Parental sleep patterns and variability at 6 months postpartum: Associations with family factors and depressive symptoms

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December 2022

A thesis submitted to McGill University in partial fulfillment of the requirements of the degree of Doctor of Philosophy in Counselling Psychology

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List of Abbreviations

CES-D	Center for Epidemiologic Studies – Depression Scale
CV	Coefficient of variation
EEG	Electroencephalogram
EMG	Electromyography
EOG	Electrooculography
GSDS	General Sleep Disturbance Scale
ISI	Insomnia Severity Index
LGBTQ+	Lesbian, gay, bisexual, transgender, queer, and others
M	Mean
PSG	Polysomnography
PSQI	Pittsburgh Sleep Quality Index
REM	Rapid eye movement
SD	Standard deviation
WASO	Wake after sleep onset

Abstract

Changes in sleep are among the most significant adjustments parents experience in the postpartum period. To date, most research on postpartum sleep has focused on maternal sleep patterns, including the link between maternal sleep disturbances and postpartum mood. Although sleep is a family process, fathers remain frequently overlooked in the literature and less is known about paternal postpartum sleep patterns. The aim of the present dissertation was to advance our knowledge about typical sleep patterns and variability in *both* mothers and fathers at 6 months postpartum, and to examine the links between parents' sleep and familial and psychosocial factors.

Study 1 described and compared sleep patterns and intraindividual night-to-night variability in both parents (N = 33 couples) at 6 months postpartum. A multi-measure approach was used to measure parental sleep, consisting of subjective (i.e., daily sleep diary) and objective (i.e., actigraphy) indices, over the course of 10 consecutive nights. Additionally, associations between parental sleep and specific family factors, including age, education level, employment status, number of children, infant feeding method, infant sleep location, and infant nocturnal sleep variables were investigated.

Study 2 examined the relationship between sleep and depressive symptoms at 6 months postpartum, exclusively in fathers (N = 54) as they represent an important, understudied population. Paternal sleep was assessed over the course of 2 weeks utilizing subjective (i.e., daily sleep diary and self-reported perceived sleep quality) and objective (i.e., actigraphy) indices, whereas paternal depressive symptoms were measured using the Center for Epidemiologic Studies – Depression Scale (CES-D). The association between fathers' sleep patterns and depressive symptoms was assessed while controlling for individual and family factors.

Findings from Study 1 revealed that mothers had more fragmented sleep than fathers, according to subjective and objective sleep measures. Results further revealed that while mothers and fathers had comparable self-reported sleep durations, mothers obtained significantly more nocturnal sleep than fathers, as measured by actigraphy. Furthermore, results demonstrated that parents had high intraindividual night-to-night sleep variability across both subjective and objective sleep measures at 6 months postpartum. Variability in sleep was also reflected by relatively high coefficients of variation in longest consecutive sleep duration and nocturnal awakenings for both parents. Moreover, Study 1 highlighted associations between parental sleep patterns and family factors; more associations were observed in mothers than fathers.

Findings from Study 2 demonstrated that first-time fathers were more likely to report more depressive symptoms compared to experienced fathers. As such, number of children was controlled for while investigating the relationship between fathers' sleep patterns and depressive symptoms. Findings revealed that fathers' objective sleep was not associated with their depressive symptomatology at 6 months postpartum. However, fathers' self-reported perceived sleep quality was significantly associated with postpartum depressive symptoms, whereby poorer sleep quality was linked to higher CES-D scores.

Taken together, results highlighted the presence of fragmented postpartum sleep patterns and increased variability in mothers and fathers of 6-month-old infants. Additionally, results underscored the importance of fathers' perceptions of their sleep quality in the association with depressive symptoms following the birth of their infant. Findings expanded our knowledge of how sleep processes unfolded within the family system in the postpartum period and advanced our understanding of how both subjective and objective facets of sleep related to familial and psychosocial functioning, providing direct implications for parents' physical and mental health.

Résumé

Les changements liés aux habitudes de sommeil font partie des défis d'adaptation les plus significatifs auxquels font face les parents après la naissance d'un enfant. À ce jour, les études sur le sommeil des nouveaux parents tiennent compte surtout du sommeil de la mère, portant entre autres sur le lien entre les difficultés de sommeil de la mère et les symptômes dépressifs postpartum. Bien que le sommeil soit un enjeu familial, l'impact de l'arrivée d'un nouveau-né sur les pères est très rarement considéré dans les études. Le but de la présente thèse est de contribuer à l'avancement des connaissances concernant les patrons de sommeil caractéristiques, ainsi que leur variabilité, des mères et des pères 6 mois après la naissance de leur enfant, et d'examiner les liens entre les patrons de sommeil des parents et les facteurs familiaux et psychosociaux.

La première étude décrit et compare les patrons de sommeil des deux parents à 6 mois postpartum ainsi que la variabilité entre les différentes nuits pour un même parent (N = 33 couples). Pour mesurer le sommeil des parents, une combinaison de méthodes subjectives (journaux de sommeil quotidiens) et objectives (actigaphie) a été utilisée durant 10 nuits consécutives. Aussi, les associations entre le sommeil des parents et différents facteurs familiaux ont été investiguées, soient l'âge des parents, leur niveau d'éducation, leur statut d'emploi, le nombre d'enfants, le mode d'alimentation du bébé, le lieu de sommeil du bébé et les variables de sommeil du bébé.

La seconde étude examine la relation entre le sommeil et les symptômes dépressifs à 6 mois postpartum, exclusivement chez les pères (N = 54), puisque ceux-ci représentent une population importante, mais sous-étudiée. Le sommeil des pères a été mesuré au cours de deux semaines consécutives à l'aide de mesures subjectives (journaux de sommeil quotidiens et

autoévaluation de la qualité du sommeil) et objectives (actigraphie). Les symptômes dépressifs ont été mesurés à l'aide du questionnaire *Center for Epidemiological Studies – Depression Scale* (CES-D) complété par les pères.

Les résultats de la première étude révèlent que les mères ont un sommeil plus fragmenté que les pères, selon les mesures subjectives et objectives du sommeil. Les résultats montrent également que malgré le fait que les mères et les pères rapportent des durées de sommeil similaires, les mères ont une durée de sommeil nocturne significativement plus grande que les pères selon les mesures objectives. De plus, les résultats montrent une grande variabilité intra-individuelle des patrons de sommeil d'une nuit à l'autre à 6 mois postpartum, tant chez les mères que chez les pères, et ce, à la fois pour les mesures de sommeil objectives que subjectives. La variabilité dans les habitudes de sommeil est également reflétée par des coefficients de variation de la durée consécutive de sommeil et d'éveils nocturnes des parents relativement élevés.

Les résultats de la seconde étude montrent que les mesures objectives du sommeil des pères ne sont pas associées aux symptômes dépressifs rapportés à 6 mois postpartum. Par contre, la qualité de sommeil subjective rapportée par les pères est significativement associée aux symptômes dépressifs postpartum chez les pères. En effet, une plus faible qualité de sommeil subjective est associée à un score plus élevé au CES-D, donc à un niveau plus important de symptômes dépressifs rapportés.

Globalement, les résultats de ces deux études montrent que le sommeil des mères et des pères est fragmenté en période postpartum, en plus d'être variable d'une nuit à l'autre. De plus, ces résultats font la lumière sur l'importance de la perception des pères de leur qualité de sommeil dans l'association avec des symptômes dépressifs. Ces études permettent de mieux

comprendre comment les mesures subjectives et objectives du sommeil sont liées au fonctionnement familial et psychosocial.

Acknowledgements

Dr. Marie-Hélène Pennestri, you have been an exceptional supervisor and mentor. I will forever appreciate your unwavering passion, encouragement, and support. Your knowledge, wisdom, and devotion, along with your positivity and caring nature has enriched my graduate experience. Your guidance has been instrumental in my growth both academically and personally. Thank you for enabling me to pursue an important life goal, I cherish the opportunity you provided.

I would like to thank Dr. Karine Dubois-Comtois, Dr. Marie-Julie Béliveau, and Dr. Évelyne Touchette for their invaluable feedback throughout the research process. I would also like to express gratitude to all oral defence committee members and thank Dr. Rachel Langevin and Dr. Claud Bisaillon for their written evaluation of my dissertation.

The work ethic and collaboration portrayed by members of our research team is phenomenal. All students contribute to fostering a supportive and motivating lab environment. I value my experiences working with all of you. I would also like to express genuine appreciation to the families who participated in our research. Your willingness to welcome us into your home and generosity with your time has enabled important contributions to the postpartum sleep literature.

My parents have demonstrated unconditional love, care, and support throughout my life. As role models, you have demonstrated the importance of family, worth ethic, and treating others with kindness and respect. I am forever grateful for your guidance. Marisa, you are my pillar of strength and stability. Your passion for psychology and genuine support has kept me motivated. I am very thankful to have an incredibly dedicated and loving partner; I look forward to building our family and progressing our careers together.

Contribution of Authors

The current dissertation represents original scholarship, comprising 2 studies (Chapter 3 and 5) that provide distinct contributions of knowledge to the field of psychology. I am the principal author of each manuscript. I participated in the study design, data collection, data extraction process, analysis, interpretation of data, drafting, and revising the manuscripts. I have also written the general introduction, review of the literature, transition statement, and general discussion of the current dissertation. The manuscripts are co-authored by Rebecca Burdayron, Christine Laganière, Dr. Karine Dubois-Comtois, Dr. Marie-Julie Béliveau, and Dr. Marie-Hélène Pennestri.

Rebecca Burdayron (second author) and Christine Laganière (third author) are both PhD students in our research laboratory. They participated in the study design, data collection, and data extraction process, along with critically reviewing the manuscripts for important intellectual content.

Dr. Karine Dubois-Comtois and Dr. Marie-Julie Béliveau are collaborators with our research team. They contributed to the study conceptualizations and designs. They also provided comments and suggestions on the manuscripts and approved final versions for submission to scientific journals.

Dr. Marie-Hélène Pennestri, my doctoral research supervisor, is an author on both manuscripts. She had an integral role in the development of the study conceptualizations and designs. She designed the data collection instruments, supervised the data collection and analysis, contributed to the interpretation of data, and critically reviewed the manuscripts for important intellectual content. Dr. Pennestri also approved the final manuscripts and the current dissertation.

Chapter 1: General Introduction

While the birth of an infant is a momentous occasion, it is also a demanding period requiring parents to undergo considerable change and adjustment (Pinquart & Teubert, 2010; Trillingsgaard et al., 2014). The challenges parents confront following the birth of their infant include increased responsibility, as they must provide adequate nurturing to their newborn, increased demands on resources and finances, and reduced time for leisurely activities and couple intimacy (Alexander et al., 2001; Perry-Jenkins et al., 2007). In the postpartum period, parents face the challenge of preventing role overload as they balance being primary caregivers while continuing to attend to their existing roles.

Additionally, and importantly, parental sleep is disrupted due to the ongoing development of their infants' sleep-wake cycles (Gay et al., 2004; Meltzer & Montgomery-Downs, 2011; Richter et al., 2019). In comparison to that of adults, infant sleep is fragmented into short periods typically resulting in awakenings every few hours, without differentiation between night and day (Anders et al., 1992; Hysing, et al., 2014). These nocturnal awakenings often elicit parental response to either feed or soothe infants, leading to parental sleep fragmentation (Gay et al., 2004; Hunter et al., 2009) which may contribute to mood changes, including the development of postpartum depressive symptoms (examined more extensively in mothers; Meltzer & Montgomery-Downs, 2011; Okun, 2016; Saxbe et al., 2016). Therefore, sleep disturbances are among the most meaningful set of adjustments in the postpartum period and contribute to parents feeling less equipped to navigate the many other adjustments that follow the birth of their child (Christian et al., 2019; Gay et al., 2004).

Despite the significance of parents' postpartum sleep changes, and the strong association between parents' and infants' sleep-wake cycles, research to date has emphasized infants

(Galbally et al., 2018; Mindell et al., 2016; Morales-Munoz et al., 2018). Although there is literature examining maternal sleep in the postpartum period (King et al., 2020; Volkovich et al., 2018), as well as the link between maternal sleep disturbances and postpartum depressive symptoms (Meltzer & Montgomery-Downs, 2011; Okun, 2016), less is known about fathers as they remain frequently overlooked. This is surprising considering fathers are becoming increasingly more involved in bedtime caregiving practices (Ragni et al., 2019). Indeed, sleep is a dynamic family process, with each member's individual sleep process influencing that of the others' (Sadeh & Anders, 1993; Teti, 2017). Investigations that examine *both* mothers and fathers are thus necessary to deepen our understanding of parents' sleep patterns and psychosocial functioning in the postpartum period.

The overall aim of the present dissertation was to advance our knowledge about typical sleep patterns and variability in both mothers and fathers at 6 months postpartum, and to examine the links between parents' sleep and familial and psychosocial factors. A more thorough review of the existing literature, including gaps the present dissertation sought to address, is presented in Chapter 2. Subsequently, the Study 1 manuscript, published in *BMJ Open* (2022), is presented in Chapter 3. Study 1 examined sleep patterns and intraindividual night-to-night variability in both parents of 6-month-old infants using a multi-measure approach consisting of subjective and objective sleep indices over the course of 10 consecutive nights. Additionally, this study investigated associations between parental sleep and specific family factors, including age, education level, employment status, number of children, infant feeding method, infant sleep location, and infant nocturnal sleep variables. Chapter 4 provides a transition statement outlining the main findings of Study 1 and offers a bridge to the Study 2 manuscript, published in *Sleep Medicine X* (2021), subsequently presented in Chapter 5. Study 2 further examined the

relationship between sleep and postpartum depressive symptoms exclusively in fathers, an understudied population (contrary to mothers). Fathers' sleep was investigated using both subjective and objective measures during a 2-week participation period and the association between sleep and depressive symptoms was assessed while controlling for individual and family factors. Finally, a general discussion highlighting key findings of the present research as well as contributions of the current dissertation to the postpartum sleep literature, including clinical and direct implications for parents' physical and psychological well-being, is presented in Chapter 6.

Chapter 2: Review of the Literature

Defining Sleep

Sleep is an active internal process that is essential to several functions in the human body (Carskadon & Dement, 2017). Specifically, good quality and sufficient sleep is necessary to sustain immune, respiratory, endocrine, and cardiovascular functioning, along with brain development, learning, and memory (Alvarez & Ayas, 2004; Irwin, 2015; Okun, 2011; Touchette et al., 2009). Therefore, sleep is physiologically essential to our survival, much like hunger and thirst (Benca & Quintas, 1997), and it is considered a pillar of health, along with exercise and nutrition (Chaput, 2014). The sleep-wake cycle emerges in utero and undergoes significant development throughout the lifespan (Pengo et al., 2018). Sleep is regulated by two processes, the homeostatic drive and circadian rhythm (Achermann & Borbély, 2017). The homeostatic process is our inherent drive for sleep, which increases the longer we are awake and decreases gradually during sleep (Achermann & Borbély, 2017). In parallel, the circadian process is a 24-hour internal clock located in the brain (and in other organs of the body) that can also be influenced by external cues in the environment, like light exposure (Reddy et al., 2020). Sleep behaviours, along with states of sleepiness and alertness, are determined through the interaction between these processes.

Measuring Sleep

Sleep is challenging to measure due to it being an active, internal human process (Carskadon & Dement, 2017). It can be measured with subjective or objective indices, each measuring different dimensions of sleep.

Subjective measures

Subjective sleep measures include sleep diaries and questionnaires. Sleep diaries are typically completed upon waking in the morning and contain standard sleep indices of bedtime, sleep latency (duration of time required to fall asleep), sleep duration, number of nocturnal awakenings, wake after sleep onset (WASO), and wake time (Acebo et al., 2005; Cross et al., 2010); some include sleep quality ratings as well. Sleep diaries thus encompass a prospective component completed each morning, as opposed to a mean retrospective of a specific period (e.g., one week, two weeks, last month). Researchers and clinicians also implement various self-report questionnaires to obtain sleep data (e.g., Pittsburgh Sleep Quality Index (PSQI), Insomnia Severity Index (ISI), General Sleep Disturbance Scale (GSDS), etc.). These measures, particularly the PSQI (Buysse et al., 1989), are frequently used to assess sleep duration, nocturnal sleep disturbances, sleep latency, sleep quality, daytime dysfunction, and sleep medication usage. Subjective measures are easy to utilize, are time-efficient and cost-effective, and do not disturb participant sleep. While self-report measures serve as a convenient method to collect data, questionnaires may be prone to response biases and other forms of error that cannot be easily accounted for. For instance, self-report measures of sleep can be impacted by individual mood and perception, along with lack of awareness of specific nocturnal sleep behaviours (Liebich et al., 2021; Martin & Hakim, 2011). Additionally, unlike the PSQI, ISI, and GSDS, not all subjective sleep measures are validated.

Objective measures

Objective measures of sleep include polysomnography (PSG) and actigraphy. PSG is considered the gold standard for measuring sleep. It records electroencephalogram (EEG), electromyography (EMG), electrooculography (EOG) and sometimes others neurophysiologic and physiological parameters during the nocturnal period (Jafari & Mohsenin, 2010). The PSG is

the only tool that assesses sleep stages. Moreover, it can diagnose sleep disorders (e.g., sleep apnea, nocturnal seizures, narcolepsy, rapid eye movement (REM) sleep behaviour disorders, etc.; Jafari & Mohsenin, 2010; Rundo & Downey, 2019). While PSG can be conducted in home-settings, it is typically a laboratory-based measure of sleep that requires participants to wear electrodes and sensors. Therefore, this measure may not easily characterize natural sleep (i.e., at home) and is less cost effective (Irwin, 2015).

Actigraphy represents an alternative objective sleep measure. Actigraphy monitors sleep-wake patterns and sleep schedules in a natural setting (i.e., at home), without the invasiveness of PSG (Paquet, et al., 2007). The actigraph is typically worn on the wrist (or the ankle when used on infants) to record movement and provide estimates of sleep patterns (Irwin, 2015). This device measures motor activity and does not provide information on specific sleep stages. The technology is based on the notion that there is less movement during sleep and more movement when an individual is awake (Ancoli-Israel et al., 2003). Actigraphy is commonly used in combination with a sleep diary requiring participants to report sleep onset and morning awakening. Unlike PSG, it can record continuously for 24 hours a day across several weeks and provides a non-invasive measure of adult and infant sleep-wake patterns. The data collected from actigraphy is downloaded onto a computer for analysis of activity and inactivity using scoring algorithms to estimate sleep parameters, including nocturnal sleep duration (or total nocturnal sleep time), 24-hour sleep duration, nocturnal awakenings, WASO, and sleep efficiency (number of sleep minutes/number of minutes in bed * 100; Ancoli-Israel et al., 2003; Paquet et al., 2007).

Despite the pros and cons related to both subjective and objective indices of sleep, one is not necessarily more superior than the other. Rather, one method may be more favourable depending on the type of research questions being investigated. However, it is important to note

that incongruent findings across studies may be drawn depending on the method of sleep measurement. Indeed, studies have revealed differences between self-report and actigraphy measured sleep (differences outlined below; Bei et al., 2015). Overall, different sleep indices may elicit different findings, underscoring the importance of incorporating a multi-measure approach in the investigation of sleep to enable comparison between subjective and objective methods.

Sleep Health

According to Buysse (2014), *sleep health* is defined as a multidimensional pattern of sleep-wake-fullness promoting physical and psychological well-being. Sleep health encompasses 5 dimensions, including: sleep quality (the subjective assessment of *good* or *poor* sleep), sleep efficiency (ease of falling asleep and returning to sleep after awakenings), sleep duration (total sleep obtained in 24 hours), timing (placement of sleep in the day), and alertness (maintaining wakefulness). High sleep quality and efficiency, adequate duration, appropriate timing, along with sustained daytime alertness characterize *good* sleep health (Buysse, 2014).

Since sleep is crucial to healthy functioning, global recommendations from the National Sleep Foundation suggest achieving 7 to 9 hours of sleep duration each night (Hirshkowitz et al., 2015). This optimal sleep duration is associated with fewer negative health outcomes in adults (Alvarez & Ayas, 2004). However, the dimensions of *good* sleep health extend beyond sleep duration. For example, *poor* sleep quality and low sleep efficiency, resulting from nocturnal disturbances and awakenings, impact general sleep health regardless of whether the recommended sleep duration (i.e., 7 to 9 hours) is achieved. Moreover, the dimensions of sleep health, such as adequate sleep duration, and the achievement of *good* sleep are likely to vary according to individuals' differing needs. In the general population, researchers examining sleep

have documented pervasive variability among individuals (i.e., interindividual variability) related to sleep duration and quality (Van Dongen et al., 2005). These findings parallel results documented by Lemola and colleagues (2013) revealing that greater variability (calculated by the coefficient of variation (CV) - ratio of the SD/mean) in actigraphy sleep duration was strongly associated with poor subjective sleep quality. Intraindividual (i.e., night-to-night) sleep variability has also been demonstrated in actigraphy measured sleep duration and fragmentation in men and women (Mezick et al., 2009). Sleep health, and the corresponding degree of sleep variability an individual experiences from night-to-night, is likely to be heightened during life transitions (Richter, 2015).

Sleep and Life Transitions

The concept of transition refers to how individuals adjust to novel circumstances and respond to life-changes (Barimani et al., 2017). Individuals experience transitions in various domains, including changes in employment, education, housing, as well as aspects of their social, romantic, and family life. Transitions are typically accompanied by changes in sleep and may interfere with one or more of the various sleep dimensions necessary for adequate sleep health.

The transition to the postpartum period following the birth of an infant represents a particularly challenging set of changes for both first-time and experienced parents (Pinquart & Teubert, 2010; Trillingsgaard et al., 2014). While parents experience joy and excitement when welcoming their newborn into their lives, they are also likely to feel stressed and overwhelmed throughout this significant period of adjustment (Rollè et al., 2017). First-time parents adjust to their new role as primary caregivers, and all parents (including both first-time and experienced) adjust to increased responsibilities and labour tasks, increased demands on resources, reduced leisurely time, along with navigating challenges preventing postpartum role overload (Alexander

et al., 2001; DeKlyen et al., 2006; Perry-Jenkins et al., 2007). The increases in responsibilities and changes proceeding the transition to postpartum may also disrupt previously established patterns of support and conflict resolution for parents (Whiffen & Johnson, 1998). Consequently, parents are more likely to experience increases in couple conflict and decreases in positive relational exchanges during the postpartum period (Belsky et al., 1998; Grote & Clark, 2001; Lawrence et al., 2007; Shapiro et al., 2000).

In addition to the existing demands ensuing childbirth, infant sleep processes occurring throughout the postpartum transition elicit parental changes in sleep (Gay et al., 2004; Goyal et al., 2007). In comparison to that of adults, infant sleep is fragmented due to the ongoing development of their sleep-wake cycles (Meltzer & Montgomery-Downs, 2011), resulting in several awakenings (every 2 to 4 hours) throughout the nocturnal period (Anders et al., 1992; Hysing, et al., 2014). Nocturnal awakenings often require parental responses to either feed or soothe infants, rendering mothers' and fathers' sleep more disturbed (Gay et al., 2004). Sleep disturbances are altered sleep patterns caused by frequent fragmentations (Hunter et al., 2009) often resulting in sleep deprivation and insufficient sleep, which is characterized by shorter sleep duration and poor sleep quality (Bonnet & Arand, 2003; Insana et al., 2014; Montgomery-Downs et al., 2010).

It is important to note that postpartum sleep disturbances in parents are not necessarily equivalent to a sleep disorder, such as insomnia. Given that poor parental sleep, such as increased sleep fragmentation, is often (though not exclusively) a consequence of infant awakenings and need for caregiving during the night, it is not necessarily characterized as a sleep disorder per se. Nonetheless, the sleep disturbances typically experienced by parents following the birth of a child place parents' healthy sleep functioning at risk. Furthermore, disturbed and

poor quality sleep adversely affects physical and psychosocial functioning (Buysse, 2014; Chaput, 2014) and represent important risk factors for developing postpartum mental health difficulties, including depressive symptoms (Irwin, 2015; Okun et al., 2009).

Taken together, transitioning to the postpartum is a sensitive and vulnerable period for mothers and fathers as they adjust to various significant changes (Barnes, 2006; Pinquart & Teubert, 2010; Rollè et al., 2017). Considering the difficult nature of achieving individual sleep needs during periods of adjustment and the importance of sleep health with regard to sustaining general well-being (Richter, 2015), sleep disturbances are not only among the most meaningful set of postpartum challenges for both first-time and experienced parents, they may also lead parents to feel less equipped to navigate the many other adjustments that follow the birth of their child (Christian et al., 2019; Gay et al., 2004).

Sleep in the Family Context

The sleep disruptions parents experience in relation to infant sleep during the transition to the postpartum period reflect that sleep is a dynamic family process (Sadeh & Anders, 1993; Teti, 2017). As posited by the transactional model, infants' sleep is bidirectionally associated with various levels of parenting and socio-contextual factors, including but not limited to parents' sleep (Sadeh et al., 2010). Indeed, sleep changes are co-occurring within the family system as each member's individual sleep process influences and informs that of the others.

Infant sleep

Sleep is fundamental for child development, especially in the first years of life (Dewald et al., 2010; Hysing et al., 2014). As such, infants spend most of their day sleeping. A longitudinal study examining sleep subjectively (mothers' reports) in 460 children, found that on average infants at 6-months-old displayed 14 hours of total sleep duration (24-hour period) and

11 hours nocturnal sleep duration (Iglowstein et al., 2003). A large population-based study in Norway, consisting of 55, 831 participants, revealed that 16.4% of infants displayed an average of 11 to 12 hours of nocturnal sleep duration, whereas 52.1% of infants slept 13 to 14 hours per night as indicated by mothers' subjective reports (Hysing et al., 2014). Sleep in infancy, as compared to sleep in adulthood, is fragmented into short periods resulting in awakenings every few hours, without differentiation between night and day (Hysing et al., 2014). Infant sleep fragmentation was documented by Hysing and colleagues (2014), revealing that 69.5% of infants displayed nocturnal awakenings at 6 months postpartum, with almost 20% of infants displaying 3 or more awakenings per night.

Infant sleep patterns evolve throughout the first year of life. Specifically, infant sleep becomes more consolidated as it progresses toward a process referred to as 'sleeping through the night,' characterized by achieving 6 or 8 hours of consecutive sleep duration without interruption (Henderson et al., 2011; Goodlin-Jones et al., 2001; Mindell et al., 2006). Consolidated sleep is also characterized by fewer nocturnal awakenings, fewer daytime naps, and higher proportions of nocturnal sleep (Mirmiran et al., 2003). Although sleep begins to consolidate at 6 months postpartum, as the circadian rhythm is further established and the need for nocturnal feeding decreases (Meltzer & Montgomery-Downs, 2011), nocturnal awakenings are still frequent (Galland et al., 2012; Hysing et al., 2014). In 20 to 30% of infants, these awakenings and the progression toward consolidated sleep continue beyond 6 months and across the first year of life (Henderson et al., 2010; Tikotzky & Sadeh, 2010). Studies have also revealed both interindividual (Galland et al., 2012; Mindell et al., 2016; Pennestri et al., 2018; Weinraub et al., 2012) and intraindividual (Goodlin-Jones et al., 2001; Pennestri et al., 2020; Scher, 2012) variability in infant sleep in the months following childbirth, suggesting that sleep consolidation

is not necessarily achieved in all infants at 6 months postpartum.

Parental sleep

Parents begin to experience sleep changes during pregnancy (Gay et al., 2004; Okun, 2016). Sleep disturbances for women result from both hormonal fluctuations and the growth of the fetus, making it increasingly more difficult to sleep comfortably, whereas men experience changes in sleep resulting from the fragmented sleep of their pregnant bed partner (Gay et al., 2004). Physical changes resulting from pregnancy are a significant contributor to the subjective and objective sleep disruptions (e.g., decrease in sleep duration and sleep efficiency) documented during childbearing (Bei et al., 2015). Pregnant women self-report poorer sleep quality (Ko et al., 2010) and experience more subjective sleep disturbances (Leung et al., 2005; Okun, 2016) compared to nonpregnant controls. Additionally, results from a meta-analysis revealed that 45.7% of pregnant women self-reported experiencing poor sleep quality as measured by the PSQI, with sleep quality worsening from the second to third trimester (Sedov et al., 2018). Pregnancy-related sleep changes commonly include gradual decreases in sleep duration and sleep efficiency (Bei et al., 2015). Consequently, childbearing women experience poor sleep quality and daytime sleepiness; such difficulties often worsen in the third trimester (Lee & Zaffke, 1999; Troy & Dalgas-Pelish, 1997).

Though sleep begins to alter during pregnancy, it is most disrupted in the postpartum period (Meltzer & Montgomery-Downs, 2011). Parents are especially susceptible to high night-to-night variability (i.e., intraindividual variability) in the postpartum period given infant sleep and feeding patterns (Dennis & Ross, 2005; Hunter et al., 2009) and the well-documented high sleep variability in infants throughout their first-year life (Galland et al., 2012; Goodlin-Jones et al., 2001; Mindell et al., 2016; Pennestri et al., 2020; Scher, 2012). Compared to sleep during

pregnancy, postpartum sleep tends to be shorter and more fragmented (Hunter et al., 2009; Montgomery-Downs et al., 2010). In fact, a study examining maternal sleep (measured objectively) from pregnancy to postpartum revealed that mothers demonstrated 3 times the number of nocturnal awakenings (measure of sleep fragmentation) and decreased sleep efficiency following childbirth (Nishihara & Horiuchi, 1998). Postpartum, mothers tend to adjust to their infants' polyphasic sleep patterns (i.e., sleeping multiple times throughout a 24-hour period; Meltzer & Montogmery-Downs, 2011), which involves attempting to "sleep when the baby sleeps;" this is a challenging process considering mothers' ongoing household and other-child care responsibilities (Meltzer & Montogmery-Downs, 2011). Findings at 4 months postpartum suggest that while mothers are not significantly sleep deprived, they do experience significant objective sleep fragmentation and low sleep efficiency, with average 24-hour sleep duration (7.2 hours) falling within the recommended range (Montogmery-Downs et al., 2011).

Though there is a fair amount of research examining maternal sleep in the postpartum period (King et al., 2020; Volkovich et al., 2018), far less is known about paternal sleep as fathers remain largely overlooked in the literature. Even though sleep disturbances are known to occur for both mothers and fathers (Gay et al., 2004; Montgomery-Downs et al., 2010; Sinai & Tikotzky, 2012), far less is known about paternal sleep patterns. Indeed, previous research has centered on maternal and infant sleep as mothers are often deemed the primary caregivers most likely to tend to their infants' nocturnal awakenings (Sinai & Tikotzky, 2012; Tikotzky et al., 2015). However, fathers are likely to endure disruptions in their sleep due to infant nocturnal awakenings and, regardless of whether they tend to their infants' awakenings themselves, fathers remain susceptible to disruptions due to their bedpartners' (i.e., mothers) awakenings. The growing evidence suggesting increased paternal involvement in childcare (Atzaba-Poria et al.,

2010; Ragni et al., 2019), coupled with findings (though still limited) documenting postpartum paternal sleep disturbances (Damato & Burant, 2008; Sinai & Tikotzky, 2012) highlight the significance of including fathers in postpartum investigations.

Of the few studies that have examined paternal sleep in the postpartum period, mixed results have been yielded in terms of whether and how maternal and paternal sleep compare, with findings varying depending on the type of sleep measurement employed. Studies utilizing subjective measures of sleep have indicated that mothers wake-up (i.e., sleep fragmentation) more than fathers during the night (Insana et al., 2014; McDaniel & Teti, 2012). Research conducted by Gay and colleagues (2004), found more self-reported nocturnal sleep disturbances in mothers compared to fathers, but fathers objectively achieved shorter sleep durations over a 24-hour period in the first month postpartum. A study implementing objectively measured sleep (i.e., actigraphy) revealed that, as compared to fathers' sleep, mothers' sleep was more fragmented due to nocturnal infant awakenings (Montgomery-Downs et al., 2010). Insana and Montgomery-Downs (2013) found that, based on self-report measures, mothers and fathers did not significantly differ in their sleep quality. Interestingly, when examined via actigraphy, these same mothers were found to have longer nocturnal sleep duration, but more disturbed and fragmented sleep than fathers (Insana & Montgomery-Downs, 2013).

While findings on mothers and fathers sleep in the postpartum period may vary depending on whether sleep is measured subjectively or objectively (Insana & Montgomery-Downs, 2013), the existing research highlights the postpartum period as a significant time placing both mothers' and fathers' sleep at risk. Furthermore, the existing research underscores the associations between maternal, paternal, and infant sleep, supporting the notion that sleep is a family process (Sadeh & Anders, 1993; Teti, 2017). Additional research that examines

postpartum sleep patterns among both parents and incorporates subjective and objective indices are necessary to deepen our understanding of fathers' sleep specifically, and to expand our more general understanding of sleep as a dynamic family process (Bai et al., 2020; Teti, 2017).

Family Factors Associated with Sleep

Following the notion that sleep is a family process, various family-level factors, including infant sleep patterns, infant sleep location, and feeding method have meaningful associations with postpartum parental sleep (Stremler et al., 2017). For instance, poor subjective sleep quality in infants has been associated with poor maternal sleep quality (Piteo et al., 2012). Additionally, infant nocturnal awakenings are associated with increased maternal sleep variability in sleep duration (measured with actigraphy; Signal et al., 2007). Regarding infant sleep location, mothers engaging in room-sharing with their infant have been found to report more nocturnal awakenings and to have poorer self-reported and actigraphy measured sleep than solitary sleeping mothers (Stremler et al., 2014; Volkovich et al., 2018). Furthermore, there have been mixed findings related to infant feeding methods and parental sleep indicating either no difference in subjective and objective sleep (Montgomery-Downs et al., 2010) or increased sleep quality for parents of breastfed infants (Doan et al., 2007). A study revealed that breastfeeding mothers averaged more objective nocturnal sleep duration compared to mothers using formula; however, no differences in objective or subjective sleep fragmentation were found (Doan et al., 2014).

Parents' age, education, employment status, and number of children represent additional family factors that can influence family sleep processes (Butler et al., 2020; Cameron et al., 2016; Hein et al., 2014; Milgrom et al., 2008; Okun et al., 2018). Regarding age, older mothers have been found to be three times more likely to report poor subjective sleep quality compared to

younger mothers at 3 months postpartum (Wen et al., 2018). In terms of employment status, employed mothers demonstrated shorter sleep duration (measured by actigraphy) compared to unemployed mothers at 5 months postpartum (Spaeth et al., 2021). Studies have demonstrated mixed findings regarding number of children. That is, research implementing subjective sleep measures have demonstrated that first-time mothers (i.e., 1 child) reported longer consecutive nocturnal sleep duration, fewer nocturnal awakenings, and high sleep quality compared to experienced mothers (2 or more children; Kenny et al., 2021). While Christian and colleagues (2019) demonstrated no differences in subjective postpartum sleep between first-time and experienced parents, other researchers have revealed poorer sleep among first-time parents (Dørheim et al., 2009a; Richter et al., 2019). Finally, changes in mood represent a notable family factor related with sleep. Specifically, sleep disturbances in parents, elicited by infant nocturnal awakenings, have been associated with postpartum depressive symptoms (Meltzer & Montgomery-Downs, 2011; Okun, 2016).

Sleep and Postpartum Depressive Symptoms

Sleep disturbances and poor sleep quality have negative consequences on psychosocial functioning and mood (Irwin, 2015; Okun et al., 2009). That is, sleep fragmentation has been shown to yield a twofold increase in the risk of experiencing depressive symptoms (Baglioni et al., 2011; Irwin, 2015). While this holds true for the general population, susceptibility to sleep disturbances (i.e., fragmentation, deprivation, and poor quality) is accentuated in the postpartum period, contributing to mood disruptions and thus increasing mothers' and fathers' risk of experiencing depressive symptoms (Buysse et al., 2008; Gay et al., 2004).

Mothers

In mothers, perinatal stress negatively affects functioning and general psychological health, thus increasing their vulnerability to experiencing depressive symptoms (Zelkowitz & Milet, 2001). Maternal postpartum depression has been studied extensively given its high prevalence rate. Postpartum depression encompasses symptoms that parallel clinical depression (Cox et al., 1993; Mao et al., 2011). Given that most studies have utilized self-report measures that assess symptomatology rather than diagnostic measures, the current research will focus on *depressive symptoms*. Paulson and Bazemore (2010) conducted a meta-analysis of 43 studies and reported that 23.8% of women experienced depressive symptomatology between the first trimester and 1 year postpartum. During the 3- to 6-month post-delivery period, estimates of depressive symptoms increased to 41.6% (Paulson & Bazemore, 2010). The development of depressive symptomatology is not specific to women living in North America. In fact, it appears to be quite prevalent in mothers, cross-culturally, including Asian and Middle Eastern countries (Mao et al., 2011; Yount & Smith, 2012). For example, studies conducted in China, indicated that postpartum symptoms of depression affected up to 14.9% of mothers (Gao et al., 2009; Mao et al., 2011).

While there may be several factors that impact maternal mood, health researchers have increasingly focused attention on postnatal sleep disturbances and poor sleep quality as they have been deemed precipitating factors for psychopathology (Hall et al., 2017; Montgomery-Downs et al., 2010). Additionally, child sleep disruptions have been significantly related to maternal sleep fragmentation and poor sleep quality (Hall et al., 2017). Consequently, poor maternal sleep quality has been linked to negative mood (i.e., depressive symptoms) and decreased daytime functioning (Hall et al., 2017; Meltzer & Mindell, 2007; Miller et al., 2006).

In a study conducted by McDaniel and Teti (2012), employing subjective measures of sleep, mothers reported experiencing more nocturnal awakenings 1 month postpartum and subsequently demonstrated worse sleep quality and more depressive symptoms overall (McDaniel & Teti, 2012). At 3 months, infant nocturnal awakenings decreased, which resulted in reduced sleep fragmentation, increased sleep quality, and decreased depressive symptomatology in mothers. These researchers concluded that improved maternal sleep quality was associated with a reduction in perinatal depressive symptomatology and enhanced psychological well-being (McDaniel & Teti, 2012). There is also evidence demonstrating that poor sleep increases the risk of women experiencing postpartum depressive symptoms (Okun et al., 2009) and linking disturbed sleep to both first-onset and recurrent depressive episodes following childbirth (Coble et al., 1994; Wolfson et al., 2003). Accordingly, Wolfson and colleagues (2003) found that women reporting more sleep fragmentation in late pregnancy were increasingly more likely to experience significant depressive symptomatology at 2 to 4 weeks postpartum.

A study examining 124 mothers from the third trimester of pregnancy to 3 months postpartum indicated that a subjectively reported increase in sleep deprivation was related to elevated depressive symptoms at both time points (i.e., third trimester and 3 months perinatal; Goyal et al., 2007). Mothers with higher postpartum depressive symptoms reported less total sleep duration, more morning awakenings, and increased daytime sleepiness as compared to mothers reporting lower depressive symptoms (Goyal et al., 2007). Moreover, Dørheim and colleagues (2009a) conducted a study consisting of 2830 mothers and reported that nearly 60% of women experienced poor sleep quality postpartum and 16.5% reported symptoms of depression. Subjectively reported sleep deprivation was associated with symptoms of depression after controlling for multiple risk factors (previous depressive episode, depression during

pregnancy, and stressful life events; Dørheim et al., 2009a). Okun and colleagues (2011) concluded that poor self-reported sleep throughout the first 17 weeks postpartum represented a key risk factor of maternal depression. Taken together, these findings strongly suggest that subjective reports of increased maternal sleep disturbances and deprivation are associated with depressive symptoms (Dørheim et al., 2009a; Goyal et al., 2007; Wolfson et al., 2003).

While studies utilizing subjective sleep indices yield a strong association between sleep and postnatal depressive symptoms in mothers (Goyal et al., 2007; Hall et al., 2017), studies relying on objective measures are less common and have produced inconsistent findings (Bei et al., 2010; Dørheim et al., 2009b). For instance, Dørheim and associates (2009b) found that mothers demonstrating depressed mood reported poorer subjective sleep at 2 months postpartum compared to mothers with non-depressed mood. However, the two groups did not significantly differ on objectively measured sleep. The findings of Dørheim and colleagues (2009b) coincide with results suggesting that subjective perception of sleep, but not objectively measured sleep quality, was associated with postpartum mood disturbance in mothers (Bei et al., 2010). Comparatively, Posmontier (2008) assessed sleep using wrist actigraphy (i.e., objective measure) and found that sleep was worse in mothers reporting symptoms of postpartum depression when compared to those reporting no symptoms. It was also concluded that deteriorating sleep quality predicted more severe symptoms of postpartum depressive symptomatology (Posmontier, 2008). Moreover, a study consisting of 25 mothers, measuring sleep at 2, 6, 10, and 14 weeks postpartum, revealed an insignificant relationship between nocturnal sleep duration (measured by actigraphy) and depressive symptoms (Park et al., 2013). However, higher objective sleep fragmentation, WASO, and lower sleep efficiency were significantly correlated with higher maternal depressive symptoms (Park et al., 2013). Despite the more recent incorporation of

actigraphy measured sleep in postpartum mood investigations, a trend in the literature suggests a stronger relationship between self-reported sleep and mood as compared to the relationship between objectively measured sleep and mood (Bei et al., 2015).

Fathers

The significant sleep changes that follow childbirth have also been found to contribute to fathers' vulnerability to mental health difficulties including depressive symptoms (Gay et al., 2004). According to a meta-analytic review by Paulson and Bazemore (2010), the development of paternal postpartum symptoms of depression is a significant public health concern, with the rate of depressive mood at 10.4% between the first trimester and 1 year postpartum. These findings correspond with results of a more recent meta-analysis indicating that 8.4% of fathers suffered from depressive symptomatology between the first trimester and 1 year postpartum, with higher estimates between 3 to 6 months perinatal (Cameron et al., 2016). There are some studies which suggest that mothers are more likely than fathers to have higher levels of depressive symptoms and increased prevalence of diagnosed postpartum depression, particularly in Western societies (Ballard et al.,1994; Edhborg et al., 2005). Contrarily, other studies, including research conducted by Wang and Chen (2006) utilizing a Taiwanese sample, have failed to find significant differences between self-reported depressive symptom scores in mothers and fathers postpartum (Gao et al., 2009; Mao et al., 2011). The inconsistency of such findings may be attributed to cross-cultural differences in psychosocial factors and values (Mao et al., 2011). Nonetheless, postpartum depressive symptoms remain a significant problem experienced by fathers (Goodman, 2004). As such, fathers represent an important at-risk population during this period regardless of whether their level of risk is equivalent to that of mothers.

Although fathers experience perinatal stress and are at risk of developing mental health problems during this sensitive period, investigations of postpartum depressive mood in fathers remains quite limited (Cox, 2005). The few studies which have examined associations between fathers' sleep and depressive symptomatology in the postpartum period have primarily relied on subjective measures of sleep. Research of this nature has revealed that poor sleep quality in fathers is associated with increased depressive symptomatology (Hall et al., 2017). Similarly, research conducted by Seymour and colleagues (2014) indicated that fathers who self-reported poor sleep quality had poorer mental health compared to fathers who self-reported better sleep. Saxbe and colleagues (2016) also employed subjective measures and found that sleep influenced the association between depressive symptomatology at 1 month postpartum and symptoms measured at 6 to 12 months later. They concluded that sleep quality appears to contribute to the worsening of depressive mood in the first year postpartum when fathers are caring for an infant (Saxbe et al., 2016). Additionally, fathers who experienced postnatal sleep deprivation also reported changes in mood and increased irritability (Fägerskiöld, 2008).

Taken together, these studies provide strong subjectively reported evidence that sleep disturbances and poor quality are associated with negative psychological health in fathers (Hall et al., 2017; Saxbe et al., 2016; Seymour et al., 2014). However, it remains unclear whether, and to what extent, such associations extend to fathers' sleep when measured objectively; this represents a major gap in the postpartum sleep literature requiring investigation.

Summary of Key Limitations in the Existing Literature

Lack of research on fathers

Most studies have failed to examine postpartum sleep among fathers, representing a major limitation within the extant postpartum sleep literature. To date, there has been limited

research examining postpartum sleep among fathers, with most of the literature centered on maternal (or infant) sleep patterns and disturbances (Elek et al., 2002; Insana & Montgomery-Downs, 2013; Montgomery-Downs et al., 2010). Considering that fathers are primary caregivers expected to experience changes in sleep due to changes in their bedpartners' (i.e., mothers) and infants' sleep, investigations examining paternal sleep are certainly warranted. Moreover, only few studies have examined postpartum sleep in both fathers and mothers (Elek et al., 2002; Insana & Montgomery-Downs, 2013; Montgomery-Downs et al., 2010), limiting our understanding how postpartum sleep progresses within the family unit. Investigations which capture sleep in *both* parents are required to advance our knowledge of how familial sleep health may be impaired during the sensitive postpartum period and more generally, how families adjust to life with a new infant.

Lack of objective sleep measures in research examining postpartum depressive symptoms in fathers

A related limitation within the literature is that few studies have examined objective sleep in the context of postpartum depressive mood specifically in fathers. Instead, research to date has heavily relied on subjective sleep measures when investigating the link between sleep and mood in this specific population. The inclusion of objective measures would improve the assessment of sleep. Actigraphy also enables sleep recording for several consecutive days (Saxbe et al., 2016). Measuring sleep over several consecutive days, and not for 2 to 3 days, provides a more accurate representation of paternal sleep, especially considering variation in infant sleep patterns. Given that fathers represent an understudied population, the nature and extent of the relationship between paternal sleep and postpartum depressive symptoms remains unclear. Moreover, the

inconsistencies regarding subjective and objective measures of sleep in the literature examining maternal mood highlight the importance of implementing both indices of sleep.

Lack of multi-measure designs

An additional, yet primary, limitation of the extant postpartum sleep literature is represented by the lack of research incorporating both subjective and objective measures of sleep. Most studies to date have implemented *either* subjective *or* objective indices of sleep. Different findings are likely to emerge according to the type of measure employed, rendering cross-study comparisons difficult and our understanding of postpartum sleep incomplete. Few studies have implemented multi-measure designs involving the simultaneous use of both types of indices, such as self-report and actigraphy (Bei et al., 2015); studies of this nature enable direct comparison of subjective and objective sleep and are thus necessary to help elucidate the differences of various dimensions of parents' sleep and sleep health in the postpartum period.

Additionally, multi-measure designs would be particularly useful in elucidating our understanding of how mothers' and father's sleep differs in the postpartum period. Studies comparing maternal and paternal sleep in the postpartum period have also yielded mixed findings according to whether sleep was measured subjectively or objectively. As discussed above, some studies have documented significant differences between mothers' and fathers' sleep using subjective measures (Insana et al., 2014; McDaniel & Teti, 2012), while others have revealed significant differences based on objective indices only and *not* via subjective measures (Insana & Montgomery-Downs, 2013). Research examining *both* maternal and paternal sleep using *both* subjective and objective measures of sleep would greatly enhance our knowledge of parental sleep in the postpartum period.

Lack of research at 6 months postpartum

Another important trend in the literature is that parental sleep patterns tend to be investigated in the early postpartum weeks or months. Few studies have examined sleep in the mid or later postpartum stages (i.e., 6 months or later). Indeed, sleep fragmentation is typically more prevalent in the weeks that proceed childbirth. However, the lack of research examining later months limits our understanding of how parental sleep unfolds in the later postpartum stages. Though there is also a widespread notion that infants achieve consolidated sleep at 6-months-old, research has documented high infant sleep variability at both 6 months (Pennestri et al., 2020) and 12 months postpartum (Sadeh et al., 1995). Parents are therefore likely to experience sleep variability at these time points as well. To our knowledge, there are no studies that examine sleep variability in parents specifically at 6 months postpartum, and only few investigated maternal sleep variability in the weeks following childbirth (Signal et al., 2007). Studies investigating postpartum sleep tend to overlook variability (Tsai & Thomas, 2012). As such, the lack of studies investigating sleep variability in parents, beyond the early postpartum stages, represents another important gap in the extant literature.

The Present Dissertation and Contribution to Original Knowledge

The present research will contribute to original knowledge by addressing each of the aforementioned limitations and advance the postpartum sleep literature by: (1) using a multi-measure design which incorporates *both* subjective and objective indices of sleep, (2) examining *both* mothers' and fathers' sleep, (3) examining parental sleep at 6 months postpartum, a sensitive timepoint in the field of sleep, and (4) assessing associations between parental sleep and important family and psychosocial factors including depressive symptoms in fathers, an understudied population.

Chapter 3: Study 1

(Manuscript Published - *BMJ Open*, 2022)

Sleep patterns and intraindividual sleep variability in mothers and fathers at 6 months postpartum: A population-based, cross-sectional study

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Abstract

Objectives: Given that postpartum sleep is an important family process, further investigations including both mothers and fathers are necessary. The present study aimed to describe and compare sleep patterns and intraindividual night-to-night variability in mothers and fathers at 6 months postpartum using subjective and objective sleep measures.

Design: Cross-sectional study.

Setting: General community-based study in Montreal, QC, Canada.

Participants: Thirty-three couples (mothers and fathers) with no self-reported history of medical and mental health conditions participated in this study.

Results: Parental sleep was measured across 10 consecutive nights using both a daily sleep diary and actigraphy. Results demonstrated that mothers' subjective and objective sleep was more fragmented compared to fathers (shorter longest consecutive sleep duration and more nocturnal awakenings; $p < 0.001$). While mothers and fathers did not differ in their self-reported nocturnal sleep duration ($p > 0.05$), actigraphy indicated that mothers obtained significantly longer nocturnal sleep duration (448.07 minutes ± 36.49 minutes) than fathers (400.96 minutes ± 45.42 minutes; $p < 0.001$). Intraindividual sleep variability was revealed by relatively high coefficients of variation for parents across both subjective and objective indices related to sleep fragmentation (between 0.25 and 1.32). Actigraphy also demonstrated variability by mothers sleeping 6 hours consecutively on less than 3 nights, 27.27% (±22.81), and fathers on less than 6 nights, 57.27% (±24.53), out of 10. Associations were also found between parental sleep and family factors, such as age and infant sleep location ($p < 0.05$).

Conclusions: These findings advance our knowledge of how sleep unfolds within the family system beyond the early postpartum weeks and/or months. Given the link between disturbed

sleep and family functioning, the current research accentuates the importance of examining postpartum sleep patterns and variability in parents.

Strengths and limitations of this study

- The present study included both subjective and objective measures of sleep.
- Examining sleep across 10 nights allowed for a more comprehensive understanding of parental sleep variability.
- Inclusion of both mothers' and fathers' sleep patterns.
- The generalizability may be limited due to the modest sample size and less varied sample.
- The cross-sectional design limited causal inference.

Introduction

Sleep represents an important family process that significantly contributes to familial health and well-being (Bai et al., 2020; Teti, 2017). Family sleep processes are particularly vulnerable in the postpartum period due to developing infant sleep-wake patterns. Accordingly, parents are susceptible to significant sleep disturbances, including sleep fragmentation and deprivation (Gay et al., 2004; Hunter et al., 2009; Montgomery-Downs et al., 2010). Given that mothers are often considered to have a more primary role in infant nighttime caregiving, much of the postpartum sleep literature has focused predominately on maternal and infant sleep (Sinai & Tikotzky, 2012; Tikotzky et al., 2015). Although infant sleep patterns also influence paternal sleep and well-being (Hall et al., 2017; Saxbe et al., 2016), less is known about this population and it is therefore less clear how fathers' sleep patterns compared to mothers. Because sleep is an important factor linked to family functioning (Bai et al., 2020; McQuillan et al., 2019), it is necessary to advance our understanding of mothers' and fathers' sleep patterns.

The few studies which have examined both mothers and fathers in a postpartum context have produced mixed findings depending on whether sleep patterns were measured subjectively or objectively in the weeks following childbirth. For instance, Insana and Montgomery-Downs (2013) found that, based on self-report measures, mothers and fathers did not significantly differ in their sleep quality (captured by the Pittsburgh Sleep Quality Index - PSQI) and fatigue between 3 and 8 weeks postpartum. However, when examined via actigraphy, these same mothers were found to have longer nocturnal sleep duration, but more disturbed and fragmented sleep than fathers (Insana & Montgomery-Downs, 2013). Gay and colleagues (2004) found that while mothers self-reported more sleep disturbances, fathers objectively achieved shorter sleep durations over a 24-hour period in the first month postpartum. These findings highlight that

fathers also demonstrate sleep disturbances in the early postnatal period (i.e., first few weeks or months), while also underscoring the utility of employing both subjective and objective measures to obtain a more complete understanding of postpartum sleep patterns in parents.

In infants, sleep-wake cycles evolve in the months following birth as their sleep progresses toward a process commonly referred to as 'sleeping through the night' (Anders et al., 1992; Mindell et al., 2006). This process is often characterized as achieving either 6 or 8 hours of consecutive sleep without parental responses (Henderson et al., 2011). While consolidated sleep may be achieved in infants at 6-months-old, studies have also revealed significant interindividual variability in infant sleep consolidation (Galland et al., 2012; Mindell et al., 2016; Pennestri et al., 2018; Weinraub et al., 2012). In a literature review, Henderson and colleagues (2011) also showed important variability in infant sleep, with 53% of infants sleeping through the night at 6 months (i.e., achieving 8 hours of consecutive sleep).

In addition to interindividual variability, intraindividual sleep variability has been documented in infants (Goodlin-Jones et al., 2001; Pennestri et al., 2020; Scher, 2012). Infant sleep variability reflects the dynamic nature of sleep consolidation and is best described as a developmental process that evolves throughout infancy rather than a milestone reached at a specific point in time (Pennestri et al., 2020). Since previous research has indicated that infants tend to have variable sleep patterns from nigh-to-night (Pennestri et al., 2020; Sadeh et al., 1995), and that sleep is a family process, parents are also expected to demonstrate high night-to-night variability in the postpartum period.

To our knowledge, few studies have examined postpartum sleep variability among parents. One study using a small sample of 19 mothers, demonstrated night-to-night objective sleep variability across 7 nights (1 week postpartum) in total sleep duration, sleep efficiency,

wake after sleep onset, and number of sleep episodes (Signal et al., 2007). More is known about sleep patterns within the general adult population as greater variability in actigraphy sleep duration has been strongly associated with poor subjective sleep quality and mood (Lemola et al., 2013). Mezick and colleagues (2009) found that adult women demonstrated greater intraindividual sleep variability compared to men in actigraphy measured sleep duration across 9 nights after controlling for covariates (e.g., sex, age, body mass index, and medication use). These authors also found greater variability in actigraphy derived sleep duration and fragmentation in women and men experiencing stressful life-events, independent of demographic and health factors (Mezick et al., 2009). The initial evidence for postnatal sleep variability in mothers (Signal et al., 2007), combined with findings on both the general adult population and infants, highlight the importance of examining night-to-night variability among mothers and fathers in the postpartum period.

The current study sought to address the aforementioned limitations in the postpartum sleep literature. To achieve a more comprehensive understanding of parents' sleep patterns, we examined mothers and fathers using both subjective and objective sleep measures over the course of 10 consecutive nights at 6 months postpartum. While parental sleep has been examined in the first few weeks and months postpartum (Gay et al., 2004; Insana & Montgomery-Downs, 2013; Montgomery-Downs et al., 2010; Signal et al., 2007), the current time point was selected based on research demonstrating high sleep variability in 6-month-old infants (Henderson et al., 2011; Pennestri et al., 2018), suggesting that parents may experience disturbed sleep across this period of time. Additionally, parents may be expecting to experience less sleep fragmentation at 6 months due to the commonly held belief that most infants should achieve sleep consolidation by this age (Ben-Zio et al., 2020; Burdayron et al., 2020). As such, the aims of the study were to:

(1) describe and compare sleep patterns in mothers and fathers, as well as their intraindividual night-to-night variability at 6 months postpartum, and (2) assess associations between parental sleep and family factors (i.e., age, education level, employment status, number of children, infant feeding method, infant sleep location, and infant nocturnal sleep variables).

Methods

Participants

A total of 33 couples (mothers and fathers) were recruited from the Greater Montreal area (Québec). Mothers in the sample ranged in age from 26 to 39 (M = 32.42 ± 3.79 years) and fathers ranged in age from 26 to 41(M = 34.55 ± 4.12 years). Participants took part in a larger longitudinal study investigating sleep in parents during the transition to parenthood. The current study utilized cross-sectional data from the first time point at 6 months postpartum. Recruitment occurred through online advertisements posted on social media forums for parents. Participation was voluntary and informed consent was obtained. The following inclusion criteria were met: (1) English- or French-speaking parents, (2) 18 years and older, (3) no self-reported history of chronic medical illness, (4) no self-reported past or current diagnosed mental health conditions, (5) no self-reported sleep apnea or use of sleep medication, and (6) no parental report of diagnosed medical illness amongst infants. Considering the aims of the present study (examining sleep patterns and intraindividual night-to-night variability), only participants who completed at least 10 consecutive nights of sleep data were included in the sample. There were no significant differences between demographic characteristics and sleep variables of participants included and excluded from the study (n = 10 excluded participants, less than 10 nights of sleep data*;* p > 0.05).

All 33 couples included in the present study were either married or in a common-law union and living with their infant. Table 1 describes family factors. Eleven couples (33.30%) reported being first-time parents, while twenty-two couples (66.70%) reported having 2 or more children. Most fathers (90.90%) reported current full-time paid employment and 81.80% of mothers reported being on maternity leave. Additionally, 84.80% of the sample indicated exclusive breastfeeding as their primary infant feeding method and 51.50% of couples indicated cosleeping with their infant. Regarding infant sleep variables, mean nocturnal sleep duration ranged from 454.50 to 672.00 minutes ($M = 576.3 \pm 54.80$) and mean nocturnal awakenings ranged from 0.70 to 4.90 ($M = 2.71 \pm 1.04$).

Insert Table 1

Procedures

Participants recruited by online advertisements were contacted via telephone and a short phone screen was conducted to assess inclusion criteria. A home visit was scheduled with eligible couples who agreed to participate. During the home visit, trained members of our research team explained the measures (including the actigraphy recording) and procedures. Mothers and fathers were asked to complete the sleep diary and questionnaires, along with wearing the Actiwatch daily during the participation period. Participants were contacted shortly after the home visit to clarify potential questions and/or difficulties. Compensation was received upon retrieval of the study materials. The opportunity of obtaining a larger sample size was limited due to COVID-19 restrictions implemented by government officials at the time of the recruitment process. However, analyses demonstrated significant results with the current sample size.

Measures

Sleep measures

Subjective sleep was assessed through a modified sleep diary adapted from Acebo and colleagues (2005). The diary consisted of a visual representation of each night with one box corresponding to 1 hour (which was further divided by lines denoting 15 min blocks). Parents were instructed to shade in the boxes corresponding to their estimated sleep period every morning to report their nocturnal sleep patterns (unshaded boxes represented wake period during the night). Three subjective sleep variables were then derived by computing means of the sleep diary data across 10 consecutive nights: (1) nocturnal sleep duration, (2) longest consecutive nocturnal sleep duration, and (3) nocturnal awakenings.

Objective sleep was assessed using actigraphy. Actigraphy is a watch-like device that is placed on the wrist of participants' non-dominant arm. The present study used the Actiwatch Spectrum Plus (Philips Respironics), a triaxial, piezo-electric accelerometer. Participants were instructed to wear the watch daily and remove the device only for immersed, water-based activities (e.g., bathing, swimming, and so on). The Actiwatch was sampled at a rate of 32 Hz. Data were recorded in 1 min epochs (Dørheim et al., 2009; Volkovich et al., 2018) and downloaded using Philips Actiware Software (V.6.0.9). Data were scored using a standardized actigraphy scoring protocol (McGrath et al., 2018). Objective sleep variables were derived by computing means of the actigraphy data across 10 consecutive nights: (1) nocturnal sleep duration, (2) longest consecutive nocturnal sleep duration, (3) nocturnal awakenings. Additionally, the longest consecutive sleep duration per night was obtained using raw data of minute-by-minute epochs recorded by the actigraphy. For all participants, activity status was defined as active, rest, or rest-sleep. Active and rest were considered wake states. Wake states

after nocturnal sleep onset were manually determined when activity level per minute was equal or above the 40-activity count threshold (medium sensitivity) for at least 5 consecutive epochs. The longest sleep period for each night indicated consecutive sleep duration. To verify whether parents engaged in daytime sleep, mean 24-hour sleep duration across 10 nights was also derived.

Family factors

Participants completed a demographic questionnaire to obtain information on their age, education level, employment status, and number of children. A questionnaire about sleep-related parental practices during the postpartum period (adapted from the Sleep Practices Questionnaire; Germo et al., 2007; Keller & Goldberg, 2004; Kenny et al., 2021) was used to assess: (1) infant feeding method (i.e., no breastfeeding, partial breastfeeding – mixed feeding, or exclusive breastfeeding) and (2) infant sleep location (i.e., solitary or cosleeping). Solitary sleep referred to the infant sleeping in his/her own room either alone or with siblings on a nightly basis, whereas cosleeping was defined as the infant sleeping in the same room as parents (i.e., same bed, bassinet, or crib). Mothers completed a separate sleep diary to record their perceived estimates of infants' nocturnal sleep duration and nocturnal awakenings across the same 10 consecutive nights; means were then calculated for every infant.

Statistical analyses

The data was normally distributed; univariate outliers ($z>|3.29|$) were converted to the nearest non-outlying value (with $z<|3.29|$; Tabachnick & Fidell, 2013). Descriptive statistics were computed for all subjective and objective sleep variables to describe parental sleep patterns. Paired sample *t*-tests were then used to compare mothers' and fathers' indices of sleep (i.e., nocturnal sleep duration, longest consecutive sleep duration, and nocturnal awakenings).

Intraindividual night-to-night variability in parents' sleep was examined by calculating a coefficient of variation (CV - ratio of the SD/mean; Lemola et al., 2013; Pennestri et al., 2020; Rowe et al., 2008) for all sleep diary and actigraphy variables. To further describe variability in mothers' and fathers' sleep process, the number of nights parents slept 6 hours consecutively was examined (i.e., consolidated sleep). Consistent with previous research, 6 hours of consecutive sleep represents a commonly used criterion for consolidated sleep (Henderson et al., 2011; Pennestri et al., 2020; Pennestri et al., 2018; Touchette et al., 2005). Using the subjective and objective longest consecutive sleep duration variable, the number of nights (out of 10) each mother and father slept 6 hours consecutively was calculated and transformed into percentages. Lastly, Pearson's correlations and independent sample *t*-tests were used to assess the associations between parental sleep and family factors (i.e., age, education level, employment status, number of children, infant feeding method, infant sleep location, and infant nocturnal sleep variables). Across analyses, statistical significance was determined based on $p < 0.05$. All data were analyzed using IBM SPSS V.24.0 for Windows (SPSS, Chicago, Illinois, USA).

Patient and public involvement

There were no patients involved in the current study. Additionally, participants were not involved in the design, conduct, reporting, or dissemination plans of the current research.

Results

Parental sleep patterns

Table 2 demonstrates a descriptive representation of subjective and objective sleep patterns in mothers and fathers. Results pertaining to the sleep diary variables indicated more maternal sleep fragmentation compared to fathers. Specifically, mothers demonstrated shorter longest consecutive nocturnal sleep duration (240.86 minutes ± 65.40 minutes) than fathers

(376.77 minutes ± 67.46 minutes; $p < 0.001$) and more nocturnal awakenings (2.27 ± 1.01) than fathers (.60 ± 0.56; $p < 0.001$). There was no significant difference in self-reported nocturnal sleep duration between mothers and fathers ($p > 0.05$). Results of the actigraphy sleep variables revealed that mothers demonstrated longer nocturnal sleep duration (448.07 minutes ± 36.49 minutes) than fathers (400.96 minutes ± 45.42 minutes; $p < 0.001$). Actigraphy also revealed more sleep fragmentation in mothers with more nocturnal awakenings (2.46 ± 0.99) than fathers (1.65 ± 0.68; $p < 0.001$) and shorter longest consecutive sleep duration (299.45 minutes ± 70.83 minutes) than fathers (376.73 minutes ± 63.39 minutes; $p < 0.001$). Additionally, mothers demonstrated more objective 24-hour sleep duration (512.15 minutes ± 34.86 minutes) than fathers (446.71 minutes ± 44.19 minutes; $p < 0.001$).

Insert Table 2

Intraindividual night-to-night variability

CV values for all subjective and objective sleep variables are presented in Table 3. A higher CV signifies greater dispersion around the mean and greater variability. A visual inspection of sleep variables CV suggest that mothers and fathers demonstrated higher levels of variability in both subjective and objective indices related to sleep fragmentation (longest consecutive nocturnal sleep duration and nocturnal awakenings) compared to nocturnal sleep duration (Table 3).

Insert Table 3

To further describe variability in mothers' and fathers' sleep, the number of nights parents slept 6 hours sequentially was examined (i.e., consolidated sleep). Table 4 represents the

percentage of nights mothers and fathers slept 6 hours consecutively across 10 nights (indicated by the sleep diary and actigraphy). Mothers self-reported 6 hours of uninterrupted sleep 15.45% (±20.48) of nights (less than 2 nights out of 10). As illustrated in figure 1A, almost half of the mothers (n = 16; 48.5%) never reported sleeping 6 hours sequentially and no mother met the criterion for all 10 nights. More fathers self-reported sleeping 6 hours consecutively, with a proportion of 61.81% (±26.98) of nights (approximately 6 nights out of 10; [$t(32) = -7.24$, $p < 0.001$]). Figure 1B shows that all fathers slept 6 hours for at least 1 night and 3 fathers (9.1%) met the 6-hour criterion every night.

Insert Table 4

Insert Fig 1A

Insert Fig 1B

Using actigraphy, the number of nights each mother slept 6 hours consecutively increased to 27.27% (±22.81; almost 3 nights out of 10). Figure 2A shows that 7 mothers (21.21%) never slept 6 hours consecutively across 10 nights and 1 mother met the criterion every night. Fathers reached the 6-hour criterion 57.27% (±24.53) of nights (approximately 6 nights out of 10) when measured with actigraphy [$t(32) = -5.79$, $p < 0.001$]. Figure 2B shows that all fathers received 6 hours of uninterrupted sleep for at least 1 night and 1 father (3.03%) met the 6-hour criterion across all 10 nights.

Insert Fig 2A

Insert Fig 2B

Parental sleep and family factors

Older mothers self-reported shorter consecutive nocturnal sleep duration (r = -0.445; p = 0.009) and had lower subjective nocturnal awakenings variability (r = -0.411; p = 0.017). Mothers with more children self-reported shorter nocturnal sleep duration (r = -0.375; p = 0.031), shorter longest consecutive sleep duration (r = -0.414; p = 0.016), and lower percentage of nights 6 hours of uninterrupted sleep was achieved (r = -0.405; p = 0.019). Regarding objective sleep variables, results revealed that older mothers had more nocturnal sleep duration variability (r = 0.436; p = 0.011).

Mothers engaging in solitary sleep reported higher subjective mean longest consecutive sleep duration (272.63 minutes ± 65.82 minutes) compared to mothers engaging in cosleeping (210.97 minutes ± 50.34 minutes; p = 0.005). Solitary sleeping mothers also had lower subjective mean nocturnal awakenings (1.73 ± 0.71) than cosleeping mothers (2.78 ± 0.99; p = 0.002), but reported more variability in nocturnal awakenings (solitary: 0.63 ± 0.28; cosleeping: 0.44 ± 0.13; p = 0.016). Mothers engaging in solitary sleep also self-reported a higher percentage of nights sleeping 6 hours consecutively (24.38% ± 25.02%) compared to cosleeping mothers (7.06% ± 9.85%; p = 0.013). Additionally, mothers on maternity leave demonstrated more subjective nocturnal awakenings (2.44 ± 1.04) compared to actively working mothers (1.49 ± 0.17; p < 0.001). There were no associations between mothers' subjective sleep variables and education level or infant feeding method (p > 0.05). However, longer subjective mothers' nocturnal sleep duration (r = 0.380, p = 0.029) and consecutive sleep duration (r = 0.702, p < 0.001), and fewer subjective night awakenings (r = -0.625, p < 0.001) were associated with longer infant nocturnal sleep. Additionally, shorter subjective maternal consecutive sleep duration (r = -0.693, p < 0.001) and more self-reported maternal night awakenings (r = 0.848, p < 0.001) were associated with more infant night awakenings. No associations between mothers' actigraphy sleep variables

and employment status, education level, infant feeding method, infant sleep location, infant nocturnal sleep duration, or infant nocturnal awakenings were found ($p > 0.05$).

Older fathers reported fewer subjective nocturnal awakenings ($r = -0.467$; $p = 0.006$) and shorter objective nocturnal sleep duration ($r = -0.562$; $p = 0.001$). Employment status, education level, infant feeding method, infant sleep location, and infant nocturnal sleep variables did not demonstrate associations with paternal sleep diary and actigraphy variables ($p > 0.05$). Lastly, these family factors did not relate to fathers' subjective and objective reports of sleeping 6 hours consecutively ($p > 0.05$).

Discussion

The current study aimed to describe and compare sleep patterns and intraindividual variability in parents at 6 months postpartum. Results revealed that mothers' sleep was more fragmented compared to that of fathers, as mothers self-reported (i.e., sleep diary) significantly shorter longest consecutive nocturnal sleep duration and more nocturnal awakenings than fathers. These results were also replicated with actigraphy given that mothers demonstrated more objective sleep fragmentation compared to fathers. Such findings parallel those of Montgomery-Downs and colleagues (2010), which indicated high sleep fragmentation via actigraphy in mothers throughout the first 4 months postpartum. Our findings also coincide with research suggesting that compared to fathers, mothers' objective sleep tends to be more disturbed by nocturnal awakenings earlier in the postpartum period (examined between 3 and 8 weeks postpartum; Insana & Montgomery-Downs, 2013). Additionally, research has shown more self-reported sleep disturbances and higher frequencies of subjective nocturnal awakenings in mothers compared to fathers at both 1 month (Gay et al., 2004) and 3 months (Cattarius &

Schlarb, 2021) following childbirth. Taken together, our findings demonstrate that subjective and objective sleep fragmentation persists at 6 months postpartum.

The current study also revealed discrepancies between mothers and fathers pertaining to objectively measured nocturnal sleep duration. That is, while mothers and fathers did not differ in their self-reported sleep duration, actigraphy revealed that mothers obtained significantly more nocturnal sleep. These findings are congruent with previous research indicating no differences in parents' subjective sleep in the initial postpartum period (Gay et al., 2004; Insana and Montgomery-Downs, 2013), yet mothers obtain longer objective postpartum sleep duration than fathers (Gay et al., 2004). Subjective and objective sleep durations reported in the current sample fall within the range of sleep duration noted in healthy adults (7 to 9 hours; Hunter et al., 2009). The nocturnal sleep durations documented in our study are also comparable to previous literature investigating self-reported postpartum sleep in mothers and fathers (Richter et al., 2019).

The increased sleep fragmentation and longer objective nocturnal sleep duration found in mothers may be explained by findings indicating that mothers tend to have a more primary role in infant nighttime caregiving than fathers (Sinai & Tikotzky. 2012; Tikotzky et al., 2015). Indeed, the majority of mothers in the present study reported that they were on maternity leave during the participation period, while most fathers reported full-time employment. Moreover, actigraphy data revealed that mothers slept more than fathers throughout a 24-hour period. Therefore, mothers likely had more flexible sleep schedules than fathers, whose opportunities for sleep were restricted to the nighttime. Furthermore, fathers' need for sleep at night may have been prioritized to facilitate adequate work functioning. As such, mothers were likely to be the designated parent to attend to their infant throughout the night, although this question was not specifically asked to participants in the current study. It is important to note that Québec's

maternity leave is typically 12 months and that postpartum parental benefits vary in other countries. Our findings build on previous research documenting sleep disturbances and fragmentation among parents in the first few weeks and months following childbirth, yet uniquely contributes to the literature by demonstrating such patterns at 6 months postpartum especially in a context where mothers are on maternity leave.

The present study also represents a unique contribution to the literature by investigating intraindividual night-to-night sleep variability in parents over the course of 10 nights. Variability in sleep was revealed by relatively high coefficients of variation in longest consecutive sleep duration and nocturnal awakenings for both mothers and fathers across subjective and objective measures of sleep. Such findings are consistent with the limited existing research documenting variability in mothers' actigraphy measured sleep at 1 week postpartum (Signal et al., 2007).

Further variability was demonstrated in the percentage of nights parents slept 6 hours consecutively. When examining sleep consolidation subjectively, mothers reported sleeping 6 hours without interruption on less than 2 nights out of 10 (15.45%), with no mother meeting the criterion every night. Similarly, actigraphy revealed that mothers slept 6 hours consecutively on almost 3 nights out of 10 (27.27%), with only 1 mother meeting the criterion nightly. Fathers slept 6 hours consecutively on approximately 6 nights out of 10 when measured with the sleep diary and actigraphy. Self-reports indicated that all fathers met the criterion for at least 1 night, but only 3 fathers (9.1%) slept 6 hours consecutively across all 10 nights. Actigraphy demonstrated similar findings, with only 1 father (3.03%) meeting the criterion nightly. Hence, both mothers and fathers displayed night-to-night variability, but sleep consolidation was more present among fathers.

Overall, our findings demonstrating variability in parents' sleep at 6 months postpartum compliments previous research illustrating intraindividual night-to-night variability among infants at 6 and up to 12 months postpartum (Pennestri et al., 2020; Sadeh et al., 1995). Given that sleep is a family process, parents' sleep is expected to vary according to whether their infants have achieved consolidated sleep. Indeed, infant nocturnal awakenings often require parental response, fostering more fragmented parental sleep (Gay et al., 2004; Anders et al., 1992). A review of the literature has outlined links between sleep fragmentation and daytime functioning, daytime sleepiness, cognitive functioning, and changes in mood among the general population (Stepanski, 2002). In the postpartum period, objective sleep fragmentation was found to predict decreased cognitive functioning in mothers at 1 month following childbirth (Wilkerson, 2015). It is thus important to consider the effects fragmented sleep may have on mothers' and fathers' ability to assume important parental and familial responsibilities. Additionally, the intraindividual sleep variability demonstrated in parents of the current study may be explained by the potential stress they experienced throughout the nocturnal period as they anticipate the need to intervene during the night (i.e., being "on call" to soothe infant during nighttime awakenings). High stress has been associated with intraindividual sleep variability in the general adult population (Lemola et al., 2013; Mezick et al., 2009) and is perhaps more pronounced for parents considering the demands of caregiving.

Parental sleep and family factors

A secondary aim of the present study was to examine associations between parental sleep and family factors. While age has been associated with changes in sleep quality in the general population (Dijk & Duffy, 1999), less is known about this relationship in the postpartum period. Our results revealed that older mothers self-reported shorter subjective longest consecutive sleep

duration and fewer night awakenings. Older mothers also demonstrated more variability in actigraphy nocturnal sleep duration. Additionally, older fathers self-reported fewer night awakenings and lower actigraphy measured nocturnal sleep duration compared to younger fathers. Our findings coincide with literature conducted in the pregnancy period demonstrating that older maternal age was associated with poor sleep quality (captured by the PSQI; Tsai et al., 2016). It is thus important to consider the process of aging as contributing to postpartum sleep difficulties in parents.

Infant sleep represented an important family factor associated with postpartum sleep patterns in parents. Unsurprisingly, self-reports of increased maternal sleep duration and less sleep fragmentation were associated with more consolidated infant sleep. However, these associations with infant sleep were only found for mothers', and not fathers' subjective sleep variables. These findings make sense in light of the fact that mothers, and not fathers, were on maternity leave and were likely the designated parent tending to their infant at night. This further supports previous research describing mothers as infants' primary nocturnal caregivers (Sinai & Tikotzky. 2012; Tikotzky et al., 2015).

Mothers who had more than one child had shorter subjective nocturnal sleep duration, shorter longest consecutive sleep duration, and lower percentage of nights sleeping 6 hours consecutively. Additionally, mothers on maternity leave reported more night awakenings than actively working mothers. While mothers on maternity leave likely tended to their infant during the nocturnal period, it is also plausible that they engaged in daytime sleep to compensate for nocturnal sleep disruptions. Increased time in bed throughout the day may have thus interfered with mothers' nocturnal sleep. Mothers engaging in solitary sleep self-reported longer consecutive sleep duration and fewer nocturnal awakenings. Solitary sleep was also associated to

more variability in subjective maternal night awakenings and related to mothers' higher percentage of nights sleeping 6 hours consecutively. Previous literature revealed that cosleeping mothers experienced more sleep related problems than solitary sleeping mothers (Teti et al., 2016, Volkovich et al., 2018). This is consistent with our findings as solitary sleeping mothers reported less subjective sleep fragmentation. Importantly, associations between infant sleep location and objectively measured sleep were not found. It is therefore possible that cosleeping mothers are more conscious of their infant as they are physically closer to them during the nocturnal period, and more likely to have brief awakenings that are not captured by actigraphy.

No associations were found between maternal sleep variables (subjective and objective) and education level or infant feeding method. No associations were observed between fathers' sleep variables (subjective and objective) and employment status, education level, number of children, infant feeding method, infant sleep location, or infant nocturnal sleep variables.

Limitations, future directions, and strengths

The generalizability of our findings may be limited due to the modest sample size consisting of healthy parents, who were mostly white, educated, married (or common law union) opposite sex couples, with most fathers working full-time and mothers on maternity leave. The inclusion of larger and more varied samples, including at-risk families (e.g., parents experiencing severe mood disturbances), is needed to expand our knowledge of postpartum family sleep processes. The present study was also limited given the cross-sectional research design, hindering our ability to draw conclusions about parental sleep patterns and variability prior to or beyond 6 months postpartum. Longitudinal investigations spanning from birth and across the first year of infancy are required to provide a more complete overview of the development of postpartum family sleep processes. Future studies should also investigate postpartum sleep

patterns and variability in dual-career families when mothers have returned to work. Additional examination of non-traditional families is also necessary to further contribute to the postpartum sleep literature.

Despite the limitations outlined above, the inclusion of mothers and fathers, along with measuring sleep subjectively and objectively represent key strengths of the current study. Examining sleep across 10 nights allowed for a more comprehensive understanding of parental sleep variability and meaningfully contributes to the existing literature. Additionally, despite the less varied sample, significant sleep fragmentation was captured in parents at 6 months postpartum.

Examining sleep patterns in both parents revealed that sleep was more fragmented in mothers, while nocturnal sleep duration (actigraphy) was shorter in fathers. Intraindividual night-to-night variability was observed in mothers' and fathers' subjective and objective sleep indices. Further variability was documented in parents' lack of consolidated sleep, especially in mothers, at 6 months postpartum.

Taken together, this study advanced our knowledge of how postpartum sleep unfolds within the family system beyond the early postpartum weeks and/or months. The current research underscores the importance of examining postpartum sleep variability in both mothers and fathers, an area of research that has been understudied in the parental postpartum sleep literature. Further investigations exploring variability is parental sleep is especially important considering the link between sleep and family functioning.

Acknowledgments: The authors would like to thank the families who participated in the study and the members of our research team in the Once Upon a Night Sleep Laboratory. The authors would also like to thank Marjolaine Chicoine and Élyse Chevrier for assistance with actigraphy scoring.

Contributors: CK participated in the study design, data collection, analysis, interpreted the data, and drafted the initial manuscript. RB and CL participated in the study design, data collection, data extraction process, participated to the data interpretation, and critically reviewed the manuscript for important intellectual content. KD-C and M-JB contributed to the study conceptualization and design, the interpretation of data and critically reviewed the manuscript for important intellectual content. MH-P acted as the principal investigator of this study, designed the data collection instruments, coordinated and supervised the data collection, contributed to the interpretation of data, critically reviewed the manuscript for important intellectual content and is responsible for the overall content as the guarantor. All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

Funding: This work was supported by the Social Sciences and Humanities Research Council of Canada (SSHRC), the Fonds de recherche du Québec-santé (FRQS) and the Canadian Institutes of Health Research *(*CIHR*)*.

Competing interests: None declared.

Patient and public involvement: Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication: Not applicable.

Ethics approval: This study involves human participants and was approved by (1) McGill University Ethics Board (REB-II) – Ethics ID number 385-0117 and (2) Hôpital en santé mentale

Rivière-des-Prairies Ethics Board – Ethics ID number 16-14P, 2017-1821. Participants gave informed consent to participate in the study before taking part.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement: Data are available on reasonable request and as per Ethics Boards regulations.

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Table 1

Family factors.

	Mothers (n = 33)		Fathers (n = 33)		Couples (N = 33)	
	n	**%**	**n**	**%**	**n**	**%**
Age						
25-34	20	60.61	15	45.45		
35-44	13	39.39	18	54.55		
Education level						
Highschool	0	0	1	3		
College	1	3	9	27.3		
University	32	97	23	69.7		
Employment status						
Full-time paid employment or full-time student	6	18.2	30	90.9		
Part-time paid employment, student, or both	0	0	2	6.1		
Home due to maternity or paternity leave	27	81.8	1	3		
Number of children						
1					11	33.3
2+					22	66.7
Infant feeding method						
Partial breastfeeding					5	15.2
Exclusive breastfeeding					28	84.8
Infant sleep location						
Solitary					16	48.5
Bed-sharing or cosleeping					17	51.5

Table 2

Parental sleeping patterns.

	M ± SD	Range	n
Sleep diary (subjective sleep)			
Mothers			
Nocturnal sleep duration (min)	437.67 ± 45.81	337.50 – 516.00	33
Longest consecutive sleep duration (min)	240.86 ± 65.40	132.00 – 405.00	33
Nocturnal awakenings	2.27 ± 1.01	0.90 – 4.60	33
Fathers			
Nocturnal sleep duration (min)	434.95 ± 45.56	348.00 – 528.00	33
Longest consecutive sleep duration (min)	376.77 ± 67.46	223.50 – 505.50	33
Nocturnal awakenings	0.60 ± 0.56	0.00 – 2.10	33
Actigraphy (objective sleep)			
Mothers			
Nocturnal sleep duration (min)	448.07 ± 36.49	348.70 – 517.10	33
Longest consecutive sleep duration (min)	299.45. ± 70.83	114.10 – 500.10	33
Nocturnal awakenings	2.46 ± 0.99	0.61 – 5.83	33
Fathers			
Nocturnal sleep duration (min)	400.96 ± 45.42	293.40 – 493.00	33
Longest consecutive sleep duration (min)	376.73 ± 63.39	224.30 – 476.30	33
Nocturnal awakenings	1.65 ± 0.68	0.49 – 3.19	33

Note: Means *(M)*, SD and ranges of sleep variable totals across 10 nights.

Table 3

Intraindividual night-to-night variability in parents' sleep (coefficients of variation).

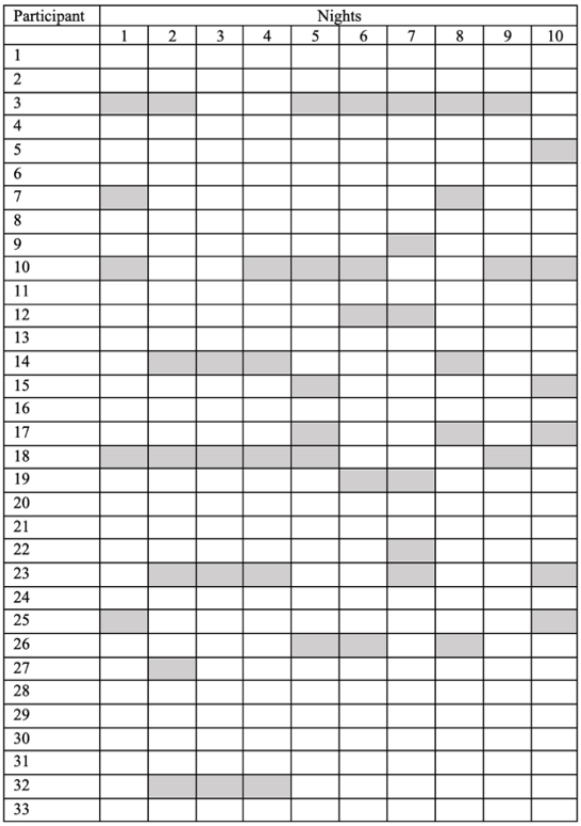
	M ± SD	Range	n
Sleep diary (subjective sleep)			
Mothers			
Nocturnal sleep duration (min)	0.15 ± 0.05	0.08 – 0.34	33
Longest consecutive sleep duration (min)	0.32 ± 0.11	0.13 – 0.62	33
Nocturnal awakenings	0.53 ± 0.23	0.26 – 1.33	33
Fathers			
Nocturnal sleep duration (min)	0.16 ± 0.06	0.06 – 0.31	33
Longest consecutive sleep duration (min)	0.26 ± 0.09	0.06 – 0.49	33
Nocturnal awakenings	1.32 ± 0.93	0.00 – 3.20	33
Actigraphy (objective sleep)			
Mothers			
Nocturnal sleep duration (min)	0.12 ± 0.03	0.06 – 0.18	33
Longest consecutive sleep duration (min)	0.29 ± 0.09	0.06 – 0.50	33
Nocturnal awakenings	0.27 ± 0.09	0.11 – 0.51	33
Fathers			
Nocturnal sleep duration (min)	0.15 ± 0.07	0.06 – 0.38	33
Longest consecutive sleep duration (min)	0.25 ± 0.10	0.11 – 0.47	33
Nocturnal awakenings	0.26 ± 0.15	0.08 – 0.93	33

Note: Means *(M)*, SD and ranges of sleep variable coefficients of variation (CV – ratio of the SD/mean) across 10 nights.

Table 4

Percentage of nights parents are sleeping 6 hours consecutively.

	M ± SD	**Range**	**n**
Sleep diary (subjective sleep)			
Mothers			
Nights 6-hr criterion is met (%)	15.45% ± 20.48	0.00 – 70.00	33
Fathers			
Nights 6-hr criterion is met (%)	61.81% ± 26.98	10.00 – 100.00	33
Actigraphy (objective sleep)			
Mothers			
Nights 6-hr criterion is met (%)	27.27% ± 22.81	0.00 – 100.00	33
Fathers			
Nights 6-hr criterion is met (%)	57.27% ± 24.53	10.00 – 100.00	33



Participant	Nights									
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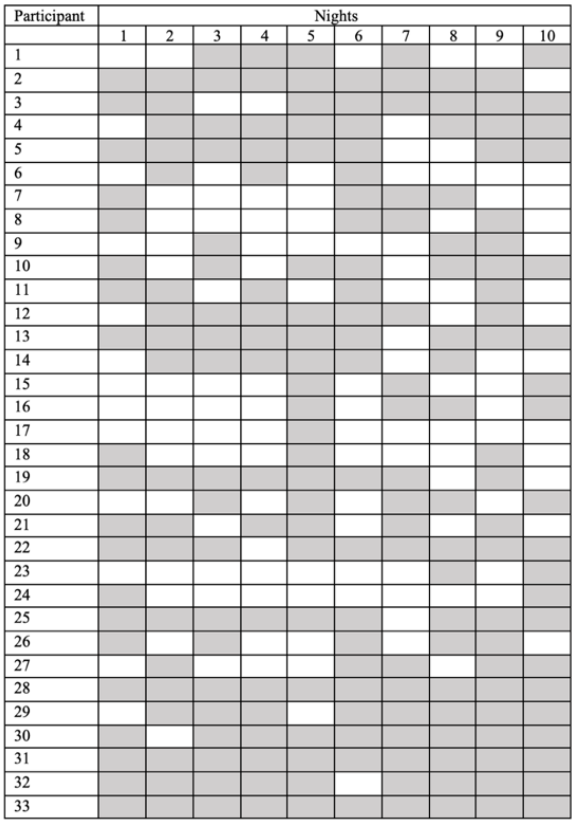
Fig 1A. Variability in 6 hours of consecutive sleep duration (sleep diary) in mothers across 10 nights. White: not sleeping 6 hours consecutively; Grey: sleeping 6 hours consecutively.



Participant	Nights									
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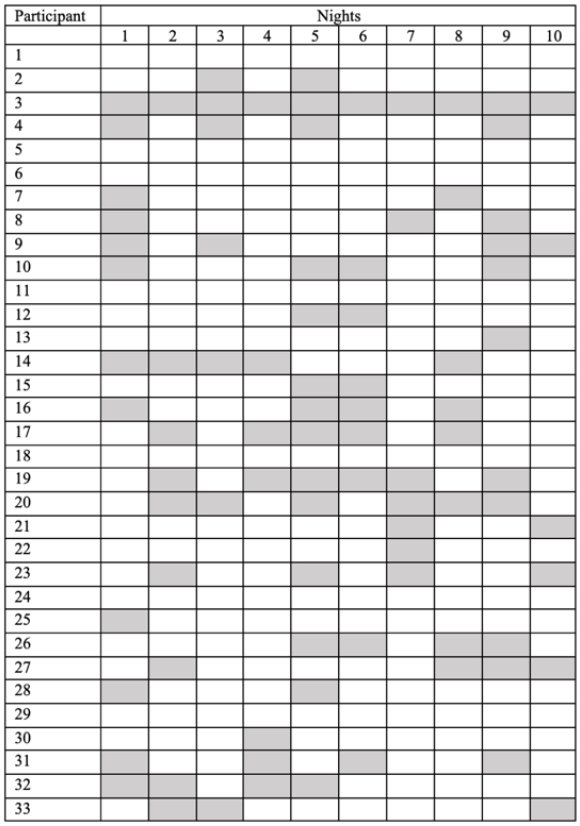
Fig 1B. Variability in 6 hours of consecutive sleep duration (sleep diary) in fathers across 10 nights. White: not sleeping 6 hours consecutively; Grey: sleeping 6 hours consecutively.



Participant	Nights									
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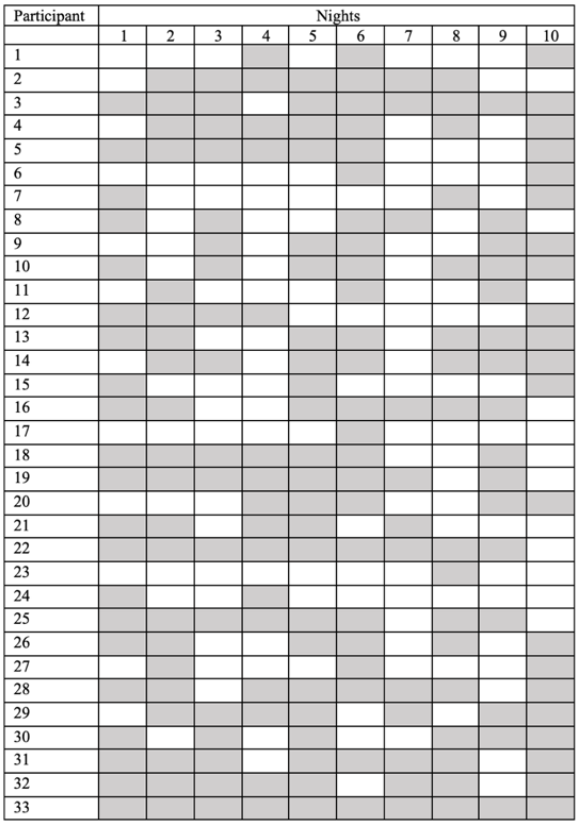
Fig 2A. Variability in 6 hours of consecutive sleep duration (actigraphy) in mothers across 10 nights. White: not sleeping 6 hours consecutively; Grey: sleeping 6 hours consecutively.



Participant	Nights									
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Fig 2B. Variability in 6 hours of consecutive sleep duration (actigraphy) in fathers across 10 nights. White: not sleeping 6 hours consecutively; Grey: sleeping 6 hours consecutively.

Chapter 4: Transition Statement Between Study 1 and Study 2

Study 1 examined mothers' and fathers' sleep patterns as well as their intraindividual night-to-night variability at 6 months postpartum using a multi-measure approach consisting of subjective and objective sleep indices. Findings revealed that parents had high sleep variability and while mothers had more fragmented sleep (subjective and objective) than fathers, their nocturnal sleep duration (objective) was longer than that of fathers. Study 1 thus offered a deeper understanding of how sleep unfolds within the family system during the postpartum period and highlighted how the sleep functioning of fathers, and not just mothers, is impaired in the postpartum period.

It has been well-established that sleep disturbances and poor sleep quality have negative implications for mood and are linked to experiencing depressive symptoms. The association between postpartum sleep and depressive symptomatology has been studied extensively amongst mothers. However, this association has been largely overlooked amongst fathers. It thus remains unclear whether and to what extent such associations extend to fathers, representing a major gap in the postpartum sleep literature. Study 2 expanded on this gap, and on the findings derived from Study 1, by examining the association between fathers' postpartum sleep and depressive symptoms. Given the breadth of findings yielded by the multi-measure approach to sleep in Study 1, Study 2 utilized a multi-measure approach consisting of subjective and objective sleep indices to enrich our understanding of the link between postpartum sleep and depressive symptoms amongst fathers.

Chapter 5: Study 2

(Manuscript Published - *Sleep Medicine X,* 2021)

Investigating the link between sleep and postpartum depression in fathers utilizing subjective and objective sleep measures

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Abstract

Background: While fathers are at risk of developing poorer sleep and depressive symptoms in the postpartum period, they represent an understudied population in the literature. The present study aimed to explore the association between sleep and postpartum depressive symptoms in fathers using subjective and objective sleep measures.

Methods: Fifty-four fathers reporting no history of depression took part in this cross-sectional study. At 6 months postpartum, paternal sleep was assessed for 2 weeks utilizing a self-report daily sleep diary, a self-report perceived sleep quality rating, and actigraphy. In the same period, depressive symptoms in fathers were assessed with the Center for Epidemiologic Studies – Depression Scale (CES-D).

Results: Regression analyses showed that paternal subjective sleep variables captured by the sleep diary (total nocturnal sleep time and number of night awakenings) were not related to postpartum depressive symptoms. However, self-reported perceived sleep quality was significantly associated with postpartum depressive symptom severity in fathers independently of demographic variables related to depression. Alternatively, the objective sleep variables (total nocturnal sleep time, number of night awakenings, sleep efficiency, and wake after sleep onset), measured by actigraphy, did not demonstrate a significant relationship with paternal depression scores.

Conclusions: These findings highlight the importance of perceived sleep quality, along with better understanding its association with postpartum depressive symptoms. Implementing a multi-measure approach enabled us to expand our knowledge about how different facets of sleep relate to postpartum depression, specifically in fathers. The results have important implications

for the development of clinical interventions targeting paternal sleep and mood in the postpartum period.

Keywords:

Subjective sleep, sleep quality, objective sleep, actigraphy, postpartum depression, fathers

Introduction

The birth of an infant is a significant life event that is joyous and exciting, yet also uniquely challenging for parents (Pinquart & Teubert, 2010; Trillingsgaard et al., 2014). Studies have demonstrated significant postpartum sleep disturbances among both mothers and fathers (Gay et al., 2004; McDaniel &Teti, 2012; Montgomery-Downs et al., 2010). Such disturbances include increases in sleep fragmentation, sleep deprivation, and poor sleep quality resulting in fatigue and potential mood disruptions (Insana & Montgomery-Downs, 2013; Montgomery-Downs et al., 2010).

Research demonstrates a relationship between disturbed sleep and mood disorders in the general population (Buysse et al., 2008; Mayers & Baldwin, 2006). In the context of the postpartum period, most studies have investigated the association between sleep (disturbances and quality) and depressive symptoms among mothers. For example, mothers who reported poor subjective sleep quality demonstrated elevated postpartum depressive symptoms at 1 and 3 months concurrently (McDaniel &Teti, 2012). Hall and colleagues (2017) outlined parallel findings at 6–8 months postpartum. Mothers' self-reported sleep disturbances and poor sleep quality were also associated with postpartum depression, regardless of risk factors including a history of depression (Dørheim et al., 2009a). Okun and colleagues (2018) found that poor sleep quality was significantly associated with maternal depressive symptoms at 6 months postpartum. Furthermore, subjective sleep disturbances, including delayed sleep onset, have been linked to elevated maternal depressive symptoms during the third trimester of pregnancy and at 3 months postnatal (Goyal et al., 2007). Although there is a clear link between sleep and depression among mothers (Okun, 2016; Okun 2015), less is known about this association in fathers.

The limited research on fathers has indicated that they, too, experience significant postpartum disruptions in sleep (Gay et al., 2004), justifying the importance of also investigating the association between sleep and depressive symptoms in this population. A few studies have provided limited evidence for such a link. Saxbe and colleagues (2016) found that self-reported paternal sleep disturbances and quality at 6 months predicted depressive symptoms concurrently and longitudinally at 12 months postpartum. Lower sleep quality (measured by the Pittsburgh Sleep Quality Index – PSQI) and fatigue in fathers was also associated with depressive symptomatology during the postpartum period (Hall et al., 2017). Taken together, these findings suggest that subjective sleep disturbances and sleep quality may contribute to the persistence and/or exacerbation of paternal depressive symptoms during the first year following childbirth.

Including fathers in the field of postpartum sleep is imperative since they are also at risk of developing both poorer sleep and depressive symptoms. Moreover, depressive symptoms may disrupt fathers' ability to assume parental tasks, impact day-to-day father-child interactions, and adversely affect family well-being (Goodman, 2004). Consequently, paternal postpartum depression negatively impacts child development (Ramchandani et al., 2005). The increasing trend toward dual-career families within North America over the last few decades (Gilbert 2014) leads us to speculate that fathers will continue to have a more central role as caregivers to their infants. Examining fathers would provide us with more understanding about the course of postpartum depression as well as its impact on the whole family unit. Additionally, focusing on fathers allows us to explore the association between sleep and depressive symptoms without the influence of maternal hormonal changes, which have been linked to postpartum mood (Soares & Zitek, 2008).

The heavy reliance on subjective sleep measures represents an additional limitation in the literature. Self-report sleep measures can be influenced by factors such as fatigue and mood. Therefore, the objective verification of sleep, in conjunction with subjective sleep measures, would be beneficial. However, studies utilizing objective sleep measures in the context of postpartum mental health research have been limited and have focused solely on mothers. Interestingly, these studies have revealed inconsistent findings. For example, one study conducted by Dørheim and associates (2009b) indicated that depressed mothers reported poorer subjective sleep quality (measured by PSQI) compared to non-depressed mothers at 2 months postpartum. However, objective sleep data did not yield such a difference between these two groups (Dørheim et al., 2009b). Bei and colleagues (2010) revealed similar findings whereby subjective sleep, but not objectively measured sleep (e.g., total sleep time, wake after sleep onset (WASO), sleep efficiency, and sleep disturbance), was strongly associated with postpartum mood disturbances in a sample of 44 mothers. Contrarily, Posmontier (2008) reported that poor objective sleep (e.g., sleep latency, WASO, and sleep efficiency) predicted more severe postpartum depressive symptomatology in 46 mothers. To our knowledge, there are no studies that examine objective sleep in the context of postpartum depressive mood in fathers, representing a major gap in the postpartum sleep literature.

The aim of the current study is to explore the relationship between sleep and depressive symptoms in fathers at 6 months. This time point was selected in light of previous research examining the link between sleep and depression (Okun et al., 2018), as well as research demonstrating that there is still high infant sleep variability at 6 months postpartum (Henderson et al., 2011; Pennestri et al., 2018). Three distinct sleep measures were used: (1) subjective sleep indices based on a sleep diary (total nocturnal sleep time and number of night awakenings), (2)

perceived sleep quality, and (3) objective sleep indices (total nocturnal sleep time, number of night awakenings, nocturnal sleep efficiency, and WASO). It should be noted that while subjective sleep and perceived sleep quality are both self-report measures, the former refers to how *long* and how *fragmented* participants thought their sleep was (i.e., subjective quantity), whereas the latter refers to how *well* participants thought they slept (i.e., perceived quality). The following variables were considered as potential covariates, given their possible association with depression in mothers and fathers: age, number of children, education level, employment status, and infant feeding method (Butler et al., 2020; Cameron et al., 2016; Hein et al., 2014; Milgrom et al., 2008; Okun et al., 2018).

Material and Methods

Participants

A total of 54 fathers with an average age of 35.06 years (*SD* = 5.18) were recruited from the Greater Montreal area (Québec). Participation was voluntary and informed consent was obtained. Recruitment occurred through online advertisements posted on social media forums for parents. Participants took part in a larger, longitudinal study investigating sleep, parental practices, and mood in parents. Cross-sectional data from the first time-point, when the participants' infants were 6 months old, were utilized for the current study. Participants met the following inclusion criteria: (1) English- or French-speaking father, (2) 18 years and older, (3) no history of chronic medical illness, (4) no past or current diagnosis of mental health conditions, (5) no current use of sleep medication. All fathers in the sample lived with their infant and were either married or in a common-law union with the child's mother. While 44.5% of participants indicated having 2 children, 38.9% reported being first-time fathers. Additionally, the majority of

the sample (85.2%) reported current full-time paid employment. Table 1 describes all participant demographic characteristics.

Insert Table 1

Measures and procedures

Subjective sleep indices were assessed through a modified sleep diary adapted from Acebo and colleagues (2005). Participants were instructed to complete the sleep diary for 14 consecutive days. Two subjective sleep variables were derived by computing means of the sleep diary data across the 2-week period: (1) total nocturnal sleep time and (2) number of night awakenings. On average, participants provided 12.17 days (*SD* = 3.32) of subjective sleep data.

In addition, the perceived sleep quality variable was obtained through paternal ratings of their sleep each morning ("rate your sleep quality – use a 1-10 scale, 1 = poor, 10 = excellent"). Higher values indicated better sleep quality. Perceived sleep quality was derived by computing a mean across the 2-week period for each participant. On average, participants provided 10.13 days (*SD* = 5.06) of sleep quality data.

Objective sleep was assessed using actigraphy. Actigraphy has been previously validated against polysomnography (Tryon, 2004). It has been deemed a reliable measure of objective sleep (Ancoli-Israel et al., 2003; Volkovich et al., 2018). Actigraphy is a watch-like device that is placed on the wrist of participants' non-dominant arm. The present study used the Actiwatch Spectrum Plus (Philips Respironics), a triaxial, piezo-electric accelerometer. Participants were instructed to wear the watch for 14 consecutive days and remove the device only for immersed, water-based activities (e.g., bathing, swimming, etc.). The Actiwatch was sampled at a rate of 32 Hz. Data were recorded in 1-min epochs (Dørheim et al., 2009b; Volkovich et al., 2018) and

downloaded using Philips Actiware Software (version 6.0.9). Data were scored using a standardized actigraphy scoring protocol (McGrath et al., 2018). Four objective sleep variables were derived by computing means of the actigraphy data across the 2-week period: (1) total nocturnal sleep time, (2) number of night awakenings (lasting >1 minute), (3) nocturnal sleep efficiency (number of sleep minutes/number of minutes in bed X 100), and (4) Wake after sleep onset (WASO). On average, participants provided 11.91 days (*SD* = 2.97) of valid actigraphy data.

The Center for Epidemiologic Studies – Depression Scale (CES-D; Radloff, 1977); was used to assess paternal depressive symptoms. This self-report measure of depressive symptoms is well validated and is widely used with both the general population and with parents pre-and-postnatally (Goyal et al., 2007; Radloff, 1977). The CES-D was selected in the current study as it has previously been utilized in examining postpartum depressive symptoms in both mothers and fathers (Hall et al., 2017). It consists of 20 items and instructs respondents to reflect on their feelings and attitudes over the past week and select a response that best describes how they felt or behaved. Items are rated on a 4-point Likert scale from 0 (*rarely/none of the time: <1 day*) to 3 (*most/all of the time: 5–7 days*). The total score ranges from 0 to 60, with higher scores indicating more frequent depressive symptoms. Cut-off scores ≥ 16 suggest a potential risk factor for depression. The CES-D has demonstrated good internal consistency (Cronbach α = 0.84 to 0.88; Goyal et al., 2007; Siddaway et al., 2017). In the current study, the Cronbach α was 0.85.

Participants completed a demographic questionnaire to obtain information on their age, number of children, education level (i.e., last diploma obtained), and employment status. Additionally, participants were asked about infant feeding method (i.e., no breastfeeding, partial breastfeeding – mixed feeding, exclusive breastfeeding).

Participants recruited by online advertisements were contacted via telephone by members of our research laboratory. Research assistants conducted a short phone screening with interested individuals to assess whether inclusion criteria were met. If fathers were deemed eligible and agreed to participate, a home visit was scheduled. Trained members of our research team visited participants at their home to obtain written consent and explain the measures and procedures, including the actigraphy recording. During the 2-week participation period, fathers were asked to complete the sleep diary, sleep quality rating, and wear the Actiwatch daily. Participants completed the demographic questionnaire and CES-D at their convenience within the 2-week period. Shortly following the initial home visit, a research assistant contacted participants to clarify potential questions and/or difficulties and to ensure that the sleep measures were being completed correctly. Fathers received their compensation upon retrieval of the study materials. The current research received approval from the McGill University Ethics Board (REB-II) and the Hôpital en santé mentale Rivière-des-Prairies Ethics Board.

Statistical analyses

Prior to analysis, outliers, missing data, and normality were addressed according to procedures outlined by Tabachnick and Fidell (2013). That is, univariate outliers ($z>|3.29|$) were converted to the nearest non-outlying value (with $z<|3.29|$). Participants that did not complete the sleep measures were excluded. The majority of items in the CES-D contained less than 5% missing data, which falls within the acceptable range (Tabachnick & Fidell, 2013). As such, missing values on the CES-D were imputed using sample mean replacement. All data were analyzed using IBM SPSS version 24.0 for Windows (SPSS Inc., Chicago, IL).

A series of one-way MANOVAs were conducted to determine whether there were significant differences between the various sleep variables among participants who completed all 14 days of the sleep data and those who did not (i.e., completed 13 days or less).

Pearson's correlations were conducted among CES-D total scores and demographic variables. Demographic variables found to be correlated significantly with depressive symptoms were entered as covariates in the primary analyses. Pearson's correlations were also conducted among subjective sleep indices to ensure that sleep diary variables and perceived sleep quality ratings were not highly correlated, and thus representative of distinct constructs.

A series of multiple regression analyses were implemented to examine the relationship between fathers' sleep (i.e., subjective sleep indices, perceived sleep quality, and objective sleep indices) and their postpartum depressive symptoms. The means for each sleep measure were the independent variables, whereas the CES-D total score was the dependent variable. As previously mentioned, demographic data significantly correlated with depressive symptoms were included in the regression models as covariates. Statistical significance was determined based on $p < 0.05$.

Results

Table 2 presents means and standard deviations of sleep variables and depressive symptoms at 6 months postpartum. Results from the one-way MANOVAs indicated no statistically significant differences ($p > 0.05$) between fathers who completed all 14 days of the sleep measures and those who completed 13 days or less of the subjective sleep variables, perceived sleep quality variable, and objective sleep variables. Given these findings, all participants were retained in the primary analyses (N = 54).

Insert Table 2

Pearson's correlations were conducted among CES-D total scores and the following demographic variables: age, number of children, education level, employment status, and breastfeeding. As illustrated in Table 3, results indicated that more paternal depressive symptoms were associated with fewer number of children (r = -0.308, p = 0.024). This was the only demographic variable that correlated with depression scores. As such, number of children was entered into the regression models as a covariate. Regarding subjective sleep indices, self-reported perceived sleep quality did not correlate with self-reported total nocturnal sleep time (r = -0.181, $p > 0.05$) and number of night awakenings (r = -0.222, $p > 0.05$) as captured by the sleep diary.

Insert Table 3

Table 4 shows the multiple regression analysis examining fathers' subjective sleep and postpartum depressive symptoms. Results indicated that subjective total nocturnal sleep time (p = 0.844) and number of night awakenings (p = 0.190) did not significantly associate with fathers' depression scores. Self-reported perceived sleep quality, however, significantly related to paternal depression scores, $F(2, 51) = 5.28$, p = 0.008, R^2 = 0.172, p = 0.034 (see Table 5). This association was present even after controlling for number of children. The final multiple regression model (see Table 6) describes the association between objective sleep and postpartum depressive symptoms. Total nocturnal sleep time, number of night awakenings, sleep efficiency, and WASO did not show a statistically significant relationship with paternal CES-D total score ($p > 0.05$).

Insert Table 4

Insert Table 5

Insert Table 6

Discussion

In the current study, three distinct sleep measures (i.e., subjective sleep indices, perceived sleep quality, and objective sleep indices) were utilized to investigate the association between fathers' sleep and postpartum depressive symptoms. Findings revealed that, after controlling for number of children, poorer fathers' perceived sleep quality was linked to more severe depressive symptoms at 6 months postpartum. Contrarily, subjective and objective sleep variables (total nocturnal sleep time, number of night awakenings, nocturnal sleep efficiency and WASO), as measured by the sleep diary and actigraphy, were not significantly associated to paternal depressive symptoms.

Although perceived sleep quality and subjective sleep variables are typically grouped and examined together as one composite factor (often labeled as subjective sleep quality) within the literature, our results (i.e., small and non-statistically significant correlational coefficients) suggest that they in fact reflect different constructs. Perceived sleep quality represents fathers' perceptions about how *well* they thought they slept. Whereas, subjective sleep, although also a self-report measure, is indicative of how *long* and how *fragmented* they thought their sleep was – it therefore relates to quantitative facets of fathers' sleep perception, specifically sleep duration and number of night awakenings.

Previous studies that have investigated subjective parental sleep variables have often relied on well-established self-report questionnaires such as the PSQI (Da Costa et al., 2019; Da Costa et al., 2017; Hall et al., 2017; Okun et al., 2011). This widely used measure provides a global score of sleep quality consisting of various subscores on sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, sleep quality, and daytime dysfunction. The PSQI also encompasses general ratings of perceived sleep quality. In general, studies have demonstrated an association between the PSQI and postpartum depressive symptoms in both mothers and fathers (Hall et al., 2017; Saxbe et al., 2016).

While the PSQI is a validated measure as a whole, research has also revealed mixed findings with regard to the specific subscores of the PSQI. In particular, sleep efficiency and duration *have not* been found to relate to depression in mothers (Dørheim et al., 2009a). Contrarily, other subscores of the PSQI, particularly those pertaining to mothers' ratings of sleep quality, *have* been specifically associated with postpartum depression (Dørheim et al., 2009a). These results presented by Dørheim and colleagues (2009a) are in line with those of the present study, which indicate that perceptions of sleep quality relate more strongly to depression as compared to perceived sleep duration. Taken together, these findings provide support for further investigations of individual sleep factors, especially those tied to perceived sleep quality (i.e., how well one thinks they slept).

Moreover, objective sleep (actigraphy) was not significantly associated with postpartum depressive symptoms in the present study. These findings are consistent with previous studies conducted in mothers and have demonstrated a lack of relationship between actigraphy-measured sleep and depression (Bei et al., 2010; Dørheim et al., 2009b). These findings, however, are inconsistent with one study by Posmontier (2008); which concluded that actigraphy-measured

sleep latency, sleep efficiency, and WASO predicted more severe depressive symptoms in mothers between 6 and 24 weeks postpartum. The incongruence may be explained by differences in sample characteristics. Posmontier (2008) included a sample comprised of mothers diagnosed with postpartum depression, whereas fathers in the current study did not report a history of depressive symptoms. As such, it is possible that poor sleep may exacerbate depressive symptoms specifically in fathers that are already depressed or more vulnerable to getting depressed. Furthermore, mothers may be particularly more vulnerable to the effects of poor sleep as compared to non-depressed fathers. Such vulnerability may be rooted in female hormonal changes as a result of pregnancy (Soares & Zitek, 2008). Because our study was the first (to our knowledge) to examine the link between objective sleep and depressive symptoms in fathers, additional cross-study comparisons were not possible.

Taken together, fathers' negative perceptions about the quality of their sleep appear to be associated with their depressive symptoms. The shared mechanisms within each of these two measures may provide a possible explanation for this link. The measures of perceived sleep quality and depressive symptoms (i.e., the CES-D) both required participants to reflect and report on their thoughts and feelings. The former derived information about father's thoughts and feelings related to the quality of their sleep, while the latter derived information about their thoughts and feelings about themselves (examples of items include: *I felt sad, I felt fearful, I thought my life had been a failure*). Alternatively, the other subjective and objective measures implemented in the current study did not assess cognitive or affective factors but instead examined the numeric components of sleep. The subjective sleep diary measures required individuals to assess and estimate quantitative facets of their sleep, whereas the objective measures focused on motor activity via actigraphy.

The importance of father's perceptions about sleep is further underscored by the results derived from the correlational analyses. Findings demonstrated a significant negative association between number of children and paternal depressive symptoms. Specifically, first-time fathers were more likely to report higher depressive symptoms compared to non-first-time fathers. First-time fathers may be more likely to catastrophize and develop hopelessness about their poor sleep. In contrast, non-first-time fathers are likely more experienced with poor sleep, which may have enabled them to form more realistic expectations and develop more effective coping strategies. This group may thus perceive their sleep less negatively, rendering them less vulnerable to the effects of poor sleep. Our findings have important implications for the development and application of clinical interventions. The results suggest that clinicians ought to target distorted cognitions and expectations pertaining to fathers' perceptions of their sleep quality when developing interventions for the treatment of paternal depression. This is in line with cognitive-behavioural treatment approaches for insomnia and depression (Saxbe et al., 2016). Clinicians may also normalize the sleep-related challenges faced by fathers, especially first-time fathers, upon the arrival of their newborn child to encourage more realistic expectations and help reduce depressive symptoms such as hopelessness. Additional research examining the potential protective advantages of already having one or more children with regard to postpartum sleep and mental health is also warranted.

Limitations, future directions, and strengths

Our sample included mostly married, white males, with the large majority completing a college education and earning full-time paid employment. In conjunction with the modest sample size, the generalizability of our findings may thus be restricted. The lack of participant baseline sleep and mood data (prior to childbirth) presents another limitation. The absence of such data

did not allow us to examine the progression of sleep and depressive symptoms in the postpartum period. While the cross-sectional design implemented in the current study provided important information about the relationship between sleep and postpartum depression, only one point was examined and the direction of this association was not assessed. As such, the development of this relationship and whether it might be causal in nature could not be determined. Lastly, given that our measure of sleep quality was not previously validated, our ability to compare our findings to other studies was limited.

Future studies including varied samples, comprised of individuals from diverse minority groups, levels of education, and socioeconomic status, may expand our knowledge on the link between postpartum sleep and mood. The inclusion of fathers with pre-existing depression would also be beneficial and would serve as an important comparison group. Indeed, research is needed on higher-risk samples, including those experiencing more severe and pervasive depressive symptoms and sleep related difficulties. Additionally, longitudinal studies implementing both subjective and objective measures of sleep and which span across a wider range of time, including pregnancy, the neonatal period, and the first 12 months of infancy are necessary as they would provide more insight into the direction of this relationship and how it unfolds over time. Longitudinal investigations may also help reveal the most sensitive period for parents with regard to sleep and depression.

Despite the limitations described above, the current research design's multifaceted approach represents a key strength. Delineating between multiple measures of sleep enabled us to draw meaningful conclusions about how different facets of sleep relate to depressive symptoms. Our focus on fathers represents an additional strength, as they are an understudied population in the postpartum sleep and mood literature.

Conclusion

Our findings demonstrated that perceptions of sleep quality were associated with depressive symptom severity in fathers at 6 months postpartum. Subjective and objective sleep indices were not associated with paternal depressive symptoms. These findings suggest that fathers' perceptions of their sleep quality, and not the actual quality or quantity of their sleep (measured by the sleep-diary and actigraphy), may have a more important role in the development of depressive symptoms in the months that follow the birth of their infant.

Further research exploring the role of social protective factors in mitigating depressive symptoms in parents with poor sleep is necessary. Such research may enable us to identify and consolidate other critical components to include in intervention programs. Ultimately, this knowledge would help address postpartum mental health challenges related to poor sleep, and help promote individual, child, couple, and overall familial well-being.

Contributors

All authors are responsible for reported research. All authors have participated in the concept and design; analysis and interpretation of data; drafting or revising of the manuscript for important intellectual content, have approved the manuscript as submitted, and agree to be accountable for all aspects of the work.

Funding source

This work was supported by the Social Sciences and Humanities Research Council of Canada (SSHRC), the Fonds de recherche du Québec-santé (FRQS), Association Québécoise pour la santé mentale du nourrisson (AQSMN), McGill University, and the Centre intégré universitaire de santé et de services sociaux du Nord-de-I'lle-de-Montréal (CIUSSS-NIM).

Disclosure statement

Financial disclosure

None.

Non-financial disclosure

None.

Acknowledgements

The authors would like to thank the families who participated in the study and the members of our research team in the Once Upon a Night Sleep Laboratory. The authors would also like to thank Jean Paquet for assistance with the statistical analyses.

Conflict of interest

There are no conflicts of interest relevant to this article to disclose.

The ICMJE Uniform Disclosure Form for Potential Conflicts of Interest associated with the article can be viewed by clicking on the following link: https://doi.org/10.1016/j.sleepx.2021.100036.

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Table 1

Demographic characteristics.

Variable	n	%
Age		
25-34	27	50.0
35-44	24	44.5
45+	3	5.5
Number of Children		
1	21	38.9
2	24	44.4
3	6	11.1
4	3	5.6
Education Level		
High school	2	3.7
College	17	31.5
Bachelor	17	31.5
Graduate	18	33.3
Employment Status		
Full-time paid employment	46	85.2
Part-time paid employment	2	3.7
Student	2	3.7
Student and paid employment	2	3.7
Home due to paternity leave	2	3.7
Infant Feeding Method		
No breastfeeding	4	7.4
Partial breastfeeding	8	14.8
Exclusive breastfeeding	42	77.8

Table 2
Means and standard deviations of paternal sleep variables and depressive symptoms at 6 months postpartum.

Variable	6 Months Postpartum
Subjective Sleep (sleep diary)	
Total nocturnal sleep time (minutes)	440.29 ± 46.69
Number of night awakenings	0.50 ± 0.39
Perceived Sleep Quality	
Sleep quality (rating from 0 to 10)	7.11 ± 0.98
Objective Sleep (actigraphy)	
Total nocturnal sleep time (minutes)	445.29 ± 51.96
Number of night awakenings	1.77 ± 0.66
Nocturnal sleep efficiency (%)	89.25 ± 4.39
WASO (minutes)	47.10 ± 21.86
Depressive Symptoms	
CES-D total score	8.19 ± 6.51

Note: N = 54, WASO = Wake After Sleep Onset. A mean was computed for each sleep variable with data across the 2-week participation period.

Table 3

Pearson's correlations among depressive symptoms (CES-D total score) and demographic variables.

	1	2	3	4	5	6
1. Depressive symptoms (CES-D)	-	-0.092	-0.308*	-0.135	0.017	0.091
2. Age		-	0.288*	0.191	-0.183	-0.061
3. Number of children			-	0.159	-0.069	0.198
4. Education level				-	-0.220	0.126
5. Employment status					-	-0.166
6. Infant feeding method						-

Note: * = statistical significance at the 0.05 level (2-tailed).

Table 4
Multiple regression analyses of subjective sleep variables (sleep diary) and paternal depressive symptoms (CES-D total score).

Variables	*B*	95% CI	β	*t*	*p*
Model 1					
Number of children	-2.38	[-4.43, -0.33]	-0.31	-2.33	0.024
Model 2					
Number of children	-2.25	[-4.33, -0.17]	-0.29	-2.17	0.035
Total nocturnal sleep time (minutes)	-0.00	[-0.04, 0.03]	-0.03	-0.20	0.844
Number of night awakenings	3.00	[-1.54, 7.54]	0.18	1.33	0.190

Table 5
Multiple regression analyses of self-reported perceived sleep quality and paternal depressive symptoms (CES-D total score).

Variables	*B*	95% CI	β	*t*	*p*
Model 1					
Number of children	-2.38	[-4.43, -0.33]	-0.31	-2.33	0.024
Model 2					
Number of children	-2.44	[-4.42, -0.46]	-0.32	-2.47	0.017
Sleep quality (rating from 1 to 10)	-1.84	[-3.53, -0.14]	-0.28	-2.18	0.034

Table 6
Multiple regression analyses of objective sleep variables (actigraphy) and paternal depressive symptoms (CES-D total score).

Variables	*B*	95% CI	β	*t*	*p*
Model 1					
Number of children	-2.38	[-4.43, -0.33]	-0.31	-2.33	0.024
Model 2					
Number of children	-2.32	[-4.66, 0.03]	-0.30	-1.99	0.053
Total nocturnal sleep time (minutes)	-0.00	[-0.07, 0.07]	-0.02	-0.07	0.944
Number of night awakenings	-0.82	[-5.20, 3.57]	-0.08	-0.37	0.711
Sleep efficiency (%)	-0.04	[-3.02, 2.94]	-0.03	-0.03	0.978
WASO (minutes)	-0.02	[-0.63, 0.58]	0.08	-0.08	0.940

Note: WASO = Wake After Sleep Onset.

Chapter 6: General Discussion

The present dissertation was designed to advance our knowledge about typical sleep patterns and variability in both mothers and fathers at 6 months postpartum, and to examine associations between parents' sleep and familial and psychosocial factors. The current research highlights how both mothers' and fathers' sleep may be disrupted following the birth of an infant and underscores the association between fathers' perceptions of their sleep quality and postpartum depressive symptoms. Together, the current studies expand our understanding of how postpartum sleep unfolds within the family system and has important implications for parents' health and well-being.

Summary of Key Findings

Maternal and paternal sleep patterns and variability at 6 months postpartum

Study 1 investigated postpartum sleep patterns in parents using a multi-measure approach consisting of subjective and objective sleep indices over the course of 10 consecutive nights. Findings demonstrated that subjective and objective sleep fragmentation occurred for both parents at 6 months postpartum. However, mothers' sleep was more fragmented compared to that of fathers, as mothers self-reported (i.e., sleep diary) significantly shorter longest consecutive sleep duration and more nocturnal awakenings than fathers. Importantly, these results were consistent with findings yielded by actigraphy, as mothers demonstrated more objective sleep fragmentation than fathers. Results also revealed differences between mothers and fathers pertaining to sleep duration, with mothers obtaining significantly more 24-hour sleep duration and nocturnal sleep duration than fathers; interestingly, such differences were yielded solely via actigraphy and not through sleep diary reports. Previous research has likewise indicated that while mothers obtain longer objective postpartum sleep duration than fathers (Gay et al., 2004),

mothers and fathers do not differ in terms of their subjective sleep duration (Gay et al., 2004; Insana & Montgomery-Downs, 2013).

Furthermore, findings from Study 1 indicated that, across the 10 consecutive nights assessed at 6 months postpartum, mothers and fathers had high variability in terms of their longest consecutive sleep duration and nocturnal awakenings across both subjective and objective measures. Regarding sleep consolidation (i.e., percentage of nights parents slept 6 hours consecutively), both mothers and fathers displayed night-to-night variability, with fathers displaying more sleep consolidation than mothers. These findings are in line with previous research documenting variability among infants at 6 to 12 months postpartum (Pennestri et al., 2020; Sadeh et al., 1995) and among adults experiencing periods of high stress (Lemola et al., 2013; Mezick et al., 2009).

Family factors associated with parents' postpartum sleep

Study 1 additionally examined associations between sleep and several specific family factors. Findings demonstrated an association between parental age and sleep, with older mothers self-reporting shorter subjective longest consecutive sleep duration and fewer nocturnal awakenings. Moreover, older mothers also demonstrated more variability in objective nocturnal sleep duration compared to younger mothers. Results revealed that older fathers self-reported fewer night awakenings and lower actigraphy measured nocturnal sleep duration compared to younger fathers. Although older parents reported fewer nocturnal awakenings, their sleep duration and longest consecutive duration were shorter than younger parents. These results coincide with findings demonstrating an association between older age and poorer subjective sleep quality and duration in the postpartum period (Tsai et al., 2016; Wen et al., 2018).

Findings pertaining to sleep location, another significant family factor in Study 1, indicated that mothers engaging in solitary sleep (i.e., sleep with partner and not with infant) self-reported longer consecutive sleep duration and fewer nocturnal awakenings. Previous research has demonstrated increased sleep related difficulties among cosleeping (or room-sharing) mothers (Teti et al., 2016). For instance, mothers engaging in room-sharing with their infant have been found to report more nocturnal awakenings and to have poorer subjective and objective measured sleep than solitary sleeping mothers (Stremler et al., 2013; Volkovich et al., 2018). However, the current research did not document associations between infant sleep location and actigraphy measured sleep; thus, cosleeping mothers may experience brief awakenings that are not captured by actigraphy.

Interestingly, no associations were found between mothers' subjective, nor objective, sleep variables and infant feeding method. Mixed findings are reported in the extant literature, with some studies similarly indicating no differences in maternal sleep between breastfeeding and non-breastfeeding women (Montgomery-Downs et al., 2010) and other studies documenting decreased sleep quality (Richter et al., 2019), increased sleep fragmentation (Gay et al., 2004), and increased nocturnal sleep duration (measured by sleep diary and actigraphy; Doan et al. 2007; Doan et al., 2014) among breastfeeding mothers. It is important to note that the latter set of studies reported associations between maternal sleep and breastfeeding at 1 to 3 months postpartum. Taken together with the current set of findings, it is thus possible that the link between maternal sleep and infant feeding method becomes less salient by 6 months postpartum and as infant sleep becomes more consolidated.

Additionally, mothers' with more than one child (i.e., number of children) reported shorter subjective nocturnal sleep duration and shorter longest consecutive sleep duration.

Previous studies have revealed no differences in subjective postpartum sleep between first-time and experienced parents (Christian et al., 2019), while other studies have documented poorer sleep among first-time parents (Dørheim et al., 2009a; Richter et al., 2019).

Lastly, Study 1 revealed that mothers on maternity leave (i.e., employment status) reported more night awakenings than actively working mothers. While working mothers have previously demonstrated shorter sleep duration (measured by actigraphy) compared to unemployed mothers (Spaeth et al., 2021), the increased night awakenings documented in the present sample were likely due to most mothers being on maternity leave and being designated the primary nocturnal caregiver. This is further supported by our finding that increased maternal, and not paternal, sleep duration and less sleep fragmentation (as measured by the sleep diary) were associated with more consolidated infant sleep.

Study 1 made meaningful contributions to the literature as it is the first study, to our knowledge, to investigate intraindividual night-to-night sleep variability in both mothers and fathers across 10 consecutive nights and to document parental sleep patterns at 6 months postpartum while considering important contextual family factors including infant sleep variables.

Sleep and postpartum depressive symptoms in fathers

Study 2 expanded on Study 1 by using a multi-measure approach consisting of both subjective and objective sleep indices to enrich our understanding of the link between fathers' postpartum sleep and depressive symptoms, as most research in this area has exclusively focused on mothers. In line with Buysse's (2014) model of sleep health, Study 2 examined depressive symptomatology in relation to various dimensions of fathers' sleep including sleep quality, sleep duration, and sleep efficiency. In line with the rich set of findings yielded from Study 1 regarding

parental sleep and familial factors, Study 2 also examined the associations between paternal sleep, depressive symptoms, and individual and family factors in the postpartum period.

Findings from Study 2 revealed number of children as the only family factor which correlated with depressive symptoms, with first-time fathers reporting higher depressive symptoms compared to experienced fathers, and congruently, having fewer children was associated with more depressive symptoms. After controlling for number of children, fathers' perceptions of sleep quality were found to be associated with depressive symptom severity. Specifically, results from Study 2 revealed that poorer perceived sleep quality was linked to more severe depressive symptoms at 6 months postpartum. However, paternal depression was not significantly associated with sleep diary and actigraphy variables (total nocturnal sleep time, number of night awakenings, nocturnal sleep efficiency, and WASO).

As such, perceived sleep quality was the only sleep variable associated with fathers' depressive symptomatology; this link may be explained by a shared mechanism between measures of perceived sleep quality and depressive symptoms, as each required participants to reflect and report on their thoughts and feelings. In contrast, the subjective sleep diary and objective measures examined numeric components of sleep, with the former requiring fathers to assess and estimate quantitative facets of their sleep and the latter capturing fathers' motor activity via actigraphy. These findings are consistent with literature demonstrating a lack of association between actigraphy measured sleep and postpartum depression in mothers (Bei et al., 2010; Dørheim et al., 2009b).

While the present set of findings may be taken as evidence that poorer perceived sleep quality is related to experiencing more severe depressive symptoms at 6 months postpartum, it is also plausible that depressive symptomatology contributes to distorted perceptions surrounding

sleep quality (Takano et al., 2016). It is well established that cognitive distortions are a primary feature of depression. Therefore, fathers with more depressive symptomatology may have been more prone to holding negative biases regarding the quality of their sleep. Nonetheless, Study 2 deepened our understanding about correlates of postpartum depressive symptoms amongst fathers, uniquely revealing that fathers' perceptions of their sleep quality, and not the actual quality or quantity of their sleep (measured by the sleep-diary and actigraphy), is more central to fathers' psychological well-being in the months following the birth of their infant.

Common Themes Across Study 1 and Study 2

The importance of multi-measure designs and perceptions of sleep

The present set of studies each utilized a multi-measure approach, consisting of subjective and objective measures, to examine parents' postpartum sleep. The results across both studies underscored the value of using this multi-measure approach, as for certain variables, different findings were yielded according to whether they were examined subjectively or objectively. In Study 1, mothers were found to have significantly longer nocturnal sleep durations than fathers when measured objectively; however, when measured subjectively, no differences were observed. These findings (including the values reported in Table 2 of Study 1) suggest that fathers may overestimate the amount of sleep they actually achieve at night, and that their perceptions about the length of their night-time sleep may be less accurate than that of mothers. A recent study by Goelema and colleagues (2019) found that in a sample of healthy middle-aged adults, females were more likely than males to notice awakenings during the night. As such, mothers may be more sensitive to disruptions in their sleep and may thus be more aware of the total amount of sleep they obtained throughout the night.

The importance of parents' perceptions of sleep was further underscored by the results of Study 2, as fathers' perceptions of sleep quality was the only sleep variable (objective or subjective) to be associated with depressive symptoms whereby poorer perceived sleep quality was associated with more depressive symptomatology. Although prior studies have not necessarily differentiated perceived sleep quality from other subjective indices of sleep, findings from Study 2 are consistent with the limited extant literature indicating associations between fathers' self-reported sleep quality and depressive symptoms (Da Costa et al., 2019). Prior research supports the implementation of multi-measure designs by revealing consistent differences between subjectively and objectively measured sleep duration (Goelema et al., 2019; Lauderdale et al., 2008). Collectively, the present studies highlight the utility of including both types of measures when assessing parents' postpartum sleep, in addition to examining several facets of sleep itself (e.g., nocturnal sleep duration, sleep quality).

The importance of number of children

Parallel findings were also yielded across Studies 1 and 2 regarding a key family factor – number of children. Study 1 revealed that mothers with more than one child had more impaired sleep (i.e., shorter subjective nocturnal sleep duration, shorter longest consecutive sleep duration, and lower percentage of nights sleeping 6 hours consecutively). Study 2 indicated that first-time fathers were more likely to experience more depressive symptoms compared to experienced fathers, and congruently, fewer children were associated with more depressive symptoms. These findings suggest that having more children may place mothers at-risk of impaired sleep, whereas having more children may be a protective factor in terms of fathers' depressive symptoms.

Recent research has indicated that mothers tend to spend more time engaged in caretaking behaviours (often due to a longer parental leave than fathers; Lévesque et al., 2020),

and relatedly, fathers tend to feel less competent in their parenting abilities (Ketner et al., 2019). Therefore, in mothers, having more children is likely to impair sleep by adding more caretaking demands throughout the day and night. In contrast, fathers with more children may be less susceptible to depressive symptoms, as having more parenting experience is likely to improve fathers' sense of competence, positively extending to their overall mood. Indeed, first-time fathers are even more likely to experience changes that are more pronounced and novel, requiring a greater level of adjustment and rendering them more susceptible to low mood than experienced fathers.

Taken together, it appears that the association between number of children and parental well-being varies according to parent (mother or father) and parental functioning (sleep or mood). A recent study by Hong and Liu (2019) further underscored the significance number of children has on parents' well-being; though mothers and fathers were not compared, findings revealed that two-child families reported more parenting stress, less social support, and lower parenting self-efficacy than one-child families. While additional research exploring the interaction of these factors is needed, especially in clinical samples, the present studies unveil number of children as a family factor that importantly contributes to parents' health and well-being.

The importance of dynamic factors and processes

Studies 1 and 2 complement our theoretical understanding of sleep as a multidimensional (Buysse, 2014) and dynamic family process (Sadeh & Anders, 1993) rather than a static individual characteristic (Goodlin-Jones et al., 2000). In both studies, the dynamic nature of sleep processes within the family system was addressed by exploring associations between parental sleep and several family factors (e.g., age, number of children, employment status,

infant sleep location, etc.). For example, and as discussed above, Study 1 revealed that mothers engaging in cosleeping with their infants reported shorter consecutive sleep duration and more nocturnal awakenings. Such factors provided meaningful context which expanded our understanding of how familial dynamics contribute to parental sleep changes during the postpartum period.

Additionally, dynamic sleep processes were captured in Study 1 by examining sleep patterns and variability in both mothers and fathers across 10 consecutive nights at 6 months postpartum. To date, most research has focused on characterizing sleep patterns according to individual means. However, intraindividual variability, which captures daily variation around the mean (and is thus a dynamic, rather than static, measure of sleep), is rarely examined, despite the fact that daily variations in sleep patterns are natural and common in humans of all ages (Bei et al., 2016). Congruent with the limited previous research demonstrating night-to-night variability amongst infants (Pennestri et al., 2020; Sadeh et al., 1995), findings from Study 1 revealed night-to-night variability amongst both parents and high variability regarding their sleep fragmentation (subjective and objective). Taken together, findings inform us about the set of co-occurring sleep-related changes mothers, fathers, and infants jointly experience at 6 months postpartum, expanding our knowledge about how sleep unfolds within the family system.

Practical Implications

The current research has meaningful implications for the development and application of clinical interventions. Findings inform parenting interventions aimed at easing the transition that follows the birth of an infant and helping mothers and fathers navigate the sleep-related challenges that tend to accompany this sensitive period. When working with first-time and experienced parents, health care professionals ought to normalize high variability in sleep at 6

months postpartum, a period when many parents expect to experience more stable sleep due to misconceptions that infants achieve consolidated sleep by this time. Correspondingly, health care professionals may disseminate this research to enable parents to develop more realistic expectations, and reduce feelings of hopelessness, about various facets of their sleep at 6 months postpartum. Parenting interventions aimed at helping mothers and fathers foster greater awareness and more realistic expectations about postpartum sleep patterns would improve parents' ability to prepare and cope with the transition process involved in welcoming a new child to their family system.

While interventions such as these would be beneficial for all parents, findings from the present research indicate that clinical interventions would be especially advantageous for experienced mothers, who appear to be more susceptible to impaired sleep in the postpartum period, as well as first-time fathers, who appear to be more at-risk of experiencing postpartum depressive symptoms (as compared to experienced fathers). In line with cognitive-behavioural treatment approaches for insomnia and depression (Saxbe et al., 2016), clinicians ought to target parents' distorted cognitions and expectations related to sleep. Specifically, perceptions pertaining to sleep quality represent important targets for the treatment of insomnia and postpartum depression. Interventions aimed at fostering parents' ability to effectively manage stressors and regulate emotions that contribute to and/or result from impaired sleep would also be particularly useful during the pregnancy and postpartum period (Ketner et al., 2019). Support for the efficacy of cognitive-behavioural interventions is provided by findings demonstrating associations between lower sleep disturbances during pregnancy and improved sleep at 24 months postpartum in mothers who received cognitive-behavioural sleep intervention in their third trimester (Bei et al., 2021).

It is important to note that not all mothers and fathers develop depressive symptoms, even in the presence of sleep disturbances. Such findings suggest the presence of protective factors which may mitigate the experience of mental health difficulties in relation to impaired sleep in some parents. For example, research demonstrates that positive relationship satisfaction, partner support, and social support provide protective effects, decreasing perinatal symptoms of depression in parents (Beck, 2001; Milgrom et al., 2008; Ngai & Ngu, 2015; Roomruangwong & Epperson, 2011; Røsand et al., 2012). Additionally, a supportive partner relationship during pregnancy has been linked to improved maternal and infant well-being in the postpartum period (Stapleton et al., 2012). It is thus reasonable to propose that these factors may also serve as a buffer for sleep disturbed parents from experiencing depressive symptomatology and may represent additional targets for clinical interventions (Hall et al., 2017; Meltzer & Mindell, 2007; Miller et al., 2006).

The present research has important implications regarding our understanding about factors (e.g., sleep disturbances) that may impede on parents' ability to navigate stressors and challenges known to occur within the postpartum period (e.g., increased demands on resources and finances, reduced time for leisurely activities and couple intimacy, and role overload; Alexander et al., 2001; Perry-Jenkins et al., 2007) and which influence the functioning of the family system as a whole. Given that *both* mothers and fathers experience sleep-related changes in the postpartum period, interventions rooted in couple therapy may prove useful in helping parents develop strategies to jointly cope with sleep disturbances and more broadly, the transitional period following the birth of a newborn. Couples may benefit from relationship counseling programs aimed at both reducing relationship distress and enhancing partner support before and/or during pregnancy to promote healthier familial functioning (Stapleton et al., 2012).

Limitations, Future Directions, and Research Strengths

Though the current research offered meaningful practical implications and several unique contributions to the literature, it was not without limitations. Firstly, the generalizability of the present findings was limited given that both studies derived from a modest sample size of healthy parents/heterosexual couples (married or common law union) who were mostly white and educated, with most fathers working full-time and mothers on maternity leave. Future studies ought to enhance generalizability by investigating postpartum sleep patterns with more varied samples, including families from diverse minority groups, levels of education, and socioeconomic status. Indeed, future research should include more varied family structures such as lesbian, gay, bisexual, transgender, queer, and other (LGBTQ+) parents. Though there have been some studies which have investigated postpartum depression in lesbian mothers (Alang & Fomotar, 2015; Khajehei et al., 2012; Maccio & Pangburn, 2012) and gay fathers (Shenkman et al., 2022), and at least one study which has examined associations between decreased sleep, increased depressive symptoms, and parental stress in same-sex couples with adopted school-age children (Goldberg et al., 2019), much remains unknown about how the sleep patterns of LGBTQ+ parents unfold following the birth of their newborn infant and how changes in sleep may be linked to depressive symptoms in the postpartum period.

Research is also needed on at-risk samples who may be prone to experiencing more severe and pervasive sleep-related difficulties and depressive symptoms. For example, parents with a previous history of insomnia, childhood adversity, or other mental health difficulties (Servot et al., 2021), as the current sample included parents with no self-reported past or current diagnosed mental health conditions or sleep difficulties. Relatedly, cross-cultural comparisons are scant within the literature; these are needed to expand our universal knowledge of postpartum

sleep, especially in light of differences regarding cosleeping and bed-sharing practices across cultures and which are likely to influence family sleep functioning.

An additional limitation of the current research is represented by the cross-sectional research designs implemented in both Studies 1 and 2, hindering our ability to draw conclusions about parental sleep patterns and variability, as well as the link between postpartum sleep and depressive symptoms, preceding and following 6 months postpartum. Consequently, the development of postpartum sleep patterns, and how parental sleep may coincide with the progression of depressive symptoms over time, could not be assessed, nor causality amongst such factors. Contamination between mothers' and fathers' data represents another limitation specific to Study 1. While paired sample *t*-tests were used to reduce contamination, future studies ought to conduct statistical analyses especially designed for dyadic data (e.g., Actor-Partner Independence Model, cross lagged models) which would further reduce data contamination. Such analyses would require larger sample sizes than the present research and would allow for a more direct and complete examination of dynamic sleep processes within the family system.

Although the present studies examined sleep across 10 and 14 consecutive nights, longitudinal research designs which span across multiple time points are required to provide a more complete overview of family sleep processes and more insight into how the association between postpartum sleep and depression unfolds over time. Moreover, longitudinal investigations would help researchers identify sensitive periods for parents regarding impaired sleep and risk of developing postpartum depression. Relatedly, such investigations are critical as they would permit researchers to investigate bidirectional associations between mothers' and fathers' sleep (and mood) over time.

To continue expanding our knowledge of postpartum sleep and the implications it has for parents' mental health and well-being, future research should build on the strengths of the present research. A noteworthy strength of Study 1 is represented by the inclusion of both mothers and fathers, which allowed for direct comparisons to be made between parents within the same couple unit. The need to include both mothers and fathers in this area of research is further underscored by previous research indicating the co-occurrence of parents' sleep difficulties and depressive symptomatology (Saxbe et al., 2016). The specific focus on fathers in Study 2 represents an additional strength given that fathers are an understudied population in the postpartum sleep and mood literature, and in developmental research altogether. Continuing to include fathers in research examining sleep and postnatal mental health is imperative as fathers, and not just mothers, are primary caregivers to their infants. Although research to date has focused solely on first-time parents, the present research additionally included experienced parents, enabling us to identify number of children as a meaningful family factor implicated in postpartum sleep processes.

Moreover, the multi-measure approach utilized across Studies 1 and 2 reflects a major strength of the present research. Employing subjective and objective sleep indices allowed meaningful conclusions to be drawn about various facets of sleep and revealed areas of incongruence regarding these two methods of measurement. As noted above, the present studies were not necessarily longitudinal in nature given that parental sleep was assessed solely at 6 months postpartum. However, the current research extensively examined parents' sleep across 10 consecutive nights (Study 1) and spanning across a 2-week period (Study 2) at 6 months postpartum (Studies 1 and 2), methodology far exceeding the common practice in the extant literature, whereby sleep is typically assessed across just a few nights and at earlier postpartum

periods. Thus, the present research provided a more exhaustive and comprehensive understanding of parental sleep variability and meaningfully contributed to the existing literature.

Conclusion

Sleep is a vital family process, integral to parents' physical and psychological well-being. The findings presented in the current dissertation greatly contributed to our knowledge about how sleep unfolds within the family system at 6 months postpartum, an understudied yet sensitive period during which parental sleep is susceptible to disturbances and high variability. The present dissertation additionally advanced the postpartum sleep literature by examining multiple facets of sleep, underscoring the importance of distinguishing between various subjective and objective components of sleep. Indeed, the current research revealed that across 10 consecutive nights at 6 months postpartum, both mothers and fathers experience intraindividual variability in their subjective and objective, with mothers experiencing more fragmented sleep (subjective and objective) and fathers experiencing shorter nocturnal sleep duration (objective). Among other meaningful findings, the current research also revealed the important role fathers' perceptions of their sleep quality, and not the actual quality or quantity of their sleep, has regarding depressive symptomatology at 6 months postpartum. Collectively, the findings offer important directions for clinical interventions aimed at fostering improved sleep and mood among first-time and experienced parents.

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Appendix A

Consent Form for Study 1 and 2

INFORMATION AND CONSENT FORM

Project Title: Infant sleep, parental sleep, parental expectations and perceptions and the parent-child relationship

Research Project Leaders:

Principal researcher and responsible for the project	**Marie-Hélène Pennestri, Ph.D., psychologist** Professeure-chercheure, Department of Educational and Counseling Psychology, McGill University; Regular Researcher, CIUSSS du Nord-de-l'Île-de-Montréal, Site Hôpital en santé mentale Rivière-des-Prairies 514-323-7260, extension 2166 marie-helene.pennestri@mcgill.ca
Co-researcher	**Marie-Julie Béliveau, Ph.D., psychologist** Professor-Researcher, Department of Psychology, University of Montreal; Associate researcher, CIUSSS du Nord-de-l'Île-de-Montréal, Site Hôpital en santé mentale Rivière-des-Prairies
Co-researcher	**Karine Dubois-Comtois, Ph.D., psychologist** **Professor-researcher, Department of Psychology, University of Quebec at Trois-Rivières;** Regular Researcher, CIUSSS du Nord-de-l'Île-de-Montréal, Site Hôpital du Sacré-Cœur de Montréal
Project coordinator	**Marjolaine Chicoine, M.Sc.** Research Coordinator CIUSSS du Nord-de-l'Île-de-Montréal, Site Hôpital en santé mentale Rivière-des-Prairies 514-323-7260, extension 2717 marjolaine.chicoine.cnmtl@ssss.gouv.qc.ca
Research assistant	**Gabrielle Chénier-Leduc, Ph. D. candidate** in Clinical Psychology R / I, Department of Psychology, University of Montreal; CIUSSS du Nord-de-l'Île-de-Montréal, Site Hôpital en santé mentale Rivière-des-Prairies 514-323-7260, extension 4548 etude.sommeil.bebe@gmail.com **Christine Laganière, Master student** Counseling Psychology, Department of Psychopedagogy and Counseling Psychology, McGill University.514-323-7260, extension 4548 etude.sommeil.bebe@gmail.com

Granting Agencies: Social Sciences and Humanities Research Council of Canada (SSHRC), Knowledge Development Grants; Fonds de recherche du Québec – Santé (FRQS); Brouse Yvon-Gauthier (AQSMN).

Preamble

Hello,

You, your life partner and your child are invited to participate in a research project. It is important to read and understand this information and consent form. This letter may contain words or phrases that you do not understand or have questions about. If so, do not hesitate to let us know. Take all the time you need to decide.

Description of the project

The newborn's sleep is fragmented into a series of short periods without differentiation between day and night. Thus, most infants wake up every 3 to 4 hours during the first few months of life, which also leads to changes in parental sleep. As the baby gets older, she/he gradually consolidates his nocturnal sleep, a phenomenon commonly known as "sleeping through the nights". Many factors influence the infant's ability to sleep. There are large differences between infants and there are also night-to-night fluctuations in the same infant. Sleeping is therefore a complex developmental task that is accompanied by several changes in the life of the parents, including their sleep, their mood and their relationship with their infant. In addition, there is a lot of conflicting information about infant sleep, so that parents can have a variety of expectations, different types of perceptions, and use of different sleep-related practices.

The main goal of this project is to study the associations between infant sleep, sleep, expectations, perceptions and mood of parents, and interactions between the mother/partner and infant and the father/partner and infant. Since changes are also occurring in the partner's life, this project will compare sleep, expectations, perceptions and behaviors of mothers and fathers, or partners. We hope this project can help us better understand the normal development of infant sleep in his family, in a population in general good health.

Project procedures

Your participation, in this project involves two stages, one when your child is 6 months old and another when your child is 12 months old.

First (1st) meeting at 6 months

By agreeing to participate in our research project, a research assistant will visit you at your home when your child is 6 months old. She will explain you again and will have you sign this document (**consent form**) and give you **questionnaires to be completed** by the parents.

Then, the research assistant will explain how to complete the **sleep diaries**[1] and the operation of the **actigraphy**[2]. We will ask you to fill out the sleep agenda for the mother, father, or the life partner, and the child. We will also evaluate the sleep of the mother, father (or the life partner) and the child using actigraphs.

[1]***The sleep diary*** *is a 1-week schedule in which the participant is asked to enter their bedtime and wake times, as well as their naps, or to indicate when they are awake during the night. You can plan about 5 minutes every day to fill the agenda.*

[2]***The actigraph*** *is a device that looks like a watch and is worn on the wrist of the non-dominant hand (eg left wrist if you are right handed) for adults and ankle in infants. It measures exposure to light and records movement (activity level). We ask you to remove it before entering the water (pool, shower, etc.), but do not forget to put it back! We ask you to wear it for 1 week. Please press the left button for 3 seconds when you consider that the night begins and ends. The research assistant will explain how. No further action is necessary.*

Do not worry, the research assistant will answer all your questions about the sleep agenda and the actigraph.

During this same visit you and your partner will participate in some activities, some common with your child and other individuals. We will ask you both to play with your child, as you usually would (free play period) and we will also ask you to tell stories, from pictures that the research assistant will present to you. These activities will be filmed so that we can analyze them later.

We estimate that this meeting will last from 60 to 90 minutes depending on your questions.

Second (2nd) meeting, one weeks after the first meeting

One week later, a research assistant will visit you again at your home to retrieve the questionnaires, the sleep diary and the actigraphs.

Third (3rd) meeting at 12 months

An additional meeting will be held at the Hôpital en santé mentale Rivière-des-Prairies Research Center or in a laboratory at the Université de Montréal when your child is 12 months old.

You and your partner will participate in two activities with your child. The first will be a free play period and the second will involve some separations and meetings with your child.

These activities will be filmed so that we can analyze them later. Finally, we will ask you and your partner to complete some questionnaires about your perceptions and expectations about your child's sleep, your emotional state, your child's temperament, your family experiences, and your socio-demographic status. The research assistant will then give you the actigraphs and the sleep agendas for another 2 weeks. We estimate that a period of 90 minutes is sufficient to complete this visit.

Benefits of participating in the project

There is no direct personal benefit to participating in this project. However, completing questionnaires about your family's sleeping habits and your emotional state may make you aware of these issues during the first few months of pregnancy. Finally, it will be a rewarding personal experience and your participation will help advance knowledge about sleep and mother/father-child interactions in the first months of life.

Risks and inconvenience

There is no direct personal risk that may arise from your participation in this research project. However, as the project involves answering questionnaires and participating in 2 meetings, this can lead to some inconveniences related to time or travel. Know that we will do our best to mitigate these disadvantages. It is sometimes possible to feel some discomfort by answering some of the questions in the questionnaires. When it occurs, this discomfort is usually short-lived. Do not hesitate to speak with a member of the research team as needed.

Provision of confidentiality

All information collected will be treated confidentially within the limits of the law. A code number will be used to link your child's name, your name and your life partner's name to your research file and only the research team will have the corresponding list. The information will be kept in a locked binder in the principal investigator's office. No identifying information will be published. All information will be destroyed 10 years after the end of the research project. For research monitoring or control purposes, researchers may be required to provide access to your research file to the Research Ethics Board of the Integrated Center for University Health and Social Services (CIUSSS) Nord-de-l'Île-de-Montréal and the research funding agencies. All adhere to a policy of strict confidentiality. You and your life partner can, at any time, ask the researcher to consult your personal research file to verify the information you have given and have it corrected as needed, as long as the researcher responsible for the project or the

researcher establishment hold this information. However, in order to preserve the scientific integrity of the project, you may only have access to some of this information once your participation in the research is complete.

Secondary use of data

With your permission, all information you provide for this research project, as well as video recordings, may be used, prior to the scheduled date of destruction, for a few research projects (approximately five) which will cover the different facets of the theme for which you are approached today. These potential projects will be under the responsibility of the Principal Investigator and will be authorized by the Research Ethics Committee of the the CIUSSS du Nord-de-l'Île-de-Montréal. The research team is committed to maintaining and protecting the confidentiality of your data under the same conditions as for this project.

Dissemination of research results

The results of the project will be disseminated as general data for all participants. This means that you will not be able to get your individual results. If you would like a written summary of the general search results, please provide an email address where we can send it to you. Please note that there may be some time between the time of your participation and the time when these results will be available: _____.

Unforeseen discoveries

If answers to certain questionnaires lead to serious concerns about your well-being or your health or the well-being or health of your partner or child, a member of our team will contact you to discuss your situation and indicate any resources to support you. In part of this study, you will complete questionnaires measuring psychological distress and anxiety. If your score is high on one of these questionnaires, we will let you know. One of the researchers responsible for the study will contact you as soon as possible to discuss your situation and we will send you information on available resources.

Financial compensation for participation in research

At the end of your third (3rd) meeting, you will receive $ 45 in compensation for the constraints of your participation in this research project. If you withdraw or if you are withdrawn from the project before it is completed, you will receive an amount proportional to your participation. Here is the breakdown of the $ 45 compensation: $ 20 at the end of the second

(2nd) visit (during the recovery of the material) and $ 25 for the third (3rd) visit, for a total of $ 45.

Liability in case of injury

By signing this information and consent form, you do not waive any of your rights or release the researchers, the institution and the granting agency from their civil and professional responsibilities.

Freedom of participation and right of withdrawal

Your participation in this study is completely voluntary. You are therefore free to accept or refuse to participate without causing you any harm. In addition, even if you first agree to participate, you can then withdraw your participation in the research project at any time by simple verbal notice, without explanation and without causing you any harm. On your request only, the information you have already provided will be destroyed. Any new knowledge acquired during the course of the study that could affect your decision to participate will be communicated to you as soon as possible. It is understood that you may, following this new information that would be communicated to you, withdraw your participation in the research project on simple verbal notice or by email, without explanation and without causing you any harm.

If you decide to withdraw from the research project before it is completed, we will ask you to share the reason for this withdrawal. Although your response is voluntary and optional, the reasons for the withdrawal of participants allow the research team to improve ongoing or future projects.

Resource persons

If you would like more information on this research project or would like to inform us of your withdrawal, please contact the Principal Investigator, Marie-Hélène Pennestri, at (514) 323-7260, ext. 2166 or the Research Coordinator, Marjolaine Chicoine, at (514) 323-7260, extension 2717.

If you have any complaints, comments, or questions about your rights as a research participant, you may contact the CIUSSS Complaints and Service Quality Commission of the CIUSSS du Nord-de-l'Île-de-Montréal, Site Hôpital en santé mentale Rivière-des-Prairies, at 514 338-2222 ext. 2259.

Consent of the participants

I have read and understood the contents of this form for the project in which I will participate and which also requires the participation of my child and my partner. I certify that it has been explained to me verbally. I had the opportunity to ask all my questions and it was answered to my satisfaction. I know that my child, my partner and I are free to participate in the project and we remain free to withdraw at any time, by verbal notice. I certify that I have been given the time to make my decision. I understand that I will receive a signed copy of this form. I consent to my child taking part in this project.

_____

Name of the minor participant

_____

Name of major participant and apt (mother/father) Signature Date

_____

Name of major participant and apt (partner) Signature Date

Secondary use of data

I agree that the information I provided as well as the recorded data will be used in future research projects aimed at deepening knowledge of sleep and attachment.

- ☐ Yes
- ☐ No

_____

Name of major participant and apt (mother/father) Signature Date

- ☐ Yes
- ☐ No

_____

Name of major participant and apt (partner) Signature Date

I accept that the research team will contact me again to invite me to participate in other research projects dealing with the same theme.

☐ Yes

☐ No

_____

Name of major and apt (mother/father) Signature Date

☐ Yes

☐ No

_____

Name of major participant and apt (partner)Signature Date

Signature of the person who obtained the consent

I explained the terms of this information and consent form about research and I answered the questions they asked me.

_____	_____	_____
Name of the person designated to explain the research program and obtain consent	Function in the research program	Signature and date

Commitment of the Principal Investigator

I certify that I have explained to the signatories the terms of this consent form, answered the questions they asked me in this regard, made it clear to me that they remain at any time free to terminate their participation and that I will give them a signed and dated copy of this consent form.

_____	_____	_____
Name of the main researcher	Signature	Date

Administrative information

This information and consent form will be kept in a locked binder in the principal investigator's office, located at the Hôpital en santé mentale Rivière-des-Prairies of the CIUSSS

du Nord-de-l'Île-de-Montréal. A signed copy will be given to the participant. The Research Ethics Board has reviewed and approved this project and is monitoring it.

Appendix B

Demographic Questionnaire

A) CURRENT FAMILY COMPOSITION

Indicate the date of birth and age of your child:

_____ _____
Date of birth (month/day/year) Age

Indicate the sex of your child : ☐ Male ☐ Female

Your child is currently living (choose one answer):

☐ With both parents (opposite-sex or same-sex parents)
☐ With his/her mother
☐ With his/her father
☐ In shared-custody
☐ Other (specify):
_____

Indicate the date of birth and the age of both the mother and her life-partner. Individuals living in the same household as the child and contributing to his/her education are considered.

Mother
Date of birth _____
(month/day/year)
Age _____

Life-partner (if applicable)
Date of birth _____
(month/day/year)
Age _____

What is the mother's current marital status (choose one answer)?

☐ Married or in a common-law union with the other parent of the child
☐ Married or in a common-law union with a new spouse (other than the father of the child)
☐ Divorced, separated, widowed, or single (living alone)
☐ Other (specify):
_____

Indicate the name, sex and age of the other **children** currently living in the family home

First name	**Sex** F = female M = male	**Age**	**Ethnic origin** (Caucasian, Hispanic, Asian, etc.)	**Relation to child** (biological child, adopted or placed child, etc.)	If the **child was adopted or placed**, how long has he/she been living with you (month/year)?

B) LEVEL OF EDUCATION, EMPLOYMENT OR OCCUPATION

Circle the highest level of education that you have completed:

Years completed (or equivalence):

Mother
- ☐ Elementary school 1 2 3 4 5 6
- ☐ High school 1 2 3 4 5
- ☐ Collegial 1 2 3
- ☐ University 1 2 3 4 and more

Life-partner
- ☐ Elementary school 1 2 3 4 5 6
- ☐ High school 1 2 3 4 5
- ☐ Collegial 1 2 3
- ☐ University 1 2 3 4 and more

Last obtained diploma:

Mother
- ☐ General education
- ☐ DVS (vocational studies)
- ☐ DEC (collegial studies)
- ☐ Other : _____

Life-partner
- ☐ General education
- ☐ DVS (vocational studies)
- ☐ DEC (collegial studies)
- ☐ Other : _____

Which of these options applies best to your situation?

	Mother	**Life-partner**
• Paid full-time employment	☐	☐
• Paid part-time employment	☐	☐
• Student	☐	☐
• Student while working a paid employment	☐	☐
• Staying at home (by choice, retired, etc.)	☐	☐
• Staying at home due to illness (ex. CSST)	☐	☐
• Staying at home due to maternity/paternity leave	☐	☐
If this applies to you, when do you plan to return to work: _____		
How old will your child be when you return to work?_____		
• Currently looking for a job	☐	☐
• Other (specify):		
Mother: _____		
Life-partner: _____		

If you have already returned to work, how old was your infant when you returned? _____

How many bedrooms do you have in your current home? _____

Are you an owner or a tenant? _____

What is the total family income before tax:

☐ Less than 20 000$

☐ 20 001$ – 35 000$

☐ 35 001$ - 50 000$

☐ 50 001$ - 75 000$

☐ 75 001 – 100 000$

☐ 100 001$ - 125 000$

☐ 125 001$ - 150 000$

☐ More than 150 000$

C) FAMILY BACKGROUND

Do any of your family members (immediate or extended) suffer or have suffered from:

	NAME OF THE CONDITION	RELATIONSHIP TO THE CHILD
Medical conditions (physical illness, operation, epilepsy, etc.)	_____	_____
Mental health difficulties (anxiety, depression, bipolar disorder, personality disorders, etc.)	_____	_____
Alcoholism or drug abuse	_____	_____
Developmental/language delays	_____	_____
Intellectual disability	_____	_____
Learning difficulties	_____	_____
Other	_____	_____

D) LIFE EVENTS

Are there any family difficulties or important events that could have influenced your child's development : ☐ Yes ☐ No

If so, specify:

_____

_____

Since the birth of your child, did a family member encounter one of the following events?

- Sickness : ☐ Yes ☐ No

  If so, specify:

_____

- Hospitalization : ☐ Yes ☐ No

  If so, specify:

  _____

- Prolonged absence : ☐ Yes ☐ No

  If so, specify:

  _____

- Loss of a loved one: ☐ Yes ☐ No

  If so, specify:

  _____

- Family move: ☐ Yes ☐ No

  If so, specify:

  _____

- Other stressful life events (ex.: car accident, fire, financial problems, etc.):

  ☐ Yes ☐ No

  If so, specify:

  _____

Was your child a witness or a victim of:

- Violence : ☐ Yes ☐ No

  If so, specify:

  _____

- Abuse : ☐ Yes ☐ No

  If so, specify:

  _____

- Negligence : ☐ Yes ☐ No

If so, specify:

_____

E) BACKGROUND

In the past, has your child consulted one of the following professionals (check all options that apply)

☐ Child psychiatrist ☐ Psycho-educator ☐ Occupational therapist

☐ Psychologist ☐ Resource teacher ☐ Medical specialist

☐ Social worker ☐ Speech therapist ☐ General practitioner

☐ Other professional (specify):

_____

Has your child been hospitalized : ☐ Yes ☐ No
If so, specify: _____

Does your child take medication on a regular basis to regulate?

- His/her behaviour or his/her mood: ☐ Yes ☐ No

  If so, specify:

  _____

- Respiratory problems: ☐ Yes ☐ No

  If so, specify:

  _____

- Any other physical health problem: ☐ Yes ☐ No

  If so, specify:

  _____

Has your child been diagnosed by a child psychiatrist or any another professional?

☐ Yes ☐ No

If so, specify: _____

Appendix C

Sleep Diary

	Date	Who?	24 h	1 h	2 h	3 h	4 h	5 h	6 h	7 h	8 h	9 h	10 h	11 h	12 h	13 h	14 h	15 h	16 h	17 h	18 h	19 h	20 h	21 h	22 h	23 h	Sleep quality (Use a 1-10 scale, 1=poor, 10=excellent)	Particular event (you may use the back of the sheet)
Day 1		Mother																										
		Partner																										
		Infant																										
Day 2		Mother																										
		Partner																										
		Infant																										
Day 3		Mother																										
		Partner																										
		Infant																										
Day 4		Mother																										
		Partner																										
		Infant																										
Day 5		Mother																										
		Partner																										
		Infant																										

…Bedtime …Risetime …Darken the box to indicate sleep

A …Nursing **C** …In bed

B …Bottle **D** …Up (not in bed)

Please remember for the watch: (1) Remove when going into water (bath, pool, etc.) (2) Press during 3 seconds on the left button when going to sleep.

Appendix D

Center for Epidemiologic Studies – Depression Scale (CES-D)

Center for Epidemiologic Studies Depression Scale (CES-D), NIMH

Below is a list of the ways you might have felt or behaved. Please tell me how often you have felt this way during the past week.

	During the Past Week			
	Rarely or none of the time (less than 1 day)	Some or a little of the time (1-2 days)	Occasionally or a moderate amount of time (3-4 days)	Most or all of the time (5-7 days)
1. I was bothered by things that usually don't bother me.	☐	☐	☐	☐
2. I did not feel like eating; my appetite was poor.	☐	☐	☐	☐
3. I felt that I could not shake off the blues even with help from my family or friends.	☐	☐	☐	☐
4. I felt I was just as good as other people.	☐	☐	☐	☐
5. I had trouble keeping my mind on what I was doing.	☐	☐	☐	☐
6. I felt depressed.	☐	☐	☐	☐
7. I felt that everything I did was an effort.	☐	☐	☐	☐
8. I felt hopeful about the future.	☐	☐	☐	☐
9. I thought my life had been a failure.	☐	☐	☐	☐
10. I felt fearful.	☐	☐	☐	☐
11. My sleep was restless.	☐	☐	☐	☐
12. I was happy.	☐	☐	☐	☐
13. I talked less than usual.	☐	☐	☐	☐
14. I felt lonely.	☐	☐	☐	☐
15. People were unfriendly.	☐	☐	☐	☐
16. I enjoyed life.	☐	☐	☐	☐
17. I had crying spells.	☐	☐	☐	☐
18. I felt sad.	☐	☐	☐	☐
19. I felt that people dislike me.	☐	☐	☐	☐
20. I could not get "going."	☐	☐	☐	☐

SCORING: zero for answers in the first column, 1 for answers in the second column, 2 for answers in the third column, 3 for answers in the fourth column. The scoring of positive items is reversed. Possible range of scores is zero to 60, with the higher scores indicating the presence of more symptomatology.

Appendix E

McGill University Research Ethics Board Office

This form must be completed to request **ethics renewal approval** or to **close a study**. A current ethics approval is required for ongoing research. To avoid expired approvals and, in the case of funded projects, the suspension of funds, this form should be returned 1-2 weeks before the current approval expires. **No research activities including recruitment and data collection may take place after ethics approval has expired.**

REB File #: 385-0117 Principal Investigator: Marie-Hélène Pennestri
Project Title: La relation mère-enfant et la qualité du sommeil: le rôle des perceptions et attentes parentales.
Email: marie-helene.pennestri@mcgill.ca
Faculty Supervisor (if PI is a student):

1. Any modifications to the study or forms must be approved by the REB **prior** to implementation. **Are there any modifications to be made that have not already been approved by the REB?** ____YES __x__NO
If yes, complete an amendment form indicating these changes and attach to this form.

2. The REB must be notified of any findings that may have ethical implications or may affect the decision of the REB. The REB must be promptly notified of any new information that may affect the welfare or consent of participants.
Are there any ethical concerns that arose during the course of this research? ___ YES _x__ NO
If yes, please describe.

3. Unanticipated issues that may increase the risk level to participants or that may have other ethical implications must be promptly reported to the REB. **Have any participants experienced any unanticipated issues or adverse events in connection with this research project that have not already been reported to the REB?** ___ YES _x__ NO
If yes, please describe.

4. Is this a funded study? ___ NO __x__YES. If yes, **indicate the agency name and project title** and the Principal Investigator of the award if not yourself. This information is necessary to ensure compliance with agency requirements and avoid interruption of funding.
Agency name: Fonds de recherche du Québec-Santé (FRQS), Subvention d'établissement.
Project title: Mieux comprendre les liens entre le sommeil du nourrisson, les interactions mère-enfant, la santé mentale des parents, et la santé mentale et physique des enfants: une perspective familiale.

Principal Investigator Signature: __ _____ Date: __2021-01-11_____

Faculty Supervisor Signature: _____ Date:_____
(if PI is a student)

____ Check here if the **study is to be closed** and continuing ethics approval is no longer required. A study can be closed when all data collection has been completed and there will be no further contact with participants. Studies involving secondary use of data no longer need ethics approval when all secondary data has been received.

x
____ Check here if this is a **request for renewal** of ethics approval.

For Administrative Use

Signature of REB Chair or designate: lynda.mcneil@mcgill.ca Digitally signed by lynda.mcneil@mcgill.ca DN: cn=lynda.mcneil@mcgill.ca Date: 2022.01.13 08:38:09 -05'00' Date: _____

Approval Renewal Period: January 18, 2022 -January 17, 2023

The researcher is responsible for ensuring that all other applicable approvals/renewals from other organizations are obtained before continuing the research.

Appendix F

Hôpital en santé mentale Rivière-des-Prairies Ethics Board

PAR COURRIEL UNIQUEMENT

Le 18 janvier 2017

Marie-Hélène Pennestri, Ph. D.
Professeure-chercheuse
Hôpital Rivière-des-Prairies
CIUSSS du Nord-de-l'Île-de-Montréal

Objet : **Projet 16-14P :** «La relation mère-enfant en fonction de la qualité du sommeil : le rôle modérateur des perceptions et attentes parentales»

Chercheure principale: Marie-Hélène Pennestri, Ph.D.

Co-chercheuses : Marie-Julie Béliveau, Ph. D. et Karine Dubois-Comtois, Ph. D.

Évaluation par le comité d'éthique de la recherche : APPROBATION FINALE

Madame,

Le CÉR a évalué, en comité plénier, votre projet au cours de sa réunion du 31 août 2016. À cette fin, **les documents suivants ont été examinés** :

- DG-52 annexe 2 - Obligation du chercheur principal signée en date du 17 août 2016;
- DG-52 annexe 3 – Questionnaire – synthèse signée et datée du 17 août 2016;
- DG-52 annexe 5 - Engagement à la confidentialité pour l'équipe de recherche signée par l'équipe juillet 2016;
- Avis de décision pour la demande de subvention au CRSH, en date du 14 juillet 2016
- Protocole de recherche, version non datée;
- Questionnaire socio-démographique, version française, non datée
- Questionnaire CES-D-FR, version canadienne-française, non datée
- Questionnaire sur les expériences familiales (version mère), version française, non datée
- Questionnaire sur le comportement du nourrisson-forme révisée, version française, non datée
- Questionnaire Sleep Practices Questionnaire (SPQ), version française, non datée
- Agenda de sommeil, version française, non datée
- Canevas d'entrevue pour le recrutement, version française;
- Formulaire d'information et de consentement, version française, en date du 17 août 2016;

- Curriculum vitae de Marie-Hélène Pennestri, Ph. D., Marie-Julie Béliveau, Ph. D. et Karine Dubois-Comtois, Ph. D.

Le CÉR a pris connaissance en comité restreint des documents que vous lui avez fait parvenir le 13 décembre 2016 en réponse aux commentaires soulevés dans sa lettre du 14 septembre 2016. Il a également évalué les réponses à ses commentaires subséquents. À cette fin, les documents suivants ont été examinés :

- Lettre de réponses à l'approbation, en date du 13 décembre 2016
- Formulaire d'information et de consentement, version française, en date du 13 décembre 2016
- Protocole de recherche, version révisée, non datée
- Canevas d'entrevue pour le recrutement, version révisée française, non datée
- Ajout d'une lettre de référence aux familles, version française, non datée
- Questionnaire socio-démographique, version révisée française, non datée
- Questionnaire Sleep Practices Questionnaire (SPQ), version révisée française, non datée
- Questionnaire sur le comportement du nourrisson-forme révisée, version révisée française, non datée
- Lettre de subvention du *Internal Social Sciences and Humanities Emerging Scholars Accelerator*, en date du 16 décembre 2016

Suite à ces documents, le comité a posé une autre question concernant le facteur du congé parental qui peut être assumé par la mère, mais aussi par le père ou un autre parent. Le comité a pris connaissance de la réponse donnée dans votre courriel en date du 13 janvier 2017 et la juge satisfaisante.

De plus, le comité a bien reçu le formulaire de la convenance final, signé en date du 22 décembre 2016.

C'est avec plaisir que le CÉR vous informe que la qualité des réponses et les modifications apportées aux documents ont été considérées satisfaisantes. Ainsi, **la présente constitue l'approbation finale de votre projet**.

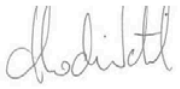
Nous vous retournons, sous pli, une copie du formulaire d'information et de consentement approuvé portant l'estampille d'approbation du Comité. Seul ce document devra être utilisé auprès des participants à la recherche.

Le CÉR vous rappelle que **l'approbation éthique du projet est valide pour un an** seulement à compter de la date d'approbation finale, **soit jusqu'au 18 janvier 2017**. Avant la date anniversaire, vous devrez compléter le formulaire de suivi annuel vous demandant de résumer le déroulement de l'étude afin d'obtenir un renouvellement de l'approbation éthique de ce projet.

Cette approbation finale suppose également que vous vous engagiez :

- à respecter la présente décision;
- **À nous transmettre l'autorisation de la CAI en temps opportun ;**
- à remettre au CÉR un rapport annuel faisant état de l'avancement du projet, lequel rapport est nécessaire au renouvellement de l'approbation éthique;
- à tenir une liste des sujets de recherche, pour une période maximale de douze mois suivant la fin du projet ;
- à aviser le CÉR dans les plus brefs délais de tout incident/accident en cours de projet ainsi que tout changement ou modification que vous souhaitez apporter à la recherche notamment au protocole ou au formulaire d'information et de consentement.
- à notifier au CÉR dans les meilleurs délais tout nouveau renseignement susceptible d'affecter l'intégrité ou l'éthicité du projet de recherche ou d'influer sur la décision d'un sujet de recherche quant à sa participation;
- à communiquer au CÉR toute suspension ou annulation d'autorisation relative au projet qu'aura formulée un organisme subventionnaire ou de réglementation;
- à informer le CÉR de tout problème constaté par un tiers au cours d'une activité de surveillance ou de vérification, interne ou externe, qui est susceptible de remettre en question soit l'éthicité du projet, soit la décision du CER;
- à notifier au CÉR l'interruption temporaire ou définitive du projet et remettre un rapport faisant état des motifs de cette interruption ainsi que les répercussions de celle-ci sur les sujets de recherche;
- à remettre au CÉR un rapport final faisant état des résultats de la recherche.

Vous souhaitant la meilleure des chances dans la réalisation du projet, nous vous prions d'agréer, Madame, l'expression de nos sentiments distingués.



Élodie Petit, présidente
Comité d'éthique de la recherche
CIUSSS du Nord-de-l'Île-de-Montréal
Site : Hôpital Rivière-des-Prairies

p.j. : *Formulaire d'information et de consentement* approuvé, version française, en date du 13 décembre 2016

EP/jh