Development and Validation of a Pediatric Insomnia Composite

by

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Dedication Page

I would like to dedicate my thesis to my parents, Heather and Mike, for their unconditional love and support. Without your encouragement, this thesis would not have been possible. In addition, I would like to extend the dedication of this thesis to my best friend, Zach and his girlfriend Kaya, who both tragically passed away on February 21st, 2016. Both of you will always be in my mind and heart with everything I do and accomplish.

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Abstract

Insomnia affects approximately 20-30% of children with consequences on daytime functioning, academic performance, social functioning, and quality of life. Insomnia is a multifaceted construct with symptoms including difficulties falling asleep, staying asleep, and waking too early. The aim of this thesis was to develop and validate a sleep diary-derived composite outcome of childhood insomnia for future treatment studies. To this end, the Pediatric Insomnia Composite (PIC) was developed and this secondary data analysis explored the psychometric properties of the PIC on a sample of 377 typically developing children aged 1 to 10 years who met criteria for insomnia. Our results indicated that the PIC has adequate construct validity and a factor structure that mapped onto the three expressions of insomnia symptoms. However, more work is needed to strengthen the internal consistency of PIC factors before implementing it in research, and potentially using this composite in clinical settings.

List of Abbreviations and Symbols Used

AASM	American Academy of Sleep Medicine
ADHD	Attention-Deficit/Hyperactivity Disorder
ANOVA	Analysis of Variance
BNBD	Better Nights, Better Days
CBCL	Child Behavior Checklist
DIMS	Disorders of Initiating and Maintaining Sleep
DSM-5	Diagnostic and Statistical Manual of Mental Disorders, 5th edition
EFA	Exploratory Factor Analysis
EMW	Early Morning Wakings
ICC	Intraclass correlation coefficient
PIC	Pediatric Insomnia Composite
POMP	Percent of Maximum Possible
PSG	Polysomnography
PSQ	Pediatric Sleep Questionnaire
SDSC	Sleep Disturbance Scale for Children
SOL	Sleep Onset Latency
TCSQ	Tayside Children's Sleep Questionnaire
TST	Total Sleep Time

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Chapter 1: INTRODUCTION

1.1 Thesis Overview

Sleep is a vital physiological process for the development and maintenance of a person's physical and mental health across their lifespan (Curcio et al., 2006; Tham et al., 2017; Mireku et al., 2019). Despite the critical role of sleep in development, sleep problems are highly prevalent, with insomnia being the most common sleep disorder affecting between 20 – 30% of children (Corkum & Vriend, 2011; Corkum et al., 2018; Owens, 2008a). Insomnia is defined in the DSM-5 as a predominant complaint of dissatisfaction with sleep quantity or quality, associated with one (or more) of the following symptoms: difficulty initiating sleep, difficulty maintaining sleep, and/or early-morning awakenings with an inability to return to sleep (DSM-5, 2013). Insomnia in childhood has been associated with many adverse outcomes, including reduced daytime functioning, academic performance, social outcomes, and quality of life, with negative secondary effects on the child's family (e.g., loss of work productivity) (Corkum & Vriend, 2011; Owens, 2008a). Behavioral and cognitive-behavioral interventions for treatment of childhood insomnia have been demonstrated to be efficacious for abating the adverse daytime consequences of insomnia, as well as improving the functioning and well-being of parents (Tikotzky & Sadeh, 2010).

In treatment studies, the primary outcome is the variable that the investigator(s) considers to be most important. It must be selected a priori in the study protocol in order to be a valid statistical test of the hypotheses (Andrade, 2015). Deciding how to measure multifaceted constructs, such as sleep, with a single outcome measure can be challenging

due to the broad range of potential variables. As an example, a pediatric sleep researcher plans to compare the impact of a new sleep-intervention on children's sleep with children who do not receive the intervention. The researcher has a breadth of variables to select as the primary outcome to demonstrate improvements in sleep as a result of the novel intervention, such as: total sleep time, sleep efficiency (i.e., the amount of total sleep divided by the amount of time spent in bed with the intention of falling asleep), sleep onset latency (i.e., the difference between the time when a child gets into bed and the time when the child falls asleep), independent sleeping (i.e., without a parent or other person there while trying to fall asleep), frequency and duration of nighttime awakenings, early morning wakings, and bedtime resistance (i.e., bedtime delay due to bedtime refusal, refusal to stay in bed, stalling). However, by selecting one sleep-related variable as the primary outcome, the researcher narrows the scope of study to a single domain of sleep. Therefore, other variables relevant to the multifaceted nature of sleep, will not be examined. To address the issue of selecting a single primary outcome variable to measure multidimensional constructs, pediatric sleep researchers have previously utilized composite outcomes (Richman & Graham, 1971; Richman, 1981; Wiggs & Stores, 1998; Montgomery et al., 2004; Gaylor et al., 2005; Appleton et al., 2012). Composite outcomes include many variables and are advantageous to capture multiple domains of a construct when used as the primary outcome of a study (Ferreira & Patino, 2017).

To our knowledge there are only six pediatric sleep studies that have used composite outcomes (Richman & Graham, 1971; Richman, 1981; Wiggs & Stores, 1998; Montgomery et al., 2004; Gaylor et al., 2005; Appleton et al., 2012). Measures used to develop these composites range from retrospective questionnaires to daily-logged sleep

diaries, with composites including variables related to settling duration and duration of night wakings (for more details on previously developed sleep composites please see Table A1-1 in the appendix section). Existing sleep composite outcomes are limited due to the absence of important sleep variables, absence of psychometric evaluation, and a lack of standardization of scores that enable meaningful comparisons between studies. Thus, the current study attempted to fill a gap by developing a composite measure of pediatric insomnia that is standardized and captures multiple aspects of sleep.

The primary goal of this study was to develop a new sleep composite outcome, called a Pediatric Insomnia Composite (PIC), from sleep diary data and examine its psychometric properties among typically developing children ages 1 to 10 years old (including toddlers, preschoolers, and school-aged children) who met criteria for insomnia. Exploratory Factor Analysis (EFA) was used to assess the dimensionality of the scale overall, as well as across each age group. Next, we assessed the internal consistency of items in the PIC using Cronbach's alpha for all children and across the three age groups. To evaluate the construct validity of the PIC, we assessed the convergent validity between the PIC and previously validated measures of pediatric insomnia, including actigraphy (i.e., a wrist-watch like device that uses an accelerometer to measure aspects of sleep), the Tayside Children's Sleep Questionnaire (TCSQ; McGreavy et al., 2005), and the Sleep Disturbance Scale for Children (SDSC; Bruni et al., 1996). Moreover, we assessed the discriminant validity between the PIC and the Child Behavioral Checklist (CBCL; Achenbach & Rescorla, 2000; Achenbach & Rescorla, 2001) using a two-way mixed effects model. Lastly, we evaluated the PIC's

treatment sensitivity from baseline to follow-up (i.e., 4 months post-randomization) using a repeated-measures analysis of variance (ANOVA).

To achieve the objectives of this study, we performed a secondary data analysis using baseline data from the Better Nights, Better Days (BNBD) study; a 2-arm randomized control trial (RCT) of an eHealth intervention for typically-developing children ages 1 to 10 years who present with insomnia (Corkum et al., 2018). Potential participants were not eligible to enroll in the BNBD-study if their child had received a diagnosis of any of the following disorders at the time of the study: a probable intrinsic sleep disorder (e.g., sleep apnea), a significant medical disorder that interferes with sleep (e.g., asthma attacks during the night), and/or a mental health disorder that required hospitalization or residual care and/or psychotropic medication use (e.g., stimulant medication for Attention-Deficit/Hyperactivity Disorder). Additionally, participants who chose to bed-share with their child were excluded from the BNBD study as the primary intervention approach is independent sleeping for the child.

The expected contribution of the current study is to offer a standardized and validated sleep diary-derived composite outcome that can be used as the primary outcome variable in the measurement of childhood insomnia in treatment studies. In addition to the utility of the PIC for pediatric sleep researchers, the PIC has potential to be used clinically. For example, in a clinical setting, the PIC could be used to summarize insomnia symptoms in children when data is collected using a sleep diary. Without a sleep diary composite, clinicians are left with large amounts of data that is difficult to interpret in a way that is meaningful for patients, parents of patients, or for clinical decision making and treatment monitoring.

Chapter 2: BACKGROUND & LITERATURE REVIEW

2.1 Sleep

Sleep is an essential biological process for the maintenance of a person's physical and mental health, and can be defined as "*an active, repetitive and reversible behaviour serving several different functions, such as repair and growth, learning or memory consolidation, and restorative processes: all these occur throughout the brain and the body."* (Curcio et al., 2006, p. 323). Researchers in the field of sleep medicine perceive sleep-wake cycles as interrelated processes, orchestrated through changes in cognitive, behavioral, electrical, cellular, biochemical, molecular, and endocrine functioning (Jan et al., 2010). A collection of neurons in the suprachiasmatic nucleus (SCN) of the hypothalamus are responsible for initiating and regulating the transitions of sleep-wake cycles, through a physiological process called the circadian rhythm (Drouyer et al., 2007; Khullar, 2012). The circadian rhythm is a biological clock in humans and other diurnal mammals that responds primarily to variations in environmental light levels (Drouyer et al., 2007; Khullar, 2012). When there is a decrease or absence of light, neurons in the SCN activate and trigger the release of melatonin, a hormone from the pineal gland (Drouyer et al., 2007). Once released, melatonin causes an increase in the propensity for sleep (Khullar, 2012). Individuals who have disrupted or abnormal circadian rhythms and melatonin release often experience sleep loss and the adverse effects of insufficient sleep.

2.2 Insufficient Sleep

Insufficient sleep can be defined as a significant loss of sleep during a period of time which results in neurological and/or physical impairment (Parish, 2009; van Cauter et al., 2007). It is important to mention that terms such as insufficient sleep, inadequate sleep, short sleep duration, sleep loss, sleep deprivation, and sleep restriction are interchangeably used to describe "less sleep than needed" and do not imply specific amounts of sleep (Owens, 2014). A lack of sleep quantity can lead to inadequate sleep, but poor sleep quality is also an important factor (Curcio et al., 2006). Moreover, insufficient sleep can be either chronic or acute, as well as partial or total (Jan et al., 2010). Acute sleep loss occurs when insufficient sleep quantity or quality is acquired during a brief time period (i.e. <24-hours). When a lack of adequate sleep becomes persistent, the condition is considered to be a chronic sleep problem (Potter et al., 2016).

Over the past three decades in North America, children are tending to go to bed later while school start times have remained unchanged (Vriend et al., 2012). Thus, there has been a recent decline in children's total sleep durations (Matricciani et al., 2013). In 2006, the international pediatric task force declared insufficient sleep in children to be a major public health concern (Hafner et al., 2017). Chronic sleep insufficiency in children has been associated with many adverse consequences in many areas of functioning, including: cognitive development, regulation of affect, health outcomes, overall quality of life, as well as parental and family functioning (Corkum & Vriend, 2011; Corkum et al., 2018; Boergers & Konnis-Mitchell, 2010). Moreover, inadequate sleep may lead to the reduction of brain functions important for executive functioning, such as learning,

memory, and attention, which may impair a child's ability to maximize their learning and academic performance (Corkum & Vriend, 2011).

In children, there are many different types of sleep problems, some of which are primarily associated with physiological etiologies (e.g., sleep apnea) and others which have primarily behavioral etiologies (e.g., insomnia) (Gruber et al., 2012; Hannah & Hiscock, 2015; Corkum & Vriend, 2011). Examples of physiological factors that can impact sleep include, hypertension, chronic pain, lung disease, and depression (Parish, 2009; van Cauter et al., 2007; Gruber et al., 2012; Hannah & Hiscock, 2015). Behavioral factors that can lead to insufficient sleep include the use of electronic devices (especially when approaching bedtime), caffeine, inconsistent bedtime, anxiety, stress, and a lack of exercise (Meltzer, 2010). In children, it is more common for sleep problems to be associated with behavioral etiologies (Corkum & Vriend, 2011; Corkum et al., 2018).

2.3 Descriptive Epidemiology of Childhood Insomnia

In typically developing children ages 1 to 12 years old, lifetime prevalence estimates of sleep problems range from 25% to 40% and occur throughout all developmental periods (Corkum & Vriend, 2011; Corkum et al., 2018). In infants (aged 1 to 2 years) the most common sleep problem is frequent and/or lasting night awakenings (Burnham et al., 2002). In preschool-aged children (aged 3 to 5 years), sleep problems related to difficulties with initiating (i.e., sleep onset) and maintaining (i.e., night wakings) sleep are the most prevalent (Kerr & Jowett., 1994; Schlarb et al., 2006). In school-aged children (aged 6 to 12 years), bedtime resistance and difficulties with sleep initiation are the most commonly reported sleep problems (Owens et al., 2000a).

Collectively, sleep problems related to resisting bedtime, difficulties initiating and maintaining sleep, awakening in the night, or waking too early in the morning, are known as insomnia (DSM-5, 2013; AASM, 2014). Insomnia is the most common sleep disorder in children and is highly prevalent (i.e., with lifetime prevalence estimates ranging between 20% to 30%) (Corkum & Vriend, 2011; Meltzer & Mindell, 2014) and impairing (Owens, 2008a). Other common sleep disorders include restless legs syndrome and periodic limb movement disorder (prevalence estimates range between 2% to 6% of the pediatric population ages 8 to 17 years old), parasomnias (behaviors that intrude upon sleep such as sleep walking and sleep talking; affecting roughly 13% of children), and sleep-related breathing disorder (e.g., obstructive sleep apnea, affecting between 1 to 3% of the general pediatric population) (Maski & Owens, 2018; Sateia et al., 2017). However, as insomnia is the most common sleep disorder in children, the remainder of this paper will focus on childhood insomnia.

2.4 Measurement of Sleep-Wake Cycles

Accurate measurement of sleep quantity and quality is crucial in order to assess that a child's sleep needs are being satisfied (Markovich et al., 2015). When measuring sleep in children, a variety of methods exist that differ in their degree of subjectivity and objectivity (Markovich et al., 2015; Francetich, 2014). Objective measures of sleep include polysomnography and actigraphy, whereas, subjective measures consist of sleep diaries and questionnaires.

2.4.1 Objective Measures

2.4.1.1 Polysomnography (PSG)

PSG is commonly used in the field of sleep medicine for evaluating sleep-related pathophysiology (Wong & Ng, 2015). It is typically conducted within a hospital or sleep center and is used to diagnose sleep disorders, particularly those with physiologically etiologies, such as sleep apnea (Ancoli-Israel et al., 2003). PSG records a patient's brain waves, blood oxygen levels, heart rate, breathing patterns, as well as eye and leg movements during a nighttime of sleep, in a controlled environment (Meltzer et al., 2012). While the controlled setting is advantageous as it allows for the monitoring of many physiological processes related to sleep, this gain in control is at the expense of reduced ecological validity (Markovich et al., 2015; Ancoli-Israel et al., 2003). Further, PSG is costly, and its use is impractical and often viewed as intrusive when studying certain populations, such as pediatric populations with insomnia (Corkum & Vriend, 2011; Marino et al., 2013).

Although PSG has been considered as the "gold-standard" for measuring sleep-wake cycles since the 1960's, its use for evaluating patients with insomnia is controversial (Ancoli-Israel et al., 2003; Marino et al., 2013; Littner et al., 2003). In 2003, the American Academy of Sleep Medicine (AASM) released practice guidelines for use of PSG to evaluate patients who present with complaints of insomnia (Littner et al., 2003). The AASM recommended against the use of routine PSG for clinical evaluation of transient or chronic insomnia for several reasons. First, most normal sleepers experience some loss of sleep quantity or quality when they sleep in a laboratory, called the "first night effect" (Littner et al., 2003). Second, as insomnia

typically varies in severity across nights, a single night of evaluation may not accurately characterize the extent of the sleep problem (Littner et al., 2003). Third, in some patients with insomnia, objective findings from PSG indicate the absence of a sleep problem while patient-complaints remain (Littner et al., 2003).

2.4.1.2 Actigraphy

Compared to PSG, actigraphs are less expensive and provide a non-invasive method of objectively measuring a person's sleep patterns, in their natural and primary sleep environment (Sivertsen et al., 2006; Martin & Hakim, 2011). Actigraphs are devices typically worn on the wrist or ankle (i.e., depending on the person's age with younger children wearing the device on their ankle and older children and adults wearing the device on the wrist of their non-dominant arm) that records movement patterns continuously over a 24-hour period using an accelerometer and memory storage (Corkum & Vriend, 2011; Sivertsen et al., 2006). In addition to recording movement, actigraphs are often equipped with light sensors and a button that allows participants to mark events (e.g., bedtime) (Francetich, 2014; Ancoli-Israel et al., 2003). Computer algorithms are used to convert, and transfer data collected from the actigraph's memory onto a computer for future analysis (Ancoli-Israel et al., 2003). Actigraphy is inexpensive relative to PSG and offers greater ecological validity than PSG (Sivertsen et al., 2006; Martin & Hakim, 2011). Thus, it has become an increasingly popular method for measuring sleep parameters in both research and clinical settings over the past 30 years (Ancoli-Israel et al., 2003; Waldon et al., 2016).

Despite its advantages, the use of actigraphy has some limitations. First, most actigraphs must be removed in situations where water can damage the device (e.g., swimming, bath time), resulting in periods with missing data capture. Second, actigraphs have been demonstrated to be less accurate when studying populations with atypical sleep and movement patterns (e.g., children with neurodevelopmental disorders such as attention-deficit/hyperactivity disorder (ADHD)) (Corkum et al., 1998; Sadeh, 2011). Third, actigraphy is used to record movement patterns and not brain activity, and thus, provides an indirect measure of a child's sleep patterns and no information about sleep stages (Martin & Hakim, 2011). Moreover, as actigraphy records only movement patterns, the range of variables captured using these devices is limited (Markovich et al., 2015). Fourth, there is some degree of subjectivity in the scoring procedure used for actigraphic data, as interpretation of actigraphy data relies on parental recordings of events, such as recording the time a child was "Down for the Night" (i.e., in bed for the night) (Ancoli-Israel et al., 2015).

2.4.1.3 Concordance of PSG and Actigraphy

Validation studies have shown that actigraphy has a moderately-high to high overall concordance with PSG (i.e., concordance ranges from 81-91%) for estimating sleep variables in adults with impaired sleep (Ancoli-Israel et al., 2003; Martin & Hakim, 2011). Compared to PSG, actigraphy was found to be valid and reliable for recording sleep in healthy adult populations, but less reliable in samples of unhealthy adults as sleep became more disrupted (Ancoli-Israel et al., 2003). Validation studies focusing on actigraphy and PSG in youth have reported similar findings to those conducted in adult

populations (Sivertsen et al., 2006). In typically developing youth, actigraphy has been shown to have high concordance with PSG in estimating certain sleep variables (e.g., sleep duration); whereas, in youth populations who have disturbed, fragmented or atypical sleep patterns (e.g., ADHD), the concordance between actigraphy and PSG decreases (Sivertsen et al., 2006; Ancoli-Israel et al., 2003).

Validation studies using sensitivity (i.e., true positive rate) and specificity (i.e., true negative rate) to evaluate the accuracy of actigraphy compared to PSG have presented a uniform pattern in youth (i.e., ≤ 18 years old), high sensitivity but low specificity (Ancoli-Israel et al., 2003; Meltzer et al., 2012). In terms of actigraphy, sleep-researchers describe sensitivity as the proportion of epochs scored as sleep using PSG that are also identified as sleep by actigraphy. Conversely, specificity is the proportion of PSG-scored wake epochs that are also accurately identified as wake epochs by actigraphy (Meltzer et al., 2012).

In terms of the sensitivity of actigraphy, in healthy adults, actigraphy over two consecutive nights has been demonstrated to yield highly sensitive results (96-99%), though with low specificity (34-75%) values (Sivertsen et al., 2006). Studies of infants have found sensitivities ranging between 83.4 – 99.3% and specificities between 17.0 – 97.8% (Sadeh et al., 1995; So et al., 2005; Meltzer et al., 2012). A study of toddlers reported a sensitivity of 97.0% and a specificity of 24.0% between actigraphy and videosomnography (Sitnick et al., 2008). Furthermore, a study of adolescence reported a sensitivity of 95.0% and a specificity of 74.5% (Sadeh et al., 1994). These authors concluded that in pediatric populations, actigraphy has been demonstrated to be consistently valid for identifying sleep periods but is less accurate when used to identify

periods of wakefulness (Meltzer et al., 2012). Therefore, the concordance between PSG and actigraphy varies depending on the sleep-parameter under investigation, with actigraphy demonstrated to overestimate total sleep time, but underestimate the frequency of nighttime awakenings, as well as the timing of sleep onset latency and wake after sleep onset (Ancoli-Israel et al., 2003). While actigraphy is often used in a research studies (e.g., to characterize disturbed sleep patterns or follow treatment outcomes), it is not often used as a diagnostic tool of insomnia due to the high rate of false positives (Martin & Hakim, 2011).

2.4.2 Subjective Measures

2.4.2.1 Pediatric Sleep Questionnaires

Pediatric sleep-questionnaires, such as the Tayside Children's Sleep Questionnaire (TCSQ; McGreavy et al., 2005) for children ages 1-5 years and the Sleep Disturbance Scale for Children (SDSC; Bruni et al., 1996) for children ages 6-10 years, are inexpensive, quick to complete, and easily administered measures of sleep disturbances in youth. Questionnaires involve subjective (and retrospective) ratings of a child's sleep behaviors (Markovich et al., 2015). For example, parents are asked to reflect on their child's sleep behaviors over the last week or last month. The TCSQ and SDSC instructs parents to rate the frequency with which their child displays various behaviors associated with common pediatric sleep disturbances (Bruni et al., 1996; McGreavy et al., 2005; Jan et al., 2010; Markovich et al., 2015). Ratings are then combined to create subscales that group responses into common expressions of sleep problems in children (e.g., bedtime resistance, daytime sleepiness). Despite the advantages of sleep

questionnaires (e.g., inexpensive, and efficient), the main limitation is that they are subject to recall bias (Sivertsen et al., 2006; Werner-Seidler et al., 2018). An additional limitation is that most pediatric sleep questionnaires have not been fully demonstrated to have strong psychometric properties. The results of a systematic review by Spruyt & Gozal (2011) showed that only 57 out of an available 183 pediatric sleep questionnaires had been psychometrically evaluated to some extent. Further, of the 57 questionnaires with some psychometric evaluation, only 2 fulfilled all the psychometric tool development requirements (Spruyt & Gozal, 2011).

2.4.2.2 Sleep Diary

A sleep diary is a physical or digital series of questions that ask participants or a proxy for the participant (i.e., parents reporting on their child's sleep) to provide a subjective estimate of sleep-related variables (e.g., sleep duration, number of night awakenings, early morning awakenings, etc.) (Francetich, 2014; Carney et al., 2012). In a sleep diary, parents record aspects of their child's sleep-wake patterns over 24-hour periods in "real time" (i.e., the recordings are supposed to be made at the time of the sleep behavior), for a typical duration lasting between 1 to 2 weeks. These diaries provide daily information about bedtime, wake time, and the frequency, timing, and duration of night wakings (Corkum & Vriend, 2011). Parents are also asked to report any situation that might impact sleep, such as the child being ill. Sleep diaries are simple, inexpensive, and advantageous for recording sleep-wake patterns in the home environment (Hall et al., 2015). The main limitation with using this method is its subjectivity. Parent's perceptions of their child's sleep behavior may be influenced by their own fatigue or biased from

their prolonged experience with a child who has disturbed sleep patterns, or the parent may not observe all their child's sleep behaviors to accurately record these (Sadeh, 1994). However, recording in real time is thought to mitigate much of this response bias. Using sleep diaries presents additional limitations as they are time consuming to complete for parents (compared to questionnaires) and yield a large volume of data that is difficult to interpret without official sleep training, as no norms exist for comparison (Markovich et al., 2015). However, parental report using a sleep diary remains as a time- and cost-effective method for collecting sleep-related data in research and clinical settings (Werner et al., 2008).

Sleep diaries have been previously validated against actigraphy in populations of infants (Sadeh, 1996; So et al., 2007) and school-aged children (Werner et al., 2008), with findings demonstrating an overall agreement ranging from satisfactory to good. In Sadeh's (1996) study that examined the concordance between actigraphy and sleep diaries in a sample of sleep-disturbed infants (n = 66), high actigraphy-sleep diary correlations were found for sleep onset (r = 0.96) and sleep duration (r = 0.74). Despite these findings, sleep diaries were also found to underestimate the duration of nighttime awakenings (r = 0.60) (Sadeh, 1996). So et al. (2007) evaluated the concordance between sleep diaries and actigraphy when used to measure sleep in infants over a 12-month assessment period. The authors of this study compared measures of sleep/wake using a Student's *t*-test, which demonstrated good overall concordance between methods, yet found that sleep diary entries overestimated total sleep time in comparison to actigraphy (So et al., 2007). Werner et al. (2008) established consistent findings in a sample of school-aged children (n = 50) to those reported in the two aforementioned infant studies.

In this study, Werner et al. (2008) found satisfactory agreement between measures for sleep onset, morning wake time, and assumed sleep variables, whereas, poor agreement between measures was established for actual sleep time and duration of nighttime awakening variables. Overall, the agreement between sleep diaries and actigraphy is moderate to high across many sleep-wake variables; however, sleep diaries have been demonstrated to underestimate the duration of nighttime awakenings and overestimate the total sleep time in pediatric populations.

2.5 The Need for a Sleep Diary Composite Outcome in a Clinical Setting

When assessing children for insomnia, it is crucial that clinicians routinely inquire and evaluate a child's sleep-wake behaviors (Corkum & Vriend, 2011). While objective measures of children's sleep behaviors yield highly reliable and valid data, they are often not administered on a wide scale due to their associated cost, time, and effort (Markovich et al., 2015). Accordingly, clinicians rely on subjective measures, such as sleep questionnaires and diaries, as these methods are cost-effective and easily administered. It is more common for clinicians to use questionnaires over sleep diaries as these measures can be administered in a timely manner and are more easily interpretable (Markovich et al., 2015). However, as data from sleep questionnaires is collected retrospectively (i.e., with parents reporting on their child's sleep behaviors over the past few weeks or months) and not contemporaneously, data may be inaccurate.

When clinicians opt to use sleep diaries, they have difficulty summarizing and interpreting the data for several reasons. First, health care providers lack training in

pediatric sleep disorders (Corkum et al., 2019a). In a recent survey assessing the knowledge, attitudes and practices of 97 Canadian health care providers (i.e., pediatricians n = 47; family physicians n = 35; general practice physicians n = 9; oncologists n = 2; nurses n = 3; and psychologists n = 1) regarding pediatric sleep disorders, only 3% of the sample had received formal training in pediatric sleep medicine (Gruber et al., 2017). Second, health care providers have knowledge gaps about sleep and sleep disorders in children and are often unaware of the knowledge deficits (Corkum et al., 2019a; Gruber et al., 2017). Third, sleep diaries are inherently difficult to interpret because this method has a high data yield (i.e., multiple aspects of sleep are recorded daily for a period lasting between 1 to 2 weeks) and there are no norms for comparison (Markovich et al., 2015). Thus, sleep diaries leave clinicians who lack formal training in pediatric sleep medicine with a large amount of data that is difficult to summarize and interpret in a meaningful way for patients, parents of patients, and for the purposes of clinical decision making and treatment monitoring.

2.6 Need for a Sleep Composite Outcome in Pediatric Sleep Studies

Pediatric sleep researchers conducting large clinical trials are also faced with the challenges of administering a cost-effective measure of children's sleep on a wide scale that still produces valid and reliable data. Often, sleep diaries are used in treatment trials as these are cost-effective, psychometrically-sound, and completed in "real time". When sleep diaries are chosen, a researcher is then tasked with selecting a single variable from many potential options to be used as the primary outcome to demonstrate treatment efficacy. In clinical trials (i.e., randomized control trials; RCTs), the primary outcome is

the variable that an investigator considers to be most important out of many potential outcomes (Andrade, 2015). A researcher must select the primary outcome of their study *a priori*, in order to prevent "cherry-picking" statistically significant results and presenting these as their main study findings (Andrade, 2015, p. e1321). This can be a challenging task when studying multifaceted constructs, such as insomnia. For example, a researcher decides to conduct an RCT comparing the effects of a novel sleep intervention to a waitlist control group on children with insomnia. The researcher wants to demonstrate that their intervention is effective at improving the sleep behaviors of children with insomnia. The question of "*which variable to select as the primary outcome?"* arises from a breadth of potential options, including: total sleep time, sleep efficiency (i.e., the ratio of total sleep time to the total amount of time spent in bed), sleep onset latency (i.e., the difference between the time when a child gets into bed and the time when the child falls asleep), sleeping independently without another person in the bed with the child, number and duration of nighttime awakenings, bedtime resistance, early morning awakenings, etc. Therefore, some researchers conducting clinical trials will use primary outcomes that are a compilation of a series of variables, referred to as a composite outcome, in order to capture the multidimensional nature of certain constructs (e.g., pediatric insomnia) (Ferreira & Patino, 2017).

Composites can be used when the instances of a single outcome are rare and/or when there is biological and clinical justification to group a set of variables (Andrade, 2015; Ferreira & Patino, 2017). When individual outcomes are aggregated, the study power for a given sample size increases as the composite outcome is more likely to occur compared to individual outcomes (Ferreira & Patino, 2017). A sleep composite outcome

can be generated by first selecting sleep-related variables (i.e., usually through consensus with pediatric sleep experts), followed by ranking the degree of disturbance across each variable, and then summing each score to yield an overall composite score.

Sleep composite outcomes have been used in six previous studies focusing on pediatric sleep problems by Richman & Graham (1971), Richman (1981), Wiggs & Stores (1998), Montgomery and colleagues (2004), Gaylor et al. (2005), and Appleton and colleagues (2012). The following section of this paper will briefly describe each previously developed sleep composite outcome. After a brief study description, the limitation(s) of each composite regarding the absence of important sleep variables and standardization of scores will be provided. For a more detailed summary of previously developed sleep composite outcomes, please see Table A1-1 in the appendix section of this paper.

2.7 Previously Developed Sleep Composite Outcomes

Richman & Graham (1971) used a sleep-diary based Composite Sleep Disturbance Scale (scores ranged from 0-24) as their primary outcome when examining the efficacy of behavioral treatment methods for severe sleep disorders in typically developing children aged 1-5 years (Richman & Graham, 1971). However, this composite measure did not include items related to the frequency of settling problems and early morning wakings. Wiggs & Stores (1998) developed a questionnaire-based Composite Sleep Index (scores ranged from 0-12) to explore whether behavioral treatment for sleep problems can be used successfully in children with severe learning disabilities and daytime challenging behaviors (Wiggs & Stores, 1998). This composite

index did not account for the number of nighttime awakenings and total sleep time of participants. In the study by Montgomery and colleagues (2004) that investigated the efficacy of a media-based behavioral treatment of sleep problems in children with learning disabilities between the ages of 2 and 8 years, a sleep diary derived Composite Sleep Disturbance Score (scores ranged from 0-8) was used as the primary outcome (Montgomery et al., 2004). The main limitation with this composite outcome is that it is missing information on the number of nighttime awakenings, early morning wakings and total sleep time of participants. In the study by Gaylor and colleagues (2005), which examined the rates and stability of protodysomnias (i.e., specific sleep behaviors related to falling asleep and sleep maintenance) in typically developing children over a period of four years, a composite measure (scores ranged from 0-8) was created based on video observation while the child was asleep. This composite, however, did not capture the number of nighttime awakenings, early morning wakings, parental co-sleeping, or the total sleep time of participants. Lastly, the study by Appleton et al. (2012), which examined whether or not immediate-release melatonin is beneficial for improving total sleep time in children with a neurodevelopmental disorder, used a questionnaire-based Composite Sleep Disturbance Index (scores ranged from 0-12) as a secondary outcome measure. The main limitation with this composite outcome is the absence of an item that captured the total sleep time of participants.

In addition to missing important sleep-parameters in the aforementioned sleep composites, the authors presented their findings as raw scores with no method of standardization (Richman & Graham, 1971; Richman, 1981; Wiggs & Stores, 1998; Montgomery et al., 2004; Gaylor et al., 2005; Appleton et al., 2012). Without a method of

standardization, meaningful comparisons between studies are difficult to deduce. For example, a child who receives a score of 4 on one composite ranging from 0-8 cannot be said to be equivalent to a child who receives a score of 6 on another composite ranging from 0-12. Although both children received a median composite score, they are not equivalent because of differences in the ranges of each composite. Thus, there is need for a psychometrically-sound composite outcome that is both standardized and encompassing of the multifaceted nature of pediatric insomnia.

We have developed a new sleep-diary derived sleep composite outcome for typically developing children aged 1-10 years, called a Pediatric Insomnia Composite (PIC). The PIC was constructed using seven sleep variables, which included: *Bedtime Resistance, Sleep Onset Latency (SOL), Frequency of Nighttime Awakenings, Duration of Nighttime Awakenings, Early Morning Wakings (EMW), Co-sleeping with Parent, and Total Sleep Time(TST).* Scores on each PIC variable were rated from 1 to 3 based on clinical severity, with higher scores suggesting a more severe sleep problem in that domain of sleep. PIC scores were calculated daily (i.e., PIC-score$_{Daily}$), and then aggregated using the arithmetic mean for each participant (i.e., PIC-score$_{Mean}$). The PIC-score$_{Mean}$ was standardized using the Percent of Maximum Possible (POMP) method (Fischer & Milfont, 2010). Following development of the PIC, we assessed its dimensionality using Exploratory Factor Analysis (EFA) including PIC scores from all children and across each of the three age groups (i.e., toddlers, preschoolers, and school-age). Once factors were identified, we evaluated the internal consistency of the PIC overall and across each factor. To establish construct validity, we evaluated the agreement between the PIC and actigraphy data, as well as commonly used pediatric

sleep questionnaires (e.g., Tayside Children's Sleep Questionnaire and Sleep Disturbance Scale for Children). In addition, to establish construct validity we assessed the discriminant validity of the PIC with children's Total Problem Score T-scores on the Child Behavior Checklist (CBCL) (Achenbach & Rescorla, 2000; Achenbach & Rescorla, 2001). Lastly, we evaluated the treatment sensitivity of the PIC from baseline to 4-months post-randomization (i.e., end of treatment) for all children and across age groups.

Chapter 3: RESEARCH QUESTIONS AND OBJECTIVES

3.1 Research Question & Objectives

3.1.1 Primary Research Question

1. What are the psychometric properties of our in-house developed PIC when used as a composite for insomnia in typically developing children aged 1 to 10 years?

3.1.2 Primary Objectives & Hypotheses

Objective 1a: To assess the dimensionality of items within the PIC for all children and across each age group.

Hypothesis 1a: We hypothesize that all seven PIC variables will account for a significant proportion of the total variance in PIC scores, and thus, all variables will be retained in the extracted solution.

*Objective 1b***:** To assess the internal consistency of the PIC for all children, as well as across each of the three age groups.

Hypothesis 1b: We hypothesize that the PIC will have good internal consistency for all children and across each age group.

Objective 1c: To evaluate the construct validity of the PIC using the TCSQ, SDSC, CBCL, and actigraphy.

Hypothesis 1c: We hypothesize a high intraclass correlation coefficient (ICC) between the PIC and the DIMS to demonstrate the convergent validity of the PIC. Further, we hypothesize a low to moderate degree of consistency between the PIC and CBCL, which will indicate that the PIC has good discriminant validity. When

compared to actigraphy, we hypothesize that the PIC will have a high sensitivity (sensitivity >90%) and low specificity (specificity <50%).

Objective 1d: To examine the treatment sensitivity of the PIC from baseline to end of treatment (i.e., 4 months post-randomization) for all children and across each age group.

Hypothesis 1d: We hypothesize a negative coefficient and reduced PIC scores for children in the treatment group relative to children in the usual care group. More specifically, we predict a negative interaction of group by time, which will indicate that children with insomnia in the treatment group will have lower PIC scores than children with insomnia in the usual care group after treatment.

Chapter 4: METHODOLOGY

4.1 BNBD Study Overview - Baseline

Participant data for the current study was collected from the Better Nights, Better Days (BNBD) study for typically developing children under the direction of Dr. Penny Corkum and her Canada-wide research team (Corkum et al., 2018). The BNBD program is an eHealth intervention (i.e., a behavioral intervention delivered via the internet) for parents/primary caregivers of children ages 1 to 10 years who present with insomnia. BNBD is a bilingual program (i.e., in both French and English), with the aim of providing accessible and evidence-informed care for insomnia in typically developing children. The treatment effectiveness of the BNBD program was evaluated through a 2-armed randomized control trial (RCT) with an equal allocation ratio of 1:1 to treatment and usual care groups. The goal of the larger study was to compare participants who received the BNBD intervention (treatment) to participants who did not receive the BNBD intervention but were able to access other treatment resources (control). Assessments were conducted at three periods: baseline (pre-treatment), 4 months post-randomization (end of treatment), and 8 months post-randomization (follow-up). Details about the research protocol can be found in Corkum et al., 2018. In the present study, we performed a secondary data analysis using the BNBD-baseline and 4-month data.

4.2 Participants

A total of 533 participants were recruited across Canada using a multipronged national recruitment strategy (e.g., social media, newsletters from healthcare

organizations, etc.). Recruitment was targeted to ensure that the study population includes representation from across Canada: Atlantic (New Brunswick, Nova Scotia, Prince Edward Island, Newfoundland and Labrador; n = 108), Central (Ontario and Quebec; n = 180) Prairies and Northern Territories (Alberta, Manitoba, Saskatchewan, Northwest Territories, Nunavut and Yukon; n = 101) and the West Coast (British Columbia; n = 144). In terms of language, participants enrolled in the BNBD intervention were 86.12% (n = 459) English speaking and 13.88% (n = 74) French speaking. Furthermore, recruitment of this sample was stratified by age group of the participant's child (toddler: 1-2 years (n = 183); preschool: 3-5 years (n = 186); and school-aged: 6-10 years (n = 164).

4.3 Inclusion Criteria

Potential participants must have met the following criteria to be eligible to participate in the BNBD intervention for typically developing children (Corkum et al., 2018):

1. Primary caregiver of a child aged 1 to 10 years. Children younger than 12 months are not included in the study as sleep patterns are still being established; youth over 10 years of age may be entering puberty, during which time other sleep problems can arise. Moreover, children over 10 years of age may have more control over their own sleep patterns and less input by parents. Therefore, it was deemed inappropriate to include the child/adolescent in the BNBD intervention given that this intervention is directed at parents.

2. Live in any province or territory in Canada.

3. Have regular access to high speed internet connection and an email account.

4. Comfortable communicating in English or French for day-to-day tasks (e.g., listening to the news on the radio or watching TV, reading books, magazines, etc.).

5. Child has insomnia based on the Behavioral Insomnia Questionnaire (BIQ), which was defined as having Sleep Onset Disturbance according to the criteria outlined by Anders & Dahl (2007; see Table A4-1 in Appendix for more details):

5.1 For Sleep Onset Disturbance, child must meet two of the following three criteria. These episodes must have been occurring for at least one month:

1. More than three reunions (i.e., reunions reflect bedtime resistance, such as protests during bedtime, repeated bids and/or struggles) (Anders & Dahl, 2007) for 12-24 month olds/more than two reunions for >24 month olds that occur two or more nights per week
2. 30 or more minutes to fall asleep for 12-24-month olds/20 or more minutes to fall asleep for >24-month olds
3. Parent remains in room for sleep onset for two or more nights per week

4.4 Exclusion Criteria

Potential participants who met any of the following criteria were not eligible to participate in the study:

1. Parent wishes to "bed-share" with his/her child. As the BNBD program focused on teaching independent sleep, participants were excluded if the parent wanted to bedshare with their child.
2. Child may have an intrinsic sleep disorder (e.g., sleep apnea) as assessed using the Pediatric Sleep Questionnaire (PSQ; PSQ score > 0.33).
3. Child has a significant medical disorder that interferes with sleep (e.g., asthma attacks during the night, tube feeding, non-ambulatory, severe developmental disability affecting sensory systems such as vision) as reported by the parent.
4. Child has a mental health disorder that has required hospitalization or residential care and/or current use of psychotropic medications that are known to interfere with sleep (e.g., stimulant medication for ADHD) as reported by the parent.
5. Parent does not have appropriate level of English or French language skill to engage in the BNBD intervention, assessed based on the Single Item Literacy Screener that captures proficiency in communication.

4.5 Data Collection

The BNBD study for typically developing children was funded by the Canadian Institutes of Health Research Team Grant (FRN-TGS 109221). Ethical approval was received from the IWK Health Centre Research Ethics Board (IWK-REB) and was conducted in accordance with the Tri-Council Policy Statement for Ethical Conduct of Research Involving Humans. The current secondary data analysis of the BNBD data received ethical approval from the IWK-REB on August 23, 2019. All participants were screened for eligibility and consented prior to participating in the Better Nights, Better

Days study. Following assessment of eligibility, participants were couriered the study package containing an actigraph and sleep diary (see Figure B4-1 in Appendix B for a copy of the author-made sleep diary) and were instructed to begin baseline measures. During the baseline measurement period, participants (i.e., parent/caregiver of a child) completed 7 days of sleep diary entries online, while their child wore an actigraph for 7 days of concurrent actigraphy data collection. Participants were additionally instructed to complete a series of online questionnaires, including the following that are relevant to the current study: the Tayside Children Sleep Questionnaire (for toddlers and preschoolers), the Sleep Disturbance Scale for Children (for school-aged children), and a demographic questionnaire (based on the Canadian National Longitudinal Survey of Children and Youth). All questionnaires were completed using REDCap (a secure web application for building and managing online databases) before the end of the 7-day actigraphy and sleep diary data collection period. The identical data collection procedure was used at baseline, at post-intervention at 4 months, and at follow-up at 8 months.

4.6 Measures

4.6.1 Sleep Diary

The author-made sleep diary (Figure B4-1 in Appendix B) was developed by Corkum et al. (2016) and based on systematic reviews by Meltzer & Mindell (2014), Mindell et al. (2006), and Wu and colleagues (2015). Sleep diaries have been validated against actigraphy and polysomnography, demonstrating good face validity and high internal consistency when used with child participants (Corkum et al., 2018).

An online sleep diary was provided to each participant (i.e., parent/caregiver of a child) to document sleep variables over a number of days/nights. Participants were instructed to fill out their sleep diary daily throughout the baseline period. Each participant was required to complete entry in their sleep diary for at least 5 days/nights to a maximum of 7 days/nights. Participants were given brief instruction on the purpose of the sleep diary, as well as a protocol for how to provide a response (i.e., with drop down menus, multiple choice responses, or text responses). The sleep diary required approximately 10 minutes per day to complete.

The sleep diary contains 25-items specifically measuring: sleep duration, nighttime sleep duration, daytime sleep duration, sleep onset latency, bedtime, wake time, presence and frequency of night awakening, and the presence and frequency of bedtime resistance. The sleep diary also provides a measure of the amount of time spent in bed extracted from the time the lights were turned off at night ("Down for the Night") to the time that the lights were turned on in the morning ("Up for the Day"). Additionally, parents have the option to record any occurrences that may have impacted the child's sleep (e.g., child being ill, traveling, etc.) (Corkum et al., 2018).

4.6.2 Sleep Diary Variables

All sleep composite variables were calculated from parental responses to questions in the sleep diary (Corkum et al., 2018). Six out of seven composite-variables (please see below) were recoded to 3-level categorical variables. These variables were recoded according to the National Sleep Foundation (National Sleep Foundation, 2015), Anders and Dahl's criteria (Anders & Dahl, 2007) or through the consensus of pediatric

sleep experts into 3-levels that indicated no problems (1), clinically significant mild to moderate sleep problems (2), and clinically significant severe sleep problems (3). The *Co-sleeping with Parent* variable was recoded to 2-levels due to the dichotomous nature of Question 7a in the sleep diary (Figure B4-1).

Bedtime Resistance

Bedtime Resistance was captured from Question 6 in the sleep diary that asked parents: "How much resistance did your child put up from being first asked to get ready for bed to falling asleep for the night?", with parents responding on 4-point Likert scale. For the PIC, *Bedtime Resistance* was recoded as follows: 0 (No resistance) or 1 (A little bit of resistance) on the Likert scale was recoded to 1; a rating of 2 (A medium amount of resistance) or 3 (Quite a bit of resistance) on the Likert Scale was recoded as 2; and a rating of 4 (A lot of resistance) on the Likert scale was recoded as 3.

Sleep Onset Latency (SOL)

SOL was calculated in minutes as the difference between responses on Q7 and Q4: "What time did your child fall asleep at bedtime?" – "What time was your child Down for the Night?". We recoded SOL for the composite as follows: ≤ 20 minutes = 1; 20.01-59.99 minutes = 2; and ≥ 60 = 3.

Frequency of Nighttime Awakenings

Frequency of Nighttime Awakenings was captured through responses to sleep diary Question 8: "After falling asleep for 10 minutes or longer at bedtime, how many times did your child wake up again?". We recoded responses for the PIC based on the frequency of awakenings, as follows: ≤ 1 awakening = 1; 2 awakenings = 2; and ≥ 3 awakenings = 3.

Duration of Nighttime Awakenings

Duration of Nighttime Awakenings was captured from responses to sleep diary Question 8a: "In total, how many minutes was your child awake throughout the night (across all night wakings)?". We recoded *Duration of Nighttime Awakenings* ≤ 20 minutes = 1; 20.01-59.99 minutes = 2; and 60+ minutes = 3, for our PIC.

Early Morning Wakings (EMW)

For the *EMW* variable, Question 9: "What time was your child Up for the Day?" was used. We recoded *EMW* using the following cut-off values: ≥ 6:00 am = 1; 5:30 – 5:59 am = 2; and < 5:30 am = 3.

Co-sleeping with Parent

Question 7a in the sleep diary asked parents to report yes or no for whether or not their child slept independently throughout the night: "Did your child fall asleep independently (i.e., without a parent or other person there while he/she fell asleep)?".

Given that this is a dichotomous variable, it was recoded as: Yes (i.e., child slept independently) = 1 and No (i.e., child slept with parent) = 3. No ratings of 2 were provided.

Total Sleep Time (TST)

TST was calculated in hours as the difference between responses to Question 9 and Question 7 in the sleep diary: "What time was your child Up for the Day?" – "What time did your child fall asleep at bedtime?". For each of the three age-groups, *TST* was recoded as follows: *1-2 year old's*: ≥ 12 hours = 1; 10 to < 12 hours = 2; and < 10 hours = 3; *3-5 year old's*: ≥ 10 hours = 1; 8 to < 10 hours = 2; and < 8 hours = 3; and *6-10 year old's*: ≥ 9 hours = 1; 7 to < 9 hours = 2; and < 7 hours = 3.

4.6.3 Actigraphy

Actigraphs are battery-operated devices typically worn on the wrist or ankle that record movement patterns continuously over a 24-hour period using an accelerometer and memory storage. Actigraphs have built-in light sensors, which are used to detect the intensity of light in the child's environment. Furthermore, actigraphs come equipped with a button called an event marker, which is pressed to indicate when the child goes to bed. As such, the event marker button and built-in light sensors enable more precise indications of a child's sleep-wake patterns. The type of actigraph used in the BNBD project was the Phillips Respironics Actiwatch 2. Computer algorithms were used to

convert and transfer data collected from the actigraphs memory onto a computer for future analysis.

Actigraphs were couriered to participants with instructions and an information handout about what the actiwatch is, its purpose, and how it should be used. Participants were instructed to ensure their child wore the actigraph during the 7 days of sleep diary collection and were instructed to record any instances when the actigraph was removed. Participants were further instructed to remove the actigraph in instances when the child was having a bath, swimming, or playing contact sports. Additional information was provided to participants regarding how the actigraph should (or should not) be worn, related to the child's handedness and whether it may be worn above the clothes.

After data collection, actigrams were reviewed by a research assistant who was familiar with actigraphy data to confirm that each participant had a minimum of 5 days of 'good-quality' data. Data was considered 'good' if the dates from the Sleep Diary and the dates from actigraphy were in concordance, for at least 5 days, and with no indication that the device malfunctioned during the assessment period. After the initial review process, data was cleaned and scored according to the BNBD Actiwatch Manual by four independent scorers who were blinded to the study protocol. Scorer interrater reliability was calculated using a two-factor analysis of variance (without replication) in order to obtain intraclass correlation coefficients with 95% confidence intervals for continuous variables (e.g., total sleep time). For categorical variables, the Cohen-Kappa's test was used to assess the agreement between scorers.

4.6.4 Tayside Children's Sleep Questionnaire (TCSQ)

The TCSQ (Figure B4-2 in Appendix B) (McGreavy et al., 2005) is used to measure insomnia symptoms in children aged 1-5 years, and in the context of the current study, the TCSQ was used to measure insomnia symptoms over the past one month prior to the baseline period. The TCSQ consists of 10 items (McGreavy et al., 2005). Only the first 9 items are used for scoring, and the last item is included to assess how parents view their child's sleep problem. For the first question, the TCSQ utilizes a 5-point intensity scale (e.g., "How long after going to bed does your child usually fall asleep?"; 0 ≤ 15 min, 1 = 15-30 min, 2 = 30-45 min, 3 = 45-60 min, and 4 ≥ 60 min); whereas, the remaining nine items consist of a 5-point frequency scale from 0 "the behavior never occurs" to 4 "the behavior occurs every night" (McGreavy et al., 2005). Each response to the first 9 items is scored from 0 to 4, and then summed to yield a cumulative sleep disturbance score of 36.

The TCSQ has three main domains: initial settling; nighttime disruption; and early morning arousal. The former domain, initial settling (i.e., contrived of items 1, 2, 3, 5, and 6 on the TCSQ), represents a modified sub-scale of questions from the SDSC that address problems associated with Disorder of Initiating and Maintaining Sleep (DIMS). The DIMS-subsection of the TCSQ has a maximum total score of 20. In the current study, as had been done for the larger BNBD study, we converted the total score on the 'initial settling domain' of the TCSQ into a percentage (i.e., $\left(\frac{Sum\ of\ items\ answered}{maximum\ DIMS\ score}\right) x\ 100\%$) for the purpose of our analyses.

The TCSQ has been demonstrated to have good internal consistency (α = 0.85) with item-total correlations of (R = 0.30 – 0.72) when used to measure sleep problems in

children aged 1-5 years (Bruni et al., 1996). Moreover, McGreavy and colleagues (2005) assessed the discriminant validity of the TSCQ using triangulated methods and found that the tool had good discriminant validity (Bruni et al., 1996). The TCSQ can be completed in approximately 5 minutes.

4.6.5 Sleep Disturbance Scale for Children (SDSC)

The SDSC (Figure B4-3) (Bruni et al., 1996) is used to measure insomnia in children ages 6-10 years. It measures a range of sleep problems, including initiation and maintenance of sleep, sleep disordered breathing, disorders of arousal, sleep-wake transition disorder, disorders of excessive somnolence, and sleep hyperhidrosis. The full SDSC assesses the aforementioned disorders using 26-items (Bruni et al., 1996). However, in the context of the current study, only the disorders of initiation and maintenance of sleep (DIMS) scale was used as this scale focuses on assessing insomnia symptoms. As the 'initial settling domain' of the TCSQ (McGreavy et al., 2005) is derived from the 'DIMS' subdomain of the SDSC (Bruni et al., 1996), we combined scores on measures into a single *TCSQ/SDSC* variable for analyses that include all children. For the remainder of this thesis, the combined *TCSQ/SDSC* will be referred to as DIMS. In children aged 1 to 5 years old, we assessed the convergent validity between the PIC and the 'initial settling domain' of the TCSQ (McGreavy et al., 2005). For children aged 6 to 10 years, the 'DIMS' subscale of the SDSC (Bruni et al., 1996) was used. Moreover, total scores in the DIMS domain were converted into a percentage for the purposes of our analyses (which was also done for the larger BNBD study). The cumulative DIMS-scale score ranges from 5-35, and is calculated by summing the scores

of 7 items: 1, 2, 3, 4, 5, 10 and 11. Items 1 (i.e., “How many hours of sleep does your child get on most nights?”) and 2 (i.e., “How long after going to bed does your child usually fall asleep?”) were answered based on the amount of time the child spent asleep and the latency of sleep initiation, with responses on a 5-point intensity scale (Bruni et al., 1996). Items 4, 5, 10 and 11 require responses to be on a 5-point frequency scale ranging from 1 “Never” to 5 “Always (daily)”. Participants were instructed to answer each question on the SDSC in the context of the past one month of the child’s life (Corkum et al., 2018).

The SDSC has been validated with high sensitivity (89%), specificity (74%), and reliability ($\alpha = 0.79$) coefficients (Bruni et al., 1996). Lewandowski and colleagues (2011) found good reliability when the SDSC was used on a population of patients with sleep disorders and good total test-retest reliability ($\alpha = 0.71$). For single items in the SDSC, reliability ranged between $\alpha = 0.21$-0.66 (Lewandowski et al., 2011). The SDSC can be completed in roughly 5 minutes.

4.6.6 Child Behavior Checklist (CBCL/1.5-5; CBCL/6-18)

The CBCL was used to measure children’s behavioral problems and was administered to participants at the three assessment periods throughout the BNBD-TD study (i.e., baseline, 4-month follow up and 8-month follow up). The CBCL/1.5-5 is appropriate for children aged 1 to 5 years old, while the CBCL/6-18 pertains to children aged 6 to 18 years old (Achenbach & Rescorla, 2000; Achenbach & Rescorla, 2001). Responses on the CBCL/1.5-5 and CBCL/6-18 are measured on a 100-itemed and 113-itemed 3-point Likert scale, respectively, with response options ranging from 0 “Not

true" to 2 "Very true or often true". The sum of responses across all items is called the *Total Problems* score, with scores ranging from 0 to 200 for the CBCL/1.5-5 and 0 to 226 for the CBCL/6-18. Responses are also scored and summed across the following seven subscales: Emotionally Reactive, Anxious/Depressed, Somatic Complaints, Withdrawn, Sleep Problems, Attention Problems, and Aggressive Behavior, and then further combined into subscales "internalizing" and "externalizing" (Achenbach & Rescorla, 2000; Achenbach & Rescorla, 2001).

For the CBCL/6-18 responses are scored and summed across different subscales appropriate for school aged children (i.e. Anxious/Depressed, Withdrawn/Depressed, Somatic Complaints, Social Problems, Thought Problems, Attention Problems, Rule-breaking Behaviour and Aggressive Behaviour) that are also grouped into either internalizing or externalizing factors with total scores. In the current study, only the *Total Problems* scores (Achenbach & Rescorla, 2000; Achenbach & Rescorla, 2001), standardized into t-scores, were used to assess the discriminant validity with children's scores on the PIC.

Both the CBCL/1.5-5 and the CBCL/6-18 have been well-established standardized diagnostic tools for total score measures of behavioral and emotional problems in preschool and school-aged children (Achenbach & Rescorla, 2000; Achenbach & Rescorla, 2001). The test-retest reliability for total scores on the CBCL/1.5-5 is ($r = 0.90$), similarly the school aged children CBCL/6-18 also had a high test-retest reliability of ($r = 0.92$) and ($\alpha = 0.97$) (Achenbach & Rescorla, 2000; Achenbach & Rescorla, 2001). The CBCL requires approximately 10 minutes to complete.

4.7 Sleep Composite Computation

The BNBD sleep diary baseline data was downloaded from REDCap to Microsoft Excel© and then imported into STATA statistical package for computation. In STATA, any participant that had missing values (e.g., participant dropped out during baseline period and/or did not have a minimum of 5 days of 'good quality' data) was deleted (n = 156). Following data cleaning (n = 377), we generated the seven variables that comprise the PIC, which include: *Bedtime Resistance*, *SOL*, *Frequency of Nighttime Awakenings*, *Duration of Nighttime Awakenings*, *EMW*, *Co-Sleeping with Parent*, and *TST*. We then summed the seven PIC variables to calculate a daily raw score for each day of participant data, called a PIC-score$_{Daily}$. Next, we calculated the arithmetic mean for each participant, called the PIC-score$_{Mean}$. Each PIC-score$_{Mean}$ was then standardized using the Percent of Maximum Possible (POMP) method (i.e., PIC-score$_{POMP}$). The POMP-method expresses raw scores in terms of the maximum possible score for each participant (Fischer & Milfont, 2010), and is calculated using the following equation:

$$POMP = \left[\frac{raw\ score - minimum\ score}{scoring\ range}\right]\ x\ 100\% .$$

As an example, imagine a child who has the following five PIC-score$_{Daily}$ values from 5 days of data collection: 14, 12, 9, 15, and 17. For this participant, the arithmetic mean, or PIC-score$_{Mean}$, is 13.4. By applying the POMP-method: $POMP = \left[\frac{13.4 - 7}{14}\right]\ x\ 100\%$, the child's score is standardized to yield a PIC-score$_{POMP}$ of 45.7%. In the current study, all analyses were conducted using the PIC-score$_{POMP}$ for each participant.

4.8 Statistical Analyses

All analyses were calculated using STATA statistical package version 15.1.

4.8.1 Analysis of Objective 1a

We evaluated the dimensionality of the PIC using Exploratory Factor Analysis (EFA) with oblique (promax) rotation for all children and across each age-group. EFA is used to examine variables that account for the majority of variance in scores and identify those that are redundant or explain little score-variance (Tabachnick & Fidell, 2013). EFA is also used to summarize patterns of correlations among observed variables into linear combinations (or subsets) of independent latent variables, called factors (Furr, 2011). Each factor is a group of highly correlated variables representing a discrete dimension of some shared underlying latent variable (Tabachnick & Fidell, 2013; Furr, 2011). If all variables are well-correlated with each other at approximately equal levels to form a single factor, the scale is considered unidimensional (Furr, 2011). Conversely, when there are two or more factors derived from a set of variables, the scale is multidimensional. Therefore, if the PIC items load onto two or more factors, then it would be viewed as multidimensional.

Results of each EFA, for all children and across the three age groups, are presented in an initial solution table, extracted solution table, unrotated pattern matrix, a factor correlation matrix, and an obliquely rotated (promax) pattern matrix. Further, findings from the initial solution are displayed in a scree plot to graphically represent factors that explain the majority of variance across PIC variables.

4.8.2 Analysis of Objective 1b

Following analysis of the PIC's dimensionality, the internal consistency of items within the PIC was examined using Cronbach's alpha for all children, as well as across each of the three age-groups: 1 to 2 years old, 3 to 5 years old, and 6 to 10 years old. As a measure of reliability, Cronbach's alpha measures the extent to which all items in the scale are related (Streiner & Norman, 1995) and therefore reflects the degree to which items in a scale are measuring the same construct (Dunn et al., 2013). The value of alpha ranges from 0 to 1, where higher values indicate a higher degree of interrelatedness, or internal consistency, between items (Tavakol & Dennick, 2011; Streiner, 2003). There is no established acceptable threshold that alpha must reach to demonstrate a high degree of internal consistency between items (Taber, 2017; Tabachnick & Fidell, 2013). However, it is generally accepted that alpha values ranging from 0.70 to 0.95 indicate a high degree of internal consistency between items (Nunnally & Berstein, 1994; Streiner, 2003; Tavakol & Dennick, 2011). Nunnally & Bernstein (1994) recommended that a minimum value of alpha = 0.70 should be demonstrated for exploratory research instruments, alpha = 0.80 for basic research instruments, and alpha = 0.90 for tools used in a clinical setting (Nunnally & Berstein, 1994; Streiner, 2003). It should also be mentioned that alpha values > 0.90 are not desirable as values exceeding this level most likely indicate unnecessary redundancy between items, rather than a high degree of internal consistency (Streiner, 2003). If the items in a scale are correlated to each other, the value of alpha increases (Tavakol & Dennick, 2011). However, a high alpha coefficient does not always mean that a scale has a high degree of internal consistency as alpha is affected by the length of the scale. When more items related to a construct are added to a scale, the value

of alpha increases (Tavakol & Dennick, 2011). Conversely, when items are removed, the value of alpha typically decreases.

4.8.3 Analysis of Objective 1c

To demonstrate the construct validity of the PIC, the agreement of the PIC with 1) DIMS, 2) the CBCL, and 3) actigraphy was assessed. We quantified the consistency between the PIC with the DIMS and CBCL using ICC-estimates based on 2-way mixed-effects models. Interpretation of the agreement between measures was as follows, ICC: <0.50 = Poor; 0.50 – 0.75 = Moderate; 0.75 – 0.90 = Good; and >0.90 = Excellent (Koo & Li, 2016).

We evaluated the discriminant validity of the PIC using children's 'Total Problem Score' t-scores on both the CBCL/1.5-5 (i.e., for children aged 1 to 5 years old; Achenbach & Rescorla, 2000) and the CBCL/6-18 (i.e., for children aged 6 to 10 years old; Achenbach & Rescorla, 2001). For each measure of agreement, analyses were performed on all children as well as across each age group. Moreover, all 2-way mixed-effects models were based on a mean rating from measures and are presented with two ICC-estimates to quantify the consistency: 1) between individual measures, and 2) between average measurements made on the same participants. ICC-estimates are presented with 95% confidence intervals.

The convergent validity between the PIC and actigraphy was evaluated using a rank biserial correlation analysis and through calculations of sensitivity, specificity, positive predictive value, and negative predictive value. To assess the agreement between

the PIC and actigraphy, we converted both measures into dichotomized "Evidence for Insomnia" indices. For actigraphy, we generated the "Evidence for Insomnia" index by dichotomizing the mean values of three continuous sleep-variables: *Sleep Onset Latency* (*SOL*), *Sleep Efficiency* (*SE*) and *Total Sleep Time* (*TST*), into "Evidence for Insomnia" and "No Evidence for Insomnia" categories. For *SOL* and *SE*, mean values exceeding 20 minutes and 86%, respectively, were used as cut-points to identify children as having "Evidence for Insomnia" based on the same criteria as the PIC. For the *TST* variable, the following age-specific cut-off values were used to classify children as having "Evidence for Insomnia": TST <12 hours (1 to 2 year old's), TST <10 hours (3 to 5 year old's), and TST <9 hours (6 to 10 year old's). Children who were classified as having "Evidence for Insomnia" across any of the three dichotomized actigraphy-variables were considered to have "Evidence for Insomnia" in the actigraphy index.

For the PIC "Evidence for Insomnia" index, the 7 PIC variables were dichotomized into "Evidence for Insomnia" and "No Evidence for Insomnia" groupings. Since children's PIC scores were calculated daily, whereas, actigraphy variables were housed as mean-values, we needed to dichotomize each PIC variable using a different procedure than the one used for actigraphy. Accordingly, we applied the DSM-5 criteria of Childhood Insomnia across each PIC variable, which states that the sleep disturbance must be present for at least three nights a week to be considered as a problem (DSM-5, 2013). Thus, children who scored >1 (i.e., in any PIC variable) for 3 or more nights during the assessment period were considered to have "Evidence for Insomnia" in that domain of sleep. Next, we generated the dichotomous PIC index based on whether children had "Evidence for Insomnia" across *any* sleep-domain. For example, if a child

had the following PIC score values for *SOL*: 1, 2, 2, 1, 1, 2, that child would be assigned the label "Evidence for Insomnia" in the domain of sleep onset (i.e., difficulties with sleep initiation). Since this child has "Evidence for Insomnia" in the variable *SOL*, they would be classified as having "Evidence for Insomnia" in the PIC index regardless of whether or not they had evidence for insomnia across the other 6 PIC variables.

4.8.4 Analysis of Objective 1d

We evaluated the PICs sensitivity to detecting changes from baseline to 4 months follow-up using a repeated measures ANOVA for both treatment and usual care groups. Results were considered to be significant if the interaction term is $p < 0.05$.

Chapter 5: RESULTS

5.1 Data Cleaning

The following five datasets (housed in Microsoft Excel) were merged into STATA statistical package for data cleaning: 1) sleep diary, 2) actigraphy, 3) CBCL, 4) DIMS, and 5) the demographic questionnaire. Case-wise deletion was used to eliminate participants with missing values in any of the aforementioned datasets. A flowchart of the data cleaning process can be seen in Figure 5-1.

Initially, the raw sleep diary file contained 533 participants. However, 106 participants were deleted because of a complete absence of data entries (i.e., parent decided not to continue in study). An additional 10 participants were deleted from the sleep diary file because of entry errors, due to several reasons (e.g., parent made a mistake when completing the sleep diary log, unexpected family circumstance that impacted diary completion). Once the sleep diary dataset was cleaned of missing values, the actigraphy file was prepared for merger. Originally, there were 515 participants included in the actigraphy data file. However, 110 participants were deleted because of missing values that were needed for our analyses. An additional 9 participants were deleted as they were missing entries in some key variables that impaired our ability to accurately calibrate the two files. Once both the sleep diary and actigraphy files were cleaned, the two files were merged into one dataset resulting in a sample size of n = 417.

After merging the two datasets, we excluded 23 subjects who had sleep diary entries but were missing actigraphy data (Figure 5-1). An additional 11 participants were excluded because there were no sleep diary entries corresponding to the participant's

actigraphy data. An additional 6 participants were deleted because they had less than 5 days of sleep diary and/or actigraphy entries, which violated the minimal days of data collection criteria. Next, using case-wise deletion, we cleaned the CBCL, DIMS, and demographic data files in preparation for merger with the sleep diary-actigraphy file. Questionnaire data was matched to participants in the sleep diary-actigraphy file. Although 21 observations in the CBCL and 10 observations in the DIMS files contained missing values, we decided to include these participants in our final analyses to reduce the amount of omitted data. Thus, the final sample size was n = 377.

5.2 Sample Demographic Characteristics

Table 5-1 shows the sample demographic characteristics. A total of 377 participants were included in the sample following data management and cleaning. Majority of the participants spoke English (n=325, 86.2%) as their primary language and 52 (13.8%) spoke French. The age distribution of participants was 117 (31.0%) 1 to 2-year old's (toddlers), 121 (32.1%) 3 to 5-year old's (preschoolers), and 139 (36.9%) 6 to 10-year old's (school-aged). In the sample there were 189 (50.1%) females and 184 (48.8%) males. There were 4 (1.1%) participants who had missing data in the sex variable. The large majority of the sample was Caucasian (n = 308, 81.7%). In terms of living location, 42 (11.4%) participants lived in rural communities, 48 (12.7%) were from towns, 132 (35.0%) participants inhabited cities under 500,000 people, 147 (39.0%) inhabited cities with a population exceeding 500,000 people and 8 (2.1%) participants had missing living area data. The geographical distribution of participants by region across Canada was 81 (21.5%) Atlantic, 121 (32.1%) Central, 72 (19.1%) Prairies and

Northern territories, and 103 (27.3%) from the West Coast. Regarding family income, 8.0% (n = 30) of the sample made less than $50,000 annually, 29.9% (n = 113) made between $50,000-$99,000, 30.8% (n = 116) made between $100,000-$149,999, 23.6% (n = 89) made equal to or more than $150,000 annually, and 5.6% (n=21) of participants indicated that they would prefer to not answer. An additional 2.1% (n = 8) of participants had missing data about annual family income. The vast majority of participants had a partner (n = 355, 94.2%), with 14 (3.7%) indicating that they were without a partner. There were 8 (2.1%) participants missing data regarding relationship status. Most participants had completed either college or university (n = 206, 54.7%). Further, 2.9% (n = 11) of the sample had completed some high school or had their high school diploma, 9.6% (n = 36) had some postsecondary education, 30.2% (n = 114) completed a postgraduate degree or more (e.g., Doctor of Medicine, Doctor of Jurisprudence), 0.5% (n = 2) indicated an education history of "other", and 2.1% (n = 8) had missing data. Most participants were children's biological mothers (n = 330, 87.5%). Further, 9.1% (n = 34) of the sample were biological fathers, 1.3% (n = 5) were adoptive parents, and 2.1% (n = 8) had missing data regarding the parent-child relationship.

5.3 Descriptive Statistics of Study Measures

Descriptive statistics for the DIMS, three actigraphy variables, and the CBCL can be seen in Table 5-2. For DIMS, total scores were transformed into a percentage. The mean DIMS score for the entire sample was 61.69% (SD = 15.34%). In toddlers, the mean DIMS score was 63.91% (SD = 7.05%), for the preschooler group, the mean DIMS

score was 61.40% (SD = 17.37%), and for the school-aged group the mean DIMS score was 57.79% (SD = 10.73%).

Three key actigraphy variables were used in our analyses: *Total Sleep Time (minutes)*, *Sleep Onset Latency (minutes)*, *and Sleep Efficiency (%)*. For all children in the sample, the mean total sleep time was 608.45 (SD = 47.19) minutes. The mean TST by age group was as follows: toddlers: 632.11 (SD = 50.85) minutes, preschoolers: 612.68 (SD = 42.88) minutes, and school-age: 584.85 (SD = 35.15) minutes. Once in bed, children took on average 28.28 (SD = 18.34) minutes to fall asleep. On average, toddlers took 24.30 (SD = 19.97) minutes, preschoolers took 30.09 (SD = 18.24) minutes, and school-aged children took 30.06 (SD = 16.51) to fall asleep. For the entire sample, the mean sleep efficiency was 95.58% (SD = 2.80%). The mean sleep efficiency was similar across age groups: toddler: 96.30% (SD = 2.95), preschoolers: 95.33% (SD = 2.83), and school-aged: 95.20% (SD = 2.53).

For the CBCL, the mean total problem t-score for the entire sample was 53.74 (SD = 10.49). The mean total problem t-score for toddlers was 50.54 (SD = 10.64), for preschoolers was 54.61 (SD = 10.98), and for school-aged was 55.74 (SD = 9.28).

5.4 Descriptive Statistics of PIC Scores

Summary statistics of PIC scores for all children in the sample and across each age group can be seen in Table 5-3. The mean PIC total score for all children in the sample was 25.60% (SD = 14.30%). The mean PIC score for toddlers was 38.90% (SD = 12.40%), for preschoolers was 23.00% (SD = 10.90%) and for school-age was 16.60% (SD = 9.20%). A one-way ANOVA was used to determine whether or not there was a

significant difference between mean PIC scores across age-groups. The results from the one-way ANOVA indicated that there were significant differences between group means ($F_{2,374} = 138.53$, $p < .001$).

To determine which pairs of differences between means were significant, we conducted a post hoc analysis using Tukey's HSD test, with the results displayed in Table 5-4. Pairwise comparisons of the means indicated that all mean differences between groups were statistically significant ($p<0.05$) (Table 5-4). Furthermore, the Tukey post hoc test showed that preschoolers scored, on average, 15.90% lower than toddlers (MD = -15.90; 95% CI = -19.20, -12.60). School-aged children had a mean PIC score that was 22.20% lower than toddlers (MD = -22.30; 95% CI = -25.50, -19.10) and 6.40% lower than preschoolers (MD = -6.40; 95% CI = -9.60, -3.20).

Figure 5-1

Participant Flowchart Detailing the Cleaning, Merging, and Matching Process of the Final Dataset (N=377)

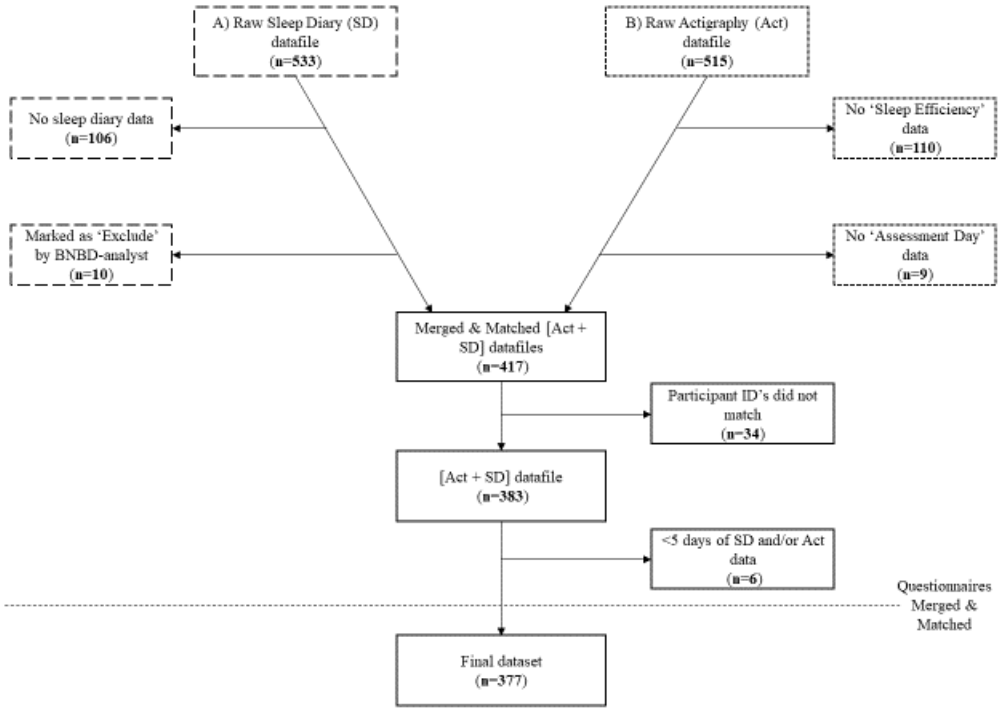


Table 5-1

Demographic Characteristics of Participants Enrolled in this Secondary Data Analysis

Characteristic	Sub-characteristic	Total
		N=377
Language	English	325 (86.2%)
	French	52 (13.8%)
Child Age Group	Toddler: 1 to 2 years old	117 (31.0%)
	Pre-Schooler: 3 to 5 years old	121 (32.1%)
	School Aged: 6 to 10 years old	139 (36.9%)
Child Sex	Female	189 (50.1%)
	Male	184 (48.8%)
	Missing	4 (1.1%)
Child Ethnicity	Caucasian	308 (81.7%)
	Non-Caucasian	27 (7.2%)
	Other	34 (9.0%)
	Missing	8 (2.1%)
Geographical Region	Atlantic	81 (21.5%)
	Central	121 (32.1%)
	Prairies and Northern	72 (19.1%)
	West Coast	103 (27.3%)
Living Area	Rural	42 (11.2%)
	Town	48 (12.7%)
	City under 500,000 people	132 (35.0%)
	City over 500,000 people	147 (39.0%)
	Missing	8 (2.1%)
Family Income	Less than $50,000	30 (8.0%)
	$50,000-$99,000	113 (29.9%)
	$100,000-$149,999	116 (30.8%)
	$150,000 and more	89 (23.6%)
	Prefer not to respond	21 (5.6%)
	Missing	8 (2.1%)
Parent Marital Status	With Partner	355 (94.2%)
	Without Partner	14 (3.7%)
	Missing	8 (2.1%)
Parent Education History	Some high school/completed high school	11 (2.9%)
	Some postsecondary	36 (9.6%)
	Completed college/university	206 (54.7%)
	Completed postgraduate or more	114 (30.2%)

Characteristic	Sub-Characteristic	Total
	Other	2 (0.5%)
	Missing	8 (2.1%)
Relationship to Child	Biological Mother	330 (87.5%)
	Biological Father	34 (9.1%)
	Adoptive Parent	5 (1.3%)
	Missing	8 (2.1%)

Note. Data are represented as n(%).

Table 5-2

Descriptive Statistics of Children's Scores on Questionnaires and Variables Used in this Secondary Data Analysis

Measure	n	Mean	SD	Min	Max
DIMS (%)	367	61.69	15.34	20.00	100.00
1 to 2-years	116	66.47	16.41	25.00	100.00
3 to 5-years	118	61.40	17.37	20.00	95.00
6 to 10-years	133	57.79	10.73	25.71	88.57
Actigraphy					
TST (Minutes)	377	608.45	47.19	476.13	753.67
1 to 2-years	117	632.11	50.95	500.88	753.67
3 to 5-years	121	612.68	42.88	515.86	729.71
6 to 10-years	139	584.85	35.15	476.13	718.33
SOL (Minutes)	377	28.28	18.34	0.00	171.00
1 to 2-years	117	24.30	19.97	0.00	171.00
3 to 5-years	121	30.09	18.24	1.14	95.71
6 to 10-years	139	30.06	16.51	4.25	78.86
SE (%)	377	95.58	2.80	76.00	100.00
1 to 2-years	117	96.30	2.95	76.00	100.00
3 to 5-years	121	95.33	2.83	86.66	99.81
6 to 10-years	139	95.20	2.53	88.32	99.33
CBCL (Total Problem T-score)	356	53.74	10.49	26.00	92.00
1 to 2-years	112	50.54	10.64	30.00	78.00
3 to 5-years	115	54.61	10.98	36.00	92.00
6 to 10-years	129	55.74	9.28	26.00	74.00

Note. DIMS: Disorders of Initiating and Maintaining Sleep (Bruni et al., 1996; McGreavey et al., 2005); TST: Total Sleep Time; SOL: Sleep Onset Latency; SE: Sleep Efficiency; CBCL: Child Behavior Checklist (Achenbach & Rescorla, 2000; Achenbach & Rescorla, 2001); SD: Standard Deviation; Min: Minimum; Max: Maximum.

Table 5-3

Summary Statistics of the PIC for All Children and Across Age Groups

Age group	n	Mean	SD	Min	Max
1 to 2-years	117	38.88%	12.49%	6.12%	69.39%
3 to 5-years	121	23.00%	10.93%	2.04%	54.08%
6 to 10-years	139	16.60%	9.22%	2.38%	62.25%
All Children	377	25.56%	14.30%	2.04%	69.39%

Table 5-4

Results of Tukey's HSD Test Used to Examine Mean Differences in PIC Scores Among Toddlers, Preschoolers, and School-aged Children

Age groups	Mean Difference	SE	Tukey's 95% CI [LL, UL]
Preschoolers vs Toddlers	-15.9%***	1.41	-19.2, -12.6
School-Aged vs Toddlers	-22.3%***	1.36	-25.5, -19.1
School-Aged vs Preschoolers	-6.4%***	1.35	-9.57, -3.21

***$p<0.001$.

Note. SE: Standard Error; LL: Lower Limit of 95% Confidence Interval; UL: Upper Limit of 95% Confidence Interval.

Chapter 6: OBJECTIVE 1a RESULTS

6. OBJECTIVE 1a: To assess the dimensionality of items within the PIC for all children and across each age group.

6.1 Exploratory Factor Analysis (EFA)

All exploratory factor analyses (EFA) were performed on the 7-items comprising the PIC using principal factor extraction with promax rotation. Two well-recognized criteria for the factorability of a correlation matrix were used (Yong & Pearce, 2013). First, Bartlett's test of sphericity was indicative of item factorability with the Chi-square statistic (χ^2) = 1847.3 (df = 21, $p<0.05$), indicating that items had patterned relationships. Second, the Kaiser-Meyer-Olkin statistic was 0.58, indicating 'adequate' factorability between variables (Yong & Pearce, 2013). Therefore, factor analysis was considered an appropriate technique for further analysis.

6.1.1 EFA – All Children

In the analysis of all children, items were observed to load into three factors. Results of the initial solution, which included all children in the sample, can be seen in Table 6-1 and in the scree plot in Figure 6-1. As expected with a large sample size (Bentler & Bonett, 1980), a χ^2-test of model fit suggested that the model was significantly different from the null model: χ^2 = 1848.01 (21, N = 2,595, p<.001). Several criteria exist for determining the number of factors to retain in the final model. The most

commonly used criterion is the *Kaiser's criterion* which suggests that all factors above an eigenvalue of 1 should be retained in the final model (Tabachnick & Fidell, 2013). Another criterion is *Jolliffe's criterion*, recommending that factors exceeding an eigenvalue of 0.70 be retained (Yong & Pearce, 2013). However, both criteria have potential to overestimate the number of factors to be retained in the extracted solution (i.e., the final model). Thus, it is recommended to cross reference eigenvalues with the corresponding scree plot to determine the number of factors to retain (Yong & Pearce, 2013). Using a scree test, the number of factors to be retained are those that exceed the point where the slope of the line changes significantly, called the point of inflection (Tabachnick & Fidell, 2013). In the scree plot (Figure 6-1), four factors were identified to be above the point of inflection, which suggested a four-factor extracted solution model. However, in the initial solution table (Table 6-1), Factor 4 was found to account for a negligible proportion of variance (i.e., 1.75% of total variance in PIC variables). Therefore, the first three factors were extracted as these factors gave the most interpretable and parsimonious solution. The three factors were rotated using promax rotation (i.e., oblique rotation) as factors were found to be correlated (Table 6-2).

The unrotated pattern matrix can be seen in Table 6-3. In the extracted solution table generated following rotation (Table 6-4), Factor 1 was found to account for 85.8% of the variance amongst PIC variables (eigenvalue of 1.04). Factor 2 had an eigenvalue of 0.69 and explained 56.7% of the variance in the data. The eigenvalue for Factor 3 was 0.47, which accounted for 38.6% of the variance in PIC variables. Due to overlap amongst common factors, the cumulative proportion of variance was found to exceed 100% as factors partly explained the same variance (Table 6-4).

The rotated pattern matrix is displayed in Table 6-5. Only items with factor loadings above 0.32 are shown, as factors with absolute loading-values below this threshold represent less than 10% shared variance and are considered to be a poor measure of the factor (Tabachnick & Fidell, 2007). All items loaded >0.32 onto one of the three factors. Factor 1 was comprised of items *Co-sleeping with Parent*, *Frequency of Nighttime Awakenings,* and *Duration of Nighttime Awakenings*, with factor loadings ranging between 0.33 – 0.65. The item *Frequency of Nighttime Awakenings* had the highest factor loading onto Factor 1 with a value of 0.65, followed by the item *Duration of Nighttime Awakenings* at 0.62, and then the item *Co-sleeping with Parent* with a loading of 0.33. Items *EMW* and *TST* loaded onto a second factor (Factor 2) with loadings of 0.48 and 0.47, respectively. The third factor (Factor 3) was composed of two items. The first item, *Bedtime Resistance*, loaded at 0.46 while the second item, *SOL*, loaded at 0.47 onto Factor 3.

6.1.2 EFA – Toddlers

Overall, items loaded into three factors. Table 6-6 displays the results of the initial solution table for children aged 1 to 2 years old. A χ^2-test of model fit suggested that the model was significantly different from the null model: $\chi^2 = 598.63$ (18, N = 802, p<.001). In the scree plot (Figure 6-2) of the initial solution table, 3 factors were identified as being above the point of inflection. Thus, in agreement with the initial solution table, the extracted solution table was comprised of three significant factors. Factors were found to be correlated (Table 6-7). Therefore, promax rotation of factors was used for interpretation of the factor structure.

The unrotated pattern matrix can be seen in Table 6-8. Table 6-9 contains the results of the extracted solution table following promax rotation of factors. Factor 1 had an eigenvalue of 0.96 and accounted for 74.4% of the variance in data. Factor 2 was found to explain 54.4% of the total variance amongst PIC variables, with an eigenvalue of 0.70. The eigenvalue for Factor 3 was 0.69 and was found to explain 53.3% of the variance among PIC variables.

Results of the obliquely rotated pattern matrix can be seen in Table 6-10. Items with factor loadings below 0.32 are represented as blanks. All items loaded onto one of the three factors. The first factor, Factor 1, included items *Co-sleeping with Parent*, *Frequency of Nighttime Awakenings*, and *Duration of Nighttime Awakenings*, with factor loadings ranging between 0.41 – 0.61. *Frequency of Nighttime Awakenings* had the highest loading onto Factor 1 with a value of 0.61. Items *Duration of Nighttime Awakenings* and *Co-sleeping with Parent* had factor loading values of 0.58 and 0.41, respectively, onto Factor 1. The second factor, Factor 2, contained items *Bedtime Resistance* and *SOL*. Both items loaded at a value of 0.53 onto Factor 2. Factor 3 was comprised of two items, *EMW* and *TST*, with loading values of 0.53 and 0.49, respectively.

6.1.3 EFA – Preschoolers

For the preschooler age group, items loaded into four factors, with the fourth considered to be unreliable as only one item loaded. Table 6-11 depicts the results of the unrotated initial solution table for children aged 3 to 5 years old. A χ^2-test of model fit demonstrated that the model was significantly different from the null model: $\chi^2 = 484.35$

(21, N = 828, p<.001). In conjunction with the scree plot (Figure 6-3), the initial solution table suggested that our extracted model be comprised of 4 factors. Factors were found to be correlated (Table 6-12). Therefore, promax rotation of factors was used for interpretation of the factor structure.

The unrotated pattern matrix is displayed in Table 6-13 and the extracted solution table for children aged 3 to 5 years old can be seen in Table 6-14. Factor 1 had an eigenvalue of 0.73 and accounted for 69.4% of total variance in the PIC. Factor 2 explained 67.5% of the total variance in PIC scores with an eigenvalue of 0.71. The eigenvalue for Factor 3 was 0.38, which accounted for 36.1% of the total variance. Moreover, the eigenvalue for Factor 4 was 0.29, explaining 27.0% of the total variance in PIC scores.

Table 6-15 contains the results of the obliquely rotated pattern matrix. *TST* did not exceed the minimum factor loading threshold of 0.32, and thus, is considered to have not loaded onto any of the four factors. The first factor was comprised of two items, *Frequency of Nighttime Awakenings* and *Duration of Nighttime Awakenings* with factor loading values of 0.56 and 0.58, respectively. Factor 2 included items *Bedtime Resistance* and *SOL*. *Bedtime Resistance* had a factor loading of 0.55 onto Factor 2. Moreover, *SOL* loaded at a value of 0.56 on Factor 2. Factor 3 included a single item, *Co-sleeping with Parent*, with a loading value of 0.33. Lastly, *EMW* was the only item to load onto Factor 4 and loaded at a value of 0.34.

6.1.4 EFA – School Aged Children

For school-aged children, items loaded onto 4 factors. However, the fourth factor was unreliable with only one item loading. Table 6-16 displays the results of the unrotated initial solution table for children aged 6 to 10 years old. A χ^2-test of model fit indicated that the model was significantly different from the null model: $\chi^2 = 401.28$ (21, N = 959, p<.001). Four significant factors were identified for the final extraction solution table from cross-referencing the initial solution with its corresponding scree plot (Figure 6-4). Factors were found to be correlated (Table 6-17). Therefore, promax rotation of factors was used for interpretation of the factor structure. The unrotated pattern matrix is displayed in Table 6-18.

Table 6-19 contains the results of the obliquely rotated factor solution for children aged 6 to 10 years old. Factor 1 explained 71.9% of the total variance in PIC scores, with an eigenvalue of 0.57. Factor 2 had an eigenvalue of 0.55 and accounted for 69.4% total variance in the data. Factors 3 and 4 had an eigenvalue of 0.35 and were found to explain 44.0% and 43.8% of the total variance in PIC scores, respectively.

The rotated pattern matrix for children aged 6 to 10 years is displayed in Table 6-20. All 7-items loaded onto one of four factors. In Factor 1, *Frequency of Nighttime Awakenings* and *Duration of Nighttime Awakenings* had identical factor loading values of 0.50. The second factor contained two items, *EMW* and *TST*, with items loading equally onto Factor 2 at 0.49. Factor 3 was comprised of the items *Bedtime Resistance* and *SOL*. *Bedtime Resistance* had a factor loading of 0.40, while *SOL* had a factor loading value of 0.39 onto Factor 3. *Co-sleeping with Parent* was the only item to constitute Factor 4, with a loading value of 0.35.

6.2 Summary of Objective 1a Results

Throughout all exploratory factor analyses, our findings were in support of our Hypothesis 1a and indicated that the PIC is multidimensional with all items loading into 3 to 4 factors. Although a fourth factor was identified to underlie preschoolers and school-aged children's PIC scores, evidence for a reliable fourth factor was poor. First, a fourth factor was identified in 2/4 exploratory factor analyses performed. Second, this factor only had 1 item loading. Third, the item loading onto the fourth factor was not identical across analyses. As factor retention is a tradeoff between enough factors for an adequate fit (i.e., the more factors included increases the variance explained by the factor solution) and parsimony (Tabachnick & Fidell, 2013), the fourth factor was deemed unreliable for reasons of parsimony.

Consistently across analyses, variables loaded reliably onto 3 factors with a common pattern amongst item-loadings. Interestingly, the pattern of items comprising each factor were in concordance with the three expressions of Insomnia indicated in the DSM-5 (2013): Difficulties with Initiating sleep, Difficulties with Maintaining sleep and/or Waking Too Early in the morning. Items *Frequency of Nighttime Awakenings and Duration of Nighttime Awakenings* always loaded together, with the addition of *Co-Sleeping with Parent* in the youngest age group and full model. As items loading onto Factor 1 related to difficulties with maintaining sleep (DSM-5; 2013), we labelled this factor as 'Problems with Sleep Maintenance'. *Bedtime Resistance* and *Sleep Onset Latency* loaded together across all factor analyses. Since both items are associated with difficulties initiating sleep, this factor was labelled 'Problems with Sleep Initiation'. The last factor, comprised of items *TST* and *EMW,* was observed in all EFAs except for the preschooler

subgroup. We labelled this factor as ‘Problems with Sleep Duration’ as both variables capture information about getting enough sleep.

Table 6-1

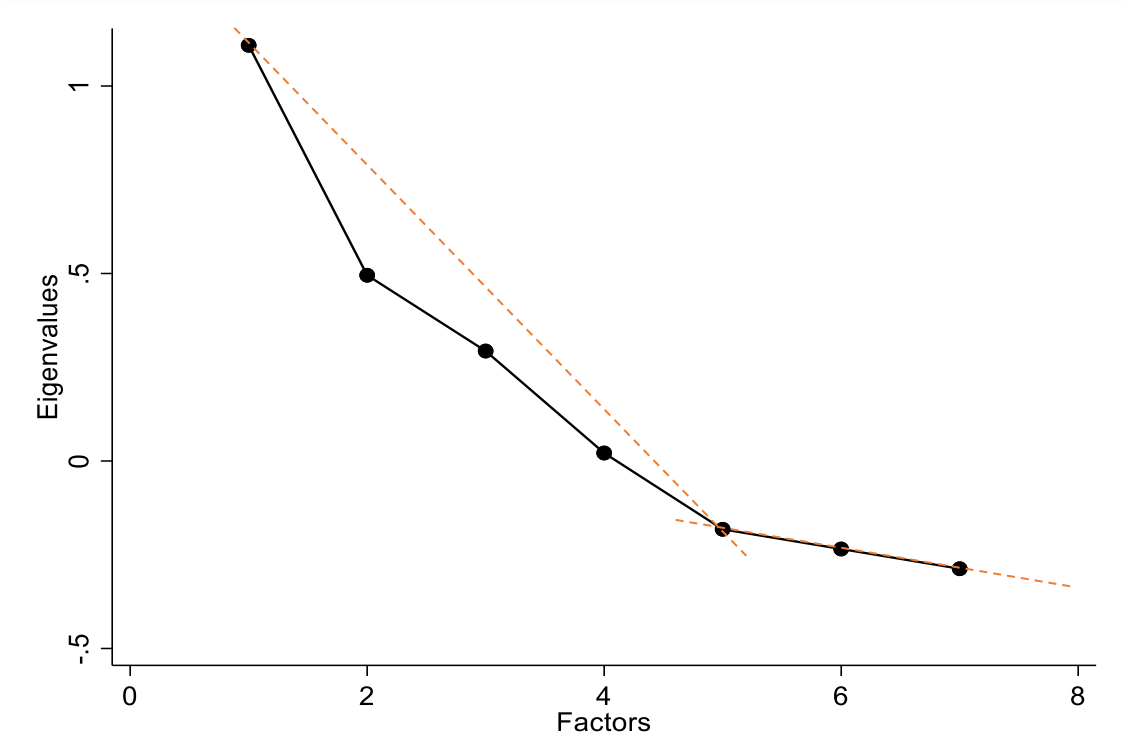
Initial Solution Table of PIC Scores for All Children in the Sample

Factor	Eigenvalue	Difference	Proportion	Cumulative
Factor1	1.11	0.61	0.91	0.91
Factor2	0.50	0.20	0.41	1.32
Factor3	0.29	0.27	0.24	1.56
Factor4	0.02	0.20	0.02	1.58
Factor5	-0.18	0.05	-0.15	1.43
Factor6	-0.24	0.05	-0.19	1.24
Factor7	-0.29	-	-0.24	1.00

Note. Eigenvalues and Proportion of Variance for Seven Factors are Displayed.

Figure 6-1

Scree Plot of Eigenvalues from the Initial Factor Solution Including All Children in the Sample



Note. The point of inflection is marked by the intersection of the two red (hyphenated) lines.

Table 6-2

Factor Correlation Matrix of Three Factors Underlying PIC Scores from All Children in the Sample

	Factor1	Factor2	Factor3
Factor1	0.9537	0.6626	0.0878
Factor2	-0.1922	0.4313	0.9133
Factor3	0.2313	-0.6123	0.3978

Table 6-3

Unrotated Pattern Matrix Containing Regression Coefficients Between PIC Variables and PIC Factors from All Children in the Sample

PIC variable	Factor1	Factor2	Factor3	Uniqueness
Co-Sleeping with Parent	0.43	-0.03	0.00	0.82
Bedtime Resistance	0.15	0.17	0.43	0.77
Early Morning Wakings	0.26	-0.34	0.14	0.80
Sleep Onset Latency	-0.11	0.21	0.42	0.77
Total Sleep Time	0.40	-0.23	0.28	0.71
Frequency of Nighttime Awakenings	0.60	0.17	-0.13	0.60
Duration of Nighttime Awakenings	0.56	0.16	-0.16	0.64

Table 6-4

Extracted Solutions Table of PIC Factors from All Children in the Sample

Factor	Variance	Proportion
Factor1	1.04	0.86
Factor2	0.69	0.57
Factor3	0.47	0.39

Table 6-5

Obliquely Rotated Pattern Matrix of the Three Factored Solution of All Children's PIC Scores

PIC variable	Factor1	Factor2	Factor3
Co-Sleeping with Parent	0.33		
Bedtime Resistance			0.46
Early Morning Wakings		0.48	
Sleep Onset Latency			0.47
Total Sleep Time		0.47	
Frequency of Nighttime Awakenings	0.65		
Duration of Nighttime Awakenings	0.62		

Note. Only items with factor loadings above 0.32 are shown.

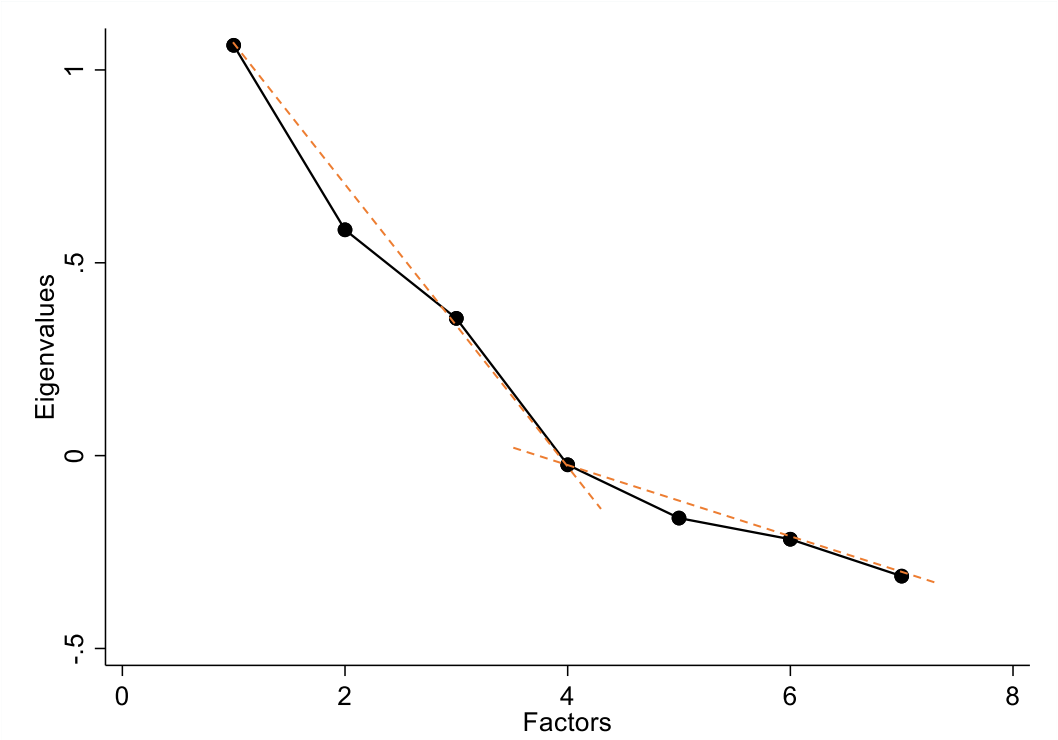
Table 6-6

Initial Solution Table of Eigenvalues and Proportion of Variance for Seven Factors Identified in the Toddler Age Group

Factor	Eigenvalue	Difference	Proportion (%)	Cumulative (%)
Factor1	1.06	0.48	0.82	0.82
Factor2	0.59	0.23	0.45	1.28
Factor3	0.36	0.38	0.28	1.55
Factor4	-0.02	0.14	-0.02	1.54
Factor5	-0.16	0.05	-0.13	1.41
Factor6	-0.22	0.10	-0.17	1.24
Factor7	-0.31	-	-0.24	1.00

Figure 6-2

Scree Plot of Eigenvalues from the Initial Factor Solution of Toddlers' PIC Scores



Note. The point of inflection is marked by the intersection of the two red (hyphenated) lines.

Table 6-7

Factor Correlation Matrix of Three Factors Underlying PIC Scores from the Toddler Age Group

	Factor1	Factor2	Factor3
Factor1	0.90	-0.54	-0.67
Factor2	0.41	0.78	0.26
Factor3	0.17	-0.32	0.70

Table 6-8

Unrotated Pattern Matrix Containing Regression Coefficients of PIC Variables and PIC Factors from Toddlers in the Sample

PIC variable	Factor1	Factor2	Factor3	Uniqueness
Co-Sleeping with Parent	0.27	0.26	0.10	0.85
Bedtime Resistance	-0.17	0.44	-0.19	0.74
Early Morning Wakings	-0.20	0.07	0.43	0.77
Sleep Onset Latency	-0.29	0.40	-0.19	0.72
Total Sleep Time	-0.49	0.24	0.27	0.63
Frequency of Nighttime Awakenings	0.52	0.28	0.10	0.64
Duration of Nighttime Awakenings	0.57	0.18	0.09	0.63

Table 6-9

Extracted Solutions Table of PIC Factors Underlying Toddlers' PIC Scores

Factor	Variance	Proportion
Factor1	0.96	0.75
Factor2	0.70	0.54
Factor3	0.69	0.53

Table 6-10

Obliquely Rotated Pattern Matrix of the Three-Factored Extraction Solution Underlying Toddler's PIC Scores

Variable	Factor1	Factor2	Factor3
Co-Sleeping with Parent	0.41		
Bedtime Resistance		0.53	
Early Morning Wakings			0.53
Sleep Onset Latency		0.53	
Total Sleep Time			0.49
Frequency of Nighttime Awakenings	0.61		
Duration of Nighttime Awakenings	0.58		

Note. Only items with factor loadings above 0.32 are shown.

Table 6-11

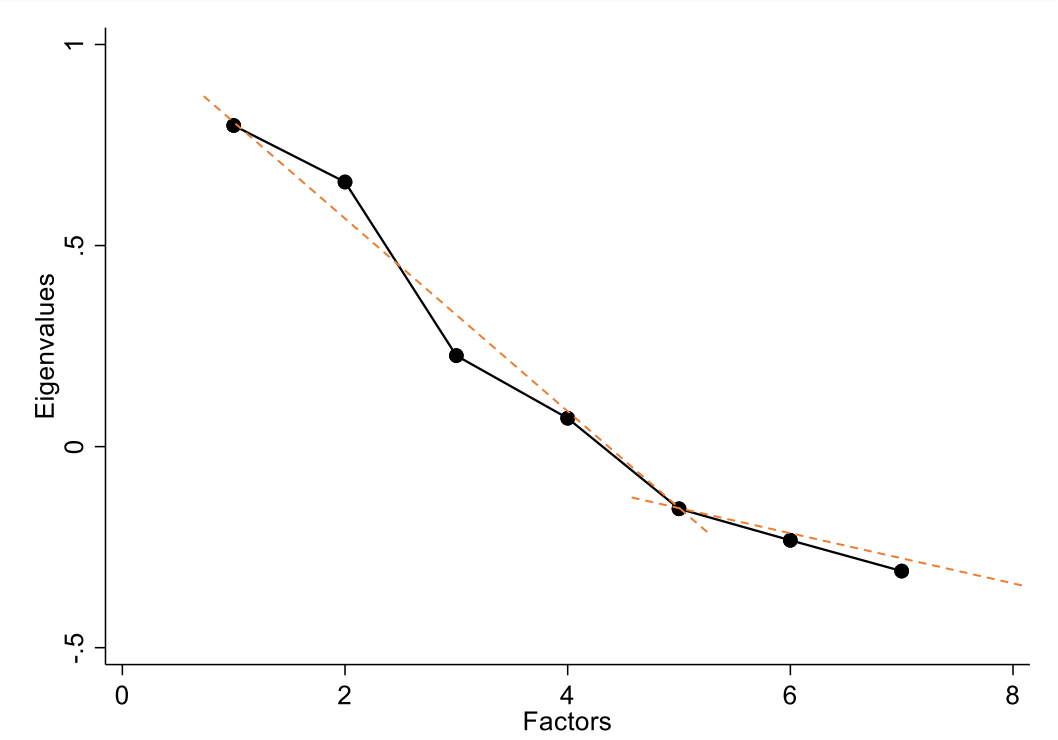
Initial Solution Table of PIC Scores from Preschoolers

Factor	Eigenvalue	Difference	Proportion (%)	Cumulative (%)
Factor1	0.80	0.14	0.76	0.76
Factor2	0.66	0.43	0.62	1.38
Factor3	0.23	0.16	0.21	1.59
Factor4	0.07	0.23	0.07	1.66
Factor5	0.15	0.08	-0.15	1.51
Factor6	0.23	0.08	-0.22	1.29
Factor7	0.31	-	-0.29	1.00

Note. Eigenvalues and proportion of variance for seven factors are displayed.

Figure 6-3

Scree Plot of Eigenvalues from the Initial Factor Solution of Preschooler's PIC Scores



Note. The point of inflection is marked by the intersection of the two red (hyphenated) lines.

Table 6-12

Factor Correlation Matrix of Four Factors Underlying PIC Scores of Preschoolers

	Factor1	Factor2	Factor3	Factor4
Factor1	0.58	0.73	0.21	0.36
Factor2	0.80	-0.67	0.59	-0.21
Factor3	-0.08	0.05	0.64	-0.36
Factor4	-0.15	-0.12	0.45	0.84

Table 6-13

Unrotated Pattern Matrix Containing Regression Coefficients Between PIC Variables and PIC Factors the Preschooler Age Group

PIC Variable	Factor1	Factor2	Factor3	Factor4	Uniqueness
Co-Sleeping with Parent	0.20	0.15	0.21	0.18	0.86
Bedtime Resistance	-0.29	0.40	-0.05	0.14	0.74
Early Morning Wakings	0.05	0.14	0.33	-0.07	0.87
Sleep Onset Latency	-0.40	0.41	-0.14	-0.04	0.66
Total Sleep Time	-0.30	0.25	0.20	-0.10	0.80
Frequency of Nighttime Awakenings	0.47	0.32	-0.09	-0.03	0.67
Duration of Nighttime Awakenings	0.46	0.36	-0.06	-0.05	0.66

Table 6-14

Extracted Solutions Table of PIC Factors from the Preschooler Age Group

Factor	Variance	Proportion (%)
Factor1	0.73	0.69
Factor2	0.71	0.67
Factor3	0.38	0.36
Factor4	0.29	0.27

Table 6-15

Obliquely Rotated Pattern Matrix of the Three Factored Extraction Solution of Preschoolers' PIC Scores

Variable	Factor1	Factor2	Factor3	Factor4
Co-Sleeping with Parent			0.33	
Bedtime Resistance		0.55		
Early Morning Wakings				0.34
Sleep Onset Latency		0.56		
Total Sleep Time				
Frequency of Nighttime Awakenings	0.56			
Duration of Nighttime Awakenings	0.58			

Note. Only items with factor loadings above 0.32 are shown.

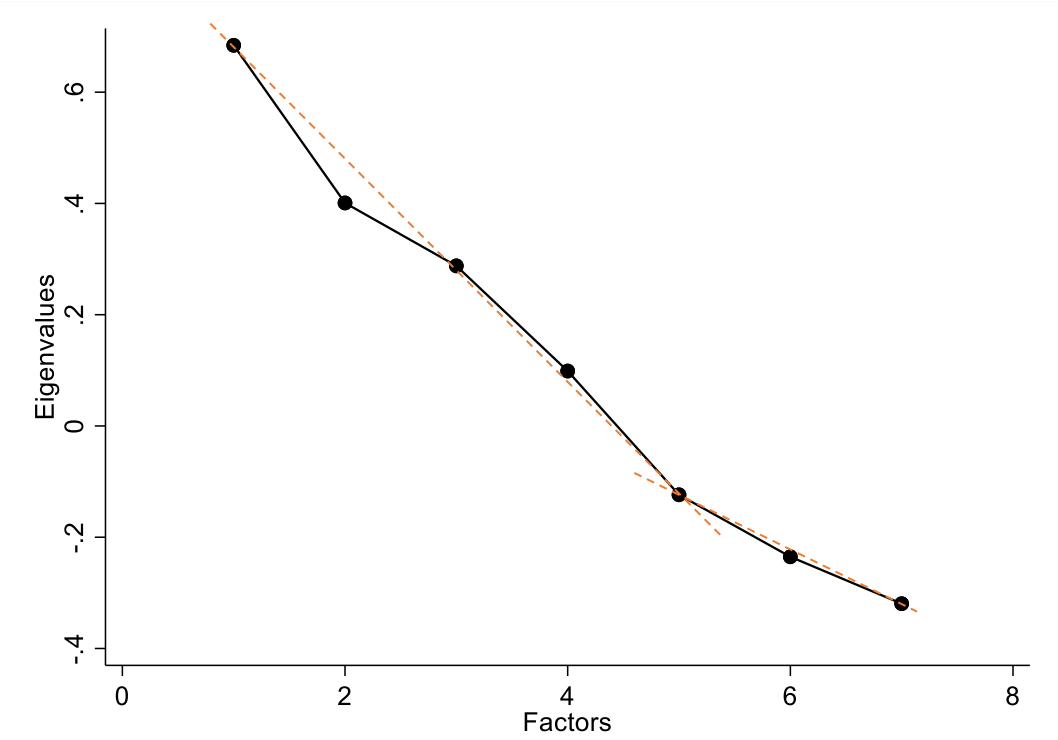
Table 6-16

Initial Solution Table Containing Eigenvalues and Proportion of Variance for Seven Factors Identified in School-aged Children

Factor	Eigenvalue	Difference	Proportion (%)	Cumulative (%)
Factor1	0.68	0.28	0.86	0.86
Factor2	0.40	0.11	0.51	1.37
Factor3	0.29	0.19	0.36	1.73
Factor4	0.10	0.22	0.12	1.85
Factor5	-0.12	0.11	-0.16	1.70
Factor6	-0.24	0.08	-0.30	1.40
Factor7	-0.32	-	-0.40	1.00

Figure 6-4

Scree Plot of Eigenvalues from the Initial Factor Solution of School-aged Children



Note. The point of inflection is marked by the intersection of the two red (hyphenated) lines.

Table 6-17

Factor Correlation Matrix of Four Factors Underlying PIC Scores from School-aged Children

	Factor1	Factor2	Factor3	Factor4
Factor1	0.79	0.76	0.30	0.60
Factor2	-0.56	0.55	0.51	-0.28
Factor3	0.19	-0.33	0.79	-0.27
Factor4	-0.12	-0.09	0.13	0.70

Table 6-18

Unrotated Pattern Matrix Containing Regression Coefficients Between PIC Variables and PIC Factors for School-aged Children

PIC Variable	Factor1	Factor2	Factor3	Factor4	Uniqueness
Co-Sleeping with Parent	0.19	-0.08	-0.09	0.25	0.89
Bedtime Resistance	0.24	0.15	0.29	0.15	0.82
Early Morning Wakings	0.38	0.24	-0.21	-0.02	0.76
Sleep Onset Latency	-0.02	0.26	0.35	-0.05	0.81
Total Sleep Time	0.36	0.29	-0.12	-0.06	0.76
Frequency of Nighttime Awakenings	0.34	-0.33	0.10	-0.06	0.77
Duration of Nighttime Awakenings	0.45	-0.23	0.10	-0.07	0.73

Table 6-19

Extracted Solutions Table of PIC Factors for School-aged Children

Factor	Variance	Proportion
Factor1	0.57	0.72
Factor2	0.55	0.69
Factor3	0.35	0.44
Factor4	0.35	0.44

Table 6-20

Obliquely Rotated Pattern Matrix of the Four Factored Solution for School-aged Children

Variable	Factor1	Factor2	Factor3	Factor4
Co-Sleeping with Parent				0.35
Bedtime Resistance			0.40	
Early Morning Wakings		0.49		
Sleep Onset Latency			0.39	
Total Sleep Time		0.49		
Frequency of Nighttime Awakenings	0.50			
Duration of Nighttime Awakenings	0.50			

Note. Only items with factor loadings above 0.32 are shown.

Chapter 7: OBJECTIVE 1b RESULTS

7. OBJECTIVE 1b: To assess the internal consistency of the PIC for all children, as well as across each of the three age groups.

7.1 Internal Consistency

Results of Cronbach's alpha for all children and across each age-group can be seen in Table 7-1. The standard errors of the alpha-coefficients were bootstrapped from n = 1000 samples to calculate 95% CI's around all alpha-coefficients. For the entire sample, Cronbach's alpha was $\alpha = 0.49$ (95% CI = 0.44, 0.55). Next, we examined the value of alpha across each of the three age groups. The PIC's internal consistency was found to decrease as the age of children increased (Table 7-1). In toddlers, Cronbach's alpha was $\alpha = 0.49$ (95% CI = 0.39, 0.59). Alpha-values for preschoolers and school-aged children were $\alpha = 0.39$ (95% CI = 0.26, 0.52) and $\alpha = 0.29$ (95% CI = 0.14, 0.44), respectively.

Table 7-2 displays the results of Cronbach's alpha for the three factored solution identified in the EFA of all children's PIC scores (See Section 6.1.1, para 3, and Table 6-5 of this thesis for more details about the factor solution of the entire sample). Factor 1, composed of variables *Co-sleeping with Parent*, *Frequency of Nighttime Awakenings* and *Duration of Nighttime Awakenings*, had the highest internal consistency of the three factors ($\alpha = 0.54$, 95% CI = 0.48, 0.60). *TST and EMW* made up Factor 2, with an $\alpha = 0.45$ (95% CI = 0.36, 0.55). Factor 3 contained the variables *Bedtime Resistance* and

SOL. The internal consistency of Factor 3 was found to be α = 0.45 (95% CI = 0.35, 0.55).

7.2 Summary of Objective 1b Results

Overall, the internal consistency of the PIC and PIC factors was demonstrated to be poor. Contrarily to our Hypothesis 1b, the internal consistency of the PIC was below an acceptable value of alpha (α < 0.70; Nunnally & Bernstein, 1994) for all children and across age groups. However, as the PIC was found to capture multiple dimensions of insomnia, in hindsight, a low internal consistency should have been predicted. Internal consistency concerns the extent to which items in a scale measure the same construct (Streiner, 2003). By construction then, a composite measure would have a reduced internal consistency compared to a unidimensional measure of the same construct. Although the PIC was found to have poor internal consistency, its multidimensional construction likely led to deflated alpha-estimates. We then believed that it was important to explore the internal consistency across each of the three dimensions, which we predicted would be higher than the PIC.

Alpha-estimates for the three factors ranged from α = 0.45 (95% CI = 0.35, 0.55) to α = 0.54 (95% CI = 0.48, 0.60), approximating the alpha-coefficient found for the PIC. Based on Nunnally & Bernstein's (1994) recommendation, the factors underlying PIC scores have poor internally consistency.

Table 7-1

Cronbach's Alpha for the Entire Sample of Children and for Each Age Group

	Alpha coefficient	Bootstrapped Std. Error	z	*p*	95% CI [LL, UL]
Toddlers	0.49	0.053	9.18	.001	[0.39, 0.60]
Preschoolers	0.39	0.069	5.65	.001	[0.25, 0.52]
School-Aged	0.29	0.076	3.80	.001	[0.14, 0.44]
Total	0.49	0.028	17.53	.001	[0.44, 0.55]

Note. Standard errors and 95% confidence intervals (95% CI) were computed from n=1000 bootstrapped samples. LL: Lower limit; UL: Upper limit.

Table 7-2

Values of Cronbach's Alpha Identified in the Three Factored Solution of All Children's PIC Scores

	Alpha coefficient	Bootstrapped Std. Error	z	*p*	95% CI [LL, UL]
Factor1 [a]	0.54	0.031	17.35	.001	[0.48, 0.60]
Factor2 [b]	0.45	0.048	9.46	.001	[0.36, 0.55]
Factor3 [c]	0.45	0.053	8.54	.001	[0.35, 0.55]

Note. Standard errors and 95% confidence intervals (95% CI) were computed from n=1000 bootstrapped samples. LL: Lower limit; UL: Upper limit.

[a] Factor1 is composed of variables Co-sleeping with Parent, Frequency of Nighttime Awakenings, and Duration of Nighttime Awakenings.

[b] Factor2 contains the variables Total Sleep Time and Early Morning Wakings.

[c] Factor3 is composed of variables Bedtime Resistance and Sleep Onset Latency.

Chapter 8: OBJECTIVE 1c RESULTS

8. OBJECTIVE 1c: To evaluate the construct validity of the PIC.

8.1 Agreement Between the PIC and the DIMS

Table 8-1 contains the ICC-estimates for the PIC and the DIMS. All ICC estimates and their 95% confidence intervals were calculated using a mean-measurement, consistency of agreement, 2-way mixed-effects model. All mean ICC were in the "moderate" range (Koo & Li, 2016). The average agreement between the PIC and the DIMS was ICC = 0.72 (95% CI = 0.65, 0.77). For toddlers, the average consistency of agreement between the PIC and the DIMS was ICC = 0.74 (95% CI = 0.63, 0.82). For preschoolers, the average consistency of agreement between the PIC and the DIMS was ICC = 0.65 (95% CI = 0.49, 0.75). In the school-aged children, the average agreement between the PIC and the DIMS was ICC = 0.66 (95% CI = 0.53, 0.76).

8.2 Agreement Between the PIC and the CBCL

Table 8-2 contains the ICC-estimates between the PIC and the CBCL (i.e., total problem t-score) for all children in the sample, as well as across each of the three age groups. All results were found to be non-significant (p>0.05). In the analysis including all children, ICC = -0.08 (95% CI = -0.18, 0.02) and is non-statistically significant. For toddlers and preschoolers, the consistency of agreement was also non-significant with

ICC = 0.07 (95% CI = -0.12, 0.25). Further, the consistency between the PIC and CBCL was non-significant in the school-aged children analysis (ICC = 0.08 (95% CI = -0.10, 0.25)).

8.3 Agreement Between the PIC and Actigraphy

8.3.1 Rank Biserial Correlation

Somers' D was conducted to evaluate the association between the PIC and the actigraphy "Evidence for Insomnia" index (See *Section 4.8.3, para. 3 & 4* of this thesis for an explanation of how the indices were generated). Results were found to be statistically significant with a low and positive correlation of $d = 0.36$ (95% CI = 0.22, 0.48) between measures.

8.3.2 Test Characteristics of the PIC

The actigraphy index identified 300 participants (n=300; 79.6%) as having "Evidence for Insomnia" and 77 participants (n=77; 20.4%) as having "No Evidence for Insomnia" (Table 8-3), whereas the PIC index classified 361 participants (n=361; 95.8%) as having "Evidence for Insomnia" and 16 participants (n=16; 4.24%) as having "No Evidence for Insomnia" (Table 8-4). Table 8-5 reports the results of the 2x2 table between the PIC and Actigraphy indices. Of the 377 participants in the sample, 294 received a positive test result (i.e., true positives) from both measures. Conversely, both indices identified 10 participants as having "No Evidence for Insomnia" (i.e., true negatives). However, 6 participants were classified as having "Evidence for Insomnia" by

the actigraphy index but not the PIC index (i.e., false negatives) and 67 participants were classified as having "Evidence for Insomnia" by the PIC index but not the actigraphy-index (i.e., false positives).

The test characteristics of the PIC are displayed in Table 8-6 and were calculated using the actigraphy index as the dependent variable or "Objective measure" and the PIC index as the independent variable. The PIC was found to have sensitivity and specificity values of 98.0% (95% CI = 95.7, 99.3%) and 13.0% (95% CI = 6.4, 22.6%), respectively. The PIC index ruled in (i.e., identified true cases as indicated by the sensitivity) 98.0% of children as having insomnia. However, the PIC index ruled out (i.e., identified true negative cases as indicated by specificity) 13.0% of children as having no evidence for insomnia. In a population of children with a 30% prevalence of insomnia, the positive predictive value (PPV) was 32.6% (95% CI = 30.7, 34.5%), indicating that if a child receives a positive PIC score (i.e., indicating evidence for insomnia), there is a 32.1% likelihood that the child has insomnia. At a prevalence of 25% and 20%, the PPV decreased to 27.3% (95% CI = 25.6, 29.1%) and 22.0% (95% CI = 20.5, 23.5%), respectively. The negative predictive value (NPV) of the PIC increased from 93.8% (95% CI = 85.0, 97.6%) at 30% prevalence to 95.1% (95% CI = 88.0, 98.1%) at 25% prevalence, and again to 96.3% (95% CI = 90.7, 98.5%) at a prevalence of 20%. Moreover, if a child receives a negative test result at a disease prevalence of 30%, the likelihood that the child does not have insomnia is 93.8% (95% CI = 85.0, 97.6%).

Figure 8-1 displays the ROC curve representing the discriminative ability of the PIC for identifying children as having "Evidence for Insomnia" or "No Evidence for Insomnia". Although statistically significant, the AUC-value was 0.555 (95% CI = 0.516,

0.594) indicating that the PIC index has a poor ability to distinguish children with "Evidence for Insomnia" from those with "No Evidence for Insomnia".

8.4 Summary of Objective 1c Results

Our findings were in concordance with our Hypothesis 1c (ICC < 0.75) as results demonstrated no statistically significant agreement between the PIC and CBCL. The absence of high (ICC > 0.70) and positive ICC-estimates between the PIC and CBCL is evidence that measures capture different constructs and demonstrates that the PIC has good discriminant validity relative to the CBCL. As the CBCL measures problem behavior in children (Achenbach & Rescorla, 2000; Achenbach & Rescorla, 2001), these findings were to be expected since the PIC was constructed to capture symptoms of insomnia. However, evaluating the discriminant validity between two measures only shows that the measures being evaluated capture different constructs, which is determined by the absence of agreement or a low agreement. Thus, we needed to demonstrate that the construct being measured by the PIC was indeed childhood insomnia.

To demonstrate convergent validity, we assessed the PICs agreement with previously validated measures of childhood insomnia. Although ICC-estimates were lower than our hypothesized value (i.e., ICC > 0.85), the PIC was demonstrated to have generally "moderate" agreement with the DIMS across analyses. Examination of CI indicated generally moderate to good ICCs, except for the preschooler age group where agreement between measures ranged from "poor" to "good", although the lower end of the CI was at the high end of the poor range (Koo & Li, 2016). As both the TCSQ and

SDSC are previously validated measures of insomnia symptoms in children (McGreavy et al., 2005; Bruni et al., 1996), our findings support that the PIC is capturing insomnia symptoms. Thus, there is evidence that the PIC measures symptoms of insomnia in children, with "moderate" to "good" convergent validity with the DIMS.

Our findings demonstrated that the PIC has an excellent sensitivity of 98.0% (95% CI = 85.7, 99.3%), but a poor specificity of 13.0% (95% CI = 6.4, 22.6%). Overall, agreement between indices was low but positive and indicated that the PIC classified children concordantly with actigraphy on 36.0% of ratings. Given that a child receives the classification 'No Evidence for Insomnia', the likelihood that this child does not have insomnia is high with NPV = 93.8% (95% CI = 85.0, 97.6%) and NPV = 95.1% (95% CI = 88.0, 98.1%) at 30% and 25% prevalence of insomnia, respectively. Conversely, when a child receives a positive-result on the PIC, the likelihood that they have insomnia would be low as PPV = 32.6% (95% CI = 30.7, 34.5%) at 30% prevalence and PPV = 27.3% (95% CI = 25.6, 29.1%) at 25% prevalence. Thus, when a child's PIC score indicates "No Evidence for Insomnia", they almost certainly do not have the disorder. However, in the event of positive test result, the PIC is poor at determining whether a child has insomnia. This finding was demonstrated by the AUC-value = 0.555 (95% CI = 0.516, 0.594), which illustrates that the PIC has a poor ability to differentiate children with insomnia from those without insomnia.

Table 8-1

Intraclass Correlation Coefficient's Between the PIC and DIMS, Using a Mean-measurement, Consistency of Agreement, 2-way Mixed-effects Model

Measure	Individual		Average		
	ICC [a]	95% CI [LL, UL]	ICC [b]	95% CI [LL, UL]	F (366, 366)
DIMS (Toddlers)	0.59	[0.46, 0.70]	0.74	[0.63, 0.82]	3.90***
DIMS (Preschoolers)	0.48	[0.32, 0.60]	0.65	[0.49, 0.75]	2.81***
DIMS (School-aged)	0.50	[0.36, 0.62]	0.66	[0.53, 0.76]	2.98***
DIMS (All Children)	0.56	[0.48, 0.62]	0.72	[0.65, 0.77]	3.50***

Note. DIMS: Disorders of Initiating and Maintaining Sleep (McGreavey et al., 2005; Bruni et al., 1996)

[a] Consistency of agreement between measures across individual targets

[b] Consistency of agreement between average ratings across targets

*** $p < .001$.

Table 8-2

Intraclass Correlation Coefficients between the PIC and the Total Problem T-score of the CBCL/1.5-5 and the CBCL/6-18 Using a Mean-measurement, Consistency of Agreement, 2-way Mixed-effects Model

Measure	Individual		Average		
	ICC [a]	95% CI [LL, UL]	ICC [b]	95% CI [LL, UL]	F (111,111)
CBCL/1.5-5 (Toddlers)	0.07	[-0.12, 0.25]	0.13	[-0.27, 0.40]	1.14
CBCL/1.5-5 (Preschoolers)	0.07	[-0.12, 0.25]	0.13	[-0.26, 0.40]	1.15
CBCL/6-18 (School-Aged)	0.08	[-0.10, 0.25]	0.15	[-0.21, 0.40]	1.17
CBCL (All Children)	-0.08	[-0.18, 0.02]	-0.18	[-0.45, 0.04]	0.85

Note. CBCL: Child Behavior Checklist (Achenbach & Rescorla, 2000; Achenbach & Rescorla, 2001

[a] Consistency of agreement between raters across individual targets

[b] Consistency of agreement between average ratings across targets

*** $p < 0.001$.

Table 8-3

Frequency of Children Classified as Having "Evidence for Insomnia" or "No Evidence for Insomnia" Based on Actigraphy

Actigraphy-index	n (%)
"Evidence for Insomnia"	300 (79.58%)
"No Evidence for Insomnia"	77 (20.42%)
Total	377 (100%)

Table 8-4

Frequency of Children Classified as Having "Evidence for Insomnia" or "No Evidence for Insomnia" Based on the PIC Index

PIC Index	n (%)
"Evidence for Insomnia"	361 (95.76%)
"No Evidence for Insomnia"	16 (4.24%)
Total	377 (100%)

Table 8-5

2x2 Table between the PIC and Actigraphy "Evidence for Insomnia" Indices

		Actigraphy Index		
		"Evidence for Insomnia"	"No Evidence for Insomnia"	Total
PIC Index	"Evidence for Insomnia"	294	67	361
	"No Evidence for Insomnia"	6	10	16
	Total	300	77	377

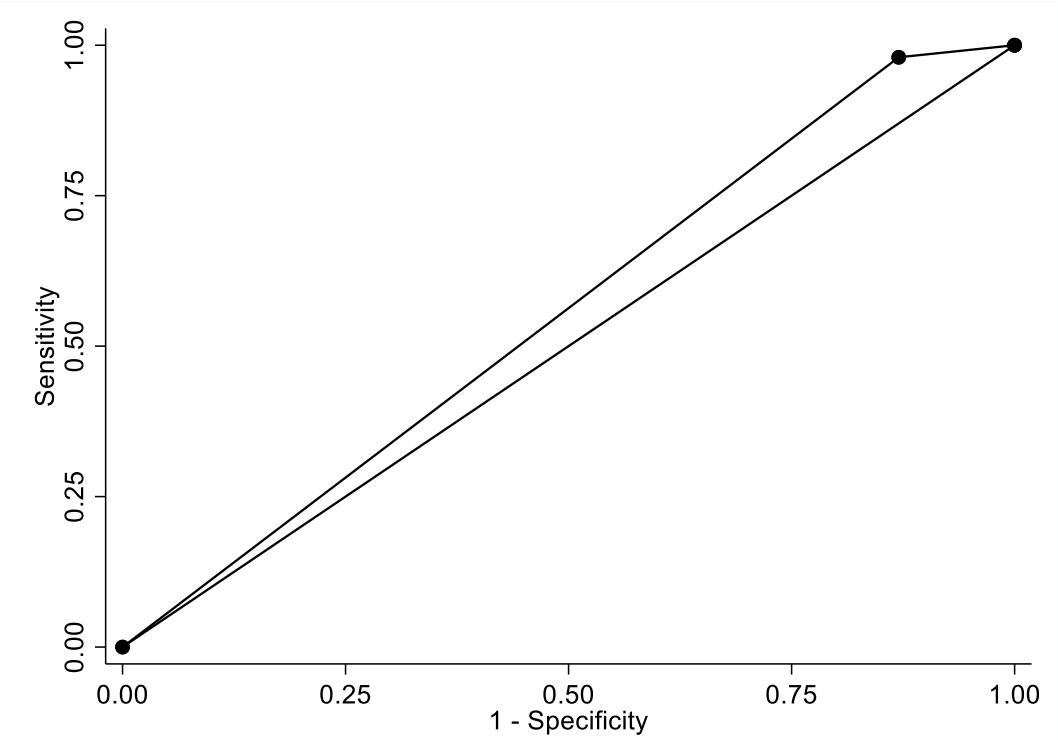
Table 8-6

Sensitivity, Specificity, Positive Predictive Values, and Negative Predictive Values of the PIC at 20%, 25%, and 30% Insomnia-Prevalence's Using Actigraphy as the "Objective Measure"

Prevalence, %	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)
30	98.0% (95.7 – 99.3%)	13.0% (6.4 – 22.6%)	32.6% (30.7 – 34.5%)	93.8% (85.0 – 97.6%)
25	98.0% (95.7 – 99.3%)	13.0% (6.4 – 22.6%)	27.3% (25.6 – 29.1%)	95.1% (88.0 – 98.1%)
20	98.0% (95.7 – 99.3%)	13.0% (6.4 – 22.6%)	22.0% (20.5 – 23.51%)	96.3% (90.7 – 98.5%)

Figure 8-1

ROC Curve Representing the Discriminative Ability of the PIC for Identifying Children as Either Having "Evidence for Insomnia" or "No Evidence for Insomnia"



Note. The AUC value corresponding to the ROC curve was 0.555 (95% CI = 0.516, 0.594).

Chapter 9: OBJECTIVE 1d RESULTS

9. OBJECTIVE 1d: To examine the treatment sensitivity of the PIC from baseline to end of treatment (i.e., 4 months post-randomization) for all children and across each age group.

9.1 Descriptive Statistics of PIC Scores by Group and Time

Table 9-1 displays the mean PIC scores for children in the Usual Care and Treatment groups at baseline and 4-months post-randomization. At baseline, the mean (SD) PIC scores for children in the Usual Care and Treatment groups were 23.68% (SD = 3.21%) and 26.96% (SD = 15.07%), respectively. At 4-months, children in the Usual Care group had a mean PIC score of 21.19% (SD = 13.20%). For children in the Treatment group, the mean PIC score was 17.85% (SD = 14.02%) at 4-months post-randomization.

9.2 Descriptive Statistics of PIC Scores by Age-group and Time

Children's mean (SD) PIC scores, stratified by age group and period, can be seen in Table 9-2. For toddlers in the usual care and treatment groups, mean PIC scores were 35.00% (SD = 12.91%) and 42.64% (SD = 9.79%) at baseline, respectively. At 4-months follow up, toddlers in the usual care group had a mean PIC score of 31.74% (SD = 13.16%) and toddlers in the treatment group had a mean PIC score of 29.78% (SD = 12.60). At baseline, preschoolers in the usual care group had a mean PIC score of 21.04%

(SD = 10.94%), which decreased to 18.36% (SD = 10.16%) at 4-months post-randomization. For preschoolers in the treatment group, mean PIC scores decreased from 22.83% (SD = 11.96%) at baseline to 14.37% (SD = 13.35%) at 4-months. School-aged children in the usual care group had a mean PIC score of 16.28% (SD = 8.06%) at baseline and 14.66% (SD = 10.01%) at 4-months. In the treatment group, the mean PIC score for school-aged children decreased from 16.24% (SD = 8.00%) at baseline to 9.94% (SD = 7.08%) at 4-months post-randomization.

9.3 Treatment Sensitivity for All Children

Table 9-3 displays the results of a two-way repeated measures ANOVA between group assignment (treatment vs usual care) and assessment period (baseline and 4 months) on children's PIC scores including all children in the sample. Significant main effects of period ($F_{1,542} = 23.75; p<0.001$) and the period-group interaction term ($F_{1,542} = 7.72; p<0.05$) were found. The significant interaction term indicated that children in the treatment group had a greater reduction in PIC scores at 4-months than did the children in the usual care group.

9.3.1 Treatment Sensitivity for Toddlers

Table 9-4 contains the results of a two-way repeated measures ANOVA between group assignment and period on children's PIC scores for children aged 1 to 2 years old. Overall, our model was found to be significant ($F_{3,170} = 8.65; p<.001$). There was no significant main effect of group assignment on children's PIC scores ($F_{1,170} = 2.32; p = .130$). Significant main effects for both the period term ($F_{1,170} = 18.64; p<.001$) and the

period-group interaction ($F_{1,170} = 6.62; p<.001$) term were found. The significant interaction term indicated that toddlers in the treatment group had a greater reduction in PIC scores at 4-months than did the children in the usual care group.

9.3.2 Treatment Sensitivity for Preschoolers

Results of the two-way repeated measures ANOVA between period and group assignment for children aged 3 to 5 years old can be seen in Table 9-5. Our model was found to be significant ($F_{3,172} = 3.80; p = .011$). The group assignment term was determined to be non-significant ($F_{1,172} = 8.65; p = 0.533$), as well as the interaction term ($F_{1,172} = 2.68; p = .104$) for this age group. A significant main effect of period on children's PIC scores was observed ($F_{1,172} = 9.99; p = .002$).

9.3.3 Treatment Sensitivity for School-Aged Children

Table 9-6 displays the results of a two-way repeated measures ANOVA between group assignment and period on children's PIC scores for children aged 6 to 10 years. Our model was found to be significant in this age group ($F_{3,192} = 5.83; p < .001$). The main effects of group assignment ($F_{1,192} = 3.89; p = .050$) and the period-group interaction term ($F_{1,192} = 3.75; p = .054$) were found to be marginally significant. The marginally significant interaction term indicated that school-aged children in the treatment group had a greater reduction in PIC scores at 4-months than did the children in the usual care group. There was a significant main effect of period ($F_{1,192} = 10.81; p = .001$) on children's PIC scores.

9.4 Summary of Objective 1d Results

Treatment sensitivity was found for the overall sample, as well as for the toddler and school-age groups. Although the group by time interaction trended in the same direction for the preschool group, it was not significant. This may be due to the larger standard deviations in the preschool group.

Table 9-1

Mean PIC Scores of Children in the Usual Care and Treatment Groups at Baseline and 4-months (Post-randomization)

Time Period	Group	n	Mean	SD
Baseline	Usual Care	153	23.68	13.21
	Treatment	120	26.96	15.07
	Total	273	25.13	14.13
4-months	Usual Care	153	21.19	13.20
	Treatment	120	17.85	14.02
	Total	273	19.72	13.64

Table 9-2

Mean PIC Scores Across Age Groups at Baseline and 4-months (Post-randomization)

Age Group	Group Assignment	Baseline			4 Months		
		n	**Mean**	**SD**	**n**	**Mean**	**SD**
Toddlers	Usual Care	47	35.00	12.91	47	31.74	13.16
	Treatment	40	42.64	9.79	40	29.78	12.60
Preschoolers	Usual Care	53	21.04	10.93	53	18.36	10.16
	Treatment	35	22.83	11.96	35	14.37	13.35
School-aged Children	Usual Care	53	16.28	8.06	53	14.66	10.01
	Treatment	45	16.24	8.00	45	9.94	7.08

Table 9-3

Results of a Two-way Repeated Measures ANOVA between Group Assignment and Period on All Children's PIC Scores

Source	Partial Sum of Squares	*df*	Mean Square	F	*p*
Model	5462.04	3.00	1820.68	9.54	0.001
Group	0.12	1.00	0.12	0.00	0.980
Time Period	4533.07	1.00	4533.07	23.75	0.001
Group*Time Period	1473.945	1.00	1473.95	7.72	0.006
Residual	103433.00	542.00	190.84		
Total	108895.10	545.00	199.81		

Table 9-4

Results of a Two-way Repeated Measures ANOVA between Group Assignment and Period on Toddler's PIC Scores

Source	Partial Sum of Squares	*df*	Mean Square	F	*p*
Model	3901.37	3.00	1300.46	8.65	.001
Group	348.43	1.00	348.43	2.32	.130
Time Period	2803.47	1.00	2803.47	18.64	.001
Group*Time Period	995.28	1.00	995.28	6.62	.011
Residual	25572.72	170.00	150.43		
Total	29474.10	173.00	170.37		

Table 9-5

Results of a Two-way Repeated Measures ANOVA between Group Assignment and Period on Preschooler's PIC Scores

Source	Partial Sum of Squares	*df*	Mean Square	F	*p*
Model	1493.14	3.00	497.71	3.80	0.011
Group	51.02	1.00	51.02	0.39	0.533
Time Period	1308.12	1.00	1308.12	9.99	0.002
Group*Time Period	350.78	1.00	350.78	2.68	0.104
Residual	22514.41	172.00	130.90		
Total	24007.55	175.00	137.19		

Table 9-6

Results of a Two-way Repeated Measures ANOVA between Group Assignment and Period on School-aged Children's PIC Scores

Source	Partial Sum of Squares	*df*	Mean Square	F	*p*
Model	1241.23	3.00	413.74	5.83	0.001
Group	275.62	1.00	275.62	3.89	0.050
Time Period	766.70	1.00	766.70	10.81	0.001
Group*Time Period	266.24	1.00	266.24	3.75	0.054
Residual	13614.17	192.00	70.91		
Total	14855.39	195.00	76.18		

Chapter 10: DISCUSSION

10.1 Study Purpose and Summary of Findings

The aim of this thesis was to develop a sleep diary-derived composite outcome of pediatric insomnia, called the Pediatric Insomnia Composite (PIC), and then evaluate its psychometric properties on a sample of typically developing children aged 1 to 10 years old with insomnia. The 7-itemed PIC was constructed from parent reported sleep diary data (Corkum et al., 2018) collected over a period of seven days and was coded based on clinical severity. In summary of our findings, the PIC was generally demonstrated to have good construct validity (including discriminant and convergent validity), excellent sensitivity, and adequate treatment sensitivity. Further, items loaded relatively consistently into three factors which were congruent with the symptoms of childhood insomnia listed in the DSM-5 and ICSD-3 (DSM-5, 2013; AASM, 2014). However, the PIC was found to have poor specificity and internal consistency across analyses.

Psychometric evaluation is a critical process underlying measurement development (Streiner & Norman, 1995). It is a crucial step prior to incorporating a new measure into a research protocol or clinical practice as it provides quantitative evidence that the tool is measuring what it was constructed for, is sensitive to detecting changes in symptomology overtime, and is capable of producing consistent findings. However, to our understanding, most previously developed composites were not psychometrically evaluated prior to implementation (Richman, 1971; Wiggs & Stores, 1998; Montgomery et al., 2004; Appleton et al., 2012). Without a thorough investigation, a researcher has no objective evidence to support that a new measure is valid beyond its face validity

(Streiner & Norman, 1995). Bypassing the psychometric evaluation process can thus threaten the validity of an entire study. The PIC, in this comprehensive evaluation, demonstrated both psychometric strengths and weaknesses, as discussed below.

10.2 Dimensionality

During our psychometric evaluation, we found that in the full sample of children ages 1 to 10 years, a 3-factor solution identified in the EFA of PIC scores to be the model that best fit our data. All 7 items loaded on to the factors, and as such supported our hypothesis regarding the dimensionality of the PIC. Interestingly, items loaded into multiple factors that represent the grouping of insomnia symptoms listed in the DSM-5 and ICSD-3 (DSM-5, 2013; AASM, 2014). This finding supports what is already established in the literature, being that insomnia has different manifestations. However, the 3-factor solution was not found across all age groups, as the preschooler and school-aged children had a 4-factor solution underlying their PIC scores. In these two age groups, the *Co-Sleeping with Parent* item loaded on its own factor. This finding may be due to the dynamic nature of insomnia which manifests differently across periods of development (Burnham et al., 2002; Kerr & Jowett, 1994; Schlarb et al., 2006; Owens et al., 2000a; Corkum & Vriend, 2011; Sateia et al., 2017). In infants and toddlers, the most common sleep problem is frequent and/or lasting nighttime awakenings (Burnham et al., 2002). Following the event of a nighttime awakening, it is not uncommon for parents in North America to bring their infant or toddler back into bed with them as an attempt to soothe their child to sleep (Owens et al., 2000b). In preschool and school-aged children, sleep problems are most often related to sleep initiation and maintenance, with school-

age children also reporting sleep problems related to bedtime resistance (Kerr & Jowett, 1994; Schlarb et al., 2006; Owens et al., 2000a). It is likely then that inclusion of the *Co-Sleeping with Parent* item within the PIC makes it a more appropriate measure of insomnia in younger children. Moreover, as co-sleeping is more common in infants and toddlers (Owens et al., 2000a; Owens, 2008a), inclusion of this item most likely explains why PIC scores were higher in toddlers relative to the preschooler and school-aged children.

10.3 Internal Consistency

Although a 3-dimensional factor structure was established, the internal consistency of each factor, as well as the PIC as a whole, was poor, which was not supportive of our hypothesis of good internal consistency for the PIC. Internal consistency is concerned with the extent to which items in a scale measure the same construct (Tavakol & Dennick, 2011). Thus, a potential explanation for our findings is that items within the PIC have a poor inter-relatedness because they are tapping into more than one construct. This explanation is supported by the factor solution underlying all children's PIC scores, where the 7-items loaded into 3 heterogenous factors. In hindsight, a lower internal consistency amongst all PIC items should have been hypothesized as reliability assumes unidimensionality across a set of items (Streiner & Norman, 1995; Tavakol & Dennick, 2011; Graham, 2006). Therefore, it was necessary to explore the internal consistency within each unidimensional factor. Across factors, internal consistency was poor with alpha estimates ranging from 0.45 (95% CI = 0.35, 0.55) to 0.54 (95% CI = 0.48, 0.60). However, it has been well documented that factors

containing only a few variables leads to an underestimation of internal consistency when using Cronbach's alpha (Streiner & Norman, 1995; Graham, 2006; Tavakol & Dennick, 2011). Accordingly, our alpha-values were likely underestimated due to the low number of items included within each factor (i.e., maximum of 3 items per factor) and the multidimensional nature of insomnia.

10.4 Construct Validity

In terms of construct validity, consistent with our hypothesis, we demonstrated that the PIC had good convergent and discriminant validity. Regarding discriminant validity, there were no statistically significant relationships between the PIC and CBCL (Achenbach & Rescorla, 2000; Achenbach & Rescorla, 2001), which provides evidence that the measures are tapping into different constructs. As the PIC was developed to measure symptoms of insomnia and the CBCL was constructed to measure problem behavior in children, this result was to be expected. In terms of convergent validity, the PIC generally had a "moderate" to "good" agreement with the DIMS subsections of the TCSQ/SDSC (McGreavey et al., 2005; Bruni et al., 1996). The TCSQ and SDSC are previously validated measures of childhood insomnia, supporting that the PIC is indeed measuring insomnia. Further, the toddler age group had the highest degree of consistency with DIMS. It is likely that including items within the PIC that capture symptoms of insomnia more prevalent in toddlers (i.e., *Co-sleeping with Parent*), led to a higher degree of consistency between measures.

The overall agreement between actigraphy and the PIC was $d = 0.36$ (95% CI = 0.22, 0.48), indicating that measures were 36% more likely to agree than disagree when classifying children as either having "Evidence for Insomnia" or having "No Evidence for Insomnia". When we assessed the convergent validity between the PIC and actigraphy using test characteristics, our findings indicated that, in a sample of typically developing children aged 1 to 10 years with insomnia, the PIC has excellent sensitivity but poor specificity. If used to screen populations of children for insomnia, the high sensitivity but low specificity of the PIC would result in many insomnia-free children screening positive for insomnia and very few children being missed (i.e., screening negative but actually having insomnia). The screen positive children would then be subject to further investigation of their insomnia symptoms. Since the PIC has high sensitivity/low specificity, it would be most appropriately used as the initial screening tool in a two-step sequential screening process for insomnia. In this manner, children who are initially positive on the PIC (i.e., with high sensitivity/low specificity) would be subjected to a second test that has low sensitivity/high specificity. Ideally, this second test would be a comprehensive clinical assessment. However, a comprehensive clinical assessment would be a very time and resource intensive intervention given that the PIC would result in many false positives. Therefore, a less resource intensive, but highly specific secondary screening for insomnia would be a good alternative for ruling-out false positives that were classified by the PIC as true positives. For example, a child who has evidence for insomnia as indicated by the PIC, could be asked to come into the doctor's office to complete a diagnostic assessment with a higher specificity. Thus, nearly all the

false positives may be correctly identified as insomnia negative in a cost-effective and timely manner.

Despite the potential utility of the PIC as a preliminary screener, it is important to mention that actigraphy (i.e., which was used to evaluate the PIC's test characteristics) is not a perfect measure of insomnia. Actigraphy has been demonstrated to have low specificity for detecting periods of wakefulness in youth populations with disturbed sleep patterns (Sadeh, 2011). For this reason, actigraphy is an appropriate and useful addition to a clinical evaluation for insomnia but is not indicated as a stand-alone diagnostic tool of insomnia (Ancoli-Israel et al., 2015). Rather, a comprehensive clinical assessment is used as the current "gold-standard" diagnostic method for pediatric insomnia. Therefore, to determine the most accurate estimates of the PIC's test characteristics, it would be ideal to assess the agreement between the PIC and comprehensive clinical assessments. Further, it is also important to mention that children in the sample were eligible for enrolment and considered to have insomnia based on the BIQ (Corkum et al., 2018). As the BIQ was completed retrospectively by parents, some children in the BNBD-TD sample may have been incorrectly classified as having insomnia (i.e., false-positives).

10.5 Treatment Sensitivity

Despite the above limitations, the PIC was demonstrated to be sensitive to treatment effects, determined through a significant group by time interaction term, at detecting changes from baseline to 4-months follow up (i.e., post-randomization) in the analyses of the total sample. The PIC's sensitivity for detecting changes with treatment

mirrored the improvements across insomnia symptoms found in the BNBD-TD intervention (Corkum et al., 2019b). Thus, providing evidence that the PIC can detect clinically meaningful improvements across insomnia symptoms over time. In the analysis involving school-aged children, the PIC had marginally significant treatment sensitivity, whereas, no treatment sensitivity was demonstrated in the preschooler age group. Thus, the PIC was most sensitive to detecting changes in insomnia symptoms for toddlers than the other age groups. Again, our findings suggest that the PIC is most suitable for capturing insomnia symptoms in younger children.

10.6 Conclusions

Overall, we demonstrated in terms of construct validity and across some aspects of reliability, that the PIC had adequate psychometric properties and was best suited as a measure of insomnia in toddlers. However, the PIC is far from perfect and more work is needed prior to incorporating it as the primary outcome in future treatment studies. Specifically, the internal consistency of PIC factors would need to be higher before there is objective evidence that the PIC is psychometrically-sound. In measurement development, it is not uncommon for new measures to need multiple development steps to become psychometrically strong. Our study, being of an exploratory nature, raises several opportunities for future research to improve the psychometric properties and/or utility of a composite outcome for pediatric insomnia.

10.7 Future Research

The goal of having a composite score to use in clinical trials is important given the need to identify one primary outcome variable. The PIC holds promise but more development is required to enhance its psychometric properties. Some important factors to consider are first to include more items than the 7-items that we included in the PIC. It is recommended as a minimum criterion that at least 4 items per composite-factor be included to ensure that an acceptable-level of internal consistency can be established within/across factor(s). An alternative to using Cronbach's alpha to estimate internal consistency is to used Omega (Dunn et al., 2013). A discussion of Omega is beyond the scope of this thesis, but it is important to mention Omega as an alternative to alpha because it has less risk for underestimating internal consistency (Dunn et al., 2013). Therefore, it may be beneficial for evaluating the *true* internal consistency of future composites containing few items within each unidimensional component. Secondly, to improve the overall psychometric properties of the PIC, we suggest that future composites of childhood insomnia be constructed for specific periods of development. We make this recommendation because the expression of insomnia symptoms changes with age (Burnham et al., 2002; Kerr & Jowett, 1994; Schlarb et al., 2006; Owens et al., 2000a; Corkum & Vriend, 2011; Sateia et al., 2017). Many of our analyses indicated that the PIC was most psychometrically-sound when used as a measure of insomnia in toddlers. This was likely due to including the *Co-sleeping with Parent* item in our composite as this behavior is more prevalent in infants and toddlers than preschoolers and school-aged children. Therefore, we recommend that future researchers who wish to develop a composite of childhood insomnia, evaluate whether one specifically tailored to

the period of development of their sample would result in stronger psychometric properties. Thirdly, we suggest that future research evaluates how the psychometric properties change across cultures. The PIC's psychometric properties are likely not generalizable to cultures that define sleep problems differently than in Canada, as what constitutes a sleep problem varies across cultures (Owens, 2008b). Fourthly, future studies should explore different methods of utilizing composites in research and clinical settings. For example, it may be beneficial for future researchers to develop a composite including only those items that a child has problem-scores on at baseline, as the primary outcome, and assign the other composite items as secondary outcomes. Assigning primary and secondary outcomes based on problem-scores at baseline would result in a dynamic and flexible measure. Utilizing a composite in this manner would allow a researcher to demonstrate improvements across problematic aspects of sleep as their primary outcome. Moreover, the non-problematic dimensions of sleep at baseline would be assigned as secondary outcomes to capture if children's sleep problems change during the study period. A dynamic composite could be beneficial to pediatric sleep researchers for capturing the full breadth of insomnia symptoms and any changes across symptoms during the time of their study.

10.8 Research & Clinical Implications

More work is needed to improve the psychometric properties of the PIC before it can be used in research and clinical settings. A revised psychometrically-sound version of the PIC, or other psychometrically-sound sleep diary composite of childhood insomnia, could be useful in research and clinical settings.

The measurement of sleep is challenging, with more psychometrically-sound measures such as PSG and actigraphy being invasive and expensive, while less psychometrically-sound measures such as questionnaires being more accessible. Sleep diaries are thought to provide more objectivity than questionnaires and to be more accessible and less resource demanding than PSG and actigraphy. As such, sleep diaries are an ideal sleep measurement tool for large research trials and for clinical practice with large numbers of children. However, the main downside of sleep diaries is that they generate lots of data that is not easily summarized. As such, a psychometrically-sound composite variable would be very useful to consolidate information. In a research setting, a sleep diary insomnia-composite could be used as a single variable measure of childhood insomnia for treatment studies. As mentioned previously, the nature of clinical trials requires a single variable to be used as the primary outcome (Andrade, 2015).

In a clinical setting, a psychometrically-sound insomnia-composite has the potential to be used to summarize insomnia symptoms in children when data is collected using a sleep diary. Without a sleep diary composite, clinicians are left with large amounts of data and have difficulty interpreting this information in a way that is meaningful for patients, parents of patients, as well as for clinical decision making and treatment monitoring. Thus, the sleep-diary composite could be used to summarize the large amount of data and provide a more meaningful interpretation to assist clinical decision making and monitoring of treatment.

With the emergence of electronic health (eHealth) services delivered through the Internet, a psychometrically-sound composite of insomnia could be made into an online format. Accordingly, parents would be able to complete a digital sleep diary in "real-

time" that would then be summarized into a meaningful score online using the composite formula. This would be a significant contribution as it would increase the clinical use of sleep diaries by reducing the time-burden on clinicians and provide those who lack official sleep training with an interpretable score. An online format would increase the accessibility of the tool, as roughly 80% of the Canadian population has access to the internet from any location (Statistics Canada, 2010).

10.9 Strengths & Limitations

This study has both strengths and limitations. One strength is the large sample size that increased the precision of our estimates and statistical power. A second strength is that the BNBD-TD sample's socio-demographics are consistent with Canadian demographics in terms of language and geographical representation (Corkum et al., 2018). A third strength of this study is the in-depth assessment of the psychometric properties of the PIC with previously validated measures for pediatric insomnia. A final strength to this study is that PIC scores were standardized using the POMP method (Fischer & Milfont, 2010). By standardizing PIC scores, our findings can be compared to other composites which use different scoring methods, populations, and instruments.

There are also several limitations. One limitation to this secondary data analysis is that the BNBD-TD sample's socio-demographics were not consistent with Canadian demographics in terms of ethnicity, income, and parental education level. Thus, the generalizability of our findings is limited to Caucasian children from middle to upper-middle income families whose parents have completed post-secondary education. A

second limitation to this study is the conversion of some ratio-level variables (e.g., total sleep time, sleep onset latency) to ordinal-scales in the construction of our PIC. This variable-transformation resulted in a decrease in the granularity of data across some variables included in the PIC. A third limitation is with the subjectivity of some statistical analyses used in this thesis. For example, EFA has a degree of subjectivity during the process of retaining and naming factors in the final factor solution, which is left to discretion of the researcher (Tabachnick & Fidell, 2013). A fourth limitation is about the construction of the PIC. The PIC was constructed from sleep diary data, which is prone to bias due to parental report, although less so than questionnaires completed by parents. Further, our study was limited by the large number of statistical analyses performed, which increased our studies probability of finding statistically significant results by chance. Although, the large sample size reduces the probability of chance findings. A sixth limitation is that all children in the BNBD-TD sample were considered to have insomnia based on the BIQ (which utilized the Sleep Onset Disturbance criteria as outlined by Anders & Dahl (2007)). As such, the range of scores across measures are left-truncated since children scoring below the insomnia-threshold on the BIQ were considered to not have insomnia and were excluded from the BNBD study. A seventh limitation was with using actigraphy rather than the BIQ as the comparator to determine the test characteristics of the PIC. We decided to use actigraphy for this analysis because of its objectivity for measuring sleep. However, actigraphy only identified 300/377 children in the sample as having insomnia. In hindsight, we should have compared the PIC with the BIQ which was the "diagnostic" measure used to identify all 377 children in the sample as having insomnia (i.e., one of the inclusion criteria for enrollment in the

BNBD-TD intervention). The BIQ was found to be more consistent with the PIC (identifying 361/377 participants) compared to actigraphy (identifying 300/377 participants). Lastly, as this study evaluated the psychometric properties of the PIC on a sample of typically developing children aged 1 to 10 years living in Canada, the generalizability of the tool outside of Canadian children with different demographic characteristics and/or cultural sleep practices is cautioned. Therefore, the psychometric properties of the PIC would need to be demonstrated in other cultures that have a different definition about what constitutes a sleep problem prior to implementation.

10.10 Conclusion

In conclusion, sleep diaries are a more valid measure of sleep than questionnaires, whilst also being more accessible and less resource demanding than PSG and actigraphy. Given that the main limitation with using sleep diaries is the high data yield, there is a clear need for a psychometrically-sound sleep diary composite to summarize data into meaningful information for sleep researchers and clinicians. The PIC shows promise to be used to summarize insomnia symptoms when data is collected using a sleep diary, but further development is required before it can be used in research and clinical settings.

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APPENDIX A: TABLES

Table A1-1

Summary of Previously Developed Sleep Composites

Author(s)		Appleton et al., 2012	Richman & Graham (1971); Richman (1981)	Wiggs, 1998, 1999	Montgomery et al., 2004	Gaylor et al., 2005
Age group		3-15 years	1-5 years	5-16 years	2-8 years	1-5 years
Study Purpose		The primary objective was to determine whether or not immediate-release melatonin is beneficial compared with placebo in improving total sleep time (TST) in children with neurodevelopmental delay, calculated using sleep diaries at 12 weeks compared with baseline. Composite Sleep Disturbance Index (CSDI) was used as secondary outcome measure	The purpose of this study was to examine the efficacy of behavioral methods of treatment for severe sleep disorders. Composite Sleep Disturbance Scale was used in the study reported in 1981/1971	The purpose of this study was to explore whether behavioral treatment for sleep problems can be used successfully in children with severe learning disabilities and daytime challenging behaviors and, if so, what are the effects of treatment on the sleep patterns of the child and the mother	The objective of this study was to investigate the efficacy of a media based brief behavioral treatment of sleep problems in children by comparing (1) face-to-face delivered treatment versus control and (2) booklet delivered treatment versus control. Composite Sleep Disturbance Score was used as primary outcome measure	This study examined the rates and stability of protodysomnias; specific sleep behaviors related to falling asleep and sleep maintenance, and sought to identify the early predictors of a later protodysomnia
Sample Characteristics		Neurodevelopmental Disorder	Typically Developing Children	Intellectual Disability and Daytime Behavioral Problem	Learning Disability	Typically Developing Children
Composite Information		Composite Sleep Disturbance Index based on questionnaire (Score 0-12)	Composite based on sleep diary (Score 0-24)	Composite Sleep Index based on questionnaire (0-12)	Composite Sleep Disturbance Score based on sleep diary (scores 0-8)	Composite based on video observation at 1 year and telephone interview for follow-up (2, 3, and 4 years) (Scores 0-8)
Variables	Settling problem frequency /week	X		X	X	X
	Settling duration	X	X	X	X	X
	Duration (months/years) of settling problem					
	Bedtime (e.g., later than 9:00pm)		X			
	Parents involved with bedtime/co-sleeping with parent	X	X	X		
	Number of night awakenings/night		X	X	X	X
	Number of night awakenings /week	X	X			
	Duration of night awakenings/night	X	X	X	X	X
	Duration (months/years) of night waking problem					X
	Early morning wakings (e.g., before 5:00 am)	X		X		
	Total sleep time at night		X			

Table A4-1

Anders and Dahl's (2007) Research Diagnostic Criteria for Sleep Onset Disturbances in Toddlers and Preschoolers

Age	Settling to sleep and reunions
12-24 months	1) >30 minutes to fall asleep 2) Parents remains in room for sleep onset 3) More than three reunions
>24 months	1) >20 minutes to fall asleep 2) Parents remains in room for sleep onset 3) More than two reunions

Note. Child must meet any two of the three disturbance criteria (two to four episodes per week for at least 1 month).

APPENDIX B: FIGURES

Figure B4-1

Sleep Diary Template Used in the Better Nights, Better Days Study for Typically Developing Children Aged 1 to 10 Years with Insomnia

Sleep Diary Template							
QUESTIONS	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Date:							
1. Please indicate how you are recording this Sleep Diary entry. (Directly online every day, recording on the template and inputting online every 3 days, from memory)							
2. What time did you ask your child to start getting ready for bed (begin the sleep routine)?							
3. What time did your child get into bed?							
4. What time was your child **Down for the Night**?							
5. How many times did your child call to you, cry, or get up from bed before falling asleep **after** your child was **Down for the Night** (i.e., after you expected your child to try to go to sleep)?							
6. How much **resistance** did your child put up from being first asked to get ready for bed to falling asleep for the night? (0 – None, 1 – A little bit, 2 – A medium amount, 3 – Quite a bit, 4 – A lot)							
7. What time did your child fall asleep at bedtime?							
7a. Did your child fall asleep independently (i.e., without a parent or other person there while he/she fell asleep)?							
8. After falling asleep for 10 minutes or longer at bedtime, how many times did your child wake up again? (Record 0 if your child did not wake up during the night)							
8a. In total, how many minutes was your child awake throughout the night (across all night wakings)?							
9. What time was your child **Up for the Day**?							
9a. How do you feel about your child's wake up time? (0 – It is way to early, 1 – It is a bit early, 2 – It is OK, 3 – It is a bit late, 4 – It is very late)							
10. How much disruption for the family was associated with your child's morning awakening? (0 – None, 1 – A little bit, 2 – A medium amount, 3 – Quite a bit, 4 – A lot)							
11. How would you rate the quality of your child's sleep? (0 – Very Poor, 1 – Poor, 2 – Fair, 3 – Good, 4 – Very Good)							
12. When your child woke up, how rested or refreshed did your child seem? (0 – Not at all rested, 1 – Slightly rested, 2 – Somewhat rested, 3 – Well-rested, 4 – Very well-rested)							
13. Did your child nap? (If Yes, complete 13a-13e. If No, proceed to question 14)							
13a. How many times did your child nap today?							
13b. In total, how many minutes did your child spend in bed for their naps? ("Spend in bed" includes both time awake and asleep)							
13c. How many minutes did your child sleep for during nap(s)?							
13d. How much **resistance** did your child put up from being asked to get ready for nap to falling asleep for their nap? (0 – None, 1 – A little bit, 2 – A medium amount, 3 – Quite a bit, 4 – A lot)							
13e. How much disruption for the family was associated with your child's naps? (0 – None, 1 – A little bit, 2 – A medium amount, 3 – Quite a bit, 4 – A lot)							
14. Additional Information: Did anything unusual happen in the last 24 hours that may have changed your child's sleep pattern (e.g., cold or flu, immunization, friend visited overnight, vacation, sleeping in parent's room, birthday party)?							
14a. If you answered Yes to Question 14, please include a few notes about what happened.							
15. Did your child wear the actigraph during the time period you're reporting on? (If Yes, complete 15a)							
15a. Was the actigraph removed at any time for any reason (e.g., swimming, bath time) (If Yes, complete 15b-15c)?							
15b. What was the reason?							
15c. From when to when was the actigraph removed?							

Note. Parental responses to questions in the sleep diary were used to generate items for the Pediatric Insomnia Composite. The author-made sleep diary was developed by Corkum et al. (2018) and based on systematic reviews from Meltzer & Mindell (2014), Mindell et al. (2006), and Wu and colleagues (2015).

Figure B4-2

The Tayside Children's Sleep Questionnaire (McGreavy et al., 2005)

Questions

1. How long after going to bed does your child usually fall asleep
2. The child goes to bed reluctantly
3. The child has difficulty getting to sleep at night (and may require a parent to be present)
4. The child does not fall asleep in his or her own bed
5. The child wakes up two or more times in the night
6. After waking up in the night the child has difficulty falling asleep again by himself or herself
7. The child sleeps in the parent's bed at some time during the night
8. If the child wakes, he or she uses a comforter (e.g. Dummy) and requires a parent to replace it
9. The child wants a drink during the night (including breast or bottle-feed)
10. Do you think your child has sleeping difficulties

Note. Only the Disorders of Initiating and Maintaining Sleep (DIMS) subscale was used for the current study.

Figure B4-3

The Sleep Disturbance Scale for Children (SDSC) (Bruni et al., 1996)

INSTRUCTIONS: *This questionnaire will allow to your doctor to have a better understanding of the sleep-wake rhythm of your child and of any problems in his/her sleep behavior. Try to answer every question; in answering, consider each question as pertaining to the* ***past 6 months*** *of the child's life. Please answer the questions by circling or striking the number 1 to 5.* Thank you very much for your help.

Name:_____ Age:_____ Date:_____

1. How many hours of sleep does your child get on most nights.	1 *9-11 hours*	2 *8-9 hours*	3 *7-8 hours*	4 *5-7 hours*	5 *less than 5 hours*
2. How long after going to bed does your child usually fall asleep	1 *less than 15'*	2 *15-30'*	3 *30-45'*	4 *45-60'*	5 *more than 60'*

					5 **Always (daily)**
				4 **Often (3 or 5 times per week)**	
			3 **Sometimes (once or twice per week)**		
		2 **Occasionally (once or twice per month or less)**			
	1 **Never**				
3. The child goes to bed reluctantly	1	2	3	4	5
4. The child has difficulty getting to sleep at night	1	2	3	4	5
5. The child feels anxious or afraid when falling asleep	1	2	3	4	5
6. The child startles or jerks parts of the body while falling asleep	1	2	3	4	5
7. The child shows repetitive actions such as rocking or head banging while falling asleep	1	2	3	4	5
8. The child experiences vivid dream-like scenes while falling asleep	1	2	3	4	5
9. The child sweats excessively while falling asleep	1	2	3	4	5
10. The child wakes up more than twice per night	1	2	3	4	5
11. After waking up in the night, the child has difficulty to fall asleep again	1	2	3	4	5
12. The child has frequent twitching or jerking of legs while asleep or often changes position during the night or kicks the covers off the bed.	1	2	3	4	5
13. The child has difficulty in breathing during the night	1	2	3	4	5
14. The child gasps for breath or is unable to breathe during sleep	1	2	3	4	5
15. The child snores	1	2	3	4	5
16. The child sweats excessively during the night	1	2	3	4	5
17. You have observed the child sleepwalking	1	2	3	4	5
18. You have observed the child talking in his/her sleep	1	2	3	4	5
19. The child grinds teeth during sleep	1	2	3	4	5
20. The child wakes from sleep screaming or confused so that you cannot seem to get through to him/her, but has no memory of these events the next morning	1	2	3	4	5
21. The child has nightmares which he/she doesn't remember the next day	1	2	3	4	5
22. The child is unusually difficult to wake up in the morning	1	2	3	4	5
23. The child awakes in the morning feeling tired	1	2	3	4	5
24. The child feels unable to move when waking up in the morning	1	2	3	4	5
25. The child experiences daytime somnolence	1	2	3	4	5
26. The child falls asleep suddenly in inappropriate situations	1	2	3	4	5

Disorders of initiating and maintaining sleep (sum the score of the items 1,2,3,4,5,10,11)	
Sleep Breathing Disorders (sum the score of the items 13,14,15)	
Disorders of arousal (sum the score of the items 17,20,21)	
Sleep-Wake Transition Disorders (sum the score of the items 6,7,8,12,18,19)	
Disorders of excessive somnolence (sum the score of the items 22,23,24,25,26)	
Sleep Hyperhydrosis (sum the score of the items 9,16)	
Total score (sum 6 factors' scores)	

Note. After parent's complete the SDSC, responses are summed into different sub-scales to obtain a sleep profile. In the current study, only the Disorders of Initiating and Maintaining Sleep (DIMS) subsection of the SDSC was used.