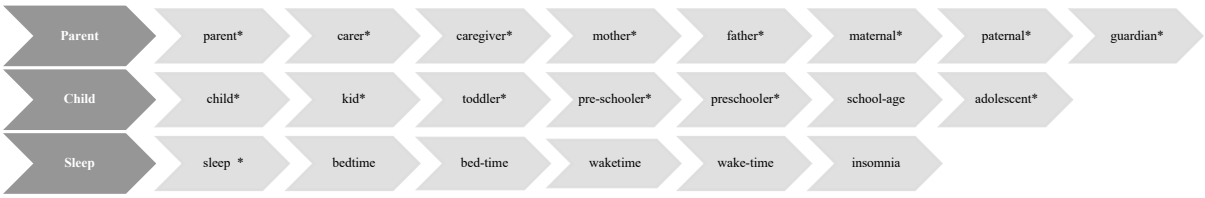

Figure 1. Search terms: List of keywords used. Asterisks were used to truncate search terms and include various endings for keywords.

Identification and selection of studies

Each database was searched to perform the initial screening. The initial search yielded 9059 articles. Two independent reviewers (PV and VL) examined the list of articles for relevant titles and abstracts. Articles were excluded if they: 1) did not measure sleep in parents and their children, 2), were a literature review, 3) conference abstracts, 4) did not assess the sleep relationship between parent and child, and 5) included infants as the primary study population. Hence, studies that included infants along with other age groups were also excluded due to lack of age-based comparisons (Komada et al., 2009; Newland, Parade, Dickstein, & Seifer, 2016; Yu, Sadeh, Lam, Mindell, & Li, 2017). Eighty-one articles satisfied preliminary inclusion criteria and were accepted for a full review. After retrieving remaining records, the following eligibility criteria were used: 1) sample included at least one parent or caregiver, 2) included a sleep measure for both parent and the child, 3) reported on sleep association between parent and child as an outcome, 4) did not investigate sleep in hospitalised children or children using medical technology, and 5) children were between 2-18 years of age, with or without sleep problems. Figure 2 provides the flow diagram of the study selection.

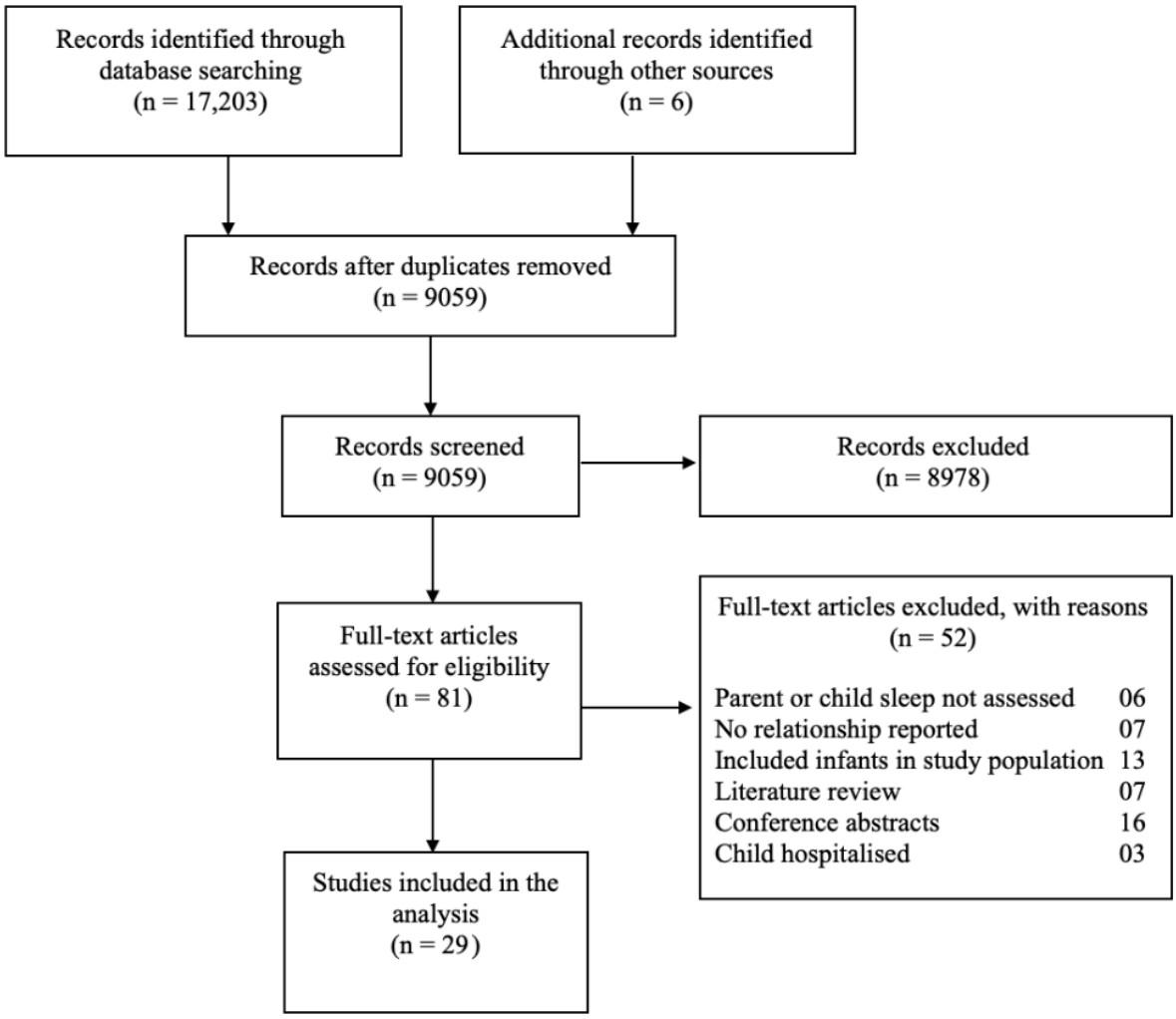

Figure 2. Flow diagram of study selection. After assessing 17, 203 records, 29 studies were included in the final analysis.

Quality assessment

PV and VL conducted data extraction and evaluation of studies independently. Inter-rater agreement was 0.98, and any discrepancies were resolved by discussion. Following data were extracted and tabulated: study design, measures used, basic demographic data, and primary outcomes. PV and RC undertook quality assessment using the Appraisal tool for Cross-Sectional studies (AXIS) tool (Downes, Brennan, Williams, & Dean, 2016). This tool assesses the risk of bias in cross-sectional studies and is often used for reporting in systematic reviews (Moor & Anderson, 2019; Wong, McAuley, & Trinh, 2018). It includes twenty components that address aims, methods, results, discussion, limitations and ethical concerns around included studies (Appendix-I).

It must be noted that within the AXIS tool, responses 'no' to Q.13 and Q.19 are considered positive, indicating lack of non-response bias concerns and lack of funding resources (respectively) that could create a potential conflict of interest (Figure 3). On average, studies scored 80%, indicating good research quality.

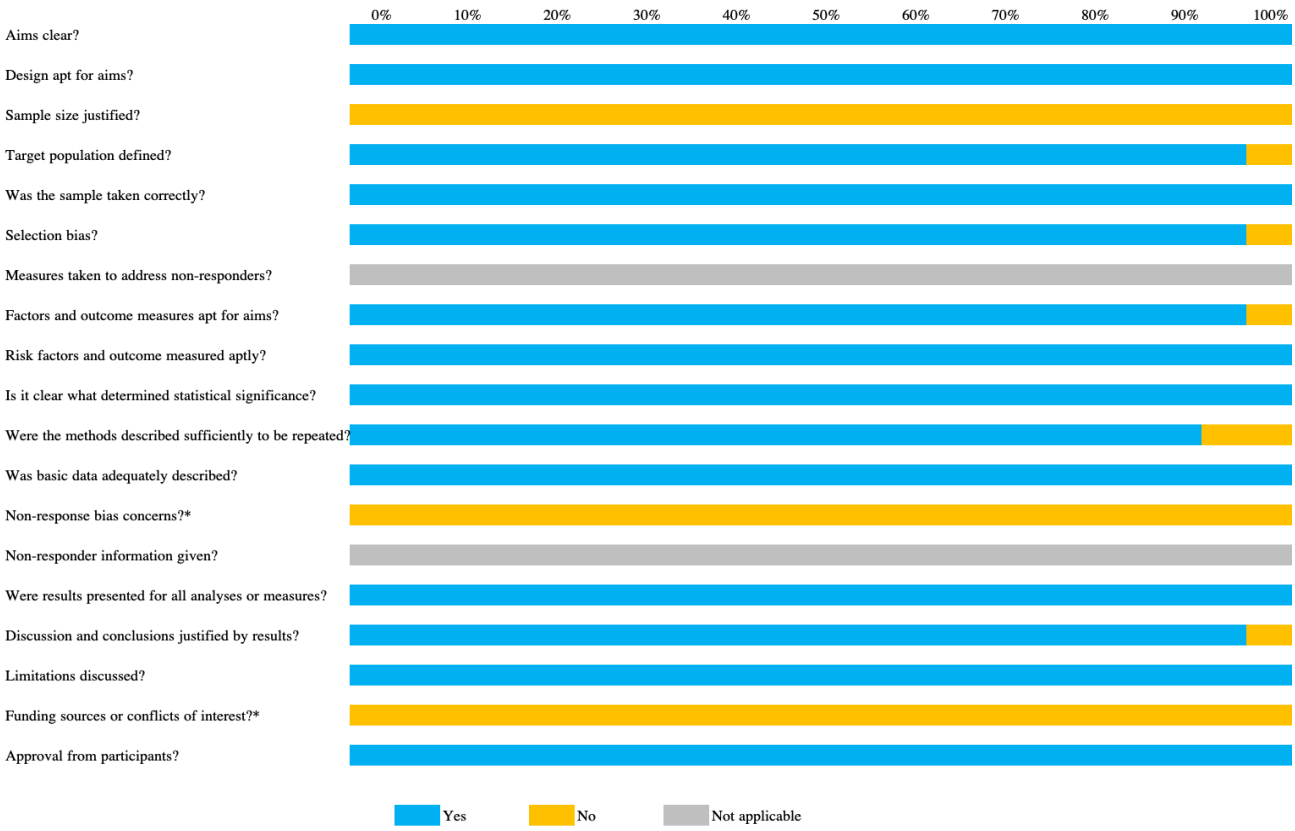

Figure 3. Quality assessment for studies included in the review.
**'no' as a response suggests good quality.*

Results

Summary of included studies

The review included 29 studies, with sample sizes ranging from 15 to 20,778 participants. Twenty studies reported on sleep associations in parents and TD children in the general paediatric population (Table 1). Of these, five studies examined children with clinical conditions – sleep disorders, anxiety, Type I diabetes, cancer, and Juvenile Idiopathic Arthritis. Ten studies were on children with NDDs and parents (Table 1). ASD and ADHD were the most common conditions (Bar, Efron, Gothelf, & Kushnir, 2016; Goldman et al., 2012; Goldman et al., 2014; Hoffman et al., 2008; Lopez-Wagner et al., 2008), followed by Angelman Syndrome (Goldman et al., 2012) and cerebral palsy (Adiga, Gupta, Khanna, Taly, & Thennarasu, 2014; Wayte, McCaughey, Holley, Annaz, & Hill, 2012). Most studies employed a cross-sectional methodology using retrospective subjective measures such as the Pittsburgh Sleep Quality Index (PSQI) and Child's Sleep Habits Questionnaire (CSHQ). Objective measurements were also common, including actigraphy, which explores real-time sleep-wake variability, reducing retrospective and response bias from self-report measures (Ancoli-Israel et al., 2003). Studies also utilised electroencephalography (EEG) or polysomnography, incorporating EEG with electrocardiography (ECG) and electrooculography (EOG) to measure sleep characteristics (Goldman et al., 2012). These measures provided a broad range of outcomes such as sleep quality (which refers to satisfaction with one's overall sleep experience), insomnia (difficulties falling asleep, staying asleep or early morning awakening), bedtime, waketime, sleep onset latency (i.e. time taken to fall asleep), wake after sleep onset (i.e. duration of night wakings), sleep onset and offset.

Effect sizes

Due to heterogeneity in studies, separate effect sizes were obtained for some commonly reported sleep outcomes. For studies using retrospective sleep measures, effect sizes were calculated for parent-child sleep disturbance (e.g. parental sleep quality or daytime sleepiness, and either of their associations with children's sleep disturbance). Effect sizes were also calculated for bedtimes and waketimes when reported. Effect sizes for sleep onset and offset were obtained for studies that used objective sleep measures. Overall, studies reported medium effect size for parent-child sleep disturbances, parent-child sleep onset and offset. In contrast, small effect sizes were noted for parent-child bedtime and waketime.

Table 1.
Summary and characteristics of included studies. 28 studies were included in the final analysis. Each study included at least one measure of parent and child sleep.

Author	Population	Participants	Mean Age *(in years)*		Comparison group	Sleep-related outcome measures		Effect size
			Parents	Children		Parents	Children	
Matricciani et al. (2019)	TD	1358 parents 1261 children	43.6±5.3*(mothers)* 46.3±7.1 *(fathers)*	12±0.4	N/A	GENEActiv accelerometers (actigraphy)	GENEActiv accelerometers (actigraphy)	Sleep onset = 0.42[a] Sleep offset = 0.58[a]
Staples et al. (2019)	TD	149 mothers 167 children	-	30 – 42 months	N/A	Actigraphy	Actigraphy	Total sleep time = .36[a]
Goldberger-Raskin et al. (2018)	TD (anxiety)	136 mothers-children	43.77 ± 6.44	11.86 ± 2.94	Yes	PSQI	CSHQ, PSAS-C	Sleep disturbance = 0.44[b]
Daniel et al. (2018)	TD	68 caregivers-children	35.87 ± 6.91	6.24 ± 2.27	No	PSQI	CSHQ	Sleep disturbance = 0.26[a]
Lee et al. (2017)	TD	28 parent-child dyads	42.79	14.93	N/A	Daily sleep reports	PSQI, daily sleep reports	Total sleep time = Not available
Urfer-Maurer et al. (2017)	TD	191 parents-children	-	9.58 ± 1.47	N/A	ISI	CSHQ, in-home EEG	Sleep disturbance = 0.23[a]
Kouros et al. (2017)	TD	163 parents-children	-	10.45 ± 0.62	N/A	Actigraphy, Sleep diary	Actigraphy, Sleep diary	Bedtime = 0.27[a] Waketime = 0.06[a]
Jaser et al. (2017)	TD (Type I diabetes)	515 parents	-	9 ± 3	No	PSQI	CHSQ	Sleep disturbance = Not available
Yuwen et al. (2016)	TD (Arthritis)	46 parents-children	34 ± 4.19 *(JIA)* 32.7 ± 4.43 *(TD)*	-	Yes	Sleep hygiene (2 questions), Actigraphy, Sleep diary	Actigraphy, Sleep diary	Sleep onset = 0.02[a] Sleep offset = 0.54[a]
Rönnlund et al. (2016)	TD	100 parents-children	36 ± 4.91 *(mothers)* 38 ± 4.91 *(fathers)*	-	N/A	JSS	Actigraphy, SDSC	Sleep disturbance = 0.25[a]
Bar et al. (2016)	NDD	62 parents-children	-	10.09 ± 2.68 *(ADHD)* 9.80 ± 2.41 *(control)*	Yes	PSQI	CSHQ, PSAS-C	Sleep disturbance = 0.44[a]
Fuligni et al. (2015)	TD	21 parents-adolescents	41.93 ± 6.77	15.03 ± 0.83	N/A	Daily Checklist on sleep, bed and wake times	Daily checklist on sleep, bed and wake times	Bedtime = Not available Waketime = Not available
Goldman et al. (2014)	NDD	17 mothers and children	-	7.4 ± 1.8	Yes	ISI, Actigraphy, ESS	Actigraphy	Sleep time = 0.49[a]
Adiga et al. (2014)	TD	50 mothers-children	23.3 ± 3.9	8.9 ± 2.45	No	PSQI	SDSC	Sleep disturbance = Not available
Iwata et al. (2013)	TD	47 children and parents	-	-	N/A	Actigraphy, Sleep log, PSQI, ESS	Actigraphy, Sleep log	Bedtime = 0.10[a] Waketime = 0.15[a]
Hodge et al. (2013)	NDD	180 mothers-children	-	-	Yes	PSQI, PSI	CSHQ	Sleep disturbance = 0.38[a]
Bajoghli et al. (2013)	TD	289 participants across 81 families	40.25 ± 7.2 *(fathers)* 43.4 ± 8.0 *(mothers)*	14.15 ± 3.93	N/A	ISI, PSQI	ISI, PSQI	Sleep disturbance = 0.41[a]
Wayte et al. (2012)	NDD	159 mothers-children 102 mothers (control)	-	-	Yes	PSQI	CSHQ	Sleep disturbance = 0.38[a]
Kalak et al. (2012)	TD	80 adolescents, 47 mothers 39 fathers	49.5 ± 4.0 *(mothers)* 50.8 ± 5.1 *(fathers)*	16.3 ± 2.0	No	Sleep EEG recordings, sleep complaints, ISI	Sleep EEG recordings, sleep complaints.	Sleep onset = 0.70[a] Sleep offset = Not available
Goldman et al. (2012)	NDD	15 parents-children	-	-	No	Actigraphy , PSG, ISI, ESS	Actigraphy , PSG, CSHQ, CBCL	Sleep disturbance = 0.66[a]

Zhang et al. (2010)	TD	4470 parents-children	39.0 ± 4.5 *(mothers)* 43.3 ± 5.4 *(fathers)*	9.2 ± 1.8	No	Sleep questionnaire	Sleep questionnaire	Bedtime = 0.27 [a] Waketime = 0.28 [a]
Li et al. (2010)	TD	20,778 children		9 ± 1.61	N/A	Demographic questionnaire	CSHQ (Chinese Version)	Sleep disturbance = Not available
Chu et al. (2009)	NDD	50 children 46 mothers	-	-	No	PSQI	Children's Sleep Score (CSS) (derived from survey)	Sleep disturbance = 0.45 [a]
Brand et al. (2009)	TD	293 adolescents	-	17.55 ± 1.54	N/A	ISI	Daily sleep log using PSQI	Sleep onset = 0.15 [a]
Lopez-Wagner et al. (2008)	NDD	442 parents-children		8.20 ± 2.69 *(autism group)* 8.62 ± 3.28	Yes	PSQI	CSHQ	Sleep disturbance = 0.46 [a]
Hoffman et al. (2008)	NDD	90 mothers-children 90 TD mothers-children	38.8 ± 6.6 -	8.3 ± 2.97	No	PSQI	CSHQ	Sleep disturbance = 0.44 [a]
Meltzer et al. (2007)	TD	47 mothers	38.4 ± 4.7	7.40 ± 2.7	No	24-hours SPI, SSS, IFS	CSHQ	Sleep disturbance = 0.41 [a]
Boergers et al. (2007)	TD	107 families	-		N/A	Parents: PSHQ.	CSHQ, Sleep diagnosis	Sleep disturbance = 0.29 [a]
Gau et al. (2004)	TD	1479 parents	40.0 ± 4.2 *(mothers)* 43.3 ± 6.2 *(fathers)*	12.0 ± 1.5	N/A	Morningness-Eveningness scale, Sleep schedules	Sleep Schedules	Bedtime = 0.08 [a] Waketime = 0.02 [a]

Note: Sleep disturbance refers to poor sleep quality or insomnia in parents and sleep disturbances in children.
[a]indicates correlation effect size.
[b]indicates Cohen's d effect size for group differences between sleep in parents of typically developing children and parents of children with neurodevelopmental conditions.
Only mother-child effect sizes are noted in studies that compared sleep in both mothers and fathers.
Abbreviations: TD – Typically developing, NDD – Neurodevelopment disorder
CBCL – Child Behaviour Checklist; CSHQ – Child's Sleep Habits Questionnaire; EEG – Electroencephalography; IFS – Iowa Fatigue Scale; ISI – Insomnia Severity Index; JSS – Jenkins' Sleep Scale; PSAS-C – Pre-sleep Arousal Scale for Children; PSG – Polysomnography; PSHQ – Parents' Sleep Habits Questionnaire; PSQI – Pittsburgh Sleep Quality Index; SDSC – Sleep Disturbance Scale for Children; SPI – Sleep Patterns' Inventory; SSS – Stanford Sleepiness Scale.

Parent-reported sleep outcomes

Studies on TD children and their parents reported on a wide range of outcomes such as sleep quality, associations between parent-child sleep and wake timing (or sleep-wake), sleep duration, sleep efficiency (time spent in bed asleep) and sleepiness. Sleep outcomes that were reported in at least two studies are summarised in Table 2. Based on self-report measures, most evidence was available for links between poor sleep quality in parents and sleep disturbances in children. Objective measures provided evidence for associations between parent-child sleep duration and sleep efficiency. In contrast, evidence for night-wakings and sleepiness was limited. Some studies reported weak associations in parent-child sleep-wake (Gau & Merikangas, 2004; Zhang, Li, Fok, & Wing, 2010) and others reported strong associations (e.g. Matricciani et al., 2019).

Boergers and colleagues (Boergers, Hart, Owens, Streisand, & Spirito, 2007) revealed increased daytime sleepiness in parents of children with diagnosed sleep disorders. TD children with health conditions experienced more sleep disturbances than healthy, TD children (e.g. Goldberger-Raskin et al., 2018; Yuwen et al., 2016). In another study on children with Type I diabetes, more than 50% of parents reported shorter sleep duration (<7 hours a night) attributed to their child's diabetes concerns. The stress of parenting a child with a clinical diagnosis can be a confounding factor impacting sleep outcomes in parents of TD children.

Objectively measured sleep outcomes

Extending on previous reports, seven studies used actigraphy or EEG to examine sleep associations in parents and their children (Iwata et al., 2013; Kalak et al., 2012; Kouros & El-Sheikh, 2017; Matricciani et al., 2019; Rönnlund, Elovainio, Virtanen, Matomäki, & Lapinleimu, 2016; Staples, Bates, Petersen, McQuillan, & Hoyniak, 2019; Urfer-Maurer et al., 2017). These studies found links between sleep efficiency and sleep duration among parent-child dyads. Recent studies that used actigraphy reported bidirectionality and the possibility of reciprocity in objectively parent-child sleep. In particular, a predictive model by Kouros and El-Sheikh revealed that positive fluctuations in sleep efficiency of mothers predict higher levels of sleep efficiency in children. A 4% change in mother's sleep efficiency predicted a 1% change in child's sleep efficiency. At the same time, better sleep efficiency and fewer long wake episodes in children were related to better sleep efficiency in mothers

for the same night. Fulgini and colleagues (2015) reported that sleep habits in parents and adolescents could be bidirectional.

Although most research using objective measures has observed similarities in parent-child sleep, some studies reported inconsistencies when comparing parent-reported child's sleep and objectively measured sleep outcomes. For instance, parent-reported sleep-wake transitions in children were related to parents' sleep disturbance, but it was not explained by the child's actigraphy outcomes (Rönnlund et al., 2016). This was also reported in a study by Urfer-Maurer and colleagues (2017) wherein parents' insomnia symptoms and perception of child's sleep was not related to the child's objective sleep outcomes.

Child's age and parent sleep

Two studies (Boergers et al., 2007; Meltzer & Mindell, 2007) recruited children across wider age-groups (2-12 years and 3-14 years respectively) and examined the links between parent-reported child's age and parents' sleep. Both studies noted no associations between the age of the child and parents' sleep outcomes, but overall interrelationships were reported between a child's sleep problems and parents' sleep disturbances. More recent studies recruited narrower age groups, observing sleep associations for different outcomes. For instance, parents and their pre-school children did not display correlated sleep-wake patterns, despite the associations between parents' sleep end time and children's bedtime and waketime (Iwata, Iwata, & Matsuishi, 2013). In comparison, sleep-wake was associated with school-age children and their parents (Matricciani et al., 2019). Similarly, adolescent-parent sleep was linked when assessed using adolescent reports (Brand, Gerber, Hatzinger, Beck, & Holsboer-Trachsler, 2009) and parent-reports (Kalak et al., 2012). However, this relationship was indirect and mediated by parenting styles (Brand et al., 2009). In another study (Lee, Miernicki, & Telzer, 2017), the authors noted that sleep timing in parents did not predict sleep timing in children. Broadly, both parent-reported and objectively measured sleep outcomes were assessed in all age-groups, which revealed associated across all age-groups in children and their parents' sleep, except adolescent-parent sleep, which was suggested to be more independent, influenced by other family factors.

Table 2
Summary of sleep outcomes reported in parents and typically developing (TD) children.

Sleep outcomes	Studies	Summary of main findings
Sleep quality	***Self-report measures***	
	Meltzer et al., 2007; Bajgholi et al., 2013; Iwata et al., 2013; Bar et al., 2016; Yuwen et al., 2016	Sleep disruptions and night-wakings in children were related to poor sleep quality in mothers (but not fathers). Parents of children with health conditions such as anxiety or arthritis had poorer sleep than healthy, typically developing children (Bar et al., 2016; Yuwen et al., 2016). Poorer sleep quality in parents did not affect sleep behaviours in children (Iwata et al., 2013).
Night-wakings	***Objective measures***	
	Rönnlund et al., 2016; Urfer-Maurer et al., 2017; Kouros et al., 2017	Parental reports of their own sleep problems related to their perception of disorders around maintaining sleep in children (Rönnlund et al., 2016;) and late sleep onset (Urfer-Maurer et al., 2017), but not related children's outcomes on objective measures of sleep. However, actigraphy use for both parent and child revealed links between mother-child wake minutes during a night (Kouros et al., 2017).
Sleep-wake	***Self-report measures***	
	Gau et al., 2004; Zhang et al., 2010; Brand et al., 2009; Fuligni et al., 2014	No significant associations between parent and child bedtime and waketime in school-age children. Indirect associations in mother-adolescent sleep, mediated by parenting styles (Brand et al., 2009). Concordant sleep-wake in adolescents and their mothers
	Objective measures	
	Iwata et al., 2013; Matricciani et al., 2019	Actigraphy reported weak associations between parent-child bedtime and waketime in pre-school children (Iwata et al., 2013), but strong associations in parents and children in older school-age children (Matricciani et al., 2019).
Sleep duration	***Subjective measures***	
	Li et al., 2010	Short sleep duration in parents was identified as a risk factor for shorter sleep duration in school-age children.
	Objective measures	
	Kalak et al., 2012; Kouros et al., 2017; Staples et al., 2019; Matricciani et al., 2019	Moderate, but significant correlations were observed between parent-child sleep duration on EEG and actigraphy. Reciprocal relationships reported in mother-child sleep (Kouros et al., 2017).
Sleep efficiency	***Objective measures***	
	Kalak et al., 2012; Matricciani et al., 2019	Daily sleep efficiency is related in children and their mothers, but not fathers. About 42% of parents and 54% of children had sleep efficiency lower than 85% (Matricciani et al., 2019).
Sleepiness	***Self-report measures***	
	Boergers et al., 2007; Iwata et al., 2013	Daytime sleepiness observed in parents of TD children with diagnosed sleep disorders (such as parasomnias, obstructive sleep apnea, insomnia and limit setting sleep disorders). Sleepiness was associated with an early bedtime in children (Iwata et al., 2013).

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Sleep in parents and children with Neurodevelopmental conditions

Studies on parents of children with ASD have consistently reported links between parent-child sleep. Parents and children in the NDD group slept more poorly than TD children and their parents. Hoffman and colleagues (2008) and Chu and colleagues (2009) revealed that poor sleep quality in mothers was associated with sleep disturbances in children with NDD. This was also supported by Lopez-Wagner and colleagues (Lopez-Wagner et al., 2008), who reported significant relationships in both ASD and TD groups. A child's sleep was a stronger predictor of a mother's sleep in the ASD group as compared to the TD group. Hodge and colleagues (2013) reported that mothers of children with ASD reported more sleep problems for themselves and their child in comparison to mothers of TD children.

These associations have also been highlighted using actigraphy. In a study by Goldman and colleagues (2014), 17 mother-child dyads wore actigraphy for 14 days. Participants were then divided into ‘good sleepers’ and ‘poor sleepers’ with ASD [based on Malow et al. (2006) criteria where parents indicated the extent of sleep concerns from 'mild' to 'severe' on a single question], and TD children. Mothers of 'poor sleepers' ASD children had a longer sleep onset latency (SOL) and higher ISI scores than those of 'good sleepers.'

Parallel to ASD, sleep associations have been noted for parents and children with ADHD, and cerebral palsy. A study of children with ADHD reported that 69.4% of children and 31.3% of parents had clinically significant sleep problems based on self-report measures (Bar et al., 2016). It was also highlighted that child's pre-sleep arousal and anxiety predicted poor sleep quality in parents. Similarly, pathological sleep disturbances were documented for one-third of children with cerebral palsy and 50% of mothers, with mothers' sleep disturbances significantly correlating to children's sleep disturbances (Adiga et al., 2014). Apart from neurodevelopmental disorders, sleep disturbances are commonly reported in children with Angelman Syndrome. Caused by missing or non-functional maternal UBE3A gene (Goldman et al., 2012), Angelman syndrome results in sleep concerns for up to 80% of children. To explore associations in parents and children with Angelman Syndrome, Goldman and colleagues used overnight polysomnography, 28-days of in-home wrist actigraphy, and measures of insomnia and daytime sleepiness for 15 children and parent dyads. Significant sleep fragmentation was noted for both children and parents. Poor sleep latency in children predicted increased daytime sleepiness and insomnia severity in their parents.

Discussion

This review consolidated previous findings on the links between parent-child sleep, revealing that sleep within the family unit is interactive and complex. Despite heterogeneity in terms of study measures and participant characteristics, some consistent themes emerged. For instance, we now have accumulating evidence highlighting the interactions between parent-child sleep using both self-report and objective sleep measures. Studies have documented that not only sleep disturbances in children are related to parents' sleep (Bajoghli, Alipouri, Holsboer-Trachsler, & Brand, 2013; Boergers et al., 2007; Meltzer & Mindell, 2007), even daily sleep outcomes such as sleep duration and awakening are interlinked (e.g., Fuligni, Tsai, Krull, & Gonzales, 2015; Iwata et al., 2013).

Quite importantly, sleep quality and insomnia symptoms in parents are linked to children's sleep disturbances within TD and NDD populations. However, parents of children NDD had poorer sleep outcomes than parents of TD children, possibly exacerbated by stresses of parenting a child with a developmental condition. Studies using actigraphy or EEG showed associations for sleep duration and sleep efficiency in parents and TD children. In contrast, reports on sleep-wake patterns were contradictory but attributable to developmental differences in child's sleep-wake patterns. For instance, younger children may sleep earlier, have later rise times and longer time in bed in comparison to their parents (Zhang et al., 2010). In contrast, older children may share similar sleep-wake patterns and subsequently, more synchronicity in their sleep onset and offset with the parents (Fuligni et al., 2015; Matricciani et al., 2019). Finally, more recent studies reveal bidirectional, reciprocal relationships in overall sleep patterns, suggesting that variability in parent-child sleep should be explored further. Associations between child's age and parent's sleep outcomes were not observed. Other salient observations from the literature are discussed below.

Child-related characteristics and their role in parents' sleep

It appears that various child characteristics can influence parent sleep. A child's diagnosis, parent-reported sleep behaviours, night-waking, bedtime resistance and bed-sharing (Meltzer & Mindell, 2007; Urfer-Maurer et al., 2017) are associated with poor sleep and insomnia symptoms in parents. One study noted that while co-sleeping and bedroom sharing may not be linked to adverse sleep patterns in the family, they can result in unfavourable sleep outcomes among parents (Iwata et al., 2013). TD children with medical conditions like

diabetes or arthritis experienced worse sleep disturbances than healthy, TD children. Their parents may experience poor sleep as well.

Overall, sleep difficulties in children were linked to higher levels of anxiety, stress, and decreased the ability to work and drive safely in parents (Elphick et al., 2019). This suggests that parent-reported sleep disturbances and night-waking behaviours in children are associated with poor sleep quality, increased insomnia symptoms and poor functioning outcomes in parents. Children's sleep disturbances can potentially increase sleep reactivity in parents, whereby they may develop exaggerated responses towards stimuli like child's night-wakings or sleep disturbances. That, along with within increased hyperarousal, can have negative consequences for parents' sleep.

Parent-related characteristics and their role in a child's sleep

Some studies postulated that children might learn sleep habits from parents (Li et al., 2010; Zhang et al., 2010), or parental sleep behaviours may influence those of their children (Iwata et al., 2013). Clinical and population-based studies report that individuals with insomnia usually have a first-degree relative who has been diagnosed with insomnia (Fernandez-Mendoza et al., 2014). This suggests that parents' sleep difficulties may be a genetic factor that can predispose children to insomnia.

At the same time, parents play an essential role in helping their children develop regular sleep patterns (Bacaro et al., 2019), often by providing cues preceding sleep (Bacaro et al., 2019; Sadeh, Tikotzky, & Scher, 2010), which can be a social factor that predisposes children to sleep difficulties. This is based on social learning theory, a prominent framework in child development, which proposes that real-life experiences and exposures involving imitation and reinforcement can shape behaviour (Gardner, Burton, & Klimes, 2006; O'Connor, Matias, Futh, Tantam, & Scott, 2013). Children may observe inconsistent sleep patterns in parents and imitate them, leading to sleep disturbances in the population. In turn, children sleep disturbances can potentially result in poor sleep quality and insomnia symptoms in parents, creating a vicious cycle of sleep difficulties within families.

There is a likelihood that a bidirectional relationship exists between parent-child sleep disturbances, such as that they both contribute to the development, and are a consequence of each other's sleep difficulties. However, it is possible that beyond genetic factors and sleep

habits, the child's effect on a parent's sleep is greater than the parent's impact on a child's sleep. For instance, child-rearing and parenting a child below the age of six years are identified as perpetuating factors for insomnia (Perlis, Smith, & Pigeon, 2005). In contrast, the studies in this systematic review reported that sleep habits in children are usually determined by school start times (Li et al., 2010; Zhang et al., 2010) and social demands related to schoolwork (Gau & Merikangas, 2004). A systematic review indicated that children's sleep behaviours were largely governed by psychosocial factors, such as screen-time and sleep timing (Belmon, van Stralen, Busch, Harmsen, & Chinapaw, 2019), and did not mention parent's sleep practices. Even though there is a genetic basis for sleep difficulties, research postulates that it is the environment that influences the sensitivity of the sleep system (Kalmbach, Pillai, Arnedt, Anderson & Drake, 2016). While parents may control a child's environment, which can impact a child's sleep, it appears that their own sleep problems are less likely to have a direct impact on the child. It is possible that parental sleep has a mediating effect on the links between family environment and child's sleep. This indicates the need to examine if insomnia, and sleep difficulties, deprivation and disruption exist in parent populations, and what role their children play in it.

Links between mother-child sleep

Maternal sleep quality and quantity were strongly predicted by a child's sleep in comparison to paternal sleep. Studies consistently documented that father's sleep-wake schedules, retrospective reports on sleep quality, and objectively measured sleep outcomes had little to no associations with child's sleep (Goldman et al., 2012; Kouros & El-Sheikh, 2017; Rönnlund et al., 2016). This may happen because mothers are considered primary caregivers and spend more time with the child (Kouros & El-Sheikh, 2017). Women's gender roles as caretakers, especially for their children, can result in disrupted sleep (Hislop & Arber, 2003, 2006). This also highlights that maternal influences on a child's sleep may extend beyond genetic contributions, including behavioural and lifestyle influences (Zhang et al., 2010).

Sleep in parents of children with neurodevelopmental disorders

Apart from TD children and their parents, sleep interactions were observed within the NDD populations and their parents. Parents in this group had poorer sleep outcomes across most indices in comparison to parents of TD children. These parents also experienced more night-wakings and stress due to caregiving responsibilities. Despite high rates of sleep disturbances

in children with NDDs, the review observed an overall paucity of research on parent-child sleep in the NDD group. There is a possibility that parents of children with NDDs may not rate their children's sleep as problematic possibly due to increased attention towards children's diagnosis and symptoms rather than their sleep, which can explain the lack of sleep-related research in this domain.

Collectively, studies in this review suggest that poor sleep in children may be indicative of poor sleep in parents. Parent-child sleep is interrelated and based on recent evidence, perhaps reciprocal. Risk of bias in these studies was low, with most studies scoring 80% or above on the AXIS tool. However, study methodologies did not allow for analysis of causal relationships. Therefore, results should be interpreted with caution and warrant further explication.

Strengths and limitations

While there is a general consensus that parent and child sleep is related, this is the first review of these associations across empirical studies. A diverse range of studies was included in this review, allowing for broader observations. The review also examined studies using both objective and subjective measures of sleep in children and parents. The measures complemented, rather than contrasting each other, assessing different dimensions of sleep. For instance, sleep quality and sleepiness were broadly assessed from studies using subjective measures, whereas sleep-wake, sleep duration and sleep efficiency were measured using actigraphy and sleep-EEG.

Several limitations should also be noted. Most study methodologies did not allow for analysis of causal relationships. We also observed that while cause-effect relationships were not discussed, most studies suggested that a children's sleep disturbances influenced parents' sleep and functioning outcomes. This may be true because sleep disturbances in children often keep parents awake; these associations need further research. Moreover, it was unclear how many parents had a diagnosed sleep problem or may have been diagnosed with some form of sleep difficulty (e.g. insomnia) in the past. Hence, we need better models of dyadic analysis and clearer inclusion/exclusion criteria for studies exploring sleep outcomes in parents and children. Further, we noted the use of inconsistent sleep measures, lack of causal links, and heterogeneity in studies which precluded us from doing a meta-analysis.

Only two studies looked at the child's age as a covariate in parents' sleep, and this may not be enough to draw age-based conclusion and comparisons. While the studies were culturally diverse, the differences in expectations around parent-child attachment and the role of parents in their children's sleep require further exploration across different cultures. While sleep associations were broadly noted for all age-groups, it is possible that the mechanisms of sleep differ across developmental stages. Parents may be more involved in their child's sleep when they are younger and less involved when they are adolescents (El-Sheikh, 2011). Other reviews may consider including age-based analysis for wider paediatric groups.

Sleepiness in parents and children was understudied and reported in only two studies. This dimension should be studied further, as daytime sleepiness is associated with fatigue-related accidents in adults and poor cognitive outcomes in children (Bener, Yildirim, Özkan, & Lajunen, 2017; Lo, Ong, Leong, Gooley, & Chee, 2016; Montgomery & Wiggs, 2015). Studies also failed to address parent-child chronotypes and how they play a role in sleep in this dyad. Only one study (Gau & Merikangas, 2004) looked at morning-evening chronotypes in parents and children but did not compare them. Only one study in this review was longitudinal (Staples et al., 2019) and only two studies examined variability or fluctuations in daily sleep and their links in parent-child dyads (Kouros & El-Sheikh, 2017; Staples et al., 2019), making it difficult to assess how sleep characteristics in parent-child dyads may fluctuate daily or change over time.

While children with NDD may have more significant sleep disturbances, we noted that TD children who were recruited as control groups had sleep disturbances as well. For instance, in a study by Hodge and colleagues, mean sleep disturbance score (on CSHQ) in TD children was 43, above the cut-off of 41 that is recommended for the questionnaire (Owens, Spirito, & McGuinn, 2000). Similarly, Wayte and colleagues reported a mean score of 42 on CSHQ for TD children recruited as controls in their study. This indicates that TD children may also have sleep disturbances that need further examination. While these studies reported more modest sleep associations in TD and their children as compared to children with NDD and their parents, it is unclear whether sleep disturbances in TD children may play a more significant role in their parents' sleep. Examining and comparing parent-child sleep disturbances in both populations, using multiple measures of sleep may provide a broad overview of how sleep difficulties may present itself in paediatric and parent populations.

Implications

Biopsychosocial influences in sleep

Children may learn sleep habits from their parents then develop sleep difficulties of their own, which in turn can play a role in parents' sleep problems and work in tandem with parent-related characteristics to influence a child's sleep, thus creating a cycle. Overall, this demonstrates the need for identifying bio-psychosocial factors that influence sleep in parent-child dyads and subsequently, the mechanisms behind sleep reciprocity. Investigating such relationships will establish the theoretical basis of sleep within the family and guide clinical practices in treating both paediatric sleep and adult insomnia. This will also provide a mechanistic model of sleep within the family, and how parents or children may influence each other. For instance, sleep problems in children may be linked to hereditary influences, modelling their parents' sleep behaviours, physiological conditions and overall family environment with some secondary influences from their school, broader culture etc., whereas sleep problems in parents may stem from their child's recurrent sleep disturbances, life stressors, mental health, and other environmental influences, such as social life and occupation.

Research can examine if improving sleep hygiene practices in parents or incorporating consistent sleep schedules in the parent can improve a child's sleep outcomes. However, studies in this review lacked information on learning sleep characteristics and how parents may transfer their sleep hygiene practices onto the child. Hence, we recommend that future studies should consider applying a longitudinal approach to explore biopsychosocial processes in parent-child sleep. This can provide a more theoretical basis to temporal relationships in parent-child sleep and also help design prevention strategies for family sleep problems.

Apart from exploring the theoretical basis behind sleep in parent-child dyads, there is a need to assess daily fluctuations in sleep further. Variability and fluctuations in sleep is an understudied area, even though sleep variability is associated with poor physical and mental health (Bei, Manber, Allen, Trinder, & Wiley, 2017; Slavish, Taylor, & Lichstein, 2019). Kouros and colleagues suggested bidirectional associations in daily fluctuations in mother-child sleep, but this area warrants further examination.

Validating parent-report using actigraphy

Interestingly, two studies in this review reported that parental reports of sleep disturbance and insomnia were not related to objective measures of their child's sleep (Rönnlund et al., 2016; Urfer-Maurer et al., 2017). Rönnlund and colleagues suggested that parents with disrupted sleep may overestimate their child's sleep problems on retrospective questionnaires. Misperception of sleep latency and total time asleep is common in adults with insomnia (Adams et al., 2017; Harvey & Tang, 2012) and could explain why parents may overestimate their child's sleep problems. Studies need to consider if parent-report of children's sleep disturbance can be explained by the child's actigraphy.

Apart from the misperception of a child's sleep, bedtime interactions with the child can prevent parents from sleeping. For instance, bedtime resistance, sleep anxiety and daytime sleepiness in children were related to parents' insomnia in the study by (Urfer-Maurer et al., 2017), but objective measures do not record this. This can be potentially reciprocal, as parent-child behavioural interactions, particularly at the time of sleep-wake transition may contribute to a child's behavioural sleep problems (McDowall, Galland, Campbell, & Elder, 2017). It is essential to note that in both Rönnlund and colleagues and Urfer-Maurer and colleagues' studies, objective sleep measurements were only used for the child, which may not accurately represent parent-child sleep relationships. Neither measure is correct or incorrect, but they measure different dimensions of sleep (Aili, Åström-Paulsson, Stoetzer, Svartengren, & Hillert, 2017). When completing self-reports, parents rely on overall sleep behaviours for themselves and their children rather than daily variability. Overall, parent perception of child's sleep and objectively measured sleep indices indicate a complex relationship that necessitates further examination. Employing more robust methodologies, with comparable sleep measures for the population can help.

Treating sleep within the family

Overall, this review highlights the importance of considering sleep in family context rather than in isolation. Healthcare providers are encouraged to inquire about the child's sleep when managing adult insomnia. Similarly, paediatricians should also assess the child's sleep more broadly, looking at parent sleep problems and how it can potentially influence the child. While sleep education is common for parents of infants, behavioural interventions might be useful for improving sleep in parents of older children. There may be benefits to developing

sleep management programs that target families rather than the individual (McQuillan, Bates, Staples, & Deater-Deckard, 2019).

No intervention studies for children satisfied the inclusion criteria for this review, primarily because they did not include a sleep measure for parents. To authors' knowledge, no studies to date have considered sleep treatments in the family context. However, sleep treatments for children are often offered via parents (Hiscock et al., 2015; Mindell, Telofski, Wiegand, & Kurtz, 2009) or schools. Similarly, partner-assisted sleep treatments are currently being trialled treat adult insomnia (Mellor et al., 2019), with a notion that partners could potentially play a role in clients' insomnia. Future studies should incorporate family as a unit when treating sleep disturbances in both children and adults. This can have two benefits. Firstly, it will allow clinicians to address the role family members may play in perpetuating sleep problems. Secondly, it can help improve mental and physical health across families.

Treating sleep within families will also address a much larger issue of the family environment and shared characteristics that influence sleep. While addressing the influence of shared characteristics and family environment on parent-child sleep was beyond the scope of this review, the authors' recognized the lack of literature examining parent sleep as a moderator for the family environment. There is separate literature on family characteristics and their impact on a child's sleep, such as low socio-economic status, household chaos, parenting practices, parental interactions, parents' psychological well-being (Bordeleau et al., 2012; Doane et al., 2019; Martinez et al., 2019), however, these characteristics have not been studied in the context of parents' sleep. Hence, there is a need to assess how parents' sleep may be a confounding factor in poor family environments and whether customized family interventions can improve that.

It is proposed that policies on health and well-being in children should consider parents' sleep. Attempts should be made to improve sleep in parents as a way to improve environments for children. Long-term sleep difficulties are linked to inadequate coping mechanisms in adults (Fernandez-Mendoza et al., 2014). Further, sleep disturbances in parents are linked to parenting practices such as harsher or reactive parenting (McQuillan et al., 2019; Tyler, Donovan, Scupham, Shiels, & Weaver, 2019). Therefore, improving parent sleep can have positive influences on the family environment and flow-on effects for the child.

Managing hyper-vigilance and arousal in parents

Overall, parents of children with sleep difficulties need more support. Studies report that parents of children with NDDs experience worse sleep outcomes, which is mainly attributed to caregiving requirements and increased night-wakings and stress-related to parenting a child with a disorder (Hodge et al., 2013). This, in turn, can continue to perpetuate parent sleep problems, potentially due to increased pre-sleep arousal. For instance, parents of children with autism can be more hyper-vigilant at night due to self-injurious or aggressive behaviours of their children (Lopez-Wagner et al., 2008), prompting them to report more sleep problems. Studies do not provide casual inferences, but children in these populations do require more caregiving, and that caregiving stress, in addition to the child's sleep problems, which can cause sleep impairments in parents. Meltzer and Montgomery-Downs' review highlighted the need for interventions that can alleviate caregiver burden and reduce sleep disruptions within parents. In future, studies may assess if this hyper-vigilance, caregiving stress can be measured and managed.

Conclusion

Sleep within families is interactive and interdependent. This review illustrates links between sleep quality, sleep duration and sleep efficiency in parent-child dyads, particularly mothers and their children. Some studies report bidirectional, reciprocal elements in sleep that must be examined further. There is a need to identify relevant bio-psychosocial characteristics of sleep within the family, and better dyadic models are required to assess cause-effect links in parent-child sleep. Overall, this review establishes a case for considering sleep management in a wider family context, which can improve both night-time and daytime outcomes within families.

Chapter 3

Examining sleep and mood in parents of children with sleep disturbances

Preamble

This chapter presents the second study of the thesis that examined sleep outcomes in parents of children with sleep disturbances. Results from the systematic review informed us that parent-child sleep is related in both typically developing children and paediatric populations with neurodevelopmental disorders. However, there was lack of clarity on how parents' sleep outcomes may differ if children had a sleep disturbance, and whether there was a difference in parent-child sleep outcomes based on the nature of the child's sleep difficulties. Considering how parents shape the child's environment, influence their development outcomes, and how sleep is related to functioning, it was deemed necessary to examine parent sleep in the context of their children. Accordingly, the rest of this thesis delved deeper into various facets of parent and child sleep. In particular, this study examined sleep outcomes in parents of children with sleep difficulties. It also employed measures of pre-sleep arousal and sleep efforts in parents to examine if children's sleep was linked to symptoms of insomnia in parents. The study also assessed the mediating effect of children's sleep disturbance on the sleep and mood of the parents.

Candidate's contribution

The candidate obtained ethics approval for this study. The candidate created the survey, recruited participants, conducted the data analysis, interpreted the data, formulated and wrote the chapter.

Publication

Varma, P., Conduit R., Junge M., Jackson, M.L. (accepted). Examining sleep and mood in parent-child dyads. *Nature and Science of Sleep*.

Abstract

Objectives: The current study aimed to examine sleep and mood associations in parents of children with sleep disturbances. Mediating effects of children's sleep on the relationship between parental sleep and mood were assessed. The study also explored the differences in parents' sleep outcomes based on the children's sleep disturbances in a) typically developing children and b) children with neurodevelopment disorders.

Methods: A cross-sectional, online survey was conducted in Victoria, Australia, where 293 parents of children aged 2-12 years completed a questionnaire on their own sleep and mood, and their child's sleep. Parental sleep was examined using the Pittsburgh Sleep Quality Index (PSQI), the Glasgow Sleep Effort Scale (GSES) and the Pre-sleep Arousal Scale (PSAS). Parental mood was measured by the Profile of Mood States-short form (POMS-SF). Measures for children included the Child's Sleep Habits Questionnaire (CSHQ) and the Strengths and Difficulties Questionnaire (SDQ), respectively.

Results: Sleep disturbances in children were associated with parents' sleep disturbances, predicting 22% of the change in poor sleep quality among parents. Children's sleep partially mediated parents' sleep and mood. There were significant differences in the sleep and mood of the parents when their child had sleep disturbances but not on the basis of the nature of the children's sleep difficulties.

Conclusion: Parents of children with sleep disturbances experience poor sleep quality, high pre-sleep arousal, which is indicative of sleep reactivity and chronic insomnia. Poor sleep in these parents relates to their mood, which can have cascading effects on the family's functioning and the development of the child. Given that parents experience cognitive arousal and insomnia, it is recommended that parents' sleep problems are addressed and treated in clinical settings. There is also a need to adopt a family perspective when diagnosing and treating sleep problems.

Keywords: parent, child, sleep, mood, family.

Introduction

As one of the three key pillars of health alongside diet and exercise, sleep plays an important role in cognitive processing, behaviour, physical and mental health (Alvaro, Roberts, & Harris, 2013; Chambers, 2017; Lowe et al., 2019). Sleep is a family concept with reciprocal sleep interactions observed between family members, home and the external environment (Buxton et al., 2015). For instance, children can experience sleep disturbance if their parents have insomnia (Zhang, Li, Fok, & Wing, 2010). Likewise, sleep disturbances in children can play a role in poor sleep or mood in parents (Meltzer & Mindell, 2007; Meltzer & Montgomery-Downs, 2011). Nevertheless, sleep associations between parents and their children are seldom examined beyond infancy (McQuillan et al., 2019). Research in this domain largely focuses on poor sleep outcomes in parents with children with neurodevelopmental conditions or children with sleep disorders. This is despite sleep problems being reported in 25%-40% of typically developing, general paediatric populations (Mindell & Meltzer, 2008), making it a paediatric public health concern (Badin, Haddad, & Shatkin, 2016). Since parents play a pivotal role in a child's upbringing, their sleep difficulties can have negative consequences for their child's development. Given the high incidence of sleep disturbances in children, it is crucial to examine how children's sleep disturbances are related to their parents' sleep difficulties, and if clinicians can offer high-quality, evidenced-based for treating sleep within families.

Generally, poor sleep in adults is related to impairments in daily mood (Konjarski, Murray, Lee, & Jackson, 2018), increased anger (Hisler & Krizan, 2017) and hostility (Medina, Lederhos, & Lillis, 2009). In particular, parent's sleep and mood are associated with stress levels (da Estrela, Barker, Lantagne, & Gouin, 2018), interactions with the child (Bordeleau, Bernier, & Carrier, 2012; Edhborg, Lundh, Seimyr, & Widström, 2003; Jouriles, Murphy, & O'Leary, 1989), which relates to parenting behaviours (McQuillan et al., 2019) that in turn affect child's sleep (Bordeleau et al., 2012; Johnson & McMahon, 2008). This can create a cycle where a child's sleep may influence a parent's sleep, affect their mood and subsequently impact parent-child interactions. For instance, in their study on links between mother-child negative behaviour, Atzaba-Poria and colleagues (Atzaba-Poria, Deater-Deckard, & Bell, 2017) suggested that children could disrupt the emotional states of their parents, thus affecting their behaviour – a process called parent-child mutual regulation. However, parental mood in the context of their child's sleep is less examined and less understood. Assessing

whether sleep in children mediates the relationship between their parent's sleep and mood can help break the cycle and could improve overall family outcomes.

Some of the previous studies that have examined sleep associations in parents and typically developing (TD) children acknowledge the associations between the child's sleep disturbances and that of their parents across a broad age range (e.g., Bacaro et al., 2019; Boergers, Hart, Owens, Streisand, & Spirito, 2007; Meltzer & Mindell, 2007; Urfer-Maurer et al., 2017). Meltzer & Mindell's study (2007) indicated that sleep disturbances in children predicted poor sleep quality and increased stress in mothers, and the associations were not influenced by the age of the child. However, the majority of previous studies do not examine multiple aspects of sleep in parents. For instance, constructs such as sleep effort, which reflects performance anxiety around sleep, heightened need to control sleep or putting too much effort into sleep (Broomsfield & Espie, 2006), have not been examined in parents. Similarly, pre-sleep arousal, which is measured as excessive worries about falling asleep and experiencing intrusive thoughts before sleep (Nicassio, Mendlowitz, Fussell, & Petras, 1985) needs to be studied further in context of parents. Reporting on these sleep outcomes can outline the characteristics and nature of sleep difficulties in parents. It can also highlight which sleep-related variables in both children and parents are associated with the largest changes in parents' sleep quality.

There is a need to distinguish parents' sleep outcomes based on whether their child is TD or has a neurodevelopmental disorder (NDD). TD children usually experience behavioural sleep difficulties, such as bedtime resistance, and difficulties falling or staying asleep (Meltzer & Mindell, 2008). However, sleep difficulties disproportionally impact children with NDD, affecting up to 80% of children with Autism Spectrum Disorder (ASD) and 50% of children Attention Deficit Hyperactivity Disorder (ADHD; Cortesi, Giannotti, Ivanenko, & Johnson, 2010). While these children may exhibit behavioural sleep difficulties, the aetiology of sleep disorders in these can be due to a combination of disease related factors, co-morbidities and circadian rhythm (Owens & Weiss, 2019; Tordjman et al., 2015). In particular, children with NDDs, such as ASD, may exhibit circadian sleep-wake rhythm alterations with increased nocturnal and early morning awakenings (Tordjman et al., 2015). A study by Lopez-Wagner and colleagues (2008) revealed that children with ASD display heightened sleep disturbances than TD children. While parent-child sleep was correlated across both groups, parents of children with ASD were more likely to experience increased sleep difficulties. Similarly,

parents of children with psychomotor disorders may be severely impacted, with increased sleep disturbances, reduced mental and social functioning (Tietze, Zernikow, Michel This is possibly due to the severity of the child's sleep problems, increased parental worries or hypervigilance (Lopez-Wagner et al., 2008). However, studies may usually draw comparisons between children with NDD and TD children with no sleep difficulties making it difficult to distinguish parents' sleep outcomes based on the nature of their child's sleep disturbance. Overall, the adverse effects of sleep problems in TD children and children with NDD, along with their parents, remains underreported.

Accordingly, the current study examined parent-child sleep in both TD and NDD populations. Our primary aim was to examine the associations between children's sleep, behavioural difficulties and age, and parents' sleep and mood outcomes. An objective of the study was to investigate whether children's sleep disturbances mediated the relationship between their parent's sleep and mood. Secondly, we aimed to explore the differences in parent's sleep outcomes based on whether the child a) had a significant sleep disturbance, and b) was TD or diagnosed with NDD. We hypothesize that a) parents' sleep and mood would be associated with their children's sleep, behavioural difficulties and age, b) children's sleep will mediate the relationship between their parent's sleep and mood, c), parents of children with sleep difficulties will have poorer sleep and mood outcomes than parents of children without sleep difficulties, and d) parents of children with NDD will have significantly poorer sleep and mood than parents of TD children.

Methods

Participants

A total of 293 primary caregiving parents (either mothers or fathers in a single household) completed this cross-sectional, online survey study. Ethics was obtained from the RMIT university human research ethics committee (Ethics approval ID: ASEHAPP 02-17) and Department of Education, Victoria, Australia (Ethics approval ID: 2017_003408). Informed consent was obtained from parents. The age range was 18 years or above for parents, and 2-12 years for the child. A broader age range was selected to examine if sleep associations in parents and their children are influenced by child's age. Participants were recruited from the local community using geographically targeted online advertisements on social media websites, and through flyers posted at schools or community centres. Recruitment advertisements included – a) targeting parents who perceived their children as 'poor sleepers,' b) targeting parents who perceived their children as 'good sleepers,' and c) targeting parents of children diagnosed with NDD. The parent responses on the survey were excluded if: 1) the parent was diagnosed with a mental health condition, 2) engaged in shift work, or 3) were breastfeeding or had another child below the age of two years. Participants did not receive any inducements for completing the study.

Measures

A Demographic questionnaire was designed to obtain information such as the age, gender, health conditions and general lifestyle of the parent (primary caregiver) and their child. To ascertain whether the child had an NDD following question was used, "Does your child has any of the following conditions that impact their sleep?" Options were: 1) autism spectrum disorder 2) attention deficit hyperactivity disorder, 3) motor disorder, 4) specific learning disorder, 5) intellectual development disorder, 6) cerebral palsy, 7) Angelman syndrome, 8) Down's syndrome, 9) any sleep disorder such as sleep apnoea, periodic limb movement disorder, sleep paralysis, parasomnias, insomnia, restless leg syndrome etc. 10) any chronic condition such as asthma, diabetes, 11) any other disorder not listed here, 12) only behavioural issues surrounding sleep (i.e., no diagnosed medical or neurodevelopmental disorder that may impact their sleep). Option 8 referred to sleep disorders and option 9 referred to clinical conditions that may impact sleep that can impact both groups. Hence, parents could choose multiple options. Based on the responses, those who responded yes to

any of the options 1-8 were classified as children with NDDs, and those who responded yes to option 12 were classified as TD children.

Measures for children

Children's Sleep Habits Questionnaire (CSHQ) is a retrospective, 45-item parent-rated questionnaire used to examine sleep behaviour in children over the past month (Owens, Spirito, & McGuinn, 2000). Items are divided into eight subscales including bedtime resistance, sleep onset delay, sleep duration, sleep anxiety, night wakings, parasomnias, sleep-disordered breathing and daytime sleepiness. A score of ≥ 41 correctly identifies 80% of patients with a diagnosed sleep disorder, making it a useful screening tool. The cut-off has been employed in other studies (e.g. Lopez-Wagner et al., 2008; Meltzer & Mindell, 2008; Goldman et al., 2012) and the scale is often used for children aged 2-12 years (Boergers et al., 2007).

Strengths and Difficulties Questionnaire (SDQ)-short form is used for behavioural screening on the following attributes in children over six months: emotional symptoms, conduct problems, hyperactivity and inattention, peer relationship problems, and prosocial behaviour, providing a total difficulties score (Goodman, Ford, Simmons, Gatward, & Meltzer, 2000).

Measures for parents

Glasgow Sleep Effort Scale (GSES) is a seven-item questionnaire that measures sleep control and worries or anxieties related to sleep in the past week (Broomfield & Espie, 2005). Sample items include, "I worry about sleeping if I cannot sleep," and "I get anxious about sleeping before I go to bed." The score ranges from 0-14, with higher scores demonstrating greater sleep effort. Internal consistency is .77.

Pittsburgh Sleep Quality Index (PSQI) assesses adult subjective sleep quality over the previous month across seven components: subjective sleep quality, sleep duration, sleep onset latency, sleep disturbances and daytime dysfunction. A cut-off score of >5 discriminates good and poor sleepers, with higher scores indicating poorer subjective sleep quality (Backhaus, Junghanns, Broocks, Riemann, & Hohagen, 2002; Buysse, Reynolds, Monk, Berman, & Kupfer, 1989).

Pre-sleep Arousal Scale (PSAS) is a 16-item questionnaire that includes two subscales measuring cognitive and somatic arousal before sleep (Nicassio et al., 1985). Sample items in the cognitive scale include, "being mentally alert or active," and in the somatic scale sample items include, "tight, tense feeling in your muscles." The subscales successfully discriminate insomniacs from normal sleepers with the internal consistency of .76 and .81 for both scales (Nicassio et al., 1985).

Profile of Mood States (POMS)-Short form is a validated, 37-item psychological scale used to assess distinct and transient mood states (Shacham, 1983). The test provides scores on six subscales: fatigue, vigour, tension, anxiety, depression, anger, confusion and is internally consistent with original POMS. Total scores are calculated to reflect the mood, with higher scores indicating mood disturbance.

Data analysis

Data were analysed using SPSS Statistics 26 (IBM, Chicago, IL, USA). Pearson's correlations were used to assess sleep health and mood associations between parent-child dyads. Stepwise regression analysis was used to determine how different sleep measures were associated with the variance in parents' sleep quality scores. Mediation analysis was used to explore if children's sleep disturbances mediated the relationship between sleep and mood in parents, using the SPSS macro PROCESS (Hayes, 2017). Parents' response to a question in the demographics section of the questionnaire was used to classify children into TD group or NDD group. Independent samples t-tests were used to compare group differences.

Results

Participant characteristics.

Parent-reported participant characteristics and summary of all outcome measures are summarized in Table 1. NDD conditions were reported by 85 parents (ASD=59, ADHD=12, others=14). Significant associations were reported for sleep and mood in parents and sleep disturbances in children, but not with the age of the child. (Table 2).

Table 1. Participant characteristics and a summary of scores for all outcome measures (N=293).

	Values
Parent characteristics	
Age (years)	35.96±5.28 (20-49)[a]
Gender	
Male	23 (7.8%)[b]
Female	265 (90.4%) [b]
Missing	5 (1.7%) [b]
Other	0
Marital Status	
Married/De-facto	264 (90.1%) [b]
Unmarried	0 (0%) [b]
Divorced/Separated	14 (4.8%) [b]
Do not wish to disclose	15 (5.1%) [b]
PSQI (parental sleep quality)	8.22±3.79
GSES (parental sleep effort)	5.30±3.45
PSAS (parental pre-sleep arousal)	
Cognitive	14.85±4.63
Somatic	12.53±7.5
POMS-SF (parental total mood disturbance)	15.03±22.80
Child characteristics	
Age (years)	6.19±2.38 (2-12)[a]
Typically developing children	206 (70.3%) [b]
Children with neurodevelopmental disorders	85 (29%) [b]
Co-sleeping (sleeping in the same room more than twice a week)	30 (10.23%) [b]
CSHQ (children's sleep disturbance)	46.32±12.79
SDQ (child's behavioural difficulties)	12.04±5.90

Note: Scores for all outcome measures presented as means and standard deviations. *Abbreviations:* PSQI – Pittsburgh sleep quality index, GSES – Glasgow sleep effort scale, PSAS – Pre-sleep arousal scale, POMS-SF – Profile of mood states-Short form, CSHQ – Child's sleep habits questionnaire, and SDQ – Strengths and difficulties questionnaire. [a] indicates actual age-range for the participants. [b] indicates the percentage value for the sample.

Table 2. Pearson's correlation between sleep quality, sleep efforts, pre-sleep arousal in parents, and sleep disturbances in children (N=293).

	PSQI *Parents' sleep quality*	**CSHQ** *Children's sleep disturbances*
Parent measures		
Sleep quality (Global PSQI scores)		0.47**
Subjective sleep quality		0.51**
Sleep latency		0.40**
Sleep duration		0.40**
Habitual sleep efficiency		0.34**
Sleep disturbance		0.30**
Use of sleeping medication		0.08
Daytime sleepiness		0.06
Sleep effort (GSES)	0.35**	0.21**
Pre-sleep arousal (PSAS)	0.47**	0.46**
Somatic arousal	0.33**	0.31**
Cognitive arousal	0.39**	0.45**
Total mood disturbance (POMS)	0.33**	0.29**
Tension	0.34**	0.23**
Anger	0.26**	0.26**
Fatigue	0.32**	0.30**
Esteem related affect	-0.21	-0.04
Depression	0.22**	0.20
Vigour	-.012	-0.14
Confusion	0.29**	0.22**
Child measures		
Children's sleep disturbance (CSHQ)	0.47**	
Bedtime resistance	0.28*	
Sleep onset delay	0.06	
Sleep duration	0.12*	
Sleep anxiety	0.23**	
Night waking	0.18*	
Parasomnias	0.39**	
Sleep-disordered breathing	0.19*	
Daytime sleepiness	0.32**	
Behavioural difficulties (SDQ)	-0.03	0.05
Children's age	0.07	0.08

Abbreviations: PSQI – Pittsburgh sleep quality index, GSES – Glasgow sleep effort scale, PSAS – Pre-sleep arousal scale, CSHQ – Child's sleep habits questionnaire, and SDQ – Strengths and difficulties questionnaire.

*p-value significant at <0.05. **p-value significant at <0.001

Following this, a stepwise regression was conducted to examine which sleep measures in parents and children predicted overall sleep quality in parents (N=284, nine participants were excluded because of lack of responses on GSES). Parent measures PSAS and GSES, and child's sleep measure CSHQ were added as independent variables (Table 3). The overall model was significant ($F(1, 283) = 82.32$, $p < .001$) with children's sleep disturbances predicting the highest variance of 22% in parents' sleep quality. Parents' pre-sleep arousal contributed an additional 7% of the variance, and sleep effort predicted a further 1% change in the variance.

Table 3. Results from stepwise regression conducted to examine how various parent or child sleep measures predicted changes in parents sleep quality measured using the Pittsburgh Sleep Quality Index (N=284).

Variables	***β***	***t***	***R***	***R2***	***ΔR2***	***p*-value**
Model 1						
Children's sleep disturbance (CSHQ)	0.47	9.07	0.47	0.22	0.22	<.001
Model 2						
Children's sleep disturbance (CSHQ)						
Parents' Pre-sleep arousal (PSAS)	0.31	5.65	0.55	0.30	0.07	<.001
Model 3						
Children's sleep disturbance (CSHQ)						
Parents' pre-sleep arousal (PSAS)						
Parents' sleep efforts (GSES)	0.14	2.45	0.56	0.31	0.01	0.15

Abbreviations: PSQI – Pittsburgh sleep quality index, GSES – Glasgow sleep effort scale, PSAS – Pre-sleep arousal scale, CSHQ – Child's sleep habits questionnaire

Child's sleep as a mediator of parent's sleep and mood

Significant associations were observed between mood disturbance in parents and a) parents' sleep quality, and b) children's sleep disturbances. Children's sleep disturbances significantly mediated the relationship between parents' sleep and mood ($\beta = 0.30, t\ (276) = 2.68, p = .007$; bias-corrected percentile bootstrap method), accounting for 49.1% of the total effect. After controlling for children's sleep, parent's sleep quality was also significantly associated with parents' mood disturbance ($\beta = 1.6, t\ (276) = 4.12, p < .001$). Therefore, the children's sleep disturbance partially mediated the relationship between poor sleep quality and mood disturbance in parents (Figure 1).

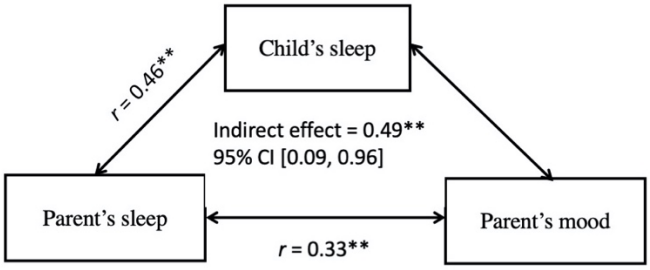

Figure 1. Mediation analysis assessing if children's sleep disturbances mediated the relationship between parents' sleep and mood. After controlling for parents' sleep quality, children's sleep disturbances accounted for 49.1% change in parents' mood.

Differences in parents' sleep outcomes based on whether the child had a sleep disturbance.

Next, sleep in parents was further examined from the context of the children's sleep disturbances. Parents of children with sleep disturbances (N=194) scored poorly on all sleep indices and had higher scores for total mood disturbance in comparison with parents of children with no significant sleep disturbances (N=99). No differences were observed for behavioural difficulties in children with or without sleep disturbance (Table 4).

Table 4. Differences in parents' sleep quality, pre-sleep arousal, sleep effort and mood based on whether the child had a sleep disturbance.

	Children with sleep disturbance (CSHQ ≥41)	**Children without sleep disturbance (CSHQ <41)**	**t**	**df**	***p***	**Effect size *Cohen's d***
Parent variables						
Sleep quality (PSQI)	9.32±3.29	6.04±3.7	7.68	291	<.001	0.93
Pre-sleep arousal (PSAS)	36.53±10.66	28.71±10	6.06	291	<.001	0.75
Cognitive arousal	22.43±7.35	15.07±6.73	6.06	291	<.001	1.04
Somatic arousal	13.59±4.73	11.39±4.07	3.93	291	<.001	0.49
Sleep effort(GSES)[a]	5±3.5	4.51±3.22	2.83	282	<.001	0.17
Mood disturbance(POMS)[a]	17.43±23.45	9.75±20.73	2.62	282	0.009	0.34
Child variables						
Behavioural difficulties (SDQ)[b]	12.06±5.61	12±6.55	0.07	247	0.94	0.00

a N=92 for children without sleep disturbances; b N=174 for children with sleep disturbances, N=75 for children without sleep disturbance. *Abbreviations:* PSQI – Pittsburgh sleep quality index, GSES – Glasgow sleep effort scale, PSAS – Pre-sleep arousal scale, POMS – Profile of Mood States, CSHQ – Child's sleep habits questionnaire, SDQ – Strengths and difficulties questionnaire.

Differences in parent's sleep based on the presence of NDD condition

Sleep in parents was compared based on whether the child was in TD group (N=206) or had an NDD condition (N=85). No significant differences were observed for children's sleep disturbances (t (289) = -1.26, p = .20), parents' sleep quality (t (289) = -1.84, p = 0.06), pre-sleep arousal (t (289) = -0.86, p = 0.38), and total mood disturbance (t (275) = -0.88, p = 0.37). Parents of children with NDD reported increased sleep efforts (M = 6.05, SD = 3.97) than parents of TD children (M = 4.98, SD = 3.36; t (289) = -2.41, p = 0.01). Significant group differences were found for behavioural difficulties in children with NDD (M = 13.21, SD = 6.32) and TD children (M = 11.51, SD = 5.65; t (246) = -2.1, p = 0.03). Following this, we ran a secondary analysis for sleep outcomes in parents across both groups using scores on CSHQ ≥ 41 as cut-off. No significant differences were found between TD children (N=126) and children with NDD (N=60) for sleep disturbances, behavioural difficulties, and parents' sleep quality, pre-sleep arousal, sleep efforts or mood (p > .05 for all).

Discussion

This study examined sleep and mood associations between parents and their TD children or children with an NDD. Across the overall sample, almost 80% of parents had poor sleep quality (PSQI scores >5), which suggests sleep problems endorsed by this sample of parents. A little over 65% of children had sleep disturbances (CSHQ ≥ 41). Sleep disturbances in children were associated with the largest variance in parents' sleep quality, accounting for 22% of the variance. In contrast, parents' own measures of pre-sleep arousal and sleep efforts predicted 8% and 1% variance in their sleep quality, respectively. Hence, the first hypothesis was partially supported as children's sleep disturbances were correlated to poor sleep quality, increased pre-sleep arousal and poor mood in parents, but children's age or behavioural difficulties were not related to parents' sleep and mood. These findings are similar to studies by Bacaro et al. 2019, Boergers et al. (2007), Meltzer & Mindell (2007) and Urfer-Maurer et al. (2017) that observed sleep associations between parents and their children regardless of the age of the child.

Children's sleep disturbances were also correlated with their parents' mood. Previous studies have revealed links between the child's sleep and mood (Bacaro et al., 2019; Meltzer & Mindell, 2007), with research suggesting a further negative impact of parents' mood on parent-child interactions (e.g. da Estrela et al., 2018; Edhborg et al., 2003; Jouriles et al., 1989). However, to the authors' knowledge, this is the first study that shows how children's sleep partially mediates the relationship between the sleep and mood of their parents. Furthermore, increased scores on tension, fatigue and anger in parents were significantly related to children's sleep disturbances. This may be attributable to heightened stress in parents of children with sleep difficulties (Bacaro et al., 2019; Meltzer & Mindell, 2007). Clinicians may consider monitoring parents' mood in the context of their child's sleep, offering resources and referrals when needed.

The hypothesis that parents of children with sleep disturbances would have poorer sleep outcomes compared to those without sleep disturbances was also supported. Similar to previous researches (Bacaro et al., 2019; Lopez-Wagner et al., 2008; Meltzer & Mindell, 2007; Urfer-Maurer et al., 2017), this study noted that parents of children with sleep disturbances experienced poor sleep quality. It also observed greater sleep efforts and increased pre-sleep arousal in parents of children with sleep disturbances, both of which are considered indicative of insomnia. Parents of children with sleep disturbances had a cognitive

pre-sleep arousal score of >20, which is reportedly an indicator of sleep reactivity, reflecting vulnerability to stress-related sleep disturbances (Puzino et al., 2019). These high scores for cognitive and somatic pre-sleep arousal may be an indicator of chronic insomnia in these parents.

Almost 30% of parents in the study reported that their child had an NDD. More than 70% of children with NDD had CSHQ scores ≥ 41, suggesting significant sleep difficulties in this population. ASD, ADHD and intellectual development disorder were commonly reported conditions. In comparison to TD children, children with NDD had significantly higher scores for night-waking, parasomnias and daytime sleepiness, reflecting circadian abnormalities. Tordjman and colleagues have noted that children with autism or similar NDDs have disrupted sleep-wake rhythm and abnormalities in cortisol circadian rhythm that can explain their nocturnal awakenings and daytime sleepiness in this study.

While some key sleep differences were noted in children within TD and NDD groups, there were no significant differences in overall sleep disturbance scores across both groups. Similarly, sleep in parents of children in TD and NDD groups did not differ, except for increased sleep efforts in parents of children with NDD. This largely contrasts with general consensus that parents of children with NDD have poorer sleep outcomes in comparison to parents of TD children. There are several explanations for these results. Firstly, parents experiencing significant distress about their child's sleep problems could be more likely to respond to the survey, and hence there were no differences in CSHQ scores between the two groups. Secondly, parents of children with an NDD are more likely to be stressed by the child's diagnosis and treating them, rather than perceiving their child's sleep issues as problematic or disruptive. Thirdly, sleep issues in children are often underdiagnosed (Badin et al., 2016), particularly in TD children. Hence, the severity of childhood sleep disturbances between the two groups may be unknown. There is a possibility that sleep disturbances in both NDD and TD groups are perceived as equally demanding or stressful by their parents. While there are resources for parents of children with NDD, there is a need to create more awareness about interventions available for sleep issues among TD children. Overall, parents in both groups must be encouraged to actively report their children's sleep disturbances. At the same time, clinicians must routinely inquire about the role of children's sleep when treating sleep disturbances in adults.

Clinical implications

This study adds to the current evidence that parent-child sleep is linked, reporting that parents of children with sleep disturbances may experience poor sleep outcomes. It also shows that the age of the child may not be related to their parent's sleep, despite the differences in children's sleep patterns across different age groups. It is reported that untreated sleep disorders observed in infancy can transition to adulthood (Palagini et al., 2015). Hence, it is possible that younger children with untreated sleep difficulties may continue to have sleep difficulties as they get older, and parental involvement may continue. Therefore, clinicians must address parent-child sleep at the family level, regardless of the child's age.

Given that sleep is linked to daily functioning, poor sleep outcomes in parents can have negative consequences for the overall family environment, and their children's sleep or development (Dahl & El-Sheikh, 2011; El-Sheikh & Kelly, 2017). Hence, intervening and treating parents' sleep difficulties can provide a conducive sleep environment for children. While children may continue to wake their parents, management tools such as cognitive behaviour therapy for insomnia (CBT-I) can be used for parents. It has been shown that CBT-I helps with adult sleep by increasing sleep drive and altering maladaptive behaviours even when there are environmental factors outside the individual's control (Bei et al., 2019). Similarly, mindfulness-based sleep interventions can reduce cognitive arousal and improve insomnia severity (Cincotta, Gehrman, Gooneratne, & Baime, 2011). Both therapies may have potential utility for parents to experience sleep disturbances or higher pre-sleep arousal. Considering that sleep problems may have ramifications for family functioning (Bell & Belsky, 2008), family-oriented sleep therapies may also be designed and tested within these populations.

Strengths and limitations

One of the strengths of this current investigation is its broad sample population. While most of the past research has recruited control groups of TD children when examining sleep in children and parents with clinical conditions, it rarely compares sleep difficulties in TD and NDD paediatric populations. We quantified parent's sleep based on the nature of the child's sleep difficulties and suggest that all kinds of sleep difficulties in children are reported and effectively addressed.

The study also measures a wide range of sleep outcomes in parents (such as sleep quality, cognitive and somatic arousal, and sleep efforts). As discussed earlier, and sleep efforts and pre-sleep arousal have been largely ignored within the literature on parent-child sleep, despite the fact these factors may reflect chronic insomnia in adults. Systematic measurement of these outcomes can help us understand the variables which should be targeted when addressing parents' sleep.

This research interesting potential mechanism – suggesting that children's sleep disturbances partially mediate the relationship between parents' sleep and mood, indicating that parents of children with less disruptive sleep may have a better mood. Given that this is a cross-sectional finding, future studies should consider incorporating a longitudinal approach to assess causal links between parents' mood and children's sleep.

Overall, parents of children with sleep difficulties have poorer sleep outcomes, including poor sleep quality, increased pre-sleep arousal and mood disturbances. Despite this, over generalisations should be avoided. Firstly, the results from this study reflect associations and thus, it cannot ascertain causality. It is possible that while parent's sleep may be influenced by their child's sleep, children themselves can learn their sleep patterns from their parents (Zhang et al., 2010). Hence, the mechanisms around parent-child sleep and its effect on family functioning require further explication.

While the study population was drawn from the local community, there is a possibility of response bias. This is reflected in high rates of sleep disturbances in our sample of TD children (61%). The study relied on parental reports of their children's NDD diagnosis and their child's sleep, allowing the possibility of attention bias, wherein poorly sleeping parents may overreport their child's sleep difficulties.

While all self-report measures employed in this study are valid and reliable, the inclusion of objective measures would help to verify these subjective outcomes. Regardless, it is important to note that subjective measures such as poor sleep quality are defining features of chronic insomnia (Harvey, Stinson, Whitaker, Moskovitz & Virk, 2008) and should not be ignored. Future studies should incorporate objective measures to investigate temporal associations between parent-child sleep, allowing both researchers and clinicians to implement treatments that respond to specific sleep-related issues.

A majority of participating parents in our study were married, and most respondents were mothers, who are likely to be primary caregivers. Parents did not respond to questions on their child's gender, which prevented us from examining gender-based sleep differences in children. Furthermore, determining the interplay between other environmental factors, such as co-sleeping, socio-economic status, housing situation, family chaos, and parent-child sleep was beyond the scope of this study. While the broader classification around the nature of a child's sleep disturbance allowed clear analysis of parent's sleep outcomes, it needs further replication. Sleep issues in children with NDDs like ASD or ADHD do stem from a range of biological factors, such as circadian rhythm abnormalities and low melatonin concentration (Owens & Weiss, 2019). However, they may be exacerbated by other poor sleep habits, poor limits on bedtimes and other family factors. Future research should account for these factors while characterizing different types of sleep disturbances in children.

Conclusion

Taken together, these results show that parents may experience poor sleep quality and increased cognitive or somatic pre-sleep arousal when their children have sleep difficulties. These results suggest that poor sleep outcomes may represent symptoms of chronic insomnia and sleep reactivity in these parents. Poor sleep in parents is linked to their mood and mediated by their children's sleep. Ultimately, sleep in these parents can have pervasive consequences on the family's environment, which can exacerbate poor sleep in children and the impact child's development. Hence, parents' sleep should be considered in the context of their child's sleep, with a particular focus on addressing sleep difficulties in parents. Family-focused sleep interventions or targeted parent's sleep interventions can have potential benefits for improved sleep health in parent populations with positive effects for the child. Future studies should use objective measures to corroborate these relationships and examine temporal associations in this dyad.

Chapter 4

Investigating sleep concordance, night-wake associations and sleep variability in parent-child dyads using actigraphy: A pilot study

Preface

Following the results from Chapter 3, this chapter continues the investigation of parent and child sleep using objective measures. While Chapter 3 demonstrated links between parent-child sleep, it must be noted that the study used parent-reports of the child's sleep. This may lead to response bias or a possible exaggeration of the child's sleep difficulties. Limited studies to date have examined sleep concordance in parent-child dyads, and temporal links in parent-child sleep are relatively unexplored. Accordingly, this study aimed to investigate sleep concordance in parent-child dyads. It also examined how sustained night-wakings were associated in this dyad using a novel, modified blip analysis. This chapter also includes a comparison of parent-report and actigraphy derived sleep outcomes in children. Using the actigraphy data, the study also analysed differences in parent-child sleep outcomes and variability in sleep.

Candidate's contribution

The candidate obtained ethics approval for this study. The candidate recruited participants, conducted data collection and analysed sleep diary and actigraphy data for parents and children across 14 nights. The candidate developed (with support from supervisors) and implemented the custom protocol for modified blip analysis and concordance analysis. The candidate formulated and wrote the chapter.

Publication

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Abstract

Objectives: To use actigraphy to 1) explore minute-by-minute sleep-wake concordance in parent-child dyads, 2) identify temporal links between parent-child night-wakings, and 3) examine variability in parents' sleep based on parent-reported sleep disturbances in children.

Participants: Parent-child dyads wore actigraphy for 14 days and nights (n=20), and parents (n=28) completed daily sleep diaries.

Measurements: Parent's sleep was reported using the Pittsburgh Sleep Quality Index (PSQI). The parental perception of child's sleep was examined using the Child's Sleep Habits Questionnaire (CSHQ). Wrist actigraphy was used for objectively measuring objective sleep. Sleep diary assessed bedtime, waketime, total sleep time, and affect using the Positive and Negative Affect Scale (PANAS).

Results: Average sleep-wake concordance between parent-child dyads was 70.6%. Modified blip analysis indicated that parents were three times more likely to wake up within ten minutes of their child's night-wakings than vice versa. Parents of children with sleep disturbances demonstrated significantly longer duration for night-wakings and higher sleep variability than parents of children without sleep disturbances.

Conclusion: Sleep and night-wakings were concordant in parent-child dyads. More than one-third of the parent's night-wakings occurred with or immediately after the child. This shows that temporal links in parent-child sleep should be explored further. Actigraphy data revealed that parents of children with sleep disturbances had a poorer sleep in comparison to parents of children with no sleep disturbances. Considering the far-reaching effects of sleep on health and family functioning, this research highlights that parent sleep should be a priority for paediatricians and psychologists working with children that have sleep disturbances. Identifying parent populations at risk for sleep problems is essential.

Keywords: parent, child, sleep, actigraphy, mood, family.

Introduction

Parents of children with sleep disturbances frequently report being woken up by their children (Burckhardt et al., 2019; Moore et al., 2006). These parents also experience poor sleep quality, increased pre-sleep arousal, and poor mood during the day (Byars, Yeomans-Maldonado, & Noll, 2011; Meltzer & Mindell, 2007). Despite this, parents' sleep difficulties and temporal links between parent-child sleep are underexamined in literature. Characterising synchrony in parent-child sleep can improve our understanding of sleep within the family context. Objective measures, such as actigraphy, can be used to examine this synchrony (Gunn, Buysse, Hasler, Begley, & Troxel, 2015).

Previous studies on parent-child sleep have reported links between actigraphy measured sleep duration and sleep efficiency in parents and children (Goldman, Wang, & Fawkes, 2014; Kouros & El-Sheikh, 2017; Staples et al., 2019). Specifically, parent-child sleep associations are observed for both daily and mean changes in sleep onset and sleep duration (Kouros & El-Sheikh, 2017). These sleep relationships in parent-child dyads were consistently observed across all age groups: pre-schoolers, school-age children and early adolescents, such that child's sleep, but not age, was related to parent's sleep (Boergers et al., 2007; Meltzer & Mindell, 2007), despite the differences in children's developmental stages. Given the findings that parent-child sleep is coregulated, and sleep is embedded within the family context (Kouros & El-Sheikh, 2017), it is plausible that night-wakings in children are linked to night-wakings in parents. Therefore, research needs to delineate temporal relationships between parent and child's night-wakings.

Apart from sleep duration and night-wakings, sleep disturbances in children are largely used to explain how effectively parents' sleep. For instance, parent-reported sleep difficulties in children predict poorer subjective sleep outcomes in parents (Bajoghli, Alipouri, Holsboer-Trachsler, & Brand, 2013; Bar et al., 2016; Boergers et al., 2007; Daniel, Walsh, Meltzer, Barakat, & Kloss, 2018; Meltzer & Mindell, 2007; Meltzer & Montgomery-Downs, 2011; Meltzer & Westin, 2011). However, studies that use objective sleep measures provide mixed results. In particular, one study (Rönnlund, Elovainio, Virtanen, Matomäki, & Lapinleimu, 2016) noted that while parents' self-reported sleep disturbances were related to their perception of the child's sleep problems, this was not reflected in the child's actigraphy outcomes. Similarly, results from Urfer-Maurer and colleagues (Urfer-Maurer et al., 2017), indicated that parents' insomnia symptoms were related to their subjective reports of their

child's sleep problems, but not to the objectively measured sleep in children. It should be noted that these studies only assessed sleep objectively in the children but not the parents, making it difficult to draw definite conclusion. Further, parents' self-report and their perception of their child's sleep is an aggregate of their overall sleep behaviour, which includes other factors like bedtime resistance, sleep onset latency, daytime behaviours, and daily variability in sleep behaviours that may not be captured by actigraphy or polysomnography alone. This demonstrates the need to further assess how parent-reported sleep difficulties in children relate to parent-child actigraphy outcomes.

Daily variations in sleep/wake patterns are common (Bei, Wiley, Trinder, & Manber, 2016), but largely ignored in parent-child sleep literature. These within-person variations in sleep may be a unique facet of disturbed sleep in adults, linked to increased risk of physical or mental health conditions (Slavish, Taylor, & Lichstein, 2019). Variability is also a characteristic of child sleep (Becker, Sidol, Van Dyk, Epstein, & Beebe, 2017) and is now given increasing importance. A few measures have been developed to assess these fluctuations in sleep-wake behaviour, including the sleep regularity index (Phillips et al., 2017), and measures of intraindividual variability (Becker et al., 2017). While acceptable limits for sleep variability have not been set, standard deviations from the mean (average value) may be used as an indicator of variability across a time period. For instance, large standard deviations may indicate higher variability for variables like bedtime (Taylor et al., 2016). Using standard deviation as a parsimonious measurement of sleep variability can help answer questions regarding sleep difficulties in children and how it is linked to sleep variability in parents.

Accordingly, the current study used actigraphy to 1) explore minute-by-minute sleep-wake concordance between parents and children, 2) identify temporal links between parent and child night-wakings lasting five minutes or longer, and 3) examine the differences and variability in parent's sleep based on parent-reported sleep difficulties in children. We hypothesised that 1) parent-child sleep would be concordant, 2) night-wakings lasting five minutes or longer would co-occur more frequently in parent-child dyads in comparison to randomly matched pseudo-parent-child groups, 3) parents of children with sleep difficulties will have poorer sleep outcomes and greater sleep variability than parents of children without sleep difficulties. For brevity, all night-wakings in this paper were defined as awakenings lasting five minutes or longer.

Methods

Participants

The study recruited primary caregivers (parent) and their children aged 2-12 years. Ethics was obtained from RMIT University (Ethics approval ID: 20762), and recruitment was restricted to Victoria, Australia, done via two concurrent advertisements. One advertisement targeted parents who thought their child slept poorly and the other advertisement was aimed towards parents who thought their child slept well. Participants were given an opportunity to get individual sleep reports from the actigraphy data. No inducements were offered.

Inclusion criteria included: 1) primary caregiving parent aged 18 years or above, 2) fluent in English, and 3) child aged two years or above. Exclusion criteria included: 1) parent receiving treatment for a sleep disorder, 2) breastfeeding or having another child below the age of two years, 3) engaging in regular shift work, and 4) co-sleeping with the child. A total of 35 parents and their children were enrolled in the study protocol. Complete sleep diary data were available for 28 parent-child dyads. Fourteen nights of actigraphy data were available for 20 parent-child dyads.

Measures

Child's Sleep Habits Questionnaire (CSHQ) is a retrospective 45-item parent-rated questionnaire that assesses sleep behaviour and degree of sleep difficulties in children (Owens, Spirito, & McGuinn, 2000). The authors of the CSHQ determined a cut-off of 41 for the questionnaire, indicating that this cut-off correctly identified 80% of patients referred to paediatric sleep disorders clinic.

Positive and Negative Affect Scale-Short form (PANAS) includes 10-item subscales to measure the positive and negative affect (Watson, Clark, & Tellegen, 1988) and demonstrated high reliability and validity. Parents completed the adult version, whereas a ten-item children's version of PANAS (called PANAS-C) was used for children in the study. (Ebesutani, Okamura, Higa-McMillan, & Chorpita, 2011).

Pittsburgh Sleep Quality Index (PSQI) measures subjective sleep quality in adults over the previous month (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989). It includes seven subscales including subjective sleep quality, sleep duration, sleep onset latency, sleep

disturbances and daytime dysfunction. A score greater than five discriminates poor sleepers from good sleepers and higher scores indicate poorer sleep quality (Backhaus, Junghanns, Broocks, Riemann, & Hohagen, 2002).

Philips Respironics Actiwatch 2 is a small, unobtrusive wrist actigraphy that measures sleep-wake using a built-in accelerometer and a light sensor (Meltzer et al., 2016). The Actiwatch is validated for both children and adults (Meltzer et al., 2016; Weiss, Johnson, Berger, & Redline, 2010). The following sleep variables were obtained for both parents and the children – bedtime, waketime, time taken to fall asleep (sleep onset latency), sleep duration (total sleep time), sleep efficiency, minutes awake (wake after sleep onset or WASO). Example actigraphy records are presented in Appendix-II.

Sleep diary was used to measure subjective perceptions of bedtime, waketime, night-wakings and total sleep time for 14 days. Parents completed a sleep diary every morning and night for themselves and their children, which were used to score sleep and wakefulness on Actiwatch. The evening portion of the diary measured daily activity and affect using PANAS or PANAS-C.

Procedure

Participants interested in knowing more about the study registered their email addresses via the university contracted survey hosting platform (Qualitrics). In total, 133 parents expressed interest and were contacted. Forty-seven participants responded to the study email and were screened for eligibility. Thirty-five participants that satisfied the preliminary inclusion criteria were contacted via phone and informed of the study details. Consenting participants were then mailed the watches and sleep diaries. Participants wore actigraphy on their non-dominant wrist 24 hours a day and pushed an event marker on the device when they attempted to go to sleep (i.e. lights' out) and when they got out of bed in the morning (parents pushed the marker for younger children). Watches were initialised to collect data in 60-s epochs. Five parents that had more than one child above the age of two years were given the option to use watches on all their children. Two parents agreed. In this case, data from the child that was deemed a 'poor sleeper' by the parent was used.

Data analysis

Sleep diaries were incomplete or lost for seven parent-child dyads, leaving 28 completed sleep diaries in the final analysis. Actigraphy data were missing for 18 participants; this was due to non-compliance in 5 children, a failure to record or retrieve data for six parents and five children, and two watches were reported as lost. Final analysis included 20 parent-child dyads who had both actigraphy and sleep diary data.

Data were analysed using SPSS Statistics 26 (IBM, Chicago, IL, USA). For the 28 parent-child dyads who had sleep diaries completed for 14 nights, each night was considered a separate entry (total 392 nights). Pearson's correlations were used to assess overall associations between sleep variables measured by the sleep diary (bedtime, waketime, sleep onset latency, total sleep time), and affect (PANAS-SF) in parent-child dyads across all 392 nights of data. Actigraphy data were analysed using Actiware software 5.0. Cole-Kripke algorithm and Sadeh algorithm to define sleep-wake in adults and children respectively (Cole, Kripke, Gruen, Mullaney, & Gillin, 1992; Jean-Louis, Kripke, Mason, Elliott, & Youngstedt, 2001).

Concordance

We used Gunn and colleagues' (2015) procedure for calculating sleep concordance between couples and modified it to measure synchrony in sleep between parent-child dyads (Gunn et al., 2015). Firstly, actigraphy files were downloaded in .csv format where each epoch was automatically scored as sleep-wake using Cole-Kripke algorithm for adults and Sadeh algorithm for children. Both sleep and wake were assigned binary codes '0' and '1' respectively. Common rest intervals were obtained from parents' *light out* to parents' *out of bedtime* as parents generally have later bedtime than the child. Concordance was calculated as the percentage of actigraphy epochs where both parents and children were in a sleeping or a waking state (epochs where both parent and child were in the same state/total number of rest interval epochs). For instance, a value of 75% suggested that parents and children were concordant for sleep and wake for 75% of the epochs during the dyadic rest interval.

Apart from sleep-wake concordance, we calculated percentages for three other outcomes: 1) parent was awake when the child was asleep; 2) parent was awake when the child was awake; and 3) child was awake when the parent was asleep. This helped determine if parents were more likely to be awake when the child was awake and vice versa.

Modified blip analysis

While concordance analysed minute-by-minute sleep-wake, modified actiblip analysis was used to measure links between parent-child night wakings lasting at least five minutes. Actiblip analysis has been previously used to determine the concordance of movement for 30-s sleep epochs between couples (Pankhurst & Home, 1994). We used a modified version of this analysis (hereon referred as "blip analysis") to a) determine the proportion of concordant night wakings of five minutes or longer, and b) examine the proportion of times where child's night wakings were followed by parent's wakings and vice-versa.

Firstly, .csv files (previously discussed in the 'concordance' section) for each parent and child were manually checked for any sustained activity lasting for at least five 60-s epochs. This sustained activity was considered an indicator for night wakings. Hence, each epoch, in this case, represented five minutes. Activity threshold was kept at the medium threshold of 40-counts (Paquet, Kawinska, & Carrier, 2007) for both parents and children for consistency. For each night waking lasting five minutes or longer, the first five minutes were tagged as a '**blip**'. Once all wakings across 14 nights were "blipped," night wakings lasting ≥5 minutes in children were cross-referenced to the parents and vice-versa. After cross-referencing, hit-rates for waking onset were calculated as √pc, where p = proportion of parent blips matched to child's blip, and c = proportion of child's blips matched to parent blips. Pankhurst and Horne [33] indicated that square root was more useful than the mean in case there is a large disparity between x and y values of a parent and their child. Similar to the original paper, **mean incidence** of blips was calculated to ascertain the probability of occurrence of blips (referring to night-wakings lasting five-minutes), that is, total blips divided by the total number of five-minute sleep epochs.

In order to determine whether night-wakings were concordant for parent-child dyads, four types of hit-rates were calculated – 1) **Epoch-Epoch** (E-E), wherein blips of five minute waking in children were compared to the same five-minute epoch in parents and vice versa, 2) **Epoch-1** (E-1) wherein blips of five minute waking in children were compared to the five-minute epoch before in parents and vice versa, 3) **Epoch +1 (E+1)** wherein blips of five minute waking in children were compared to the five-minute epoch before in parents and vice versa, and 4) **Combined Epoch ±1 (E-E±1)** which is an amalgamation of all three forms of hit-rate. These hit-rates displayed initiation of night-wakings ≥ 5 minutes or longer and demonstrated if parents and their children had some common night waking episodes. We also

obtained hit-rates for twenty randomly matched pseudo-parent-child dyads (by randomly matching parents and children from true parent-child groups) for comparison with our true parent-child groups in order to verify that the common wake periods were greater than observed by chance. This was done by replacing either the parent or the child's actigraphy data with data from a different subject (from the same study). Differences in hit-rates were compared using independent samples t-test.

In order to determine the nature of temporal relationships between parent-child night-wakings, we calculated the percentage of times parents woke up in the same five-minute or the next five-minute window of their child waking up (i.e., occurring within 10 minutes of child's awakening). The following equation was used:

E-E(p) + E+1(p)/total number of blips (parents) * 100

Similarly, we calculated the total percentage of times the child woke up in the same five-minute or the next five-minute window of their parent waking up (i.e., occurring within 10 minutes of parent's awakening), using the following equation:

E-E(c) + E+1(c)/total number of blips (child) * 100

Independent samples t-test were used to analyse the differences between the percentage of times parent waking occurred within 10 minutes of their child's awakening, versus the percentage of times child waking occurred within 10 minutes of their parent's awakening.

Actigraphy composites and children's sleep disturbances

Mean actigraphy scores were obtained for both parents and children for the following sleep variables – bedtime, waketime, sleep onset latency, total sleep duration, wake after sleep onset, and sleep efficiency. Variability in bedtime, waketime and sleep duration was quantified as standard deviation (SD) from individual's mean for each composite, such that large SDs would indicate higher variability, suggested by Taylor and colleagues (2016). An independent samples t-test was used to compare differences in parent and child actigraphy composites based on whether or not the child had sleep difficulties (a score of ≥ 41 on CSHQ).

Results

Sample characteristics

Table 1 presents sample demographics for both parents and children. Out of 28 parents that completed the sleep diary, and three children were reported to be diagnosed with autism spectrum disorder (ASD). Eighteen children had significant sleep disturbance based on CSHQ scores, and actigraphy sleep data were available for 11 of them.

Table 1. Participant characteristics.

	Values
Parent Characteristics	
Age *(in years)*	37.33±5.89 (25-48)
Gender	
Female	18
Male	2
Marital Status	
Married/Cohabitating	17
Separated/ Divorced	3
Single	0
Sleep quality (PSQI)	7.88±4.60
Actigraphy composites (*n*=20)	
Sleep onset latency *(in minutes)*	23.67±37.48
Total sleep time *(in minutes)*	380.74±111.57
Sleep efficiency *(in percentage)*	70.2±18.53
Wake after sleep onset *(in minutes)*	121.79±94.95
Sleep diary variables (*n*=28)	
Sleep onset latency *(in minutes)*	32.03±41.79
Total sleep time *(in minutes)*	400±60.81
Number of night wakings	1.70±1.20
Child Characteristics	
Age *(in years)*	5.32±2.70 (4-10)
Gender	
Female	6
Male	14
Sleep disturbance (CSHQ scores)	43±6.50
Actigraphy composites (*n*=20)	
Sleep onset latency *(in minutes)*	16.41±25.67
Total sleep time *(in minutes)*	407.29±143.40
Sleep efficiency *(in percentage)*	88.58±68.87
Wake after sleep onset *(in minutes)*	139.74±96.98
Sleep diary variables (*n*=28)	
Sleep onset latency *(in minutes)*	10.83±7.06
Total sleep time *(in minutes)*	540±60.31
Number of night wakings	1±1.06

Parent-child sleep diaries – relationships between sleep and mood

Significant associations were observed between several parent-child sleep indices measured by sleep diaries. Specifically, the sleep onset latencies of the children were associated with their parent's sleep onset latencies (r=0.29, p <.001). Daily negative affect in children was associated with later bedtimes (r=0.34, p <.001) for parents. Daily positive affect in parents (r=0.31, p <.001) and children (r=0.38, p <.001) was associated with the total sleep time respectively of both parents and their children.

Concordance analysis – overall sleep and wake

Based on the actigraphy data for 60-s epochs, overall sleep concordance in true parent child-dyads ranged from 58% to 89%. Table 2 presents averages for different combinations of sleep concordances calculated for parents and their children. Further, there was a significant difference in the percentage of times a parent was awake during child's wakings (M=35.00, SD=7.80), in comparison to the percentage of times the child was awake during parent waking (M=11.80, SD=4.31) conditions; $t(38)$=12.05, p<0.001.

Table 2. Sleep concordance for 20 parent-child dyads. These participants wore actiwatches for 14 days, following which, each epoch of common rest interval was coded as sleep or wake. Both parents and children were concurrently awake for 35% of wake epochs.

Concordance combinations	**Mean and Standard deviations *(%)***
Overall sleep-wake concordance	70.6 ± 9.97
Percentage of times	
The parent was awake when the child was asleep	15 ± 3.6
The parent was awake when the child was awake	35 ± 7.8
The child was awake when the parent was asleep	7.3 ± 3.7

Actiblip analysis – night wakings ≥ five minutes

Modified blip analysis was used to calculate hit-rates for when parents and children woke up within the same five-minute epoch, an epoch before, an epoch after, and combined E-E±1. Overall hit-rates for true parent-child dyads are presented in Figure 1.

The mean incidence of an occurrence of a night-waking (i.e. blip) for any five-minute epoch was 0.09±0.04 (9%). Blips showed a substantial degree of concordance for parent-child night-wakings lasting five minutes or longer, with a hit-rate of 0.17 or 17% for the same five-minute epochs and 0.26 or 26% for all epochs combined. If this was an entirely random

process, the hit-rate would be 0.09 (i.e. mean incidence rate). Further, a t-test indicated that combined epoch to epoch ± 1 hit rates for night-wakings was significantly higher in the twenty true parent-child dyads (M=0.26±0.12) than randomly matched twenty pseudo-parent-child dyads (M=0.03±0); (t(38)=8.57, p <.001; Figure 2).

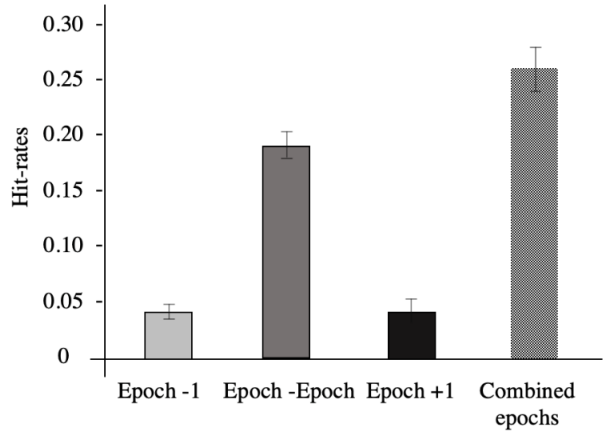

Figure 1. Hit-rates for night-waking onset between parent-child dyads.
Epoch to -1 epoch compares parent to the previous five-minute epoch of the child, and vice versa, direct epoch to epoch match for both parent and child, epoch to +1 epoch compares five-minute epoch in parent to subsequent epoch of the child and vice versa. Combined epoch is a total of all three epoch scores. Image style adapted from Pankhurst & Horne, 1994.

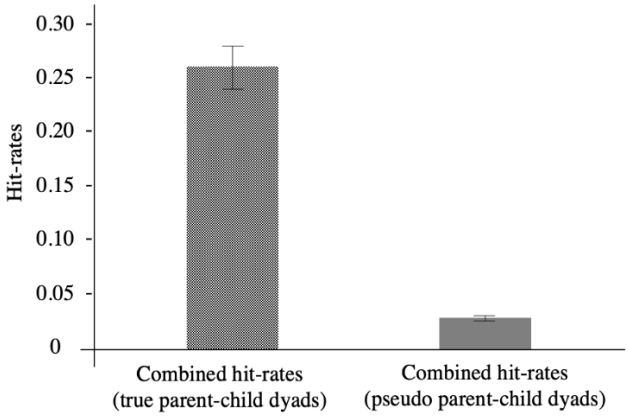

Figure 2. Hit-rates (combined) between parent-child dyads for 1) true parents and children, and 2) randomly matched pseudo parents and children.
Since night-wakings for five minutes or longer were coregulated in true parents and children, the combined hit-rate for randomly matched pseudo-parent-child dyads was quite low. Image style adapted from Pankhurst & Horne, 1994.

Temporal associations in parent-child night-wakings

A secondary t-test was performed to examine differences in hit rates for parent night wakings occurring within 10 minutes (Epoch to Epoch or E+1) of child's waking and vice-versa. A significant group difference was observed ($t(38)=4.81$, $p<.001$), wherein parents were more likely to wake up within ten minutes of their child's night-waking ($M=33.50\pm20.75$) in comparison to the child waking up within the ten minutes of their parent's night-waking ($M=10.83\pm3.60$).

Parent-child actigraphy composites and children's sleep disturbances

Children with sleep disturbances (CSHQ scores ≥ 41) had significantly higher wake after sleep onset, reduced sleep efficiency and reduced total sleep time than children without sleep disturbances (Table 3). Further, parents of children with sleep disturbances displayed significantly higher scores on PSQI, higher wake after sleep onset (*Figure* 3), and higher variability in sleep duration and bedtime in comparison to parents of children with no sleep difficulties.

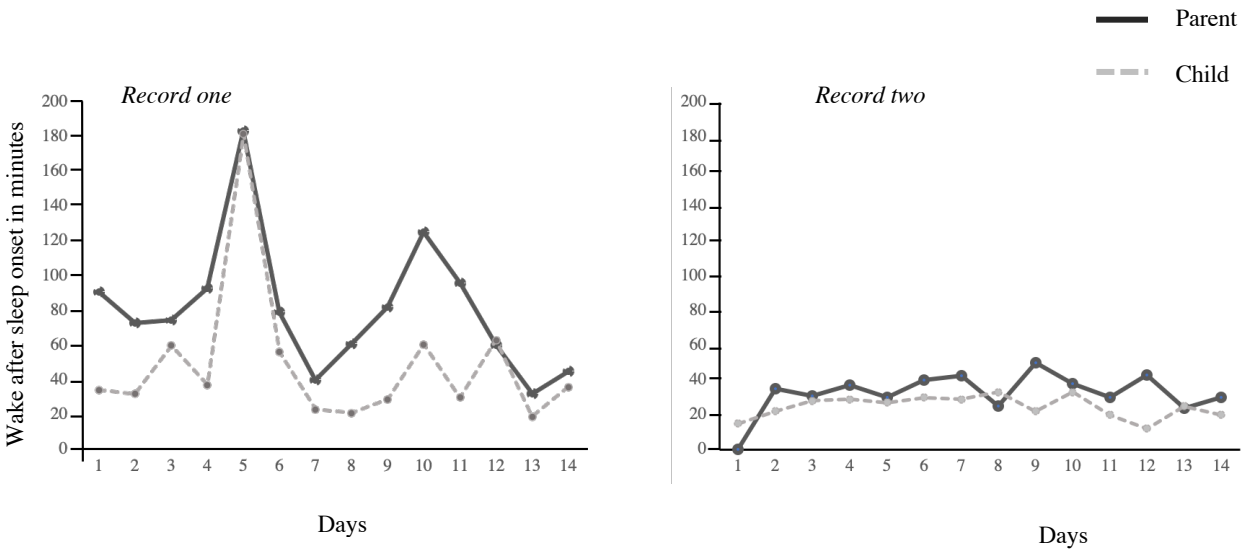

Figure 3. Wake after sleep onset (WASO) between parent and their child as recorded by actigraphy. Record one shows WASO similarities in a parent ($WASO_{mean}$=81 minutes) and child ($WASO_{mean}$=48 minutes) where the child had sleep disturbances (CSHQ >41) and Record two shows WASO similarities in parent ($WASO_{mean}$=32 minutes) and child ($WASO_{mean}$=24 minutes)where the child did not have sleep disturbances (CSHQ<41).

Table 3. Differences in parent and child sleep based on parent-reported child sleep disturbances.

	Children with sleep disturbance (n=11)	**Children without sleep disturbance (n=9)**	***t***	***df***	***p***	**Effect size *Cohen's d***
Child's sleep variables *(in minutes)*						
Sleep onset latency	29.85±22.94	15.53±9.70	1.74	18	0.09	0.81
Sleep efficiency	65.66±14.94	80.14±7.10	-2.60	18	0.01*	1.23
Wake after sleep onset	180.28±81.56	76.30±38.67	3.50	18	0.002**	1.62
Total sleep time	418.12±84.93	457.89±57.28	1.14	18	0.26	0.48
Variability in sleep duration[1]	79.80±18.99	61.90±10.88	2.54	18	0.02*	1.15
Variability in bedtime[1]	20.36±6.30	18.01±5.98	0.94	18	0.35	0.38
Variability in waketime[1]	19.72±4.73	15.96±4.80	1.80	18	0.08	0.78
Parent's sleep variables *(in minutes)*						
Sleep onset latency	27.78±28.54	19.07±27.62	0.68	18	0.50	0.31
Sleep efficiency	65.74±17.17	76.78±10.40	-1.68	18	0.10	0.77
Wake after sleep onset	159.21±64.48	98.40±37.22	2.50	18	0.02*	1.15
Total sleep time	356.84±84.13	392.84±102.25	-0.86	18	0.39	0.38
Variability in sleep duration[1]	89.33±33.00	57.91±20.50	2.48	18	0.02*	1.14
Variability in bedtime[1]	100±29.30	65.81±20.50	2.95	18	0.008*	1.13
Variability in waketime[1]	68.32±30.51	73.83±26.21	0.42	18	0.67	0.19
Sleep quality (PSQI)	10.12±2.86	6.76±3.10	2.51	18	0.02*	1.12

Note: * p-value <.05; **p-value <.01. Abbreviations: PSQI – Pittsburgh Sleep Quality Index.

[1]variability was calculated as standard deviation from the mean scores for each variable, with higher standard deviation indicating higher variability.

Discussion

This study examined sleep concordance and night-wake associations in a sample of twenty parents and their children. We observed concordance in minute-by-minute sleep-wake patterns as well as links between parent-child night-wakings. Temporal links were also observed, wherein one-third (33%) of parents' night-wakings occurred within the ten minutes of their child waking up as opposed to approximately 11% of children's night-wakings that occurred within the ten minutes of their parent waking up. Quite importantly, parental perception of their child's sleep problems (measured using CSHQ) was related to their child's actigraphy composites, demonstrating that parent reports are a good indicator of sleep difficulties in their child and can be used reliably in clinical settings.

In support of the first hypothesis, it was observed that parent-child sleep was concordant on actigraphy. While previous studies have assessed concordance in mother/child sleep patterns (Fuligni et al., 2015; Goldman et al., 2014), this was the first study that examined the percentage of concordance using 60-s epochs. The results showed that the concordance values in parent-child dyads were comparable to couples who co-sleep (Gunn et al., 2015; Walters et al., 2020), indicating interdependence in family sleep.

Apart from sleep concordance, significant night-wake associations were reported within the dyad. Modified blip analysis was used to calculate hit-rates for awakenings lasting five minutes or longer. Supporting the second hypothesis, true parent-child dyads had significantly higher hit-rates than randomly matched pseudo-parent-child dyads, which indicated that true parent-child dyads were more likely to have common night-wakings lasting five minutes or longer. Blip analysis also revealed that parents were three times more likely to initiate a night-waking within the ten minutes of their child waking up (i.e. E-E or E+1 awakening) than the child waking up within ten minutes of their parent's awakening. This result shows temporal precedence for night wakings, revealing that parents are more likely to wake up after their child's awakening than vice versa. This finding is not surprising since as primary caregivers, parents are likely to attend to their child's needs in the middle of the night.

We hypothesised that parents of children with reported sleep difficulties would have poorer sleep outcomes than parents of children without sleep difficulties. Two observations were made. Firstly, children with CSHQ ≥ 41 scores demonstrated longer wake after sleep onset,

reduced sleep efficiency and reduced total sleep time on actigraphy. Hence, parent-reported sleep difficulties in children was corroborated the actigraphy outcomes. This is in contrast to the previous work by Rönnlund and colleagues, and Urfer-Maurer and colleagues, which reported that parental reports of children's sleep problems were not explained by actigraphy and polysomnography respectively. Secondly, parents of children with significant sleep difficulties had longer wake after sleep onset as reported via actigraphy. While total sleep time did not differ across parent groups, wake after sleep onset could have contributed to a decrease in parental perception of sleep quality. No significant differences were observed for any other actigraphy composites in parents. Whether this result was due to our sample size or lack of effect is unclear.

Variability in sleep timing and duration, which is seldom examined in parent-child sleep, was also investigated in this study. Variability in sleep duration was observed but no significant sleep variability was noted for children's bedtime or waketime. This can be attributed to the fact that children's bedtime and waketime are externally regulated by their parents, especially before adolescence (Jenni & Carskadon, 2007). Otherwise, parents may allow their children to sleep for longer if children experience longer night wakings, explaining some variability in their sleep duration. In comparison, parents had more variability in their sleep duration and bedtime if their child experienced sleep difficulties. Actigraphy revealed almost a 90-minute variation in parent's sleep duration and a 100- minute variation in their bedtime if their child had sleep difficulties. Recent literature has documented the effects of this sleep variability on cognition, mood and behaviour, with greater variability in bedtime or sleep duration associated with a poorer daytime function (Murray et al., 2019) and increased risk of depression (Slavish et al., 2019) respectively. Factors like ruminative thoughts, parenting stress, hypervigilance around the child (Lopez-Wagner et al., 2008; Meltzer & Mindell, 2007; Takano, Iijima, & Tanno, 2012) may impact parent's sleep and sleep variability, which should be examined further.

Clinical implications

This study has several implications. Firstly, it reveals that sleep and night-wakings are concordant in parents and their children aged 2-12 years. Secondly, parents are likely to wake up when their child wakes up. These frequent night-wakings can cause an inability to fall back to sleep and may reflect insomnia in adults (Morin, 2004). Combined with increased variability in sleep, these parents with poor sleep may become more vulnerable to poor mood,

and poor physical or mental health. In turn, this can also increase parental stress, which has adverse effects on the family environment and consequently, on child development. While the temporal associations between parent-child sleep and variability in sleep require further investigation, the results from this study highlight the need to identify parents who may be at risk for insomnia. Further inquiries into the health and well-being of parents are necessary and warranted.

The data from this study illustrates the need for improving sleep outcomes in parents. While it is well known that parents may have to get up and attend to their child's needs, exactly how much this impacts on their own sleep quality has not been examined sufficiently. Living with a child aged six years or younger has been already identified as a precipitating factor for insomnia in women (Bastien, Vallieres, & Morin, 2004), so it is possible that sleep difficulties in children could make their parents or primary caregivers more vulnerable to insomnia. Further, children can learn sleep habits from their parents. Hence considerable efforts are required to reduce the duration of their night-wakings (or wake after sleep onset) and improve sleep variability in parents. These issues can be potentially addressed by clinicians using a combination of the following: a) providing parents psychoeducation on sleep, b) recommending optimal sleep behaviours for children and adults, c) increasing access to non-pharmacological sleep treatments for both parents and children (e.g., mobile phone applications providing sleep support), and d) promoting self-help tools that can reduce rumination, stress and worry in parents, which often increase sleep difficulties. These strategies can also help reduce the perpetuation of insomnia once the child's sleep has improved. Concurrently, parents should be provided more support to deal with their child's sleep problems. Adopting these approaches can improve sleep and functioning outcomes at the family level.

Strengths and limitations

The current study builds on previous work in this area and contributes significantly to the literature by quantifying the associations between parent and child sleep. It reveals that objectively measured parent-child sleep-wake patterns are coregulated. It solidifies the validity of parental reports on their child's sleep, as parent-reported sleep difficulties in children were associated with sleep outcomes as measured by actigraphy. Study measures were robust, as actigraphy and self-report measures of sleep captured both daily sleep fluctuations and general sleep behaviours in the dyad.

We assessed night-wakings in parent-child dyads using a modified blip analysis. This novel use of the modified blip analysis allowed us to examine the associations between parent and child night-awakenings. Mean incidence provided the probability of times when night-wakings were random, giving some indication towards the true influence of children and parents on each other's sleep. Ultimately, the analysis offered insight into night-waking behaviours among parents and children.

Limitations of this study should also be noted. For instance, we had a small sample size, and our actigraphy study population included four children with neurodevelopmental conditions that are known to impact sleep (Meltzer & Montgomery-Downs, 2011). We chose a broad age-range for participating children (2-12 years), and while previous studies have not noted age-based differences in parent-child sleep associations (Boergers et al., 2007; Meltzer & Mindell, 2007), these need to be examined further. While recruiting a diverse sample helped us make broader observations, we could not assess any inter-group differences based on developmental conditions that impact sleep and the age of the child. Since this is a pilot study, we hope that future research would scale-up these techniques and methodologies and apply them to larger study populations.

Conclusion

This study provides a novel way of understanding how parent-child sleep and night-wakings are correlated. Parent-reported child sleep difficulties were corroborated on the actigraphy of the children studied. Moreover, parents reported longer periods of being awake after sleep onset and greater variability in their sleep as measured by actigraphy if their children experienced sleep difficulties. Considering the impact of sleep on functioning, this study highlights that the parents' sleep should be a priority for clinicians working with children. Providing parents with tools to manage their sleep can have positive consequences for parental sleep and have flow-on effects on the functioning of both parent and child. Overall, adopting a family approach towards treating sleep difficulties may be helpful.

Chapter 5

A pilot study examining the efficacy of six-weeks mindfulness training using a self-help tool for improving parent sleep

Preamble

Chapters 3 and 4 reported poor sleep quality and increased duration of night-wakings in parents of children with sleep disturbances. These parents experienced significantly higher pre-sleep arousal and poorer mood outcomes in comparison to parents of children with no sleep disturbances. Despite this, no studies to date have assessed the benefits of a targeted sleep intervention for such parents. Hence, an initial attempt was made to run a pilot trial of a face-to-face mindfulness sleep intervention. This intervention was based on the principles of Mindfulness-Based Therapy for Insomnia (MBT-I) by Ong and colleagues (2009, 2017) and was customised with the intent to improve caregivers' sleep. A copy of the customised six-week version that was developed is available in Appendix-III. MBT-I was chosen because it combines elements of both mindfulness and Cognitive Behaviour Therapy for Insomnia (CBT-I). Theoretically, mindfulness was postulated to help reduce parents' cognitive arousal or hyperarousal and may have improved their stress, whereas CBT-I was hypothesised to address elements around sleep practices, habits and cognitions that may impair sleep. We aimed to test the efficacy of MBT-I against a psychoeducation comparison protocol. However, during recruitment, it was discovered that parents were hesitant to commit to two hours of face-to-face sessions for six weeks. Several reasons were cited, including lack of time, employment, childcare responsibilities and long commutes. While we could not test the effectiveness of MBT-I for parents' sleep, it is hoped that the protocol could be applied in other caregiver settings. Alternatively, a self-help tool, like a mobile phone application, was deemed as more practical in terms of parent participation and study demands. It was also considered to be ecologically valid as a more realistic intervention that would be taken up by parents and therefore investigated instead. The study reported in this chapter was a pilot intervention that investigated if a self-help, mindfulness training app used for six-weeks could improve sleep and mood in parents of children with sleep disturbances.

Candidate's contribution

The candidate obtained ethics approval for this study. The candidate collected and analysed the data, formulated and wrote this chapter.

Abstract

Objectives: This study aimed to examine the effectiveness of mindfulness, using a self-help tool to improve sleep in parents. A further objective was to assess if there were any flow-on effects of the intervention on sleep in children.

Design: A quasi-experimental design.

Participants: Five parents with poor sleep quality and their children with sleep disturbances were recruited in this study.

Measurements: Parents completed a range of questionnaires on a) sleep quality, insomnia severity, sleep effort, pre-sleep arousal, and mood for parents, and b) children's sleep disturbances, and behavioural strengths and difficulties. Parents and children wore actigraphy for 14 nights, and parents completed a sleep diary with questions related to sleep and affect.

Results: The majority of the actigraphy data was unavailable. Hence data from the sleep diaries and questionnaires were analysed at baseline and follow-up. Effect sizes were obtained. Large effect sizes were noted for sleep onset latency, sleep quality, insomnia severity, pre-sleep arousal and sleep efforts. Moderate effect sizes were reported for behavioural difficulties but not sleep difficulties in the children.

Conclusion: The results from this study suggest that parents may benefit from mindfulness training using a self-help tool. Future studies need to expand upon this pilot investigation and examine the potential efficacy of self-help tools using more rigorous methods. Regardless, the results from this study indicate the need to diagnose and treat the parental sleep problem, especially if their child experiences sleep disturbances.

Keywords: parent, child, sleep, mindfulness, self-help, sleep problems.

Introduction

Medical professionals recognise that childhood sleep problems are one of the most common concerns reported by parents (Roberts et al., 2020). As primary caregivers, parents of children with sleep difficulties often display poor sleep quality, increased night-awakenings and poor mood (Fuligni et al., 2015; Herbert et al., 2015; Iwata et al., 2013; Jaser et al., 2017; Kalak et al., 2012; Lopez-Wagner et al., 2008; Meltzer & Mindell, 2007; Meltzer & Moore, 2008; Meltzer & Westin, 2011). Still, a large number of studies examining sleep interventions for children do not report any direct or indirect effects on parents' sleep, making it difficult to ascertain whether childhood sleep interventions alone can have a positive impact on the parents. Hence, targeted interventions to improve parental sleep (Daniel et al., 2018; Meltzer & Moore, 2008) across different populations are necessary.

Family systems theory (Brown, 1999) postulates reciprocity in family subsystems, where individual behaviour of one family member can have an impact on individual, dyads or on the overall family. At the same time, there is a crossover effect (Bolger, DeLongis, Kessler, & Wethington, 1989), which is a dyadic process where states of well-being can 'crossover' to another individual, including both positive or negative experiences. This explains bidirectionality in parent and child sleep, wherein poor sleep in children can have negative impacts on parents' sleep and well-being, whereas stress, anxiety and depression in parents can create an environment which has negative implications for children's sleep (Martin, Papadopoulos, Chellew, Rinehart, & Sciberras, 2019; Waddington, McLay, Woods, & Whitehouse, 2020).

Apart from the crossover, parental accommodation may also occur, where parents may allow the child to continue with problematic bedtime behaviours as a form of reducing distress in both the parent and the child (Roberts et al., 2020). These behaviours usually include things like reactive bed-sharing or reactions to the disruptive, middle of the night sleep difficulties, and are related to both mental health and sleep in parents (Roberts et al., 2020). Since children's sleep-wake habits often run parallel to their parents (Roberts et al., 2020; Zhang, Wang, & Huang, 2010), these accommodating behaviours may be a sign of parental inconsistencies with sleep that can further influence sleep habits of all family members, particularly children(Meltzer & Booster, 2016). Over time, the condition which set off the initial onset of insomnia (such as a children's sleep disturbance) may become different from the factors that continue to perpetuate it. For instance, a child's sleep difficulties and parents'

insomnia itself can be a stressor (Palagini et al., 2014), which perpetuates sleep difficulties in parents. Therefore, providing parents with tools to manage their sleep can have two benefits. Firstly, it can facilitate the crossover of positive sleep and mood experiences between parent-child dyads. Secondly, altering parental sleep patterns can have positive benefits for parental mood and stress, which can promote parental resilience and help parents respond to their child's sleep needs better.

Current treatments for parents' sleep

No studies to date have quantified the possible benefits of using targeted sleep interventions for parents. However, there are interventions that aim to improve sleep during pregnancy and postpartum periods. One such program is piloted by Bei and colleagues (Bei et al., 2019), which uses a combination of general skills to address unhelpful behaviours around sleep, identify differences between insomnia and sleep deprivation, psychoeducation around infants' sleep patterns, and mindfulness-based strategies to target pain and cognitive arousal.

While the efficacy of infant-parent sleep treatments adapted for other parent populations is yet to be examined, there is a need to consider other interventions simultaneously. Parent sleep problems may differ based on their child's development period. For instance, parent sleep deprivation during infancy usually stems from the lack of consistent sleep patterns in the child. In contrast, parents of older children report sleep problems due to behavioural sleep difficulties in the child, such as sleep disorders, night-wakings, bedtime resistance and nightmares (Meltzer & Montgomery-Downs, 2011). Hence, the nature and aetiology of sleep problems in parents of infants and parents of older children may differ. Previous literature reports that insomnia symptoms in mothers are associated with their perceptions of child's sleep anxiety, sleep-disordered breathing and bedtime resistance (Kalak et al., 2012), suggesting that parents of children beyond infancy may experience insomnia rather than sleep deprivation alone.

Apart from sleep difficulties associated with the child, primary caregivers may also display excessive cognitive activity, including increased hyper-vigilance, such frequently checking on the child (Lopez-Wagner et al., 2008), increased arousal and worries for the child. The assumption of their child waking them or the potential need for night-time support can become an external sleep-related threat cue that can keep parents awake. As noted in Chapters 3 and 4, parents of children with sleep disturbances exhibit increased pre-sleep

arousal. Particularly, their cognitive pre-sleep arousal is high, which may be indicative of chronic insomnia and sleep reactivity. This excessive cognitive activity prior to sleep can trigger emotional distress and selective attention to sleep-related threat cues, which can impair an individual's sleep quality (Harvey & Payne, 2002; Yang et al., 2020). Increased arousal in these parents may be a sign of increased reactivity towards their child's night-waking, movements or towards other external cues.

While unavoidable sleep issues in children need parents' attention, aspects of hypervigilance and other behaviours practised by parents contribute to parents' own insomnia symptoms. These symptoms can be addressed using sleep interventions. A common intervention is mindfulness, which allows individuals to shift their focus from the contents of the awareness to the awareness itself (Shapiro, Carlson, Astin, & Freedman, 2006). Regular practice of mindfulness may reduce distressing thoughts, including worry and rumination (Fisak & Von Lehe, 2012) and consequently, help with sleep. Previous studies report that mindfulness is associated with positive outcomes in adults, such as lower levels of depression and anxiety, greater emotional regulation, and better sleep (Blanck et al., 2018; Hill & Updegraff, 2012; Ong et al., 2018; Winbush et al., 2007). Mindfulness-based interventions promote sleep and reduce pre-sleep arousal (Cincotta et al., 2011; Ong et al., 2009).

Mindfulness for sleep

Recently, research has adopted a mindfulness-based approach to treating insomnia. Cultivated through meditation, mindfulness encourages humans to be present-centred and non-judgmental (Dreyfus, 2011) and defined as receptive attention to and awareness of present events and experiences (Brown & Ryan, 2003). Rooted in Eastern philosophy, mindfulness encourages a non-judgmental, self-compassion perspective, which theoretically reduces negative emotional reactions while increasing individual resilience (Ong & Sholtes, 2010). Ultimately, this has to led to an increased use of mindfulness in behavioural medicine. This includes treatment programs like Mindfulness-based stress reduction (MBSR) and mindfulness-based cognitive therapy (MBCT) used for depression, anxiety, stress and eating disorders. These programs have been adapted for treatment of insomnia and sleep disturbances and offered promising results. For instance, a systematic review of MBSR and MBCT type mindfulness approaches suggested improvements in sleep quality and overall insomnia symptoms among multiple population groups such as menopausal women, veterans and cancer survivors (Winbush et al., 2007). A more recent meta-analysis (Rash, Kavanagh,

& Garland, 2019) also reported favourable outcomes from mindfulness-based therapies, revealing that improvements in sleep quality and insomnia were greater when participants were recruited in mindfulness groups rather than control groups.

A growing treatment intervention involving mindfulness is mindfulness-based therapy for Insomnia (MBT-I), which combines mindfulness meditation training with salient principles of Cognitive Behaviour Therapy for Insomnia (CBT-I) and appears to provide sleep benefits (Ong et al., 2014; Ong et al., 2009). Using CBT-I in conjunction with mindfulness allows clinicians to reduce unhelpful cognitions and sleep behaviours. It also gives an opportunity to apply practices like sleep restriction, which can improve sleep efficiency and increase sleep pressure in individuals with insomnia. Randomised control trials using MBT-I report reduction in self-reported insomnia symptoms and increased sleep quality. The benefits appear to sustain during three- and six-month follow-ups, with at least 50% of participants reporting treatment remission and 78% of participants reporting treatment response. While there is a need to test whether treatment responses in MBT-I were more attributable to mindfulness or CBT-I, the overall research on mindfulness-based therapies illustrates the potential utility of mindfulness for insomnia and sleep disturbances in the adult population.

Mindfulness for caregivers

Although mindfulness has not been studied in the context of parent sleep, previous literature provides evidence for the benefits of mindfulness in different caregiver populations. For instance, in a study that used MBSR for caregivers of people with dementia, the authors noted positive benefits of the intervention for mental health and stress in caregivers (Whitebird et al., 2013). Similar mindfulness programs were found to be associated with decreased stress and total mood disturbance scores in caregivers (parents) of children with chronic illnesses (Minor, Carlson, Mackenzie, Zernicke, & Jones, 2006), and improved well-being in parents of children with developmental disabilities (Bazzano et al., 2015). A systematic review of mindfulness for parents' well-being indicated that mindfulness interventions were related to significantly reduced stress levels and increased levels of psychological well-being among parents (Cachia, Anderson, & Moore, 2016). Providing adequate information and resources for caregiving can reduce stress and improve sleep in caregivers (Liu et al., 2020). Qualitative findings from using mindfulness treatments for caregivers also report that it can increase acceptance and reduce judgment of reactions (Hoppes, Bryce, Hellman, & Finlay, 2012). This can be quite useful for parents who

experience increased reactivity towards child's behaviours, particularly the ones related to their sleep. While caregiving responsibilities may differ across groups, the literature indicates the theoretical benefits of using mindfulness in any caregiving population, including parents.

Mindfulness within families

Studies consistently report that mindfulness exudes positive effects on the overall family system. For instance, a recent study by Fereydooni and colleagues (Fereydooni et al., 2020) reported that mindfulness training increased parent-child interaction in mothers of anxious pre-school children. Maternal mindfulness is also associated with positive parenting practices (Ren et al., 2020). In the context of families, research indicates positive effects of parental mindfulness on parent and child relationship quality (Coatsworth et al., 2010) and parenting practices (Van der Oord et al., 2012). Similarly, a mindfulness-based well-being program for parents has shown to increase self-compassion and reduce general stress in parents (Jones et al., 2018).

While mindfulness-based interventions appear promising for this population, parents may find it difficult to engage in long-term program delivery due to geographical location, time restrictions, financial constraints and general routines. Most of the sleep interventions targeting adults, in general, require longer time commitment (e.g., CBT-I or MBT-I) and may not be applicable. The ability of parents to attend multi-session sleep intervention may be limited (Meltzer & Booster, 2016). Research suggests that even in the general adult population, individuals with insomnia are more likely to seek out self-help options than professional help (Lo et al., 2020; Morin et al., 2006). Treatments adopting multi-session protocols may lack real-world feasibility. Furthermore, previous studies report that parents of children with sleep difficulties can benefit from the simplest forms of support, including psychoeducation or self-management (Brandhorst, Hautzinger, & Schlarb, 2016). Hence, providing parents with a self-help tool for improving sleep may be a more ecologically valid option. Accordingly, this pilot study assessed the effectiveness of a mobile phone application-based mindfulness training on parents' sleep and mood. As sleep is a family concept, our objective was to further examine if parent training in mindfulness can have flow-on effects for child's sleep or behaviour. We hypothesised that parent training in mindfulness would have positive benefits for their sleep, mood and affect.

Methods

Participants

The sample consisted of seven participants recruited from the previous study that demonstrated temporal associations between parent and child sleep using actigraphy. Participants included primary caregiving parent aged 18 years or above, and their child aged two years or above. Ethics approval was obtained from RMIT University (Ethics approval ID: 20762). Eligibility criteria included: adequate English-speaking ability, a score of ≥ 5 on the Pittsburgh Sleep Quality Index for parents and ≥ 41 on the Child's Sleep Habits Questionnaire (CSHQ). Parents with more than one child reported CSHQ for both children. Only the child with clinically significant sleep disturbance (CSHQ ≥ 41) was included in the study. Participants were excluded if: parent was receiving treatment for a sleep disorder, was pregnant or nursing a child below the age of two years and engaged in regular shift work. A total of seven participants indicated interest to participate, but five completed the overall protocol.

Measures

Child's Sleep Habits Questionnaire (CSHQ) is a retrospective 45-item parent-rated questionnaire that assesses sleep behaviour and degree of sleep difficulties in children (Owens et al., 2000). The authors determined that a score of ≥ 41 correctly identifies 80% of patients referred to paediatric sleep disorders clinic [45].

Glasgow Sleep Effort Scale (GSES) is a seven-item questionnaire that measures sleep control and worries or anxieties related to sleep (Broomfield & Espie, 2005). The score ranges from 0-14, with higher scores demonstrating greater sleep effort. Internal consistency is .77.

Insomnia Severity Index (ISI) is a self-report, seven-item scale that measures insomnia severity in terms of sleep onset, sleep maintenance and early morning awakening (Bastein, Vallieres & Morin, 2001). ISI demonstrates good reliability and validity (Bastein et al., 2001), with a score of 15 or above indicating moderate to severe insomnia and a score between 8-14 indicating subclinical insomnia.

Positive and Negative Affect Scale-Short form (PANAS) includes 10-item subscales to measure the positive and negative affect (Watson et al., 1988) and demonstrated high

reliability and validity. Ten item children's version of PANAS was used for children in the study (Ebesutani et al., 2011).

Philips Respironics Actiwatch 2 is a small, unobtrusive wrist actigraphy that measures sleep-wake using a built-in accelerometer (Meltzer et al., 2016). The device also uses a light sensor to monitor light levels. The Actiwatch is validated against polysomnography for both children and adults (Meltzer et al., 2016; Weiss et al., 2010).

Pittsburgh Sleep Quality Index (PSQI) measures subjective sleep quality in adults over the previous month (Buysse et al., 1989). It includes seven subscales including subjective sleep quality, sleep duration, sleep onset latency, sleep disturbances and daytime dysfunction. A score greater than five discriminates poor sleepers from good sleepers and higher scores indicate poorer sleep quality (Backhaus et al., 2002). Change of 3 or greater points in the score is considered a good treatment response for PSQI (Buysse et al., 2011).

Pre-sleep Arousal Scale (PSAS) is a 16-items questionnaire that includes two subscales measuring cognitive and somatic arousal prior to sleep (Nicassio, Mendlowitz, Fussell, & Petras, 1985). Nicassio and colleagues noted that the subscales successfully discriminate insomniacs from normal sleepers and has an adequate internal consistency of .76 and .81 for somatic and cognitive scales.

Profile of Mood States (POMS)-Short form is a validated, 37-item psychological scale used to assess distinct and transient mood states (Shacham, 1983). The test provides scores on six subscales: fatigue, vigour, tension, anxiety, depression, anger, confusion and is internally consistent with original POMS. Higher scores indicate increased mood disturbance.

Sleep diary was used to measure subjective perceptions of bedtime, waketime and total sleep time for 14 days. Parents completed a sleep diary every morning and night for themselves and their children. It was used concurrently with the Actiwatch to score sleep and wake variables. Sleep diary includes PANAS and PANAS-C, which was completed by the parents every evening. Following variables were obtained from sleep diary: sleep onset latency, total sleep time, number of night awakenings, duration of night-awakenings, bedtime variability (defined as standard deviation [in minutes] from average bedtime across 14 nights), waketime variability (defined as standard deviation [in minutes] from average waketime across 14 days), sleep duration variability (defined as standard deviation [in minutes] from average sleep duration across 14 nights), average positive and negative affect (PANAS).

Strengths and Difficulties Questionnaire (SDQ)-short form is used for behavioural screening on following attributes in children: emotional symptoms, conduct problems, hyperactivity and inattention, peer relationship problems, and prosocial behaviour, providing a total difficulties score (Goodman, Ford, Simmons, Gatward, & Meltzer, 2000). A score of 16 or above indicates behaviour difficulties.

Headspace (Headspace Inc., Santa Monica, CA, USA) is a mobile phone app that provides guided meditation sessions. Launched in 2010, Headspace provides access to hundreds of mindfulness practices that are offered as either single practices or as a part of 'packs.' These packs usually include customised, mindfulness training modules on particular topics, such as anxiety, stress, sleep, relationships and motivation. Users can determine which 'pack' they wish to choose and the length of meditations, which can run from three minutes to a duration of thirty minutes. Male and female voiceovers are available.

Procedure

Parents of children with sleep difficulties that previously completed actigraphy study assessing temporal links in parent-child sleep were invited to participate in this intervention. Interested participants were given a code to access to the Headspace mindfulness application. Participants were instructed to practice guided meditation exercises lasting for 10 minutes or more daily for a period of 6 weeks. They were asked not to use the application as a direct method to fall asleep (i.e., avoid using the app at least two hours before bed). Participants were given an option to choose any of the mindfulness programs offered on the phone app, including but not limited to Foundation pack, Sleep pack, Anxiety pack, and Stress pack, among others. Baseline measures included all questionnaires used in the survey study (Chapter-3), along with actigraphy, sleep diaries and questionnaires used in the last study (Chapter-4).

Data analysis

Data were analysed using SPSS Statistics 26 (IBM, Chicago, IL, USA). Actigraphy data were missing for two parents and three children, due to non-compliance or actigraphy failure. Hence, only the sleep diary data were analysed for this study. Due to the small sample, Wilcoxon Z Test was used pre- and post-intervention, and standardised effect sizes were calculated for sleep diary variables, ISI, PSQI, PSAS, GSES, POMS, and CSHQ.

Results

Participant characteristics

Five parents (37.2 ± 4.95 years) of children aged 2-12 years (6.4 ± 4.03 years) participated in the study. The parent sample included four mothers and one father. The child sample included three males and two females. Two parents had a child with a clinical condition that impacts sleep (autism), and three parents had children with behavioural sleep disturbances (i.e., no clinical condition that affects sleep). The usage data from Headspace indicated that parents completed an average of 25 exercises (range 15-90 exercises) with a mean duration of nine minutes, translating to a total of 1620 minutes spent by all participants on the app.

Changes in sleep diary variables from baseline to follow-up

Mean scores of all outcome variables for the participating parents and children are presented in Table 1. Wilcoxon Z Test did not indicate any significant differences in participants daily sleep characteristics from baseline to follow-up. However, strong effect sizes were noted for sleep onset latency, the number of night-awakenings. Medium effect size was noted for variability in sleep duration, and positive and negative affect. No changes were observed in the child's sleep diary variables from baseline to follow-up. Wilcoxon Z Test did not indicate any significant differences in sleep characteristics across the two time-points. Only moderate effect size was reported for positive affect in children.

Changes in overall sleep outcomes from baseline to follow-up

Large effect sizes were observed for parent self-reported sleep quality, pre-sleep arousal, sleep effort and insomnia severity. Specifically, sleep quality improved by three points. Medium effect sizes were reported for parent mood states. Small effect size was noted for children's sleep disturbance, but medium effect size was reported behavioural strength and difficulties in children (Table 1).

Table 1. Wilcoxon Z-tests for sleep diary variables, sleep quality, arousal sleep efforts and mood in parents, and sleep diary variables, sleep disturbances and behavioural difficulties in children. Measured at baseline and follow-up after six weeks (N=5).

	Participant group (*n=5*)		**Wilcoxon Z test**		
	Baseline	**Follow-up**	***z***	***p***	***Standardised effect size***
Sleep variables - Parents					
Sleep onset latency	34.98 (18.19)	27.48 (12.84)	1.86	0.06	0.84
Total sleep time	410 (27.20)	408.6 (32.91)	0.13	0.89	0.06
Number of night-wakings	1.8 (0.74)	1.2 (0.4)	1.44	0.14	0.83
Duration of night-wakings	15.19 (4.47)	13 (5.44)	0.23	0.81	0.12
Bedtime variability	54.89 (31.69)	45.89 (25.23)	1	0.31	0.48
Waketime variability	60.80 (32.86)	57.08 (32.26)	0.48	0.62	0.24
Sleep duration variability	52.65 (25.20)	40.57 (11.93)	1.53	0.12	0.72
Positive affect	31.2 (4.5)	34.26 (6.01)	-1.62	0.10	0.73
Negative affect	20.4 (5.57)	18.44 (4.41)	1.21	0.22	0.83
Insomnia (ISI)	12.2 (3.42)	9 (3.63)	1.81	0.07	0.90
Sleep quality (PSQI)	8.61 (2.41)	5 (1.09)	1.89	0.05	0.85
Cognitive arousal (PSAS)	22.42 (4.78)	19.68 (2.28)	1.62	0.10	0.93
Somatic arousal (PSAS)	25.33 (4.12)	18.61 (2.65)	1.89	0.05	0.85
Sleep efforts (GSES)	8.6 (1.85)	7 (2.09)	1.80	0.07	0.90
Total mood disturbance (POMS)	9.80 (2.88)	7.19 (2.33)	0.93	0.18	0.49
Sleep variables - Children					
Sleep onset latency	19.60 (9.32)	18.66 (8.76)	0.13	0.89	0.06
Total sleep time	571.88 (74.93)	574.44 (56.89)	0	1	0
Number of night-wakings	1.4 (0.48)	1.43 (0.48)	-0.20	0.84	0.10
Duration of night-wakings	13.62 (5.98)	12.86 (5.88)	0.13	0.89	0.06
Bedtime variability	20 (6.89)	20.21 (7.05)	0	1	0
Waketime variability	37.83 (13.34)	39.26 (10.04)	0.27	0.78	0.12
Sleep duration variability	51.62 (13.81)	48.8 (12.77)	0.94	0.34	0.42
Positive affect	16.6 (2.53)	17.08 (2.92)	-1	0.26	0.49
Negative affect	5 (1.26)	4.21 (1.46)	0.34	0.14	0.11
Sleep disturbance (CSHQ)	51.63 (4.27)	50.2 (3.54)	0.54	0.58	0.31
Behavioural difficulties (SDQ)	18.4 (1.85)	17.63 (1.8)	1.36	0.17	0.79

Discussion

This pilot study aimed to examine the effectiveness of a mobile phone application-based mindfulness training on parents' sleep and mood. Five parent-child dyads completed mindfulness training using a smartphone application for a period of six weeks. At baseline and follow-up, parents completed a range of questionnaires assessing sleep quality, pre-sleep arousal, sleep effort and mood in parents, and sleep disturbances and behavioural difficulties in children. Before and after the intervention, parents completed a sleep diary for themselves and the child across 14 nights. We hypothesised that mindfulness training using a self-help intervention would have positive effects on parent sleep, mood and affect outcomes. No significant differences were observed between baseline and follow-up sleep characteristics. This lack of observed statistical significance may be attributed to the small sample size, as p-values are dependent on sample sizes (Sullivan & Feinn, 2012). Hence, standardised effect sizes, which are independent of the sample size (Sullivan & Feinn, 2012) were calculated. In particular, large effect sizes were noted for sleep onset latency, the number of night-awakenings, variability in sleep duration, and both positive and negative affect in parents. Moderate effect sizes were reported for positive affect and strength and difficulties in children. These results suggest that there may be benefits to using digital, self-help intervention for improving sleep in parents.

These improvements in parent sleep were observed using a digital, self-help tool only. While this was a pilot study, the findings are consistent with other research showing the effectiveness of face-to-face mindfulness interventions for insomnia. For instance, improvements in sleep onset latency and cognitive pre-sleep arousal is related to theoretical models of insomnia and has been previously researched by Ong and colleagues (Ong, Ulmer, & Manber, 2012; Ong et al., 2018). Further, previous research by Garland and colleagues (Garland et al., 2014) suggests that mindfulness can improve daytime outcomes as well, as noted in increased positive affect and decreased negative affect in parents who undertook mindfulness training. Therefore, these findings indicate that parent use of self-help mindfulness can have increased benefits for their sleep, mood and daytime functioning.

While large effect size was noted for parental insomnia from baseline to follow-up, the scores are still at the lower end of subclinical insomnia category. This is further supported by only moderate changes in parents' bedtime variability, which indicates that parents may benefit

from additional or longer intervention support. Individual perceptions and behaviours around sleep may cause or exacerbate insomnia (Harvey & Tang, 2012) and hence, psychoeducation can be employed in conjunction with mindfulness for improving any dysfunctional beliefs or attitudes around sleep. Psychoeducation can target misperceptions around sleep (Anderson, Goldsmith, & Gardiner, 2014; Van Houdenhove, Buyse, Gabriëls, & Van den Bergh, 2011) which can improve sleep outcomes in these parents.

Children had improved scores for behavioural strength and difficulties at follow-up (large effect size), but this was not statistically significant. It is unclear whether there was an actual change in children's behaviour, or if this was due to changes in parent perception of child's behavioural difficulties. Considering that there were no major differences in any of the child's sleep indices, particularly their sleep disturbances, it is possible that parents using the intervention could have become better equipped to deal with child's behavioural or sleep difficulties. Alternatively, parent perception of child's behavioural difficulties may have reduced because they perceive themselves to be sleeping better. This assumption should be tested in future studies. Current evidence does indicate that parents with mindfulness training are more likely to respond more positively to their child's needs (Coatsworth et al., 2010). Therefore, future studies can examine if using these tools can promote better family outcomes.

Overall, results from this primary study demonstrate positive uptake for a self-help tool to improve parent sleep. Considering that night-waking in parents did not change from baseline to follow-up, the results indicate that while parents may still have to wake up and possibly attend to their child's needs, using self-help tools can promote them to sleep better on the days their child does not need support. Further, mindfulness can be employed beyond sleep to address sleep-related stress and improve resilience, which can help individuals bounce back when encountering difficulties and alter negative narratives (Wells & Klocko, 2018). Parent sleep interventions, particularly through the use of self-help measures, can be adopted as an adjunct treatment strategy when treating children with sleep difficulties. Such a strategy will improve a child's sleep while simultaneously treating parent sleep. Using this family-oriented approach to sleep can improve outcomes for all members of the family.

Strengths and limitations

This is the first study to explore the usefulness and applicability of a digital, self-help intervention for managing sleep problems in parents. The results present a cohesive, consistent image that mindfulness may have benefits for parents of children with sleep difficulties. While the study highlights the potential use of self-help tools for managing sleep in parents, caution must be exercised, and overinterpretation of the results should be avoided. For instance, the repeated analysis did allow for assessment of any changes over time for these parents; however, without the control comparison, it is difficult to draw conclusions regarding the specific effects of this intervention. The small sample size is an issue, followed by lack of actigraph recordings for the majority of participants. The small sample size meant that statistical analysis of how parent sleep changed based on the nature and severity of their children's sleep disturbance was not possible. Similarly, statistical analyses assessing differences in sleep based on how often parent used the mobile phone application, age-based differences and gender-based differences, were not conducted.

Regardless of these limitations, the results from this study highlight the potential benefits for encouraging parents to utilise self-help tools to improve their own sleep or least better deal with the stress of not sleeping well. Continued investigation of mindfulness using more structured, consistent protocols can help examine the utility of such therapies for parent sleep and its flow-on effects for the child. Using actigraphy for parent and child across a wider sample would be beneficial to assess if there is any agreement in actigraphy and parent reports of child's sleep before and after the intervention, and if the intervention improves sleep at the objective level.

Conclusion

Parents of children with sleep disturbances often have sleep difficulties of their own. However, sleep difficulties in the parent population are underrepresented, and no studies have previously assessed the efficacy of sleep intervention for parents. This pilot study aimed to examine the efficacy of a self-help program. Interested parents used a self-help tool for mindfulness training. Results from the study demonstrated changes in parents sleep onset latency, sleep quality and symptoms of insomnia. Although these changes were not statistically significant, the effect sizes observed support conducting a larger study. Considering that parents influence their child's sleep and the overall family environment,

there is a need to examine and address parental sleep further. Self-help tools exhibit ecological utility as they are cheap, easy to use and require less time-commitment than formal courses or classes, but their validity needs to be demonstrated further. The study should be expanded upon heir, and the potential utility of self-help tools should be tested using randomised controlled trials.

Chapter 6

General Discussion

Sleep within a family is a synchronous and interactive process. Accordingly, this thesis aimed to investigate sleep in parent-child dyads, with a particular focus on children's sleep disturbances and the role this may play in the sleep of their parents. We observed that while parents can shape children's sleep habits, their child's sleep disturbances themselves were associated with sleep difficulties in their parents. Using both subjective and objective measures, the data presented in this thesis demonstrated that parents of children with sleep difficulties experience heightened physiological and cognitive arousal prior to sleep, have poor sleep quality, insomnia symptoms, increased night-wakings and variability in their own sleep. Since parents influence the family environment and consequently affect their child's development, it is crucial to provide them with sleep interventions. Self-help tools, such as mindfulness, may be useful because of their utility in improving sleep and arousal while requiring less time and effort. Results from the pilot intervention using a mindfulness self-help tool suggested positive improvements in parents' sleep despite no improvement in their child's sleep. This indicates the potential benefits of using sleep interventions in the parent population, which should be studied further for its effects on sleep and any flow-on benefits on parental mood and overall family functioning.

A brief overview of the findings

Given that sleep disturbances are commonly noted in both typically developing (TD) paediatric populations and in children with Neurodevelopmental disorders (NDD), Study 1 (Chapter 2) systematically reviewed past literature with the aim to examine sleep associations in parents and children across both population groups. A total of 29 studies were included in the review. In TD populations, there were significant associations between parent-child sleep quality, sleep duration and sleep efficiency. Children with NDD demonstrated more significant sleep problems. Consequently, parents of children with NDD had poorer sleep and mood in comparison to parents of TD children. Potential bidirectionality in sleep was observed, suggesting that parents' sleep is impacted by children's sleep disturbances, and in turn, children may learn sleep habits from their parents. However, the review noted a limited number of studies comparing sleep in parents of TD and NDD children. It also highlighted

the need to investigate multiple sleep outcomes such as pre-sleep arousal, sleep efforts and insomnia symptoms in parents.

Study 2 (Chapter 3) extended the current literature by examining sleep and mood between parent-child dyads. It also compared sleep and mood outcomes in parents of TD children and children with NDD. The study surveyed 293 parents (primary caregivers) and reported significant associations in parents' sleep quality, pre-sleep arousal, sleep efforts and mood disturbance, and children's sleep disturbances and behavioural difficulties. While more than half of the adults in Western countries experience intermittent sleep problems at some point (Mollayeva et al., 2016), the parent population that completed our survey reported a higher percentage of sleep problems. Children's sleep disturbances were associated with the largest changes in parents' sleep quality, and partially mediated the associations between parent's sleep and mood. Overall, the study observed significantly poorer sleep quality, increased sleep efforts and pre-sleep arousal in parents of children with sleep disturbances, regardless of whether they were from TD or NDD paediatric populations.

Study 3 (Chapter 4) expanded these findings by investigating the concordance between sleep and night-wake associations in parent and child dyads using actigraphy. A novel method (modified blip analysis) was used to measure sustained night-awakenings in parents and their children. Secondly, the study compared actigraphy sleep outcomes and sleep variability in this dyad based on parent-reported sleep disturbances in children. Twenty parents and their children wore actigraphs for 14 nights. Results from the actigraphy study indicated high sleep-wake concordance in parent-child dyads. Further, the modified blip analysis showed that at least one-third of parents' night-wakings occur within ten minutes of their child waking up. Parent-reports were a reliable measure of children's sleep and were corroborated by the data from children's actigraphy. Results revealed that parents of children with sleep difficulties experienced increased sleep variability and increased duration of night-wakings. These results, along with self-reported sleep difficulties in parents (from Chapter 3) indicated the need to address parent's sleep.

Study 4 (Chapter 5) was a pilot investigation of a self-help mindfulness tool for sleep and mood in parents. Five parents underwent mindfulness training using a mobile phone application, at least ten minutes a day for six weeks. Self-report measures were completed at baseline and follow-up. Overall, the results indicated some benefit of the self-help mindfulness tool on parents self-reported sleep quality, insomnia symptoms and mood,

despite no significant changes in child's sleep. These initial findings suggest that the utility of such self-help tools warrants further investigation.

Discussion of findings

Reciprocal interactions in parent-child sleep and family environment

Given that sleep is a family concept, previous studies postulate that parent-child sleep is related. Accordingly, Chapter 2 systematically examined the previous literature for evidence on shared sleep dynamics between parents and children. The review noted that different facets of sleep, such as sleep quality, duration and efficiency, were related in parents (mostly mothers) and their children. It was also observed that parents of children with NDD had significantly poorer outcomes than parents of TD children. Further, children with chronic conditions such as asthma, Type I diabetes and arthritis, and their parents demonstrated poor sleep quality. Several studies implied causality, indicating that children's sleep disturbances impacted parents' sleep and not vice versa. It was also shown that as primary caregivers, parents experienced worries, were stressed and hypervigilant, and had night-wakings related to their child (Bar et al., 2016; Goldberger-Raskin, Gothelf, Bachner-Melman, Lang, & Kushnir, 2018; Meltzer & Montgomery-Downs, 2011). The overall observation was that parents might find themselves up and awake when their child has sleep difficulties, potentially contributing to poor sleep in parents.

Paradoxically, the review noted that while parents could experience sleep difficulties due to their child, children could also have sleep issues due to parental cognitions or beliefs around sleep (Buckhalt, El-Sheikh, Keller, & Kelly, 2009; Sadeh, Tikotzky, & Scher, 2010). Hence, poor sleeping practices in parents may translate to poor sleep practices in children. For instance, irregular sleep habits in parents, particularly those with an evening chronotype, affects child's sleep and increases the child's frequency of daytime dozing (Komada et al., 2009). Children have higher chances of developing insomnia if their parents have it (Zhang et al., 2010). This has led to a suggestion that parents' sleep habits are an important target for intervention, which can help improve sleep in their children (Chen et al., 2014). However, a recent systematic review on sleep in children (Belmon, van Stralen, Busch, Harmsen, & Chinapaw, 2019) determined that psychosocial factors such as screen time, socio-economic status and sleep timing play a role in child's sleep, and did not include parent's own sleep as a predictor of child's sleep. This suggests that while children's sleep disturbances are more

likely to influence their parents' sleep, parents' sleep practices may shape their children's general sleep behaviours.

Parents may also influence their children's sleep through pathways around a family environment. For instance, a child's sleep disturbance could increase parental frustration and potentially lead to greater interparental conflict due to the parent's lack of sleep (Peltz et al., 2016). The resulting marital discord can then lead to increased levels of night-time anxiety and poor sleep in children (El-Sheikh et al., 2017; Peltz et al., 2016). Similarly, parent's objective sleep and their sensitivity towards their child is linked. Mothers with poorer objective sleep continuity demonstrate decreased sensitivity towards their infants (King, Rangel, Simpson, Tikotzky, & Manber, 2020), which impacts their infant's sleep and well-being (Teti, Kim, Mayer, & Countermine, 2010). This parental sensitivity is important, as it can reduce sleep problems, night-awakenings and bedtime resistance in children (Sanders & Morawska, 2018). While decreased parental sensitivity is understudied in parents of children beyond infancy, there is a possibility that sleep deprivation can impact the way parents may respond to their children's needs, exacerbating sleep difficulties in children. Furthermore, sleep problems in children are related to parents' mood (Martin et al., 2007; Meltzer & Mindell, 2007), and psychosocial functioning, mediated by parents' depressive symptoms, sleep quality and marital aggression (Peltz et al., 2016), which suggests transactional influences in parent-child sleep.

Ultimately, the family environment plays a complex role in children's sleep and sleep disturbances. Most of these family factors are related to sleep in parents. This is because the immediate family environment is a microsystem that includes parents own background and development (Giannotti & Cortesi, 2009). Hence, poorly sleeping parents can exert an influence on the family environment with pervasive consequences for children's sleep and family functioning. Considering that sleep is a modifiable behaviour (Johnson, Billings, & Hale, 2018), one of the simplest things to do is understand how parent-child sleep is related and if improvements in parents' sleep can have positive impacts on children. It should be recognised that while more studies are needed to assess models in parent-child sleep and family factors, there is a crucial need to address links in parent-child sleep that are still understudied. Learning how children's sleep disturbances are related to multiple sleep outcomes in their parents can help identify clinically actionable mechanisms that can improve parentals sleep and functioning, with the possible flow-on effects for their child.

Pre-sleep arousal and sleep efforts in parents

One of the key issues observed in Chapter 2 was the limited number of measures used to assess parents' sleep indices. Most of the self-report studies included in the systematic review used a measure of sleep quality in parents. Outcomes such as pre-sleep arousal, which refers to psychophysiological arousal and may delay the onset of sleep (Nicassio et al., 1985), and sleep efforts that reflect attempted control over sleep or anxiety around sleep (Broomfield & Espie, 2005), were rarely included. Both factors represent insomnia symptoms and perpetuation of insomnia, indicating possible areas of sleep problems in parents. Accordingly, Chapter 3 used measures of sleep quality, pre-sleep arousal and sleep efforts to assess multiple sleep outcomes in parents. It also assessed if parent scores on these outcomes differed based on a) whether their child had sleep difficulties, and b) if the child was TD or had an NDD.

Two major observations were made. First, parents of children with sleep disturbances had significantly higher scores on somatic and cognitive pre-sleep arousal scales (PSAS), as well as sleep efforts compared to parents of children with no sleep disturbances. This suggests that parents of children with sleep difficulties may experience physiological symptoms such as increased heart rate, tightness in muscles and shortness of breath, or psychological symptoms like worrying about falling asleep or thoughts running through their head that are other commonly observed in individuals with insomnia. Second, parents of children with NDD had significantly higher scores for sleep efforts on the Glasgow sleep efforts scale (GSES). These sleep efforts are more commonly noted in poor sleepers. In contrast, good sleepers report sleep as passive and effortless (Broomfield & Espie, 2005). This illustrates that parents of children with NDD may have anticipatory anxiety around sleep and sleeplessness. Overall, parents in both groups experienced mood disturbance, which was directly related to parents' own sleep quality but was also mediated by children's sleep disturbance. This validates our observation in Chapter 2 that children's sleep disturbance can have some effect on the parent's psychosocial functioning and mood.

Furthermore, the presence of high cognitive pre-sleep arousal in parents of children with sleep disturbances is known to interfere with sleep in adults. It creates a state of hyperarousal, which suggests heightened vigilance (Ong et al., 2012) and is a key component of insomnia (Kalmbach et al., 2018). Given that parents experience heightened vigilance due to children's sleep disturbances, it is possible that this level of vigilance causes difficulties in de- arousal

in parents and prevents them from falling asleep. As discussed in the introduction to this thesis, the cognitive model of insomnia (Harvey, 2002) suggests that increased hyperarousal may be related to poor sleep quality (Cellini, Duggan, & Sarlo, 2017). Further, the 3P model highlights that this arousal can be both a predisposing and perpetuating factor of insomnia (Puzino, Amatrudo, Sullivan, Vgontzas, & Fernandez-Mendoza, 2019). Increased scores on cognitive pre-sleep arousal measure were noted as a sign of sleep reactivity (Puzino et al., 2019), and indicated insomnia symptoms in parents. Furthermore, poor sleep in these parents was related to their mood disturbances, which can create a vicious sleep-functioning cycle. Hence, teaching parents strategies around de-arousal and improving sleep quality can help. In particular, there may be benefits to increasing awareness and providing psychoeducation to parents on ways to reduce cognitive and physiological arousal prior to sleep.

Age-based associations

Previous studies have suggested links between parent and child sleep across all age-groups. Separately, studies have noted sleep associations between parents and preschool children and school-age children (Iwata et al., 2013; Urfer-Maurer et al., 2017). The literature also suggests that relations between parent and adolescent sleep may be indirect (Brand et al., 2009), possibly due to less parental control on adolescents' sleep-wake patterns. However, limited studies to date have compared parent and child sleep and subsequent links in sleep change based on different age-range in children. Some studies have reported no effect of the child's age on parent's sleep (Boergers et al., 2007; Meltzer & Mindell, 2007). Another study found no significant differences in sleep maintenance problems, sleep apnoea, and difficulty initiating sleep between different age-groups (Komada et al., 2009).

More recent studies have focussed on one particular age-range in children, which can make it difficult to ascertain how these associations may change over time. It is quite possible that while a child's bedtime, waketime and sleep duration may change over time, parental involvement may still continue, particularly if the child has a clinical condition (such as asthma, chronic rhinitis, or a sleep disorder) that impacts sleep. For instance, Gau and Merkingas noted a lack of significant associations for sleep-wake patterns in parents and their school-aged children (2004). However, Meltzer and Mindell reported that children's age was only related to their bedtime and not to other sleep indices in mothers. The findings reported in Chapter 3 supported previous studies, revealing overall sleep associations in the dyad but no age-based associations with parent's sleep in the age of the child. Biological differences in

sleep needs of an adult and a child can explain the lack of associations in parent-child sleep-wake patterns, but overall links between sleep outcomes are observed regardless of the child's age.

The mechanisms controlling these sleep associations in parent-child dyads may change over the course of a child's development. Parents of preschool children may find that their sleep is influenced by their child's night-wakings and increased parental involvement may be required throughout the night (for issues like bed-wetting or toilet training). Nightmares are also common. Lack of sleep due to increased night-wakings may prompt these parents to adopt more accommodation behaviours, such as co-sleeping (Roberts et al., 2020), which can impact a parent's sleep further. In contrast, school-age children are more likely to display bedtime resistance and have later sleep onset (Blader, Koplewicz, Abikoff, & Foley, 1997), late bedtime and earlier waketime, which can result in irregular sleep schedules and shortened sleep duration in up to 75% of children in this age-group (Li et al., 2013). This age group also experiences nightmares and parasomnias (Hochadel, Frölich, Wiater, Lehmkuhl, & Fricke-Oerkermann, 2014). Given that parent-child sleep is related, it is possible that parents of children in this age group have more variability in their sleep and shorter sleep duration, leading to the perception of poor sleep quality.

Some of the causes identified for sleep disturbances in different age-groups are modifiable. For instance, while night-wakings in children may require parental involvement, the accommodation behaviours in parents can be reduced through adequate psychoeducation and by helping parents recognise those behaviours (Honaker & Meltzer, 2014). Otherwise, issues like bedtime resistance can be dealt with via limit setting (Honaker & Meltzer, 2014). Establishing a bedtime routine early in life is related to better sleep in later childhood (Mindell, Sadeh, Kwon, & Goh, 2015). However, a recurring issue is that sleep is often overlooked in paediatric clinical practice and is often undiagnosed (Owens & Moore, 2017; Smedje, Broman, & Hetta, 2001), which can prevent parents from seeking or obtaining support. Considering the determinantal effects of sleep disturbance on both child and adult functioning, there is a need to provide parents with systematic access to sleep support and early interventions. Possible options include psychoeducation for parents in clinical settings, sleep support offered by nurses and clinicians, and school-based teaching programs.

Temporality and variability in parent-child sleep

While retrospective, subjective reports of parent-child sleep were linked, this thesis examines if concordance and temporal links in parent-child sleep and night-wakings. There was an interest in exploring whether parent-perception of their child's sleep is corroborated by actigraphy. Some of the previous studies that have examined sleep difficulties in children used objective measure for the child and not the parent, making it difficult to draw a conclusion (Rönnlund et al., 2016; Urfer-Maurer et al., 2017). Hence, in Study 3 (Chapter 4), primary caregiving parents and their children wore actigraphs for 14 nights.

An average concordance of 70% in our parent-child dyads was observed. This means for every night parents, and their child slept, 70% of sleep and wake activities were concordant or synchronised. Modified blip analysis was used to assess the concordance of night-wakings lasting five minutes or longer. These night-wakings were also significantly linked between true parents and their children in comparison to randomly matched pseudo parents and children. To note, the novel use of blip analysis showed that parents were three times more likely to wake up within ten minutes of their child's awakening than vice-versa, suggesting that children may wake up their parents more often. This study is one of the first which to examine temporal links between parent-child sleep.

The study also examined variability in sleep. Variability was defined as standard deviation from the mean for bedtime, waketime and sleep duration across 14 nights, such that larger standard deviations indicate increased sleep variability. Variability was chosen as it is increasingly linked to negative health consequences and poor functioning in both children and adults (Becker et al., 2017; Slavish et al., 2019). In Chapter 4, we observed that there was increased variability in parents' bedtime and sleep duration if their child had sleep disturbances. Theoretically, variability in parents' sleep duration may be a direct consequence of increased night-wakings linked to the child, as parents of children with sleep disturbances had longer wake after sleep onset on actigraphy.

It is suggested that sleep variability in parents should be studied further, especially if it mediates the associations between family functioning and children's sleep. This is because sleep variability affects not just health; it also has an effect on the labour market and workforce. Sleeping an hour less per night significantly decreased maternal labour force participation and the number of hours worked (Costa-Font & Flèche, 2020). It also led to

reduced household income, which was independently related to more sleep problems in children (Schwichtenberg, Abel, Keys, & Honaker, 2019). Hence, examining sleep variability in parents can outline how sleep variability affects parents and overall family functioning.

Bedtime variability was not observed for children in this study. Whether this reflects consistent bedtime routines for children is still unclear. Bedtimes routines, defined as recurring activities that parents encourage their children to follow before bed, are usually associated with shorter sleep latency, reduced night-waking and less bedtime resistance (Tikotzky, 2017). Noting whether children with lesser bedtime variability also have a more consistent bedtime routine and how it relates to their overall sleep is important to understand the mechanisms behind children's sleep disturbances.

Inconsistent with previous studies comparing parent-report and actigraphy (Rönnlund et al., 2016; Urfer-Maurer et al., 2017), our study observed that parent-reports were reliable indicators of sleep disturbances in children. Particularly, it was noted that children who had a higher level of sleep disturbance scores on the parent-report had significantly longer wake after sleep onset, demonstrating longer night-wakings or more fragmented sleep. Further, these children also experienced lower sleep efficiency. Our actigraphy results might be more consistent with parent-reports of their child's sleep patterns than those reported in other studies because children wore actigraphy for longer periods (i.e., 14 nights), in comparison to other studies that used actigraphy for seven nights (Kouros & El-Sheikh, 2017; Rönnlund et al., 2016). This captured daily fluctuations in child's sleep more comprehensively in the study. However, it must be noted that while actigraphy can provide an overview of children's sleep, it cannot provide information around other sleep-related behaviours such as nightmares and parasomnias, bedtime resistance, and difficulties in falling asleep. As primary caregivers, parents can provide such information through retrospective tools like the Child's Sleep Habits Questionnaire.

Therefore, this study demonstrates that parent-reports have excellent clinical utility and should be used as a tool to assess symptomology in children. However, these parent reports can be strengthened further with the use of actigraphy, especially when trying to assess issues around sleep timing and nature of night-waking in children or parents. Findings from Chapter 4 demonstrate that clinicians should consider factors like sleep variability in parents and children when treating sleep disturbances in either population.

Efficacy of sleep-help tools in improving parent's sleep

This thesis demonstrates poor sleep outcomes in parents of children with sleep disturbances. Parents' own sleep may be de-prioritised due to their child's night-wakings and sleep difficulties, which can impact on parental mood. Combined with previous findings in this area, the studies presented in this thesis indicate that treating parents' sleep can have a positive impact on their mood and family functioning. Considering family perspectives in sleep and well-being, it follows that one should treat parents' sleep to prevent functioning difficulties in parents and improve the future outlook for children.

Accordingly, Chapter 5 of this thesis describes a pilot study that tested the efficacy of a self-help mindfulness tool in improving parent's sleep and mood. We also examined if there were any flow-on effects to the child. Interested parents used a mobile phone app to practice mindfulness for ten minutes a day for six weeks. Comparison of baseline and follow-up data revealed large effect sizes for parents' self-reported sleep onset latency, sleep quality, cognitive and somatic arousal. While this was a self-help tool, the results are similar to other studies that have used mindfulness training to improve sleep. For instance, mindfulness reduces pre-sleep arousal or hyperarousal (Ong et al., 2012). Mindfulness-based interventions have also demonstrated positive effects on sleep in different populations (Cincotta et al., 2011; Ong et al., 2014; Ong et al., 2012; Winbush et al., 2007; Yang et al., 2020). Specifically, mindfulness can help in reducing sleep onset latency and improving sleep quality (Caldwell, Harrison, Adams, Quin, & Greeson, 2010; Gong et al., 2016; Howell, Digdon, Buro, & Sheptycki, 2008). It appears mindfulness can work on the high cognitive activity that is otherwise related to problems with de-arousal. Through acceptance, it can allow individuals to reduce their negative sleep cognitions and improve their perpetuating behaviours around sleep (Ong & Smith, 2017; Ong et al., 2012).

The preliminary outcomes from Chapter 5 suggest some benefits of self-help mindfulness training on parents' sleep and mood indices. Based on the results, it is suggested that the effectiveness of self-help tools on parents' sleep and overall family functioning should be tested further. Scaling the scope of these interventions and assessing if they have any short and long-term effects on parents is recommended, and the feasibility of such tools needs to be evaluated further. Given that sleep is a family concept, there may be further benefits in assessing the effects of such interventions on family environment and child's sleep.

Mothers as primary caregivers

Within this thesis and previous literature, we consistently observed that mothers were more likely to a) be a participant in parent-child sleep research studies, b) experience poor sleep outcomes in relation to their child. It appears that sleep problems affect mothers more than fathers, primarily because they assume more caregiving responsibilities (Eckerberg, 2004). This has been observed in the studies included in Chapter 2, where most of the participants were mothers. Studies, including both father and mother, reported greater links in maternal-child sleep in comparison to paternal-child sleep. In Chapters 3 and 4, we observed that the majority of our participants were mothers. This could be due to the fact that we only recruited primary caregivers and mothers are more likely to assume that responsibility. Child-rearing can be a potential perpetuating factor for insomnia in women (Arber et al., 2007).

Apart from caregiving, there are a few different reasons why mothers' sleep may be linked to the child. Firstly, Groeger, Zijlstra, and Dijk (2004) reported that women were significantly more likely than men to perceive children as a cause for their sleep problems. Over the years, qualitative research has observed that women's gender roles as caregivers, especially for their children, resulting in disrupted sleep (Hislop & Arber, 2003, 2006). Further, these roles also included women's engagement with the family and worries about night-time needs of the family (Arber et al., 2007). Secondly, the 'work of worrying' about family members like children and partners can be a potential sleep disruptor in women (Arber et al., 2007). The authors further suggested that this may disrupt women's access to sleep resources. Thirdly, women, in general, have higher rates of insomnia than men, and anecdotally they may refer to family responsibilities and caregiving factors behind their symptoms of insomnia. This could explain why women are more likely to participate in parent-child sleep studies and report sleep difficulties of their own. Maternal participation in these studies may indicate a need for further support or intervention around sleep, which should be considered as an outcome in future studies. It also illustrates the need to explore differences between mothers and fathers that provide primary caregiving and if the fathers may experience similar sleep difficulties.

Limitations and future perspectives

While most of the strengths and limitations of this thesis have been highlighted in each study chapter, there are some broader limitations that should be acknowledged. For instance, while we did have primary caregiving fathers completing parent-reports in Chapter 3, we observed no differences in paternal or maternal sleep. It is unclear whether this was due to similar effects of a child's sleep on primary caregivers regardless of their gender, or due to a low number of fathers participating in the study. Further, Chapter 3 included many parents who experienced poor sleep quality. It needs to be determined whether this is because parents, in general, have poor sleep or if there was a response bias and more parents responded to the questionnaire if they had sleep difficulty themselves.

Several psychosocial and parent-related factors may affect sleep in both parents and children, which were not examined within this thesis. This includes factors like parent-child attachment, which is considered an evolutionary factor behind chronic insomnia in parents (Perogamvros et al., 2020). Parent-child attachment may also be associated with how quickly parents respond to their child's night-wakings, which in turn may relate to their own sleep perceptions. Other factors, such as parenting styles and parent temperament, may impact their attention to child's sleep problems and subsequently affect their own sleep quality. Adverse parenting styles are linked to poorer sleep in children (Brand, Hatzinger, Beck, Holsboer-Trachsler, 2009; Owens et al., 1997). Parental stress, birth-order of the child and psychopathology in children may also influence the associations between parent-child sleep. Apart from this, cultural practices may also mediate the relationships between parent-child sleep. Theoretically, any factor that can increase parental involvement in their child's sleep could influence parent perception of their own sleep. Conversely, low involvement from parents may be associated with poorer sleep in children. However, how these factors may affect sleep in this dyad is still unclear. The authors note that within the literature as a whole, these factors are underexamined and would benefit from more research.

Testing phenomenological differences in a child's sleep in relation to their age is important. Within this thesis, we collapsed several age-groups and assessed parent-child sleep at a broader level. Previous studies have observed no age-based associations between parent-child sleep, and we also observed no age-based associations between the dyad. However, it is necessary to explore how children's sleep during various developmental stages differ and what sleep characteristics in parents may differ accordingly.

More research is needed to explore how parents' sleep problems can affect the family environment and have negative repercussions for children's sleep and overall development. Future studies could examine how sleep might be a protective factor against parenting stress and parent-child relationships. Investigating whether parents' sleep beliefs or cognitions have an effect on the chronicity of sleep problems in both children and their parents is essential. Longitudinal studies can be used to explore other biopsychosocial elements that can affect sleep within the family, and if clinicians and researchers can adopt certain mechanisms to modify their consequences.

It was beyond the scope of this thesis to examine how other family-level dyads or triads can affect sleep in individuals. For instance, there is a paucity of research on how having siblings, having more than one child or living in joint families can impact an individual's sleep. For instance, siblings, i.e. child-child dyads, can influence each other's sleep. While our study included parents that had more than one child, we only analysed sleep in one parent and one child. Hence, it is unclear how siblings can affect each other's sleep or how having more than one child with sleep disturbances can affect their parents. These multi-level sleep relationships need to be examined further.

The thesis did not include children that were hospitalised. Sleep in parents of these children may be worse than parents of other TD children and children with NDDs. Parents of children who are hospitalised or have chronic health conditions that need constant attention were not included as they may experience more stress due to child's condition rather than child's sleep, which in turn can impair their own sleep. These parents may also benefit from sleep interventions.

It should also be acknowledged that the nomenclature around children's sleep problems is unclear as inconsistent typologies are used. Sleep difficulties in children are usually divided into behavioural or physiological (Blunden, 2012). While it helps in distinguishing between behavioural sleep disturbances like bedtime resistance, waking up in the middle of the night, versus physiological conditions like sleep apnoea or teeth-grinding, it does not account for possible deviations. For instance, behavioural sleep problems may group both TD and NDD children together, despite the fact that NDD children may simultaneously experience a biological or physical disorder that impairs sleep. Similarly, physiological sleep disturbances may not account for behavioural sleep difficulties that can exacerbate sleep issues in children. Moreover, distinguishing sleep problems solely on the basis of whether a child has an NDD

can oversimplify the nature of sleep disturbances and other chronic health conditions such as asthma or diabetes that co-occur in both TD and NDD populations may be ignored. This demonstrates the need to consider a nomenclature that accurately captures these disturbances.

Overall, the low sample size in our pilot intervention study preluded any generalisable conclusion. Despite this, we noted some positive improvements in parents' sleep and mood with large effect sizes for changes in sleep quality and pre-sleep arousal, suggesting that sleep interventions for parents should be investigated further.

Clinical implications

Overall, more translational research is required in the context of sleep within the family unit. However, from a clinical perspective, six general strategies can be implemented when addressing sleep within families.

First of all, this research illustrates the need to routinely ask about sleep problems in both parents and their children. Clinicians should take a systematic sleep history of both parents and their children to identify if a) parents' sleep-related practices are causing unhelpful sleep behaviours in the child, b) how the nature, duration and severity of the child's sleep problems is affecting the parent, and c) if the parent or the child has a circadian rhythm disorder, physiological sleep disorder such as sleep apnoea, or conditions such as restless leg syndrome that may be exacerbating their insomnia symptoms. Further, clinicians should evaluate components such as sleep schedules and night-wakings in both parents and children, particularly sleep variability, as this can indicate whether regular bedtimes and waketimes are followed and if circadian rhythm disruptions are present in either party. Evening behaviours in the child need further inquiry, as these are not assessed by objective sleep measures, and could be one of the main issues behind parental stress and lack of sleep.

Secondly, clinicians should consider evaluating parent-child sleep using objective assessments. Wrist actigraphy is inexpensive, easy to use and commonly employed in both adult and paediatric sleep research, but maybe underutilised in clinical settings. While parent-report can provide a good overview of the child's sleep disturbances, actigraphy can help clinicians understand nightly behaviours and variations in sleep. Actigraphy can also be a good alternative when polysomnography is deemed unnecessary or expensive. Furthermore, it can be used for a few days or weeks. This type of comprehensive sleep evaluation will help identify mechanisms behind poor sleep in parents or their children. It can also help examine

parental involvement in their child's sleep and whether parents own temperaments and attachment styles might affect their sensitivity or attention to their child's awakenings.

Thirdly, there is a need to provide sleep interventions for parents. Losing sleep as a parent is considered the norm, which may prevent parents from seeking support for their sleep problems. Even when adults do seek treatment for insomnia, clinicians may overlook psychological treatments (Chung et al., 2018). Alternatively, there may be an overreliance on using behavioural treatments for children as a method of treating sleep problems in parents. This is due to the assumption that treating children's sleep can improve sleep in their parents. However, that is not always the case. For instance, Hiscock and colleagues (2015) tested the potential benefits of an intervention for children with ADHD and noted that while sleep in these children improved at both three and six months follow-up, there were no improvements in parental mental health. Similarly, a behavioural-education intervention for mother and child sleep delivered early postpartum had no significant effect on maternal sleep (Stremler et al., 2013). This does not mean that treating a child's sleep has no benefits for the parents. Research shows that providing a sleep intervention in infants is associated with greater parental efficiency and reduced parental stress (Wolfson, Lacks, & Futterman, 1992). Treatment of sleep problems in children with ASD appears to have caregiver crossover effects in forms of quality-adjusted life years (Tilford et al., 2015), indicating overall cost-effectiveness of behavioural sleep programs on the family. This means that while there are some flow-on effects of sleep interventions for children, parents themselves may benefit from more dedicated support, especially in terms of their sleep. Timely sleep interventions for children with simultaneous psychological support for parents can improve family outcomes.

Adults with sleep problems usually consult their general practitioners more often than other healthcare professionals (Chung et al., 2018). Hence, the fourth general strategy is that general practitioners must be actively encouraged to undertake a thorough sleep assessment of these parents. While parent and child sleep are interrelated, parents may potentially develop sleep difficulties of their own. This was evidenced by positive changes in their sleep using a self-help tool despite no changes in their child's sleep. These findings need further validation in terms of feasibility and efficacy, but they do provide an optimistic picture that parents of children with sleep disturbances do not have to endure sleep difficulties of their own and that there are tools available for support. General practitioners can provide frontline support through guidance on sleep hygiene and improving sleep practices, or they can offer

adequate referrals when needed. When providing these interventions, the utility of self-help tools should not be ignored. Since digital health tools are easy to use and have some benefits for mental health (Ong & Moore, 2020), clinicians can motivate parents to use evidence-based sleep support tools, such as mobile phone applications to improve their sleep.

The fifth strategy is that clinicians must consider changes in the family environment when treating children or adults' sleep. Parents who get sufficient sleep, maintain good health and eat and exercise well have more resources and energy to invest in parenting, which has a positive impact on child's development (Sanders & Morawska, 2018). Factors like shared lifestyle, family stressors, and family environment can impact an individual's sleep and mood should be taken into account.

Lastly, based on the findings from this thesis, we strongly recommend looking at sleep within the family context. Apart from the family environment, sleep in one member of the family can have profound effects on sleep in other members of the family. This illustrates the need to further understand the mechanisms that drive sleep in parents and children. Both researchers and clinicians should adopt a more family-based approach to diagnose and treat sleep problems. This means a) inquiring about the nature of family's sleep health, and particularly the child's sleep whenever an adult comes to a clinic for insomnia, and b) providing adequate resources and referrals for managing children's sleep. By having a more holistic approach, clinicians can provide customised sleep interventions for the family with an increased probability of success.

Conclusion

The overarching aim of this thesis was to examine sleep in parent-child dyads beyond infancy. This was accomplished using retrospective reports and objective sleep measures. We also examined if parent-reported sleep difficulties in children were corroborated on actigraphy. This thesis reported poor sleep quality as well as increased sleep efforts and high pre-sleep arousal in parents of children with sleep disturbances, which may indicate parental insomnia. Poor parental mood and negative affect were also observed, suggesting mood disturbances in parents that sleep poorly. Furthermore, parent-report of children's sleep difficulties were validated against actigraphy, demonstrating that parental reports about their child's sleep should be considered to be accurate. For the first time, this thesis examined temporality in parent-child night awakenings and tested the use of a self-help tool to improve

sleep in parents. Three key themes emerged. Firstly, this thesis highlighted the importance of assessing parents' sleep problems, regardless of the nature of their child's sleep disturbances. Secondly, it demonstrated the potential utility of self-help tools for improving parent's sleep and mood. Thirdly, it illustrated the need to diagnose and treat sleep problems at a family level. Transactional influences in parent-child sleep and family environment must be examined further. Children's sleep plays a role in parents' sleep difficulties, and that should not be undermined or overlooked. In future, researchers and clinicians should consider adopting a family approach when treating sleep difficulties in both children and adults. This can have positive influences on parent-child sleep, family functioning and child development.

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Appendices

Appendix – I

Risk of Bias (Chapter 2)

Study	Aims clear	Design apt for aims	Sample size justified	Target population defined?	Was sample taken correctly	Selection bias	Measures taken to address non responders	Factors and outcome measures apt for aims	Risk factors and outcome measured aptly	Is it clear what determined statistical significance	Were methods described sufficiently to be repeated	Was basic data adequately described	Non-response bias concerns? (no indicates positive)	Non-responder information given? If apt	Were result internally consistent	Were results presented for all analyses or measures	Discussion and conclusions justified by results?	Limitations discussed?	Funding sources or conflict of interest? (yes indicates lack of conflict)	Approval from participants?
	INTRO	METHODS										RESULTS					DISCUSSION		OTHER	
1. Matricciani et al.	Y	Y	N	Y	Y	Y	N/A	Y	Y	Y	Y	Y	N	N/A	Y	Y	N	Y	Y	Y
2. Staples et al.	Y	Y	N	Y	Y	Y	N/A	Y	Y	Y	Y	Y	N	N/A	Y	Y	Y	Y	Y	Y
3. Urfer-Maurer et al.	Y	Y	N	Y	Y	Y	N/A	Y	Y	Y	Y	Y	N	N/A	Y	Y	Y	Y	Y	Y
4. Kouros et al.	Y	Y	N	Y	Y	Y	N/A	Y	Y	Y	Y	Y	N	N/A	Y	Y	Y	Y	Y	Y
5. Rönnlund et al.	Y	Y	N	N	Y	N	N/A	Y	Y	Y	Y	Y	N	N/A	Y	Y	Y	Y	Y	Y
6. Fuligni et al.	Y	Y	N	Y	Y	Y	N/A	Y	Y	Y	Y	Y	N	N/A	Y	Y	Y	Y	Y	Y
7. Lee et al.	Y	Y	N	Y	Y	Y	N/A	Y	Y	Y	Y	Y	N	N/A	Y	Y	Y	Y	Y	Y
8. Iwata et al.	Y	Y	N	Y	Y	Y	N/A	Y	Y	Y	Y	Y	N	N/A	Y	Y	Y	Y	Y	Y
9. Bajoghli et al.	Y	Y	N	Y	Y	Y	N/A	Y	Y	Y	Y	Y	N	N/A	Y	Y	Y	Y	Y	Y
10. Kalak et al.	Y	Y	N	Y	Y	Y	N/A	Y	Y	Y	Y	Y	N	N/A	Y	Y	Y	Y	Y	Y
11. Zhang et al.	Y	Y	N	Y	Y	Y	N/A	N	Y	Y	N	Y	N	N/A	Y	Y	Y	Y	Y	Y
12. Li et al.	Y	Y	N	Y	Y	Y	N/A	Y	Y	Y	N	Y	N	N/A	Y	Y	Y	Y	Y	Y
13. Brand et al.	Y	Y	N	Y	Y	Y	N/A	Y	Y	Y	Y	Y	N	N/A	Y	Y	Y	Y	Y	Y
14. Meltzer et al.	Y	Y	N	Y	Y	Y	N/A	Y	Y	Y	Y	Y	N	N/A	Y	Y	Y	Y	Y	Y
15. Boergers et al.	Y	Y	N	Y	Y	Y	N/A	Y	Y	Y	Y	Y	N	N/A	Y	Y	Y	Y	Y	Y
16. Gau et al.	Y	Y	N	Y	Y	Y	N/A	Y	Y	Y	Y	Y	N	N/A	Y	Y	Y	Y	Y	Y
17. Goldberger-Raskin et al.	Y	Y	N	Y	Y	Y	N/A	Y	Y	Y	Y	Y	N	N/A	Y	Y	Y	Y	Y	Y
18. Daniel et al.	Y	Y	N	Y	Y	Y	N/A	Y	Y	Y	Y	Y	N	N/A	Y	Y	Y	Y	Y	Y
19. Jaser et al.	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N/A	Y	Y	Y	Y	Y	Y
20. Yuwen et al.	Y	Y	N	Y	Y	Y	N/A	Y	Y	Y	Y	Y	N	N/A	Y	Y	Y	Y	Y	Y
21. Bar et al.	Y	Y	N	Y	Y	Y	N/A	Y	Y	Y	Y	Y	N	N/A	Y	Y	Y	Y	Y	Y
22. Goldman et al.	Y	Y	N	Y	Y	Y	N/A	Y	Y	Y	Y	Y	N	N/A	Y	Y	Y	Y	Y	Y
23. Hodge et al.	Y	Y	N	Y	Y	Y	N/A	Y	Y	Y	Y	Y	N	N/A	Y	Y	Y	Y	Y	Y
24. Wayte et al.	Y	Y	N	Y	Y	Y	N/A	Y	Y	Y	Y	Y	N	N/A	Y	Y	Y	Y	Y	Y
25. Goldman et al.	Y	Y	N	Y	Y	Y	N/A	Y	Y	Y	Y	Y	N	N/A	Y	Y	Y	Y	Y	Y
26. Chu et al.	Y	Y	N	Y	Y	Y	N/A	Y	Y	Y	Y	Y	N	N/A	Y	Y	Y	Y	Y	Y
27. Lopez-Wagner et al.	Y	Y	N	Y	Y	Y	N/A	Y	Y	Y	Y	Y	N	N/A	Y	Y	Y	Y	Y	Y
28. Hoffman et al.	Y	Y	N	Y	Y	Y	N/A	Y	Y	Y	Y	Y	N	N/A	Y	Y	Y	Y	Y	Y
29. Adiga et al.	Y	Y	N	Y	Y	Y	N/A	Y	Y	Y	Y	Y	N	N/A	Y	Y	Y	Y	Y	Y

Figure: Quality assessment of the 29 studies included in the systematic review.

Appendix – II

Example actigraphy records

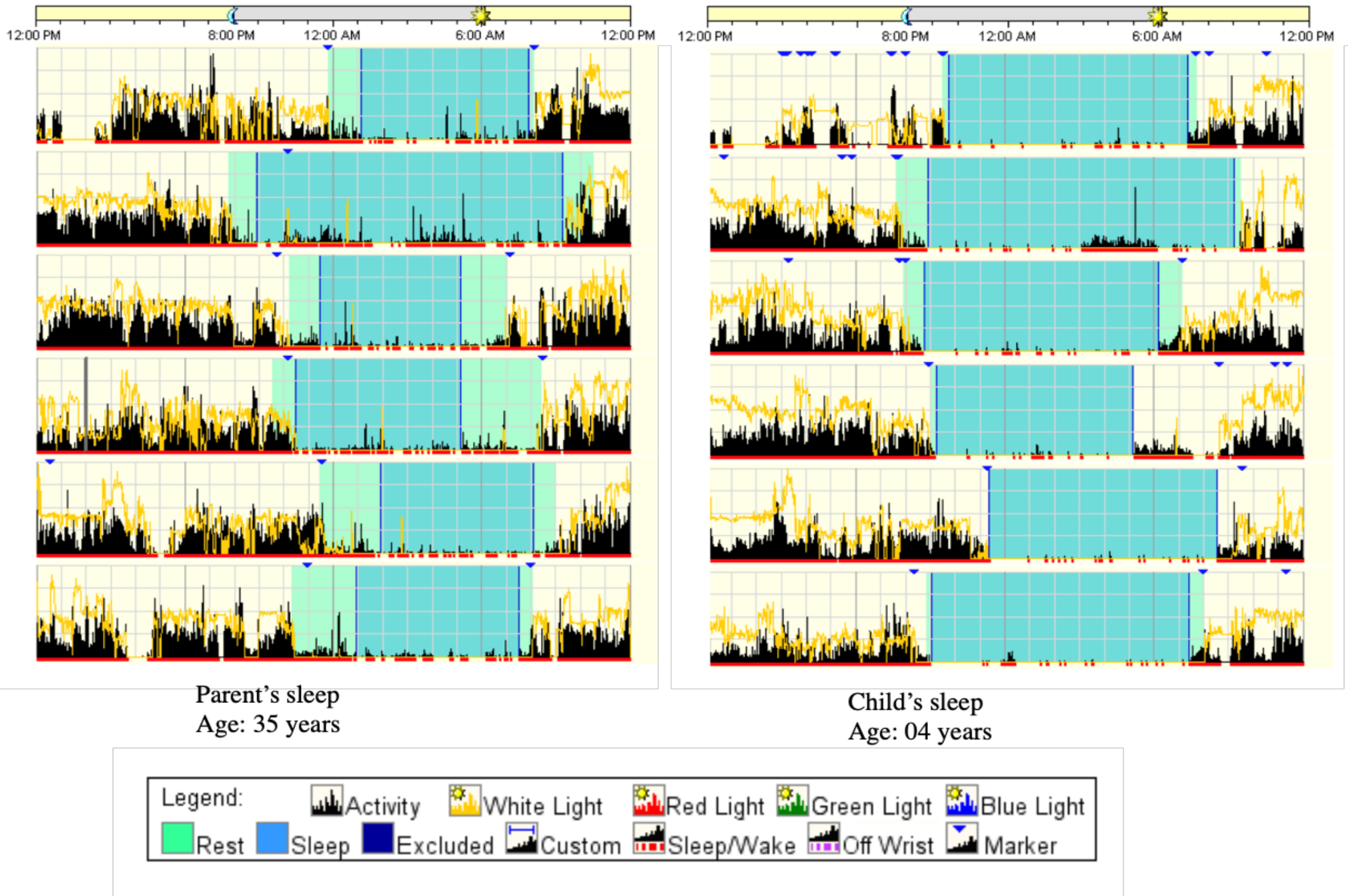

Figure: An example of seven-day actigraphy record for a parent (mother) and their child.

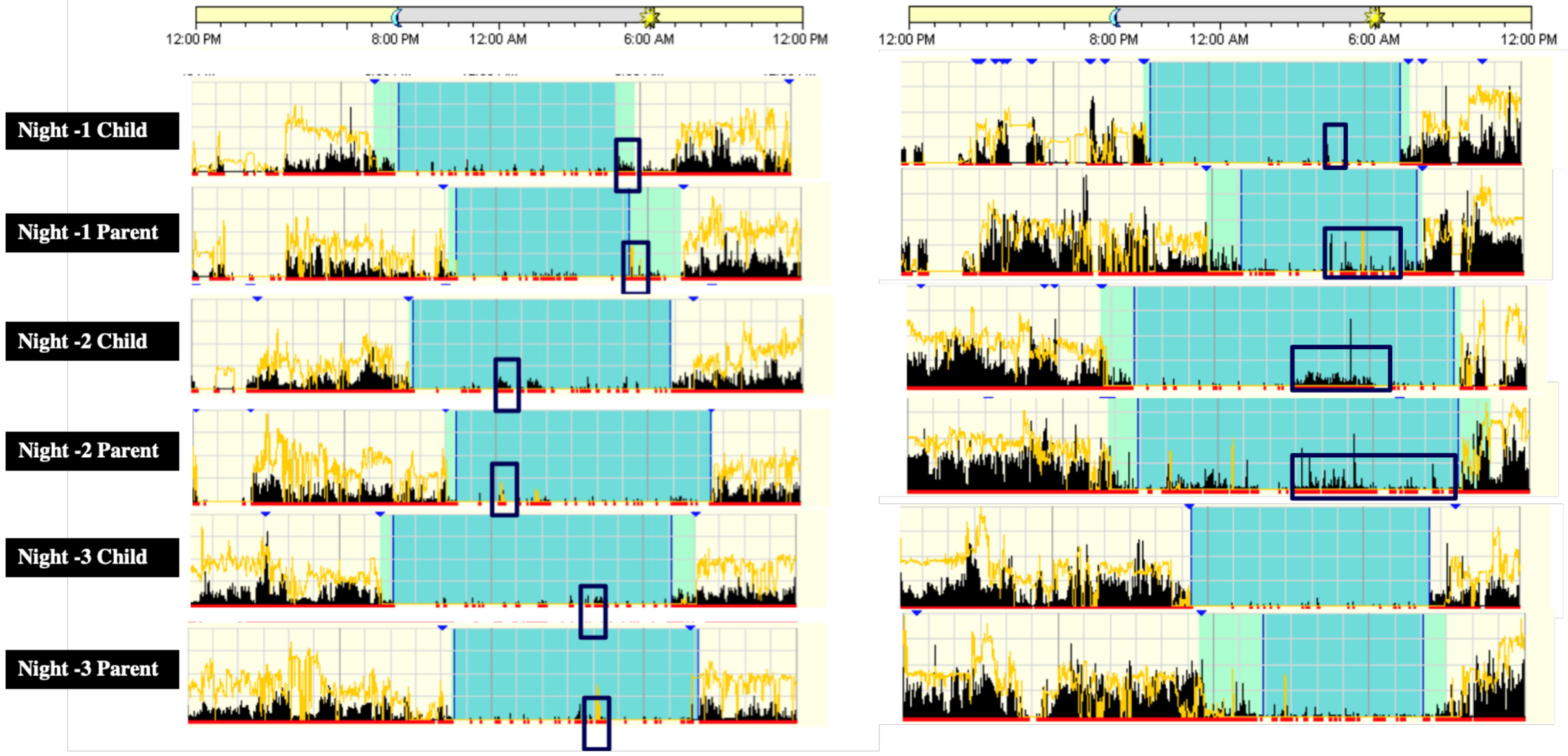

Figure: Night-wakings (recorded using movement sensor) by actigraphy. Two records presented – a) parent and their child with no sleep disturbances (i.e. CSHQ score of <41), and b) parent and their child with sleep disturbance (i.e. CSHQ score >41). Note the differences waking bouts between parent of the child without sleep disturbance and parent of the child with sleep disturbance.

Department of
Education & Training

2 Treasury Place
East Melbourne Victoria 3002
Telephone: 03 9637 2000
DX210083

2017_003408

Miss Prerna Varma
School of Health and Biomedical Sciences
RMIT University
Plenty Road
KINGSBURY 3803

Dear Miss Varma

Thank you for your application of 12 May 2017 in which you request permission to conduct research in Victorian government schools and early childhood settings titled *An Investigation of Sleep in Parents of Children with Sleeping Problems.*

I am pleased to advise that on the basis of the information you have provided your research proposal is approved in principle subject to the conditions detailed below.

1. Department approved research projects currently undergoing a Human Research Ethics Committee (HREC) review are required to provide the Department with evidence of the HREC approval once complete.

2. The research is conducted in accordance with the final documentation you provided to the Department of Education and Training.

3. Separate approval for the research needs to be sought from school principals and centre directors. This is to be supported by the Department of Education and Training approved documentation and, if applicable, the letter of approval from a relevant and formally constituted Human Research Ethics Committee.

4. The project is commenced within 12 months of this approval letter and any extensions or variations to your study, including those requested by an ethics committee must be submitted to the Department of Education and Training for its consideration before you proceed.

5. As a matter of courtesy, you advise the relevant Regional Director of the schools or governing body of the early childhood settings that you intend to approach. An outline of your research and a copy of this letter should be provided to the Regional Director or governing body.

6. You acknowledge the support of the Department of Education Training in any publications arising from the research.

7. The Research Agreement conditions, which include the reporting requirements at the conclusion of your study, are upheld. A reminder will be sent for reports not submitted by the study's indicative completion date.

I wish you well with your research. Should you have further questions on this matter, please contact Youla Michaels, Project Support Officer, Insights and Evidence Branch, by telephone on (03) 9637 2707 or by email at michaels.youla.y@edumail.vic.gov.au.

Yours sincerely

28/06/2017

VICTORIA
State Government

College Human Ethics Advisory Network (CHEAN)
College of Science, Engineering and Health

Email: seh-human-ethics@rmit.edu.au
Phone: [61 3] 9925 4620
Building 91, Level 2, City Campus/Building 215, Level 2, Bundoora West Campus

3 February 2017

Dr Russell Conduit
School of Health and Biomedical Sciences
RMIT University

Dear Dr Conduit

ASEHAPP 02-17 An investigation of sleep in parents of children with sleeping problems

Thank you for submitting your amended application for review.

I am pleased to inform you that the CHEAN has approved your application for a period of **18 Months** from the date of this letter to **3 August 2018** and your research may now proceed.

The CHEAN would like to remind you that:

All data should be stored on University Network systems. These systems provide high levels of manageable security and data integrity, can provide secure remote access, are backed up on a regular basis and can provide Disaster Recover processes should a large scale incident occur. The use of portable devices such as CDs and memory sticks is valid for archiving; data transport where necessary and for some works in progress. The authoritative copy of all current data should reside on appropriate network systems; and the Principal Investigator is responsible for the retention and storage of the original data pertaining to the project for a minimum period of five years.

Please Note: Annual reports are due on the anniversary of the commencement date for all research projects that have been approved by the CHEAN. Ongoing approval is conditional upon the submission of annual reports failure to provide an annual report may result in Ethics approval being withdrawn.

Final reports are due within six months of the project expiring or as soon as possible after your research project has concluded.

The annual/final reports forms can be found at:
www.rmit.edu.au/staff/research/human-research-ethics

Yours faithfully,

Associate Professor Barbara Polus
Chair, Science Engineering & Health
College Human Ethics Advisory Network

Cc	Student Investigator/s:	Ms Prerna Varma, School of Health & Biomedical Sciences
	Other Investigator/s:	Dr Melinda Jackson, School of Health & Biomedical Sciences

Human Research Ethics Committee (HREC)
Research Integrity, Governance & Systems

Email: humanethics@rmit.edu.au
Phone: [61 3] 9925 2251
Building 91, Level 2, City Campus

26 June 2017

Dr Russell Conduit
School of Health and Biomedical Sciences
RMIT University

Dear Russell

RE: HREC20762 *Examining the efficacy of two interventions on sleep in parents of children with sleep problems*

Thank you for submitting the above ethics application for consideration by the Human Research Ethics Committee (HREC) of RMIT University.

The application was considered and reviewed by the HREC at meeting 05/17 held Wednesday 21 June 2017.

Status: Conditionally approved subject to minor amendments

In accordance with the requirements of the *National statement on ethical conduct in human research*, *NHMRC, 2007* (NS) the HREC requires further information and/or clarification on the following points before approval can be granted:

1. Application Form;
    a. Section 2.1:
        i. Details of two interventions (MBT-I and sleep education) are not clear. There is information in the application, research protocol and in the PIS&CF. Please revise application form and ensure consistency (NS, 1.1).
        ii. Please ensure it is clear in the application when you are referring to participants whether you are referring to adults or their children. Please revise (NS, 1.4).
    b. Section 3.1:
        i. It was noted that that a sample of 100 participants will be sought. Please clarify what this number includes. Are children counted as well, and advise how this figure was determined (NS, 1.4).
2. Attachments;
    a. Research protocol
        i. Please advise how randomisation sequence is generated. Also, what's the participation allocation method and advise whether participants are blinded to allocation and the outcome measure.
        ii. Please use CONSORT flowchart to present figure 1 'study outline' in order to improve clarity. 'Figure 1' does not clearly indicate the interventions, who receives them, and the time points of outcome measures.
        iii. What is the WHO format on research protocol?
        iv. Is randomised comparator group trial a typical randomised controlled trial (RCT)? If not please indicate the key elements of this unique trial design.
    b. Child Participant Information Statement

Human Research Ethics Committee (HREC)
Research Integrity, Governance & Systems

Email: humanethics@rmit.edu.au
Phone: [61 3] 9925 2251
Building 91, Level 2, City Campus

i. The tone of this document should be re-considered so it is clear that it is not the parents who are responsible for the research or who are asking their child to take part. It should also be clear that the child has a choice in the matter. This should be re-worded to show that it is part of a research project conducted by researchers not the parents. For example, re-write 'You have to wear it every day …' to something like 'The researcher would like you to wear it …'.
It is noted that the child is told by the parent that 'we will give you a watch to wear'. The child should also be informed if they are only having this watch during the time of the study or whether they will retain it. Questions about the research '[do you have any questions you would like to ask?'] need to be directed to researchers not parents. Perhaps, this should say something like 'if you have any questions about the research that I can't answer, I will ask the researcher to find the answer'. Please revise.

c. Participant Information Statement and Consent Form (PIS&CF):
   i. The title of the project mentions 'two interventions'. A reasonable question for participants to ask is what are the two interventions and what is the difference? Should these points be addressed in the PIS? Please consider and revise where necessary.
   ii. In item 6 please commence section with standard wording; i.e., 'We cannot guarantee or promise that you will receive any benefits from this research…'.
   iii. In item 8 there is the vague comment that the '…information complies with the law'. Please revise or delete.
   iv. In item 10 it is stated that 'all personally identifiable information will be removed'. Does this mean that identifiable information will not be retained? Please clarify or confirm.
   v. It is indicated that questions from participants would be directed towards the student researcher (section 13). As this is a trial it would be more appropriate for the chief investigator to receive inquiries regarding the project from participants. Please revise.

Responding to conditional approval

Please respond to each of the above points in a summary letter/table, which captures the points and the responses to these points, including reference to supporting documentation. Revise the application and any other relevant documentation i.e. Participant Information and Consent Form (PICF), recruitment materials, research instruments, etc, as required.

Email your letter/table of response along with copies of all supporting documentation to humanethics@rmit.edu.au for review.

Please note, if the committee does not receive a response to this letter within six weeks from the date of the letter, it will be assumed that you are no longer seeking approval for your project and your application will be withdrawn.

If there is anything in this letter that you are unclear about or require further clarification upon then please contact the HREC secretary, Dr Peter Burke.

Yours sincerely

Human Research Ethics Committee (HREC)
Research Integrity, Governance & Systems

Email: humanethics@rmit.edu.au
Phone: [61 3] 9925 2251
Building 91, Level 2, City Campus

Professor Stephen Bird
Chair, Human Research Ethics Committee
RMIT University

cc Ms Prerna Varma, Principal research student
Dr Melinda Jackson, Co-investigator/Associate supervisor
Dr Peter Burke, HREC secretary.