Infant Sleep in the First Year of Life: Common Patterns, Predictors and Consequences.

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Abstract

Despite the known health benefits of sleep for developing infants, there remains limited knowledge about the patterns, predictors and developmental consequences of sleep during infancy.

This thesis used unique prospective data from 448 NSW mothers and offspring, across gestation and early infancy, to examine the nature, predictors and consequences of infant sleep. Measures included the Brief Infant Sleep Questionnaire, the Depression Anxiety and Stress Scales, the Edinburgh Postnatal Depression Scale and The Bayley Scales of Infant Development-III. Statistical analyses included Pearson's correlation; repeated measures ANOVA, multiple regression and structural equation modelling. The thesis provided new knowledge in three areas. First, examination of infant sleep patterns over the first year of life found that sleep reduced consistently. Second, infant sleep and maternal mental health were found to be bidirectionally related over time. Finally, higher quality and duration of infant sleep in the first 8-weeks of life predicted increased cognitive and language development scores at 12-months of age.

This thesis improves the understanding of sleep in the first year of infancy and identifies numerous critical predictors and consequences of infant sleep. Implications of these findings in relation to assessment, education, and intervention of infant sleep and its related concomitant factors are discussed.

Statement of Candidature

I certify that the research described in this thesis has not already been submitted for any other degree.

I certify that this submission is my own work and that to the best of my knowledge all sources used and any help received in the preparation of this dissertation have been acknowledged. The contributions of each of the authors listed for the three studies contained in this thesis are detailed by study below.

Study 1, 2 and 3: Hannah Fiedler was responsible for formulation of research questions, application for Ethics Committee approval, data preparation, statistical analysis and preparation of all three studies. Professor Ronald Rapee and Dr Delyse Hutchinson supervised the design, statistical analysis and writing of all three studies. The Triple B Pregnancy Cohort Study provided the data set used in this thesis.

Signature _____

Hannah Fiedler

Date _____

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General Introduction.

1. Early Infancy

Early infancy is a remarkably short phase of an individual's life and yet it represents a period when the bases of one's personality, behaviour and early patterns of emotional regulation are first laid down (Bornstein, 2010). Major developmental theorists and researchers have documented considerable stability in infant characteristics over time through childhood, and into adolescence and adulthood (Bornstein, 2010). Indeed, many studies have found that both prenatal and postnatal events have long-lasting effects on an individual's behaviour, health and wellbeing (Bornstein, 2010). For example, infants who show emotional distress at 3-4-months of age are more likely to show behavioural inhibition or shyness at 7-years of age (Kagan & Snidman, 1991; Meili-Dworetzki & Meili, 1972). Similarly, parent reports of early infant activity levels, smiling, laughter, distress and fear at 6-months of age have also been shown to predict behavioural adjustment at 5.5-years (Komsi et al., 2006). Moreover, prematurity has been strongly associated with reduced motor skills, attention and cognition problems, delayed language, lowered Intelligence Quotients (IQs) and developmental disabilities, and social and academic difficulties when compared with full term infants (Bhutta, 2002; Caravale, Tozzi, Albino, & Vicari, 2005; Foster-Cohen, Edgin, Champion, & Woodward, 2007; Gayraud & Kern, 2007; Saigal, Hoult, Streiner, Stoskopf, & Rosenbaum, 2000; Saigal, 2000; Salt & Redshaw, 2006; Schothorst & van Engeland, 1996; Shenkin, Starr, & Deary, 2004). One developmental domain in infancy that is recognised as critically important to ongoing physical and mental health is the quality of early infant sleep (Coulombe, Reid, Boyle, & Racine, 2010; Dahl, 1996b; Taylor, Lichstein, & Durrence, 2003). The following section describes the nature of infant sleep and why it is of such importance early in development.

2. Infant Sleep

The importance of sleep to overall health and wellbeing is well established, however infant sleep has received somewhat less attention in the literature (Davis et al., 2004). Adequate sleep in early infancy is crucial for normal growth and development, emotional health, and immunity function (Davis et al., 2004). Further, sleep is a period of considerable neurological and physiological activity that involves intense brain activity and higher cortical functioning (Davis et al., 2004; Zee & Turek, 1999). Indeed, the human brain is more active during sleep than during wakefulness (Davis et al., 2004). Moreover, young infants spend the majority of their time asleep, which makes sleep critically important for the rapidly developing brain and body of a young infant (Dahl, 1998; Davis et al., 2004).

2.1. Infant sleep patterns.

The sleep patterns of young infants vary greatly compared with older toddlers and children. Notably, the circadian rhythm of a newborn infant is irregular, and gradually matures through the first year of life (Davis, Parker, & Montgomery, 2004; Sheldon, 2002; Tikotzky et al., 2015). Infant sleep patterns begin to follow a developmentally prescribed path (Anders, 1994) as infants consolidate their nocturnal sleep duration and timing; have longer wake periods during the day; and, become increasingly sensitive to environmental and social cues (e.g., sounds and facial expressions) (Anders, Sadeh, & Appareddy, 1995; Davis et al., 2004; Sheldon, 2002; Tikotzky et al., 2015). The following section summarises what is known about common patterns of infant sleep duration, and frequency of day sleeps and night sleeps.

2.2 Sleep duration.

A systematic review conducted by Galland et al. (2012) summarised the present literature on the sleep patterns of infants and children aged 0-12-years. The review of 34 studies in 19 countries, including America, the Asia-Pacific, and Europe, found a wide range

in sleep duration for infants over a period of 24-hours (see Table 1). The review also identified a decline in sleep duration across the first 6-months of life (Galland, Taylor, Elder, & Herbison, 2012). An online study examining the sleep patterns of 2,154 infants in Australia and New Zealand reported similar results (see Table 1); with infants gradually reducing their total sleep duration across a 24-hour period. Similarly, a recent study by Tikotzky et al. (2015) found that infnat sleep efficiency (time asleep divided by time in bed) significantly increases between 3 and 6-months, suggesting that sleep was become more consolidated.

2.3. Day sleep.

Galland et al.'s (2012) review of infant sleep patterns found that as infants progressed through their first year of life, there was a decrease in the average number of day sleeps (see Table 1). Specifically, the average number of day sleeps decreased from 3.1 at 0-5-months of age (Matthey, 2001; Montgomery-Downs & Gozal, 2006; Sadeh et al., 2009), to 1.2 day sleeps between 1-2-years of age (BaHammam, Bin Saeed, Al-Faris, & Shaikh, 2006; Montgomery-Downs & Gozal, 2006; Sadeh et al., 2009).

A similar pattern was found in the Australian and New Zealand sample (see Table 1), with a decrease from 3.03 sleeps between 0-2-months to 2.37 sleeps between 12-17-months (Teng et al., 2012). Similary, the study by Tikotzky et al. (2015) found there was a decrease in infant day sleeps, with the Whilst it appears that infants in Australia and New Zealand may have more day sleeps, when the number of sleeps is averaged across age categories, findings across the studies appear fairly consistent (see Table 1).

2.4. Night sleep and waking.

Galland et al.'s (2012) international review of infant sleep patterns reported that night wakings also decrease over the first year of life (see Table 1). Night wakings decreased from 1.7 night wakings at 0-2-months old (Matthey, 2001; Meijer & van den Wittenboer, 2007), to 0.7 night wakings between 1-2-years of age (Fazzi et al., 2006; Mindell, Telofski, Wiegand,

& Kurtz, 2009; Montgomery-Downs & Gozal, 2006; O'Connor et al., 2007; Sadeh et al., 2009; Xiao-Na et al., 2009). Once more the results from the international review are consistent with those of the Australian and New Zealand sample (see Table 1), with night wakings decreasing from 1.83 night wakings between 0- 2-months to 0.96 night wakings between 12-17-months (Teng et al., 2012). Interestingly, the findings of Tikotzky et al. (2015) suggest higher incidences of night wakings, with infants wakign an average 2.52 times at 3-months, and an average of 3.17 times at 6-months. It is difficult however, to compare these figures given the different ages when measurements were taken. It would be imporatnt to consider night wakings as infants continue to matrue past 6-months of age, as well, before direct comparisons can be made. These results show that night waking is a common behaviour during infancy.

The consistency between the international systematic review and the online study of infant sleep in Australia and New Zealand is the first step in understanding typical infant sleep patterns across different cultures and countries. This permits clearer assessment of deviations from average sleep and identification of sleep problems where supportive interventions may be helpful. However, a number of limitations should be noted. First, many of the studies analysed in the systematic review were cross-sectional, making it difficult to determine how individual sleep patterns may change over time, and the developmental trajectory of infant sleep. Second, many of the studies included in the review had small sample sizes and used varying methods of reporting infant sleep patterns, with some studies using categories to assess sleep patterns and others using open-ended reporting of sleep patterns. Nevertheless, the consistency between the two reviews, despite measurement differences, suggests that these findings are likely to be relatively robust.

Table 1
Average Sleep Patterns (Age in Months) in the International and Australian/New Zealand Sample

	Sleep duration (hours)					Day sleeps					Nightwakings				
International[a]	**0-2**	**3**	**6**	**9**	**12**	**0-5**		**6-11**		**12-24**	**0-2**	**3-6**	**7-11**		**12-24**
	14.6	13.6	12.9	12.6	12.9	3.1		2.2		1.2	1.7	0.8	1.1		0.7
Australia and New Zealand[b]	**0-2**	**3-5**	**6-8**	**9-11**	**12-17**	**0-2**	**3-5**	**6-8**	**9-11**	**12-17**	**0-2**	**3-5**	**6-8**	**9-11**	**12-17**
	14.9	13.8	13.7	13.3	13.1	3.03	3.79	3.14	2.75	2.37	1.83	1.3	1.28	1.19	0.96

a Galland, T., Taylor, B., Elder, D., & Herbison, P. (2012). Normal sleep patterns in infants and children: A systematic review of observational studies. *Sleep Medicine Reviews*, *16*(3), 213–222
b Teng, A., Bartle, A., Sadeh, A., & Mindell, J. (2012). Infant and toddler sleep in Australia and New Zealand. *Journal of Paediatrics and Child Health*, *48*(3), 268–73

2.5 Parent concerns about infant sleep.

Infant sleep disruption is a particularly common area of concern for parents (Acebo et al., 2005) with recent studies finding that around 30% of Australian and New Zealand parents describe their infants sleep as 'problematic' (Armstrong, Quinn, & Dadds, 1994; Bayer, Hiscock, Hampton, & Wake, 2007; Teng et al., 2012). Whilst there is some variation across cultures, in more developed countries the most common concerns reported by parents include frequent and long nocturnal waking, requiring nursing to fall asleep, taking extended periods of time to fall asleep, and co-sleeping (Giallo & Vittorino, 2011; Hiscock & Wake, 2001; Martin et al., 2007; Symon, Bammann, Crichton, Lowings, & Tucsok, 2012). Despite infant sleep often being an area of concern for parents, few studies have investigated common patterns of infant sleep and the way these patterns change and develop over the first year of life.

3. A Model of Infant Sleep

During the first year of life, the course of infant sleep is influenced by a large variety of biological and psychosocial factors (Goodlin-Jones, Burnham, Gaylor, & Anders, 2001; Sadeh, 2007). For example, a recent study of 4507 Australian mothers and infants, found that infants who were breastfed were more likely to experience night waking and experience difficulty sleeping alone (Galbally, Lewis, McEgan, Scalzo & Islam, 2013). In order to best account for the wide variety of factors that may affect infant sleep, a transactional model of infant sleep was proposed by Sadeh and Anders (1993, pg. 20). The model (see Figure 1) identifies multiple etiologies of infant sleep patterns using a systems perspective. Specifically, the model is multi-factorial, including biological, psychological and sociocultural factors that may influence infant sleep. Further, the transactional nature of the model suggests that relationships between sleep and its possible etiologies are dynamic and bidirectional. The model suggests that the most proximal and influential factors on infant

sleep patterns are in relation to the intrinsic context of the infant (i.e., infant temperament and biological factors) as well as the extrinsic parental context (i.e., parent personality and psychopathology). The model also posits that infant sleep patterns influence infant health, maturation and developmental factors, as well as infant temperament. As such, infant sleep can be viewed as both an exposure and predictor variable, and as an important outcome in infancy. The model also suggests that interventions targeted at specific parts of the model will need to be dynamic and multifactorial to affect the entire system (Sadeh & Anders, 1993). The use of transactional models for understanding an infant's environment in this systemic way is discussed below.

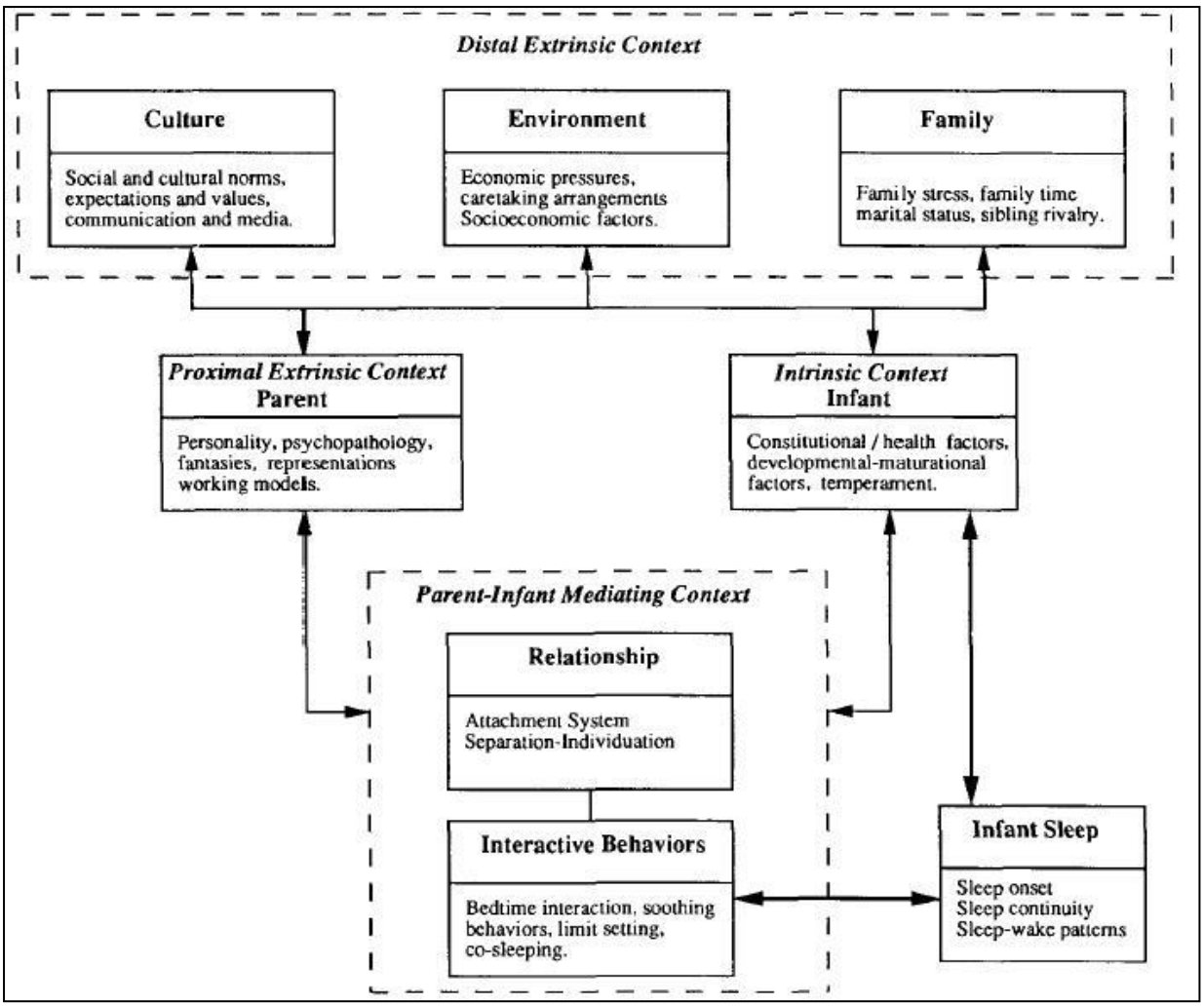

Figure 1: Transactional Model of Infant Sleep. Taken from "Infant Sleep Problems: Origins, Assessment, Interventions," by A. Sadeh, and T. Anders, 1993, *Infant Mental Health Journal, 14 (1),* p. 20

3.1. Transactional models.

A key goal of developmental research is to investigate the processes that lead to optimal developmental attainment or dysfunction (Sameroff & Mackenzie, 2003). In order to do so, an individual must be understood in the context of their immediate environment (Sameroff & Mackenzie, 2003). Such a relationship can be understood through the lens of transactional models, whereby individual development is subject to the dynamic interplay between an individual and their familial and social environment (Sameroff & Mackenzie, 2003). This allows for the contextual representation of the dynamic relationship between infant sleep and the infant's environment (Goldberg et al., 2012) and is in line with the aforementioned model of infant sleep (see Figure 1). As such, it allows for comprehensive assessment of the way in which infant sleep may impact the larger family system, and conversely, how systemic influences can influence infant sleep (Anders, 1994; Goldberg et al., 2012). One of the extrinsic parent factors proposed in this model to influence infant sleep is *parent psychopathology* or *negative affect*. To better understand the systemic factors that may influence, or be influenced by, infant sleep, the following section describes the specific relationship of maternal negative affect and infant development.

4. Infant Sleep and Maternal Negative Affect

The birth of a baby is a significant life event involving major life transitions for family members. This often results in changes in relationships between couples, within families, and can also lead to other environmental and financial stressors (Yelland, Sutherland, & Brown, 2010). The birth of a baby can also lead to increased stress and negative affect for some mothers. Indeed, the prevalence of maternal stress, anxiety and depression in the first year after childbirth has been well documented in the literature (Lewis, Bailey, & Galbally, 2012; Lewis, Galbally, & Bailey, 2012b; Woolhouse et al., 2009). Specifically, a study of 1,396 women in Melbourne, Australia, found that 13% of women

experienced anxiety when their child was 6-months old (Woolhouse et al., 2009). This is consistent with another study of 4,366 women in Victoria and South Australia, which found that 14% of women met criteria for Generalised Anxiety Disorder (Yelland et al., 2010) when their child was 6-months old. Further, amongst a sample of 80 Australian mothers, 49% and 25% reported intense stress or anxiety respectively, when their infant was between 6-9-months old (Symon et al., 2012). Maternal depression after birth is also relatively common, with around 10-15% of women reporting depression in the first year after birth (Lewis, Galbally, & Catherine Bailey, 2012; Woolhouse et al., 2009; Yelland et al., 2010).

One factor that has been strongly associated with poor maternal mental health during the post-natal period is infant sleep (Hiscock & Wake, 2001; Hiscock, 2010). Mothers commonly report that disruption in infant sleep is associated with disruption in their own sleep, with 71% reporting that their own fatigue negatively impacts their parenting abilities (Giallo & Vittorino, 2011). Moreover, many mothers report that physical and cognitive symptoms, such as tension and incessant worry, contribute to a feeling of tiredness and exhaustion (Giallo, 2011), making it difficult for them to attend to their infant's sleep needs. However, the exact direction and nature of causality between maternal mental health and infant sleep remains somewhat unclear. As such, infant sleep can be considered a predictor as well as an outcome in the relationship with maternal negative affect. The following sections describe the existing research on this complex relationship. First, the way in which infant sleep may predict maternal negative affect and second, the way in which infant sleep may be an outcome of maternal negative affect.

4.1. Infant sleep as a predictor of maternal negative affect.

There is a clear link in the research literature between infant sleep patterns and maternal negative affect (Armstrong, O'donnell, McCallum, & Dadds, 1998; Dennis & Ross, 2005; Martin et al., 2007). Australian mothers who report sleep problems in their child are

twice as likely to report clinical symptoms of depression (Hiscock & Wake, 2001; Lam, Hiscock, & Wake, 2003; Martin et al., 2007). Intervention studies have also suggested that improving infant sleep patterns, subsequently improves maternal mood (Hiscock & Wake, 2002; Symon et al., 2012) suggesting a causal relationship between the two. Specifically, a study of 328 mothers in Melbourne Australia, found that families who were randomly assigned to receive sleep intervention from primary health care professionals, reported a reduction in sleep problems from 10-months to 12-months, as well as a reduction in maternal depressive symptoms (Hiscock & Wake, 2002). Likewise, 85 mothers from Adelaide, South Australia, received intervention from their General Practitioner or Health nurse, for their infants at 6-12-months. The study found that primary healthcare intervention significantly reduced the number of infant night wakings, and was also associated with a significant reduction in maternal depressive symptoms (Symon et al., 2012). Moreover, it has been proposed that disruptive infant sleep patterns result in disrupted maternal sleep, as well as an increase in irritability, inattention and emotion regulation difficulties in the infant themselves (Hiscock et al., 2007; Lavigne et al., 1999). In turn, this is associated with adverse effects on maternal functioning, including decreased mood, cognition and motor function (Hiscock et al., 2007; Pilcher & Huffcutt, 1996).

4.2. Maternal negative affect as a predictor of infant sleep.

Recent research shows that maternal mental health may also influence infant sleep patterns (Goldberg et al., 2012). This is best understood in the context of a mother experiencing depressive symptoms who has less positive and more negative coping strategies and interactions with their infant (Coyl, Roggman, & Newland, 2002). As such, mothers with depressive symptoms may find it difficult to provide their young infants with the necessary resources to cope with stress or to regulate their behavioural and physiological responses to their environment (Field, 1994). In fact, a 2012 study of 45 mothers and their infants in

America, found that the association between maternal depressive symptoms, maternal dysfunctional cognitions, and infant night waking (Teti & Crosby, 2012). Specifically, the results suggest that the relationship between maternal depressive symptoms and dysfunctional cognitions (e.g. worry about their infants night needs) were inter-correlated, and the relationship between maternal negative affect and infant sleep was mediated by maternal behaviour (Teti & Crosby, 2012). This suggests that depressive symptoms and cognitions in mothers, leads to an increase in night time behaviour such as close maternal presence, and mother-infant contact, which disrupts the sleep patterns of the young infant. It is worth noting, this result was only found during night time sleep, and the study was cross-sectional in nature, making it difficult to determine if this relationship may hold over time. Further, research has found that maternal depression is associated with an increase in an infant's risk of developing both sub-clinical and clinical sleep disorders (Armitage et al., 2009; Pinheiro et al., 2011). Similarly, high levels of maternal stress and anxiety during pregnancy have been associated with later infant sleep problems (O'Connor et al., 2007). These preliminary findings support a relationship between maternal mental health and subsequent poor quality infant sleep. Surprisingly, few studies examine the potential bidirectional and longitudinal nature of these relationships (Goldberg et al., 2012).

As reviewed above, infant sleep is likely to be both a predictor and outcome of maternal negative affect in early infancy. One other area in which infant sleep plays an important role is infant development. The following section summarises the available literature on the relationship between infant sleep and early infant development in five key domains; cognition, language, motor, social-emotional and adaptive behaviour.

5. Infant Sleep and Development

Sleep plays a crucial role in early infant health and development. In fact, sleep has been determined as essential to healthy development through childhood, including brain

maturation (Ednick, Cohen, & McPhail, 2009), learning and memory (Dahl, 1996a; Davis, Parker, & Montgomery, 2004; Ednick et al., 2009; O'Brien, 2011), school performance (Dahl, 1996a; Davis et al., 2004; O'Brien, 2011) behavioural and emotional adjustment (Dahl, 1996a; Davis et al., 2004), emotional regulation and temperament (Davis et al., 2004; O'Brien, 2011), and physical maturation and health (Dahl, 1996a; Davis et al., 2004; Ednick et al., 2009; El-Sheikh & Sadeh, 2015; Gregory & Sadeh, 2012). Moreover, young infants spend more time in sleep than in wakefulness, particularly during the first year of life (El-Sheikh & Sadeh, 2015; Galland et al., 2012; Iglowstein et al., 2003) and sleep problems are one of the most widely reported reasons for parents seeking professional help in early childhood (Byars, Yolton, & Rausch, 2012; Mindell, Kuhn, Lewin, Meltzer, & Sadeh, 2006). The role of sleep in five key developmental domains of cognition, language, motor, social-emotional and adaptive behaviour are outlined below.

5.1. Cognitive development.

Numerous studies have found an association between infant sleep and cognitive functioning in children, in both clinical and non-clinical settings. Specifically, disrupted sleep patterns have been shown to be associated with a decrease in executive functioning, including memory and inhibition (Beebe, 2011; Bernier, Carlson, Bordeleau, & Carrier, 2010). A cross-sectional study of sleep-wake regulation and cognitive function in 50 low risk infants in Israel found that more consolidated sleep patterns were positively correlated with higher cognitive scores on the Bayley Scales of Infant Development-II (Scher, 2005), a standardised neuropsychological measure of infant and toddler development (Bayley, 2005). More recently, Gibson et al (2012) conducted an actigraph study of infant sleep with 52 infants in Wellington, New Zealand. This study found that greater sleep duration and sleep efficiency (time asleep divided by time in bed) were both significantly related to cognitive development and sleep quality was positively associated with the development of problem solving skills at

11-14-months of age. Similarly, a study by Sadeh et al. (2015) of 43 infants from Tel Aviv and Helsinki combined, found that low qualtiy sleep in early infancy (at age 12-months) predicted poor executive fucntion and attention regulation skills at 3-4-years old.

5.2. Language development.

There is limited research on the relationship between infant sleep and language development. Of the studies available, there is some evidence that sleep quality and consolidation (i.e sleep without intermittent wake episodes) are positively associated with infant communication skills (Scher, 2005). Further, preliminary research with 74 infants in Massachusetts, America, found that more consolidated sleep patterns between 7-19-months of age were associated with increased language and communication skills at 36-months (Dearing, McCartney, Marshall, & Warner, 2001). Developmental theorists have argued the link between infant sleep and language may be due to the role sleep plays in memory consolidation and higher order functioning, which consequently allows the infant to attend to, and process, language (Dearing et al., 2001; Dionne et al., 2011; Freudigman & Thoman, 1993; Gómez, Bootzin, & Nadel, 2006; Scher, 2005; Touchette, Petit, Séguin, & Boivin, 2007).

5.3. Motor development.

Research has demonstrated a strong association between sleep quality and adult procedural learning (i.e., acquisition of skills and knowledge to perform tasks) (Walker et al., 2003; Walker, Brakefield, Morgan, Hobson, & Stickgold, 2002), yet there is minimal research investigating this relationship in young children. Studies of pre-adolescent children with deficits in attention, motor control and perceptions, have shown a relationship with disturbed and un-restful sleep (Palm, Persson, Bjerre, Elmqvist, & Blennow, 1992), however follow-up studies investigating the mechanisms of this relationship are scant. Interestingly, one study of 52 infants aged between 11 and 13-months from Wellington, New Zealand,

found that increased sleep efficiency was associated with a decrease in fine motor skills. However none of these infants showed clinically significant impairments in fine motor skills; indeed most performed in the average range for their age (Gibson, Elder, & Gander, 2012). Much of the remaining literature regarding infant sleep and motor development has concentrated on the physical position an infant adopts whilst sleeping, rather than the quality and duration of sleep (Davis, Moon, Sachs, & Ottolini, 1998). As such, the relationship between infant sleep and motor development requires further research.

5.4. Social-emotional and adaptive behaviour development.

Sleep has consistently been associated with a child's ability to regulate their emotions and behaviours, with disturbed sleep a consistent predictor of symptoms of depression, anxiety, aggression and low self-esteem in children (Fredriksen, Rhodes, Reddy, & Way, 2004; Gregory, Van der Ende, Willis, & Verhulst, 2008; Vriend et al., 2013). Research has also suggested that infants who experience disturbed sleep patterns are described as having a difficult temperament, lower approachability, low sensory thresholds, un-adaptability and high distractibility (Scher, Epstein, Sadeh, Tirosh, & Lavie, 1992; Spruyt et al., 2008). Hence, the consolidation and quality of infant sleep appear to be important factors in establishing an infant's ability to attend to, process, and interact effectively in social situations (Spruyt et al., 2008). Moreover, disturbed sleeping patterns are a key marker of many social and developmental psychiatric disorders such as Autism Spectrum Disorder and Attention Deficit/Hyperactivity Disorder (American Psychiatric Association, 2013; Richdale & Schreck, 2009).

Taken together, the current literature provides evidence that sleep plays a crucial role in development through the life course, including infancy. Additionally, it is evident that sleep plays an important role in the health and wellbeing of infants and can not only influence, but can also be influenced by, the immediate environment. Despite knowledge of

the importance of sleep, the existing research literature is characterised by a number of important methodological limitations. These will be described in the next section.

6. Summary of Limitations in the Literature on Infant Sleep

A large body of research has elucidated the importance of sleep during infancy for healthy development. However, there are a number of important limitations, which characterise the infant sleep research field. First, studies concerning child sleep patterns tend to focus on the early postnatal period or the later preschool years and onwards (Meltzer & Mindell, 2007). Few studies focus on the sleep patterns of infants at 12-months of age, which is surprising given knowledge around the importance of child development at this time (Berger, Miller, Seifer, Cares, & Lebourgeois, 2012). In order to understand the way in which a child optimally develops, it is important to investigate factors associated with development at times of key developmental transitions and markers (e.g. walking and talking).

Second, most studies have focused on the effect of child sleep patterns and the experience of maternal depression, specifically that of post-natal depression (Sadeh, Tikotzky, & Scher, 2010; Symon et al., 2012). However there is evidence that a relationship also exists between child sleep and other maternal psychopathology including anxiety and stress (Symon et al., 2012).

Third, the present literature has primarily focused on maternal psychopathology as the outcome, and the idea that poor child sleep patterns predict mental health concerns in mothers. This focus in the current literature exists, despite evidence that there is likely to be a bidirectional relationship between maternal mental health and child sleep patterns (Sadeh et al., 2010), and that maternal psychopathology may in fact predict poorer sleep patterns for infants through the early years (Armstrong, Van Haeringen, Dadds, & Cash, 1998; Lam et al., 2003). A lack of studies examine infant sleep and maternal negative affect in the dynamic

way they present in real life, leading to difficulties in understanding how best to approach and treat reported problems in maternal mental health or infant sleep.

Fourth, existing studies have examined the relationship between infant sleep and development at isolated time points, however there is a lack of studies which examine these constructs in the context of one another longitudinally, over the first year of life (Spruyt et al., 2008). Whilst the existing evidence suggests a strong association between infant sleep and related developmental outcomes, the univariate and cross-sectional nature of these studies make it difficult for predictive relationships to be ascertained and do not take into account potential confounding factors or statistical issues such as multicolinearity.

Finally, while many of the existing studies lay important groundwork for better understanding infant sleep and its predictors and consequences in the first year of life, many of these studies consist of small sample sizes, are cross-sectional in nature, and few have included an Australian specific sample. Using longitudinal research to assess infant sleep over multiple time points will allow for a better understanding of how it may impact infant development. The following section outlines the main aims of the current thesis and how they address these limitations.

7. Aims of the Thesis

Given the limitations in the existing literature on infant sleep, this thesis aimed to examine the patterns of infant sleep across the first year of life, and the possible predictors and consequences of infant sleep in a sample of 448 infants from New South Wales, Australia. The thesis used a longitudinal design, and conducted multiple assessments of infant sleep, and related factors, over the first year of life. Specifically, the thesis consists of three studies each described in turn below.

7.1. Study One: Characterisation of infant sleep patterns and associated demographic factors.

Study one aimed to describe typical infant sleep patterns over the first year of life using a sample of infants from New South Wales, Australia. Specifically, the study characterised the typical quantity, duration and quality of sleep at infant age birth-8-weeks, 2-6-months, 6-9-months and 9-12-months. Changes in sleep patterns during the first year of life were also reported. The relationship between infant and maternal sleep quality was also examined, and potential maternal and infant demographic factors that may be associated with infant sleep were explored.

7.2. Study two: Maternal negative affect and infant sleep.

Study two aimed to examine the predictive relationship between maternal negative affect and infant sleep patterns in the first year of life. The study prospectively examined the nature of the relationships between maternal negative affect and infant sleep patterns, in particular, the potential bidirectional relationship between maternal negative affect and infant sleep.

7.3. Study three: Infant sleep and infant development.

Study three aimed to examine the relationship between infant sleep and infant development. The study examined the extent to which infant sleep across the first year of life predicts 12-month developmental outcomes in five key domains: cognition, language, motor development, social-emotional, and adaptive behaviour. The study also examined whether this relationship remains or is attenuated after controlling for potential confounds (e.g., gender and parity).

8. References

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STUDY 1

Target journal: Journal of Sleep Research

Title: Sleeping Patterns in a Cohort of Australian Infants from 8-weeks to 12-months of Age

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Key words: *Infant sleep, paediatric sleep development, infant and maternal sleep*

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Abstract

Objectives: Due to gaps in infant sleep research, this study investigated: (1) typical sleeping patterns of Australian infants, (2) changes in infant sleep during the first year of life, (3) the relationship between infant and maternal sleep quality, and (4) relationships between demographic factors and infant sleep patterns.

Methods: Data was from a longitudinal pregnancy cohort of mothers and their children (n=448) recruited in NSW, Australia. Demographics, patterns of infant sleep (Brief Infant Sleep Questionnaire), changes in sleep patterns, maternal perceptions of infant sleep and maternal sleep quality were documented. Relationships between infant sleep patterns, maternal sleep patterns and demographic variables were then further explored using Pearson's correlation, multiple regression and repeated measures ANOVA.

Results: Across the first year of life, average sleep frequency reduced from 3.8 to 1.9 sleeps in the day and from 2.7 to 1.9 sleeps at night. Overall sleep duration reduced from 14.4 to 13.3 hours in a 24-hour period. Significant relationships were identified between infant and maternal sleep patterns, as well as between infant sleep patterns, parity and maternal anxiety.

Conclusions: There was a reduction in typical sleep frequency and duration in the first year of life, and strong connections between infant sleep and maternal sleep, maternal satisfaction and other demographic factors. Understanding average patterns of infant sleep provides critical groundwork for the examination of optimal and sub-optimal sleeping patterns in infants, and may help identify key times where mothers may require further support or education around their infant's sleep.

Key Words: *Infant sleep, paediatric sleep development, infant and maternal sleep*

1. Introduction.

1.1. Importance of Infant Sleep

Between 36-45% of Australian parents report sleep problems in their infants at 6-12-months of age (Armstrong, Quinn, & Dadds, 1994; Hiscock & Wake, 2001; Lam, 2003). These sleep problems are commonly defined by parents as frequent night waking, poor/interrupted daytime sleep, and difficulty settling at night (Armstrong, Quinn, & Dads, 1994); Hiscock & Wake, 2001; Lam, 2003).

The importance of sleep for young infants is established, with sleep playing a pivotal role in the cognitive, behavioural, and physical development of a young child (Coulombe, Reid, Boyle, & Racine, 2009; Lam, 2003; Scher, 2001; Symon, 2012). Sleep deprivation results in lower executive functioning, particularly lower working memory (Berger, Miller, Seifer, Cares, & LeBourgeois, 2012; Goel, Rao, Durmer, & Dinges, 2009) among young children, which may be detrimental in new learning environments such as childcare and preschool. Young infants with poor sleeping patterns are significantly more tired, irritable and at a higher risk of injury (Hiscock & Wake, 2001; Meltzer & Mindell, 2007). Further, sleep-deprived young children show poorer emotional processing and reactivity, with more sensitive responding to negative stimuli and conversely, less sensitive responding to positive stimuli (Berger et al., 2012).

Infant sleep patterns have also been shown to be associated with maternal sleep patterns, with significant relationships evident between disruptions in infant sleep and poor maternal sleep, negativity, parenting stress and decreased maternal daytime functioning (Armstrong, O'donnell, McCallum, & Dadds, 1998; Meltzer & Mindell, 2007). Further, a recent study by Tikotzky et al. (2015) found that there is a significant relationship between infant sleep and maternal sleep at 3-months and 6-months of age. The study also found that that maternal sleep efficiency, and night wakings at 3-months, predicted infant sleep

efficiency and night wakings at 6-months. This suggests that not only is sleep critical for the health and wellbeing of the young infant, but that it also plays a key role in healthy family functioning (Meltzer & Mindell, 2007). As sleep disturbances negatively influence a child's executive functioning and learning ability (Berger et al., 2012), it is important to understand sleep patterns at the time when children achieve important milestones such as walking and talking, which is typically around 12-months old.

1.2. What is Known about Infant Sleep?

It is widely acknowledged that sleep is critical to good health in the early years (Coulombe et al., 2009), yet the understanding of what constitutes typical sleep during infancy is scant (Hiscock et al., 2007; Lam, Hiscock, & Wake, 2003). Studies of child sleep have generally focused on the early postnatal period or the later preschool years and onwards (Meltzer & Mindell, 2007). Few studies have focussed on infant sleep patterns at 12-months of age, and most have not followed children to determine change in sleep over time (Martin et al., 2007). This situation is surprising given knowledge of the importance of child development at this stage (Bellam, 1969; Berger et al., 2012; Kyle, 2008; Thompson, 2001).

A recent international review of 34 studies documented the sleep patterns of children aged up to 12-years from community samples. Among infants aged zero to 12-months, the review found a large range of sleep patterns (Galland, Taylor, Elder, & Herbison, 2012). Typically, the average number of hours infants slept in the first year of life varied from 12.9 to 14.6 hours across a 24-hour time period (Galland et al., 2012). This included between 0.8 to 1.1 night wakings, as well as between 1.2 and 3.1 daytime naps across the first year of life. Additionally, a recent online study of 2,154 children in Australia and New Zealand revealed that sleep patterns varied across age ranges and that between the ages of zero and two,

children usually sleep for 15 hours over a 24-hour time period (Teng, Bartle, Sadeh, & Mindell, 2012).

Whilst these studies provide initial data to better understand typical infant sleep, there were a number of limitations. Many studies included in the review, had small sample sizes and restricted ages of children in the study and few focused on an Australian sample. Specifically, those using an Australian sample focused predominantly on the older years (10-12 years) and those that did focus on the early infant years had smaller sample sizes (N=20-158) (Galland et al., 2012). Additionally, none of these studies were longitudinal, and there is a lack of studies that examine the natural history of Australian infant sleep patterns in the first year of life (Lam et al., 2003). Given the importance of sleep to optimal functioning and the paucity of research on young infants, research is needed to understand typical sleep patterns in Australian infants.

1.3. Current Study

The study aimed to document the sleeping patterns of a cohort of infants in the first year of life, from New South Wales, Australia. This involved an examination of the frequency and quantity of daytime and night time sleeps, the total duration of sleep across a 24-hour period, perceived quality of infant sleep by mothers, and perceived quality of maternal sleep. The relationship between infant sleep and maternal sleep quality was examined as well as the change in sleep patterns as infants matured from birth to 12-months of age. Participants in the present thesis were a convenience sample of the first 448 women for whom data was available in NSW. The full sample of 1,600 families was not used in this thesis as the data were not collected at the time of data analysis.

2. Method.

2.1. Participants

Data for this study were drawn from The Triple B Pregnancy Cohort Study, a National Health and Medical Research Council (NHMRC) funded longitudinal study (Hutchinson et al., 2015). At the time of thesis preparation, data was available for 513 women and their infants. Of the 513 women for whom data was available, 65 were excluded as they did not participate at all follow up time points, resulting in a final sample of 448. Available demographic data for the thesis subsample was compared to the overall Triple B sample to determine if it was a representative sample. Both samples were similar in regards to maternal age during pregnancy (32 years (Triple B) vs. 33 years (thesis), country or origin (57% Australia (Triple B vs. 56% thesis), employment (64% (Triple B) vs. 71% (thesis), and whether they identified as Aboriginal or Torres Straight Islander (2.9% (Triple B) vs. 1% (thesis). Both samples also reported a similar number of participants who had completed Year 12 and tertiary education (91% (Triple B) vs. 96% (thesis). The Triple B sample reported lower parity rates with 55% reporting no other children, whilst in the thesis sample 76% reported they had other children in their care. For full demographics of the Triple B sample see Hutchinson et al. (2015).

2.1.1. Eligibility.

Eligibility criteria for the thesis sample included: being pregnant (at any stage from conception to 40 weeks gestation); being aged 16-years or more; having no major medical complications (mother or foetus); residence in NSW; intention of mother or both parents to be the primary caregiver/s; being mentally able to complete interviews and questionnaires; and possessing sufficient literacy in English.

2.1.2. Recruitment.

Participants for this thesis were recruited during pregnancy in the period between 2009 and 2013. Pregnant women were approached and invited to participate in waiting rooms at general antenatal clinics attached to The Royal Hospital for Women, Royal Prince Alfred Hospital, and Liverpool Hospital, in NSW. Project staff were allocated across the antenatal clinics to ensure equal recruitment distribution across clinics. Recruitment took place on days when general antenatal clinics were held to ensure all women were approached and screened for eligibility.

2. 2. Measures

2.2.1. Demographics.

During pregnancy participants were asked their age (in years), level of education, income, relationship status, employment status, country of birth, living arrangements, whether this was their first child (parity), and if they identified as being Aboriginal or Torres Strait Islander or not (see Appendix A).

2.2.2. Sleep frequency and duration.

Questions about the frequency and length of daytime and night time sleeps were adapted from the Brief Infant Sleep Questionnaire (BISQ) (Sadeh, 2004) which has been validated against actigraph sleep studies as a screening measure for infant sleep patterns (Lomeli et al., 2008). The length of day and night time sleeps was combined to calculate the total duration of sleep infants had over a 24-hour period. These questions were asked during the follow-up interviews when infants were 8-weeks old and 12-months old (see Appendix B).

2.2.3. Sleep quality.

Mothers were asked to rate on a 10-point likert scale (1= poor, large problem, 10= excellent, no problem) the quality of their child's sleep, their own sleep pattern and the extent to which they perceived their child's sleep as problematic. These questions were asked during

the follow-up interviews when infants were 8-weeks old and 12-months old (see Appendix B).

2.2.4. Covariates.

Maternal psychosocial factors (age at pregnancy, education, stress, anxiety and depression scores during pregnancy, and other children in care) and infant factors (gender) were included in regression analysis as associative factors that may affect infant sleep. Education level was measured during pregnancy as level of education in years, maternal stress and anxiety were measured using the Depression and Anxiety Stress Scales (DASS) (Lovibond & Lovibond, 1995), and maternal depression was measured the Edinburgh Postnatal Depression Scale (EPDS) (Cox, Holden, & Sagovsky, 1987). The DASS and EPDS were completed by mothers through self-complete questionnaires during pregnancy, at 8-week and 12-month follow up.

2.3. Procedure.

2.3.1. Ethics approval.

The Triple B Study was approved by all relevant NSW Human Research Ethics Committees (HRECs), and the Macquarie University Ethics Committee ratified ethics approval for the current thesis (see Appendix D). All participants gave informed consent to be involved in the study (see Appendix F).

2.3.2. Data collection.

Data used in this thesis was from mothers who completed telephone or face-to-face interviews and self-complete questionnaires during their pregnancy, at 8-week follow up, and at 12-month follow up. Telephone interviews took approximately 60-minutes to complete, and self-complete questionnaires took approximately 15-minutes for each participant to complete. Mothers were reimbursed $25 at the baseline interview; and $40 at the 12-month follow up. See Figure 1 for a timeline of the data collection process.

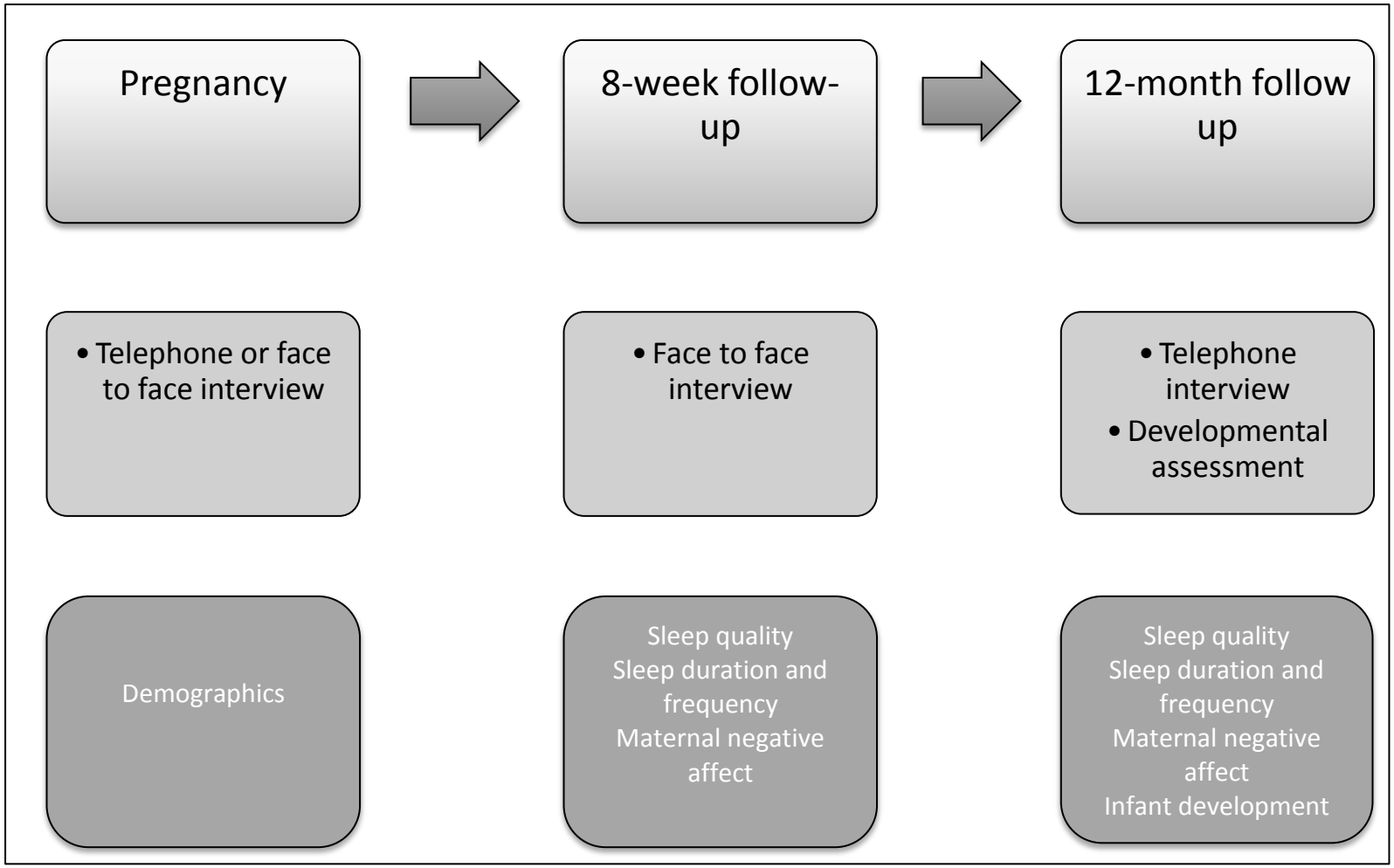

Figure 1. Data collection process for the thesis

2.3.3. Statistical analysis.

Longitudinal data from infant birth to 12-months of age were reported. All analyses were conducted using IBM SPSS software, version 22 (IBM Corp, 2012). Statistical assumptions of ANOVA were tested and met. Chi-squared tests were used to examine the difference between the current sample, and urban NSW. Average sleep frequency and duration were calculated for day and night, as well as the average amount of sleep infants were having over a 24-hour period. These variables were analysed using repeated measures ANOVA. Pearson correlation was used to calculate the relationship between infant sleep and maternal sleep from infant birth through to infant age 12-months. Regression analysis was used to investigate the relationship between family demographic factors and infant sleep patterns at 9-12-months, once infant sleep pattern are assumed to be settled (Moore & Ucko, 1957; Sadeh & Anders, 1993; Teng, Bartle, Sadeh, & Mindell, 2012).

3. Results.

3.1. Sample Characteristics

Participants in this sample consisted of 448 women and their infant offspring, Table 1 shows the demographic characteristics of the sample. The majority of participants were in stable employment (71%) and housing (47%) and reported an average weekly household income of $2,300, which is above the 2011 Urban NSW median weekly household income of $1,401 (Australian Bureau of Statistics, 2011). Compared to urban NSW data (Australian Bureau of Statistics, 2011), participants in the current sample had a lower median age (33-years compared with 36-years in urban NSW) and were significantly less likely to be in paid employment (X^2 (2, N = 448) = 96.80, $p < 0.01$). The fact the sample comprised pregnant women, may explain these differences.

Table 1

Demographic Characteristics of Thesis Participants (N=448)

	Current sample	**ABS 2011 Urban NSW Females**	**Test of difference (X^2)**
Age (years)			
Median	33	36	
Country of birth			
Australia	56%	61%	0.41
Aboriginal/Torres Strait Islander			
Yes	1%	1%	0.00
Weekly household income			
Median	$2300	$1401	
Education			
University/College	73%	25%	92.16**
Tafe/technical	13%	8%	3.13
Year 12	10%	40%	22.5**
Did not complete Year 12	4%	27%	19.59**
Employment			
Full-time	50%	50%	0.00
Part-time	21%	38%	7.61*
Not in paid employment	27%	5%	96.8**
Housing			
Privately owned	47%	65%	4.98
Rental	47%	32%	7.03*
Other	6%	3%	3.00
Living with partner			
Yes	96%	84%	1.71
Other children under care			
Yes	76%	64%	2.25

*p<0 .05, ** p< 0.01.

Note. ABS = Australian Bureau of Statistics

The age of women was more comparable with the median age of pregnant women (33-years) reported in the NSW 2011 Australian Government report on mothers and babies (Li, Zeki, Hilder, & Sullivan, 2013). Compared to females in urban NSW, the current sample had a significantly higher proportion of women with university degrees, (X^2 (3, N = 448) = 92.16, p < 0.01) Notably, whilst the sample was comparable to another recent sample of pregnant women in NSW (Li, Zeki, Hilder, & Sullivan, 2013), when compared to urban NSW, the

current sample had higher socio-economic status and may be considered a somewhat advantaged sample.

3.2. Typical Sleep Patterns and Changes over Time

Table 2 shows the average number of independent sleeps infants had in the day, at night, and over a 24-hour period across the first year of life. Repeated measures ANOVA revealed a significant decrease in day sleeps $F(3,1344) = 496.44$, $p < 0.001$, night sleeps ($F(3, 1347) = 76.234$, $p < 0.001$) and overall sleep in a 24-hour period ($F(3, 1341) = 30.31$, $p < 0.001$). Notably, there was an increase in night time sleeps at 2-6-months, which then decreased from 6-months to 12-months of age.

3.3. Maternal perceptions of sleep patterns.

Next, maternal perceptions of the quality of both their infant's sleep and of their own sleep were examined. Repeated measures ANOVA revealed that maternal ratings of infant sleep ($F(3, 1341) = 30.20$, $p < 0.001$), ratings of problematic sleep ($F(3, 1341) = 18.98$, $p < 0.001$), and ratings of their own sleep ($F(3, 1341) = 62.79$, $p < 0.001$) all changed significantly across the first year of life. Table 3 shows mothers generally rated infant's sleep as above average (7, where 10 =excellent) across all time points. Interestingly, Table 3 shows that there was a decrease in ratings of infant sleep at 2-6-months old, however ratings then increased again at 6-9-months. Similarly the extent to which mothers found their infants sleep problematic changed significantly across the first year of life with the largest change in problem ratings between 6-9-months and 9-12-months (see Table 2). Mother's ratings of their own sleep appeared to be more variable, ranging from a mean rating of 5.5 at 2-6-months to 7 at 9-12-months.

Table 2
Sleeping Patterns of the Cohort (n = 448)

	Birth to 8-weeks	**2-6 months**	**6-9 months**	**9-12 months**
Average sleeps per day				
Mean	3.8	3.0	2.3	1.9
SD	1.3	.83	0.5	0.5
Mean difference		-.77*	-.74**	-.40**
Average sleeps per night				
Mean	2.7	2.9	2.4	1.9
SD	1.0	1.4	1.5	1.2
Mean difference		-.25*	-.52**	-.45**
Average total hours per 24 hours				
Mean	14.4	13.9	13.5	13.3
SD	2.7	2.6	1.8	1.6
Mean difference		-.44*	-.45**	-.15

* p<0 .05, ** p< 0.01

Table 3
Average Maternal Ratings of Sleep Patterns

	Birth to 8-weeks	**2-6 months**	**6-9 months**	**9-12 months**
Average rating of child sleep				
Mean	7.44	6.92	7.28	7.72
SD	1.91	2.74	2.30	2.18
Mean difference		0.73**	-.036**	0.67**
Average problem rating				
Mean	7.09	7.03	7.37	7.75
SD	2.42	2.66	2.38	2.37
Mean difference		-0.20	-0.24	-0.66**
Average rating of maternal sleep				
Mean	6.05	5.57	6.52	7.07
SD	2.21	2.21	2.20	2.21
Mean difference		0.63*	-0.80**	-0.78**

Note.1= poor/large problem, 10 = excellent/no problem

* p<0 .05, ** p< 0.01.

3.4. Correlation between Infant Sleep and Maternal Sleep

Table 4 shows a strong positive relationship between the perceived quality of infant sleep and maternal sleep, such that mothers who rated their infant's sleep more positively, also rated their own sleep more positively. Analysis of the difference between correlations (Soper, 2014) revealed that this relationship was significantly weaker at birth-8-weeks old when compared to the relationship at 2-6-months (z = -4.04, p <0.001), 6-9-months (z = -6.04, p < 0.001) and 9-12-months (z = -6.42, p < 0.001). There was no significant difference in the relationships between child and maternal sleep at 6-9-months and 9-12-months old (z = -0.38, p = 0.07), which were both significantly stronger than at 2-6-months, respectively (z = -2.00, p < 0.05, z = -2.38, p < 0.05). The results also revealed a positive relationship between maternal sleep and overall infant sleep at 2-6-months, 6-9-months, and 9-12-months. There was a negative relationship between maternal sleep and the number of night time sleeps at all time points.

3.5. Associative Factors of Infant Sleep

Table 5 shows demographic factors which were significantly associated with infant sleep patterns at 9-12-months. Parity was also significantly related, such that for each additional child in care, infant sleep duration decreased by 0.21 hours. Maternal anxiety during pregnancy was positively related to infant sleep duration, with higher levels of anxiety associated with a decrease in infant sleep duration by 0.08 hours. No other maternal or infant demographic variables were related to infant sleep at 9-12-months.

Table 4
Correlations between Infant and Maternal Sleep Ratings

	Mother sleep at birth to 8 weeks	**Mother sleep at 2-6 months**	**Mother sleep at 6-9 months**	**Mother sleep at 9-12 months**
Infant birth to 8 weeks				
Sleep rating	0.55**			
Total sleep	0.09			
Day frequency	-0.04			
Night frequency	-0.24**			
Infant sleep at 2-6 months				
Sleep rating		0.71**		
Total sleep		0.67**		
Day frequency		0.07		
Night frequency		-0.17**		
Infant sleep at 6-9 months				
Sleep rating			0.77**	
Total sleep			0.25**	
Day frequency			-0.11*	
Night frequency			-0.57**	
Infant sleep at 9-12 months				
Sleep rating				0.78**
Total sleep				0.29**
Day frequency				-0.05
Night frequency				-0.59**

* p<0 .05, ** p< 0.01.

Table 5
Co-efficient Statistics for Regression Analyses between Demographic Factors and Infant Sleep Patterns

	Sleep duration 9-12 months			**Sleep frequency 9-12 months**			**Maternal ratings of infant sleep 9-12 months**		
	B	**SE B**	**β**	**B**	**SE B**	**β**	**B**	**SE B**	**B**
Maternal age at pregnancy	0.03	0.61	0.09	-0.00	0.01	-0.04	0.00	0.03	0.01
Other children in care	-0.21*	0.10	-0.10	0.14	0.08	0.09	-0.21	0.14	-0.07
Infant sex	-0.16	0.15	-0.05	0.02	0.13	0.01	0.08	0.22	0.02
Maternal education	0.10	0.10	0.05	0.10	0.09	0.06	-0.08	0.14	-0.03
Maternal stress during pregnancy	0.00	0.02	0.02	-0.01	0.01	-0.04	-0.01	0.02	-0.16
Maternal anxiety during pregnancy	-0.08**	0.02	-0.24	0.02	0.02	0.06	-0.02	0.03	-0.05
Maternal depression during pregnancy	0.00	0.03	0.00	0.01	0.02	0.03	-0.03	0.04	-0.06

* $p<0.05$, ** $p< 0.01$.

4. Discussion.

The aim of this study was to document reported sleeping patterns of infants from birth to 12-months of age. Documentation of common sleep patterns allows for mothers and practitioners to better understand and compare infant sleep in the context of Australian-specific patterns, in particular, to note deviations from these typical sleep patterns.

Infants were typically having between 1.9-3.8 day sleeps, between 1.9-2.9 night sleeps, and were sleeping for 13.3-14.4 hours in a 24-hour period across the first year of life. These results are similar to infant sleep patterns reported in international studies in which infants aged 12-months were sleeping between 12-14 hours in a 24-hour period, having between 1-2 night time sleeps and between 1-3 different day time sleeps (Galland et al., 2012; Teng et al., 2012). The results are also consistent with information from the Sleep Health Foundation of Australia, which reported that whilst sleep requirements vary, newborns generally sleep for 16-18 hours in the early months, with less sleep required from 6-months onwards (Sleep Health Foundation, 2011).

Overall, there was a significant reduction in the amount of sleep reported and in the number of daytime naps and night waking through the first year of life. It is interesting to note that there was an increase in the number of night time sleeps at 2-6-months of age; however this then reduced again from 6-months onwards.

Mothers in the current sample generally rated the quality of their infant's sleep as positive, with the majority of mothers rating their infant's sleep in the high average range across the first year of life. The majority of mothers also rated their own sleep in the average to high average range across the first year of their infant's life. There was a significant relationship between reported infant sleep quality and reported maternal sleep quality, such that the more positively mothers rated their infant's sleep, the more positively they rated their own sleep. This relationship was strongest at 6-9-months and 9-12-months of age. This

finding is consistent with other research that suggests a strong connection between infant sleep patterns and maternal sleep patterns (Armstrong et al., 1998; Meltzer & Mindell, 2007). Importantly, the findings suggest that the relationship tends to improve over the course of the first 12-months of infancy (Meltzer & Mindell, 2007). This is likely the case as infant sleep becomes more routine over time (Sadeh & Anders, 1993; Sadeh, Raviv, & Gruber, 2000). Likewise, mothers may adapt over time to the infant sleep routine, rating it more positively than in the early postnatal period. Previous literature has reported that 50% of infants stabilise their sleep routine by 6-months of age, with 90% stabilising their sleep patterns by 12-months of age (Moore & Ucko, 1957; Sadeh & Anders, 1993; Teng et al., 2012). This suggests that sleep routines are yet to be stabilised at 8-weeks old. These results are consistent with this literature, with the weakest relationship between maternal and infant sleep between birth and 8-weeks. Although mothers rated their infant's sleep in the high average range at this time, there was considerable variability in infant sleep in the cohort. This substantial variation supports the idea that infant sleep routines are yet to be stabilised by 8-weeks. It may be this lack of routine and predictability that accounts for the somewhat weaker association between infant and maternal sleep at 8-weeks. The study also found a negative relationship between maternal sleep and infant sleep frequency at night time such that as infants increased their frequency of night sleeps (i.e more night wakings) mothers were more likely to rate their own sleep quality as lower. Similarly there was a positive relationship between maternal sleep and total infant sleep, such that the more sleep infants were receiving over a 24-hour period, the more positively mothers rated their own sleep quality. These findings suggest that maternal sleep quality may be influenced by sleep frequency as well as overall sleep duration in infants. Interestingly it appears that although mother's sleep quality was associated with infant sleeping patterns (specifically night wakings), mothers still perceived infant sleep as

generally positive (as reported above) and again supports the idea that perhaps mothers begin to adapt to their infant's sleep pattern.

This study also found that for all infant age groups mothers generally did not perceive their infant's sleep as problematic, despite the occurrence of night wakings. Developmental literature suggests that the need for young infants to wake in the night for food or comfort is a functional part of early survival (Bamford et al., 1990; Daws, 1989; Henderson, France, Owens, & Blampied, 2010; Scher, 2001). Moreover, it is considered part of the maturation process, with early night wakings representing psychological adaption as infants begin formation of important attachment relationships to caregivers (Daws, 1989; Scher, 2001).

Current results also suggest that demographic factors may play an important role in the development of infant sleep, with significant relationships found between infant sleep patterns and parity, and maternal anxiety during pregnancy. These findings raise the important issue of considering infant sleep patterns in the context of the familial and social environment in which the child lives. Further, it lays the groundwork in which to educate parents about the interaction between infant sleep patterns and other factors within the family home.

4.1. Strengths and Limitations

Strengths of this study include the large community sample of NSW mothers and children. Additionally, the longitudinal methods allow for the documentation of the natural history of infant sleep in the first year of life, and the ability to measure changes in these patterns. There are a number of limitations. First, the measurement of child and maternal sleep were based on maternal report, which may be subject to biases in reporting in regards to sleep quality, as well as lack of parental knowledge regarding exact duration and frequency of sleep. However, the sleep questionnaires used have been validated against biological methods, (Lomeli et al., 2008) and past laboratory validation studies suggest self-report is an

accurate method for assessing general sleep patterns (Hiscock et al., 2007; Minde et al., 1993). Thus, any bias in reporting is likely to be minimal. Second, it is also possible that sleep patterns vary across different cultures. Given the current results suggests the significance of socio-demographic factors such as maternal anxiety and number of children, it is plausible that other cultural factors such as sleep practices (e.g. co-sleeping), and culturally based parenting practices may be related to sleep patterns. Third, the sample is relatively advantaged, who may be better able to deal with sleep patterns of a new infant. As such, some caution should be taken in generalising these findings to other groups. Finally, data for partners/fathers of the infants in the current study were not available for investigation at the time of thesis preparation. However, given the knowledge that infant sleep can be affected by multiple contextual and familiar factors, it would be important to examine paternal factors (e.g.; demographics, mental health and sleep patterns) when considering infant sleep development. While further research on infant sleep patterns across a variety of cultures and samples both in Australia and internationally may be of interest, the sleep patterns in this study are consistent with existing international research (Galland et al., 2012; Teng et al., 2012).

4.2. Clinical Implications

The current results provide important information on the typical patterns of sleep experienced by infants in the first year of life. Documentation of typical sleep patterns and the way in which these change in the first year of life, provides important information for practitioners and families. This information may be of particular importance for first time mothers, who are unsure of what to expect of their new infant's sleep patterns. Highlighting key areas of fluctuation and change in infant sleeping patterns may help mothers and families prepare and adapt to changes in a young infants sleeping routine. Further, access to such information in the context of Australian infants allows for better comparison of sleep, in

particular, noting deviations from typical sleep patterns and recognising the potential need for intervention. Given the strong connection between infant and maternal sleep, the understanding of key patterns of infant sleep may also allow mothers to seek out extra support at times when their own sleep may be disrupted or affected.

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STUDY 2

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Title: Maternal Negative affect and Infant Sleep: Investigating Bidirectional Relationships

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Key words: A*nxiety, depression, stress, infant sleep, predictive relationships, bidirectional*

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Abstract

Objective: Case control studies show higher depressive and stress symptoms in mothers of children with inconsistent sleeping patterns. There is also evidence that infant sleep patterns may also predict maternal negative affect. It remains unclear whether maternal mental health predicts sleep disturbances in infants. The aim of the current paper was to examine the possible bidirectional relationship between infant sleep patterns and maternal negative affect over time.

Methods: Data were from a longitudinal pregnancy cohort of mothers and their children (n=448) recruited in NSW, Australia. Mothers were interviewed during pregnancy, at infant age 8-weeks and infant age 12-months. Maternal negative affect was measured using the Edinburgh Postnatal Depression Scale and the Depression Anxiety Stress Scales. Questions about infant sleep were adapted from the Brief Infant Sleep Questionnaire as well as maternal ratings of infant sleep. Structural equation modelling was used to assess possible bidirectional relationships.

Results: Maternal negative affect during pregnancy predicted poorer infant sleep at birth-8-weeks and 2-6-months. Likewise, poor infant sleep at birth-8-weeks predicted maternal negative affect at 8-weeks. The results suggest that the first eight weeks of life is when bidirectional relationships are most salient.

Conclusions: This study found some evidence of bidirectional relations between maternal negative affect and infant sleep in a prospective pregnancy cohort but only in the first 8-weeks of life. The results highlight the need for both constructs to be considered in the context of one another during assessment. Additionally, they highlight the need for education about infant sleep patterns in the early postnatal, along with early intervention for maternal mood problems and infant sleep difficulties.

Key Words: A*nxiety, depression, stress, infant sleep, predictive relationships, bidirectional*

1. Introduction.

1.1. Early Infant Sleep Patterns

The importance of sleep for young infants is well established, with studies showing that sleep plays a pivotal role in the cognitive, behavioural, and physical development of infants (Coulombe, Reid, Boyle, & Racine, 2010; Lam, Hiscock, & Wake, 2003; Scher, 2000; Symon, Bammann, Crichton, Lowings, & Tucsok, 2012). During the first year of life, infant sleep patterns vary considerably, with infants typically having between 2-4 day sleeps and 2-3 sleeps at night (see Study 1 section 3.2). Infant sleep patterns typically do not stabilise until after 6-months of age (Moore & Ucko, 1957; Sadeh & Anders, 1993; Teng et al., 2012). As sleep patterns vary considerably, parents commonly report frequent and long nocturnal waking in infants, the infant requiring extended comfort and nursing to fall asleep, and co-sleeping (Giallo & Vittorino, 2011; Hiscock & Wake, 2001; Hiscock et al., 2007; Symon et al., 2012). The prevalence of these infant sleep behaviours is high with as many as 46% of mothers reporting them when infants were 6-12-months (Martin, 2007) and 33% of Australian mothers reported these sleep behaviours in their young children between 1-2-years of age (Armstrong, Quinn, & Dadds, 1994; Symon et al., 2012). Whilst these infant sleep patterns are common, they can be demanding for mothers and the family if they lead to parent sleep disruption (Armstrong, O'donnell, McCallum, & Dadds, 1998; Meltzer & Mindell, 2007). Such sleep disruption, may increase the risk for depression, stress and anxiety in mothers.

1.2. Maternal Negative Affect after Birth

Pregnancy and post birth are critical periods when women undergo an important developmental transition taking up new life roles and responsibilities (Britton, 2008). This transition can be positive and enriching, but given the major life task of becoming a parent and caring for children, it is also a time of heightened risk for mental health issues and

negative affect, including stress, anxiety and depression (Beck, 1999; Britton, 2008; Lewis, 2014; Murray, Fiori-Cowley, Hooper, & Cooper, 1996; Najman, Andersen, Bor, O'Callaghan, & Williams, 2000). It has been reported that 13-15% of women experience anxiety when their child is 6-months old, and 4% of women report symptoms of Generalized Anxiety Disorder (Woolhouse et al., 2009; Yelland, Sutherland, & Brown, 2010). Amongst Australian mothers, 9% report intense anxiety or panic attacks when their infant is between 6-9-months old (Symon et al., 2012), with many mothers reporting that the physical and cognitive symptoms of their stress and anxiety, such as tension and incessant worry, contributed to a feeling of tiredness and exhaustion (Giallo & Vittorino, 2011). One of the common factors that has been linked to these documented increases in negative affect and mental health problems in the postnatal period, is reduced sleep quality as a result of infant waking (Armstrong et al., 1998; Armstrong, Van Haeringen, Dadds, & Cash, 1998).

1.3. Relationship between Maternal Negative Affect and Infant Sleep

The extant literature indicates that disrupted infant sleep patterns predict increases in maternal negative affect postnatally, with some studies finding this association in mothers with no reported history of depression (Dennis & Ross, 2005; Martin et al., 2007). It has been shown that infant sleep patterns impact directly on maternal sleep quality (see Study 1, section 3.4), which in turn, negatively affects maternal mood, cognition and motor function (Hiscock & Wake, 2001; Hiscock, 2010). Case control studies consistently report greater depressive symptoms in mothers of infants with inconsistent sleep patterns (Hiscock & Wake, 2001; Lozoff, Wolf, & Davis, 1985; Meltzer & Mindell, 2007; Richman, 1981). Further, mothers of children with unpredictable sleep patterns are twice as likely to report clinically significant symptoms of depression (Hiscock & Wake, 2001; Lam et al., 2003; Martin et al., 2007), and to experience higher levels of stress and caregiver overload (Sinai & Tikotzky, 2012). A recent study of mothers attending paediatric outpatient sleep clinics found

that 40% of these mothers reported depressive symptoms. Moreover, sleep intervention studies suggest that improvements in child sleep patterns can reduce maternal depression (Armstrong, Van Haeringen, et al., 1998; Hiscock & Wake, 2001; Hiscock et al., 2007; Martin et al., 2007; Symon et al., 2012).

There is also evidence which indicates that maternal negative affect is predictive of unsettled child sleep patterns, especially when maternal negative affect is elevated during pregnancy (Armstrong et al., 1998; Lewis, Galbally, & Bailey, 2012). Numerous studies show that maternal depression and anxiety are modifiable risk factors in the development of disrupted sleep patterns in infants (Armstrong, O'donnell, et al., 1998; Bayer et al., 2011; Pinheiro et al., 2011).

1.4. Gaps in the Literature and the Current Paper

To date, most studies have examined the predictive effects of infant sleep and maternal negative affect independently (Goldberg et al., 2012; Sadeh & Anders, 1993). The extent to which the relationships between maternal negative affect and infant sleep patterns may in fact be bidirectional when assessed within the same model remains unclear (Giallo & Vittorino, 2011; Hiscock et al., 2007; Martin et al., 2007). Developmental theorists have emphasized the need for such transactional models of maternal negative affect and infant sleep to allow for assessment of potential bidirectional pathways of influence (Goldberg et al., 2012). Such models allow for more comprehensive and contextual representation of the relationship between mother and child (Goldberg et al., 2012; Sadeh & Anders, 1993) in order to better understand infant sleep patterns in the context of the wellbeing of the mother, and vice versa. This information is important when considering assessment and treatment of mothers and children in the first year post-partum (Goldberg et al., 2012).

Previous studies have begun to examine these transactional models and one study has found support for both hypothesised paths of influence between maternal negative affect and

infant sleep. Specifically, it has been found that mothers with lower wellbeing reported more sleep issues in their infants at age 6-months and 12-months (Goldberg et al., 2012). Moreover, these results were found when data was analysed both cross-sectionally and longitudinally (Goldberg et al., 2012), further supporting the idea of the need to study the two constructs together. Whilst these results are key in beginning to understand the interplay between maternal negative affect and infant sleep, some limitations must be noted. Mainly, prenatal maternal negative affect was not taken into consideration despite this period of time being of great importance for mothers and children (Goldberg et al., 2012) and infant sleep was measured only by maternal ratings of quality. No measures of sleep duration or frequency were included, reducing the objective nature of measurement.

Considering the literature on infant sleep more generally, few studies have examined the natural development of early infant sleep patterns, focusing on the later pre-school and adolescent ages, many come from small samples, or from samples of infants with clinical sleep problems only (Jenkins, Owen, Bax, & Hart, 1984; Kosten, Rounsaville, & Kleber, 1987; Lam et al., 2003; Zuckerman, Stevenson, & Bailey, 1987).

Given infancy is a critical time when sleep patterns are first established and potential disturbances may first begin to emerge, and mothers are vulnerable to changes in their affect and wellbeing, understanding the relationship between these constructs is important. This may help shape assessment practices for the wellbeing of mothers and infants in the postnatal period. Further, understanding the direction of these relationships may better inform the need for potential psychological or sleep intervention for mothers and infants.

The aim of the current paper was therefore to (1) prospectively examine the relationship between infant sleep patterns and maternal negative affect through the first year of life; and, (2) determine the direction of these relationships.

2. Method.

2.1. Participants

Data for this study were drawn from The Triple B Pregnancy Cohort Study, an NHMRC funded longitudinal study. See Study, 1section 2, for details regarding participants, recruitment, data collection, sample characteristics and ethics approval.

2.2. Measures

2.2.1. Maternal negative affect.

Maternal negative affect was measured using the seven item anxiety and stress subscales from the Depression and Anxiety Stress Scales (DASS) (Lovibond & Lovibond, 1995) and the Edinburgh Postnatal Depression Scale (EPDS) (Cox, Holden, & Sagovsky, 1987). The anxiety and stress subscales of the DASS, each have a maximum score of 21, with higher scores suggesting higher presence of stress and anxiety symptoms. The EPDS has a total possible score of 30, with higher scores suggesting higher presence of depressive symptoms. These were completed by mothers through self-complete questionnaires during pregnancy, at 8-week and 12-month follow up. The DASS subscales have been shown to be a psychometrically reliable and valid measure of maternal anxiety and stress (Crawford & Henry, 2003). Cronbach's alpha for the stress scales during pregnancy, 8-week and 12-month follow up was 0.84, 0.84 and 0.86 respectively. Cronbach's alpha for the anxiety scales during pregnancy, 8-week and 12-month follow up was 0.65, 0.61 and 0.79 respectively.

The EPDS has been shown to be a valid screening measure of depression in postnatal women, at longitudinal follow up time points past birth, as well as in non-postnatal women (Cox, Chapman, Murray, & Jones, 1996). The EPDS is widely used both in clinical and research settings (Parry & Piontek, 2002). Cronbach's alpha for the EDS during pregnancy, 8-weeks and 12-months was 0.83, 0.82 and 0.82 respectively.

2.2.2. Infant sleep patterns.

Infant sleep patterns were measured at the 8-week and 12-month follow up interviews. Mothers were asked to answer questions about their infant's sleep in the first 8-weeks of life (8-week interview), at age 2-6-months and age 9-12-months (12-month interview). Questions about the frequency and length of daytime and night time sleeps were adapted from the Brief Infant Sleep Questionnaire (Sadeh, 2004) which has been validated against actigraph sleep studies as a valid and reliable screening measure of infant sleep (Lomeli et al., 2008; Sadeh, 2008). The reported length of day and night sleeps were combined to calculate the total amount of sleep infants had on average over a 24-hour period. Additionally mothers were asked to rate on a 10-point likert scale (1=poor/large problem, 10 =excellent/no problem) the quality of their child's sleep, their own sleep quality, and the extent to which they perceived their child's sleep as problematic.

2.2.3. Covariates.

During pregnancy mothers were asked about their level of education and the number of biological children (parity). These factors have been known to be associated with maternal stress, depression and anxiety during pregnancy (Britton, 2008; Solem & Christophersen, 2011) and were included in later analyses. Specifically these variables were included to determine whether the relationship between maternal negative affect and infant sleep patterns maintained after accounting for education and parity.

2.3. Statistical Analyses

SPSS (IBM Corp, 2013) was used to conduct descriptive statistics and test statistical assumptions. One item in the EPDS had missing data for 59 cases (13%). Mean substitution was used to handle this missing data, such that the mean scale score for a participant was used to substitute the missing score for that participant. Square root transformations were used to normalise skewed distributions. Analyses were then conducted on both transformed and untransformed data. Both techniques produced similar results and so untransformed

results have been reported for ease of understanding. Structural equation modelling was used to investigate the fit of various models to explain the interrelations amongst maternal negative affect and infant sleep using AMOS (IBM SPSS Amos, 2012). Maximum likelihood estimation was used for all models. To arrive at a model that best represented the predictive relationships between maternal negative affect and infant sleep, four models were compared. First, a theoretical model was fitted which measured the extent to which infant sleep predicted maternal negative affect. Second, a model was fitted which examined the extent to which maternal negative affect predicted infant sleep. Finally two bidirectional models were fitted which measured the predictive relationship between maternal negative affect and infant sleep, such that both constructs predicted each other. To do this, all possible bidirectional relationships (model 3) and then only the more proximal (i.e., to the next two consecutive time points) bidirectional relationships were measured (model 4). In the best fitting model, maternal years of education and number of biological children at the time of pregnancy were included to determine whether relationships changed once these factors were considered (model 5). Error terms were inter-correlated for each measurement variable (i.e., all depression errors were inter-correlated, all anxiety errors were inter-correlated and so on).

2.3.1 Fit statistics.

The chi-square test assesses the magnitude of discrepancy between the sample and fitted covariance matrices and was used to assess global model fit, where small or non-significant values indicate adequate model fit (Hu & Bentler, 1995). As the chi-square test of fit is sensitive to large sample sizes (Hoyle, 1995; Kline, 1998; Schermelleh-Engel, Moosbrugger, & Müller, 2003) other fit statistics were also used to assess model fit. Measures of fit included the root mean square error of approximation (RMSEA), the root mean square residual (RMR), goodness of fit index (GFI), the adjusted goodness of fit (AGFI), the comparative fit index (CFI) and the normed fit index (NFI). The RMSEA is a

parsimony-adjusted index, which is often referred to as a "badness of fit" index, whereby values closer to 0 indicate best fit and higher values indicate worse fit. Literature suggests that RMSEA values of less than 0.05 represent close approximate fit, and values between 0.05 and 0.08 suggest reasonable fit (Browne & Cudeck, 1992; MacCallum, Browne, & Sugawara, 1996). The RMR is a measure of the mean absolute value of the covariance residuals, with a value of 0 meaning perfect model fit and higher values indicating worse fit. Values less than 1.0 are generally considered to indicate favourable model fit (Hu & Bentler, 1995; MacCallum et al., 1996). AGFI and GFI are measures of absolute fit, which assess how well an a-priori model reproduces the sample data. The CFI and NFI are incremental fit indexes, which assess the relative improvement in fit between the target model against the restricted baseline model (Hoyle, 1995; MacCallum et al., 1996). The GFI, AGFI, CFI and NFI result in values between 0 and 1, with values higher than 0.9 representing reasonable fit (Bentler, 1990; MacCallum et al., 1996; Schermelleh-Engel et al., 2003).

3. Results.

3.1. Descriptives of Infant Sleep and Maternal Negative Affect

As previously discussed in Study 1,section 3.2, infant sleep patterns were consistent with those in international studies in which infants aged 12-months were sleeping between 12-14 hours in a 24-hour period, having between 1-2 night time sleeps and between 1-3 different day time sleeps (Galland et al., 2012; Teng et al., 2012). Table 1 shows that that generally mothers in the sample were reporting low levels of negative affect.

Table 1
Descriptive Statistics for Maternal Negative Affect

	Pregnancy	8 weeks	12 months
Depression			
Mean	4.38	4.03	4.65
SD	3.83	3.78	3.78
Anxiety			
Mean	4.39	1.56	2.03
SD	4.75	2.86	4.14
Stress			
Mean	8.66	7.08	8.04
SD	7.20	6.39	7.19

3.2. Measurement Model

A two-step approach was used, such that first the measurement model (see Figure 1) was verified before fitting a structural model which allowed for relationships between the latent variables. A theoretical measurement model was hypothesized by specifying the relationship between constructs and choosing indicator variables which would produce the latent constructs of maternal negative affect and infant sleep. The construct of maternal negative affect was developed using the indicator variables of maternal scores of stress, anxiety and depression. The construct variable of infant sleep was developed using the indicator variables of total sleep over 24-hours, maternal rating of infant sleep quality, and maternal ratings of the extent to which infant sleep was a problem. To assess the full measurement model and to determine the reliability of the latent constructs the amount of variance (R^2) for each indicator variable that was explained by the construct variable was examined (Table 2). All indicator variables accounted for a reasonable proportion of variation in the latent construct variables (Cohen, 1992) and the fit of the measurement model was adequate (Table 3) and thus was used in further analyses.

Table 2
Variance (R^2) in the Indicator Variables Accounted for by the Outcome Constructs of Maternal Negative Affect and Infant Sleep

	Maternal constructs		
	Pregnancy	**8-weeks**	**12-months**
Maternal negative affect			
Depression	0.79**	0.81**	0.73**
Stress	0.89**	0.88**	0.91**
Anxiety	0.56**	0.62**	0.68**
	Infant constructs		
	0-8 weeks	**2-6 months**	**9-12 months**
Infant sleep			
Sleep over 24 hours	0.22**	0.41**	0.38**
Quality rating	0.87**	0.87**	0.95**
Problem rating	0.81**	0.91**	0.97**

** $p < 0.01$.

Table 3
Fit Indices of the Measurement Model

x^2 (df)	**CMIN/ DF**	**N**	**P**	**RMSEA**	**RMR**	**GFI**	**AGFI**	**CFI**	**NFI**
295.60 (113)	2.62	448	0.00	0.06	1.42	0.94	0.90	0.96	0.93

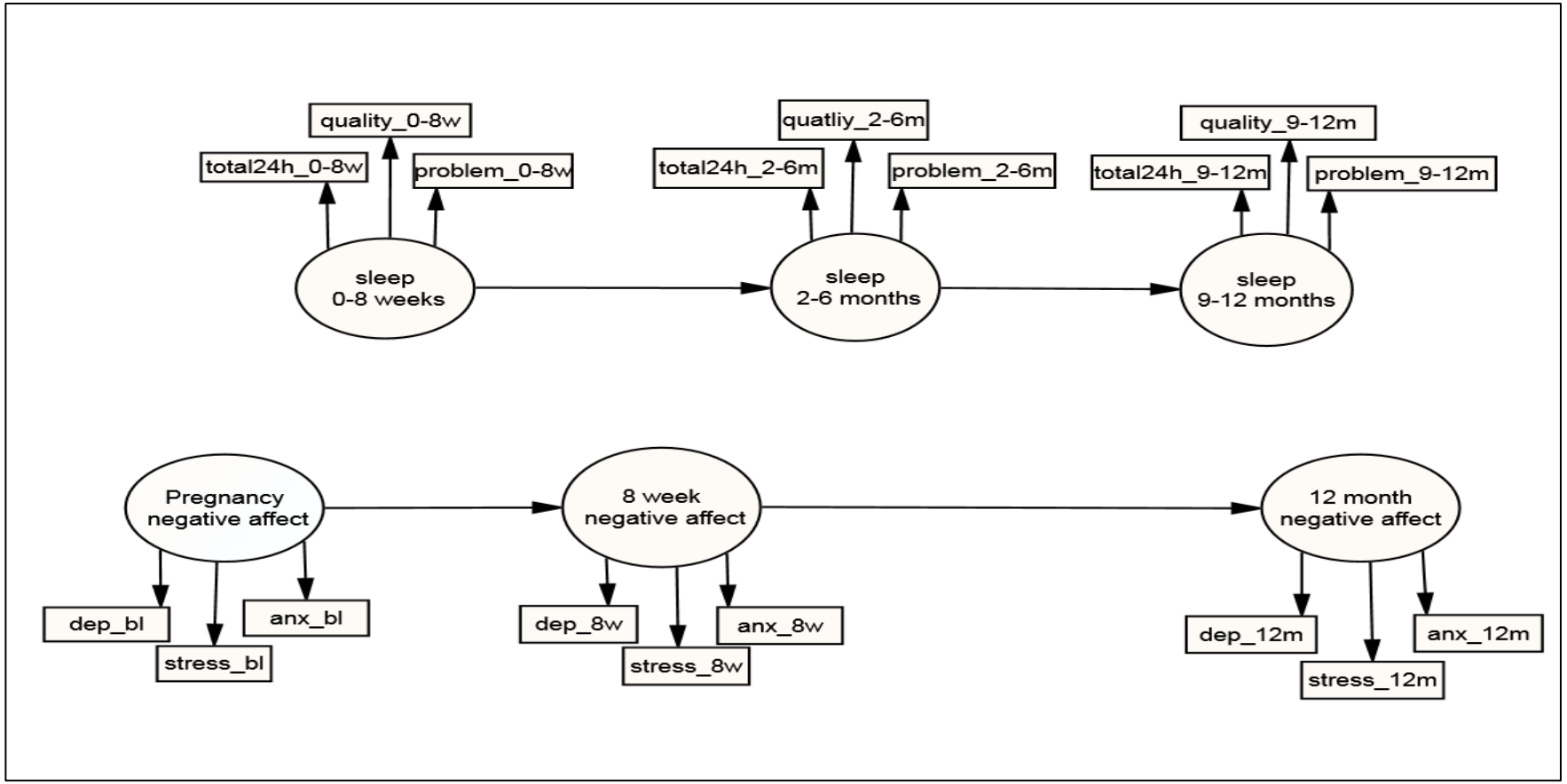


*Figure 1***.** Measurement model

3.3. Model 1: Infant Sleep Predicts Maternal Negative Affect

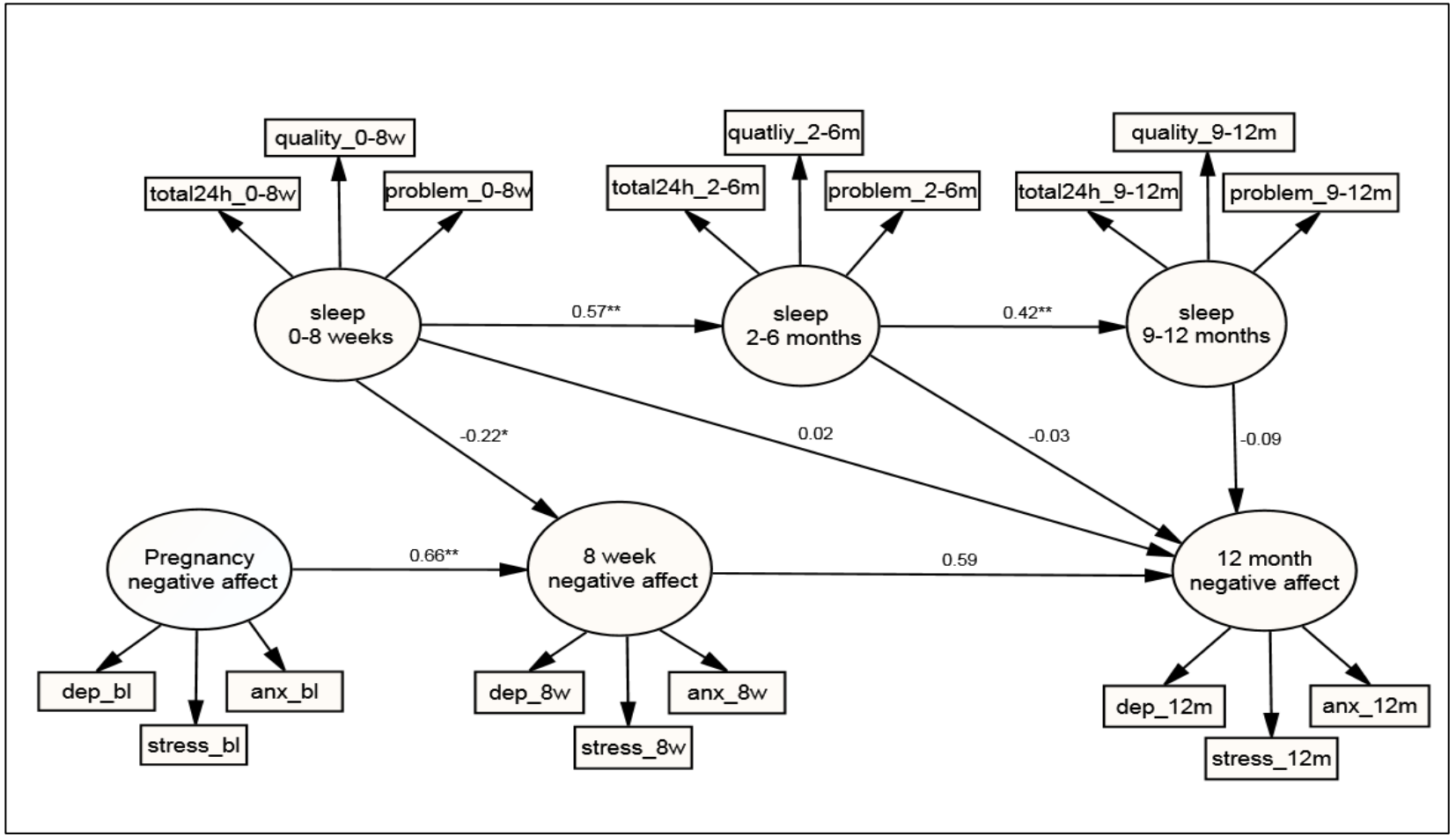
This model examined the extent to which infant sleep predicted maternal negative affect (see Figure 2). All pathways in this model were non-significant except for the pathway between infant sleep at birth-8 weeks to maternal negative affect at 8-weeks (β = -0.216, p = 0.001). The pathway between sleep at 9-12-months to maternal negative affect at 12-months approached significance (β = -0.09, p = 0.058). The fit statistics of model 1 (GFI, NFI, AGFI and CFI >0.9) suggest a reasonable fit, although one that is not considered ideal (RMSEA >0.5, RMR >1). Model 1 was the poorest fitting model of all the models tested.

3.4. Model 2: Maternal Negative Affect Predicts Infant Sleep

This model examined the extent to which maternal negative affect predicted infant sleep (see Figure 3). All pathways in this model were non-significant except for the pathway between maternal negative affect in pregnancy and infant sleep at birth-8 weeks (β = -0.237, p = 0.002). The fit statistics of the model suggest reasonable fit (GFI, NFI, AGFI and CFI >0.9, RMSEA >0.5, RMR <0.1).

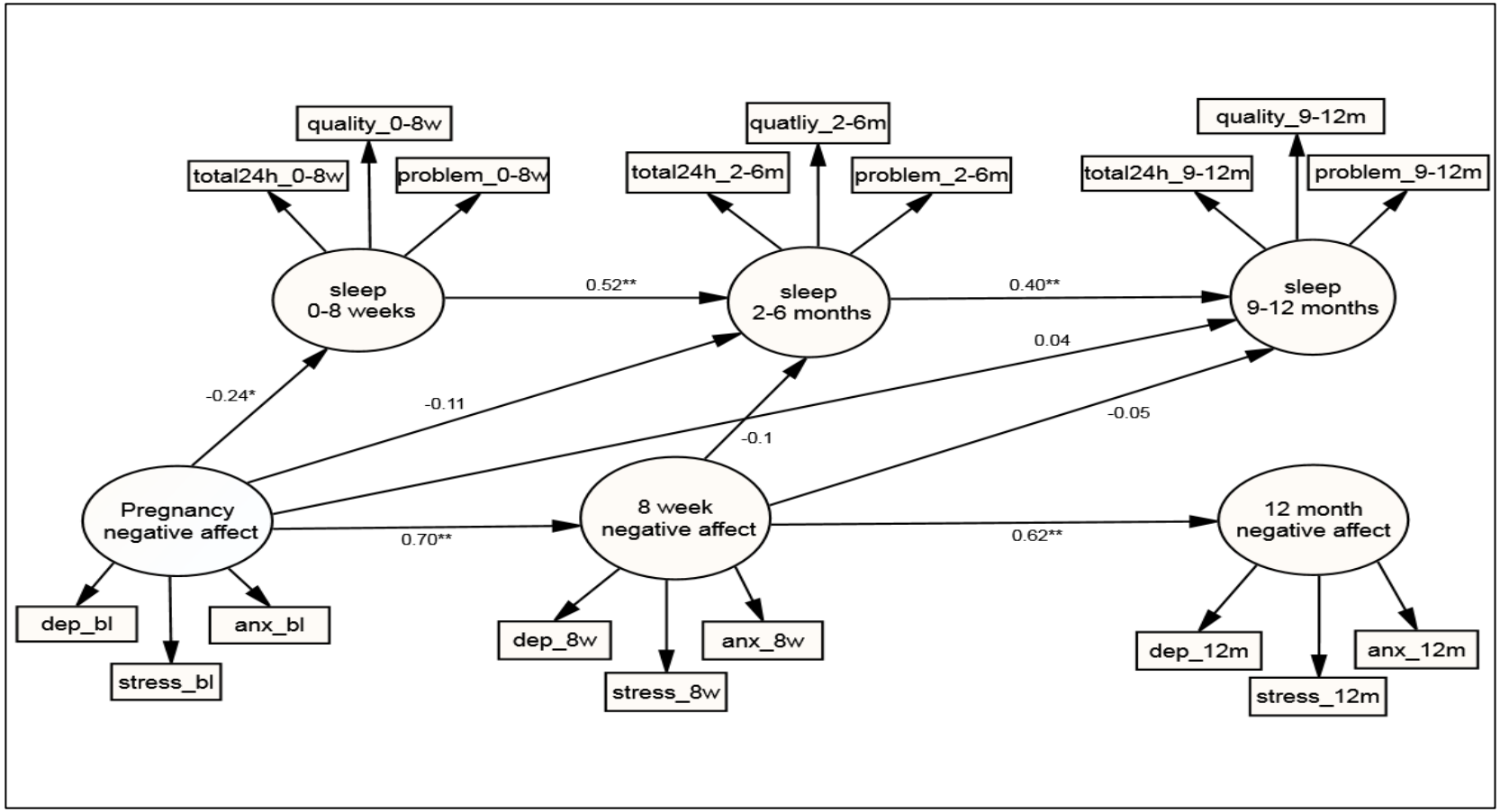
3.5. Model 3: All Possible Bidirectional Relationships

This model examined all possible bidirectional relationships between maternal negative affect and infant sleep across the first year of life (see Figure 4). Significant pathways included maternal negative affect during pregnancy to infant sleep at birth-8 weeks (β =-0.214, p = 0.004) and infant sleep at 2-6-months (β = -0.144, p = 0.036), and infant sleep at birth-8 weeks to maternal negative affect at 8-weeks (β = -0.193, p = 0.002). All other pathways were non-significant. The fit statistics suggested improved fit on earlier models (RMR = 0.081, RMSEA = 0.053, GFI, NFI, AGFI and CFI >0.9).



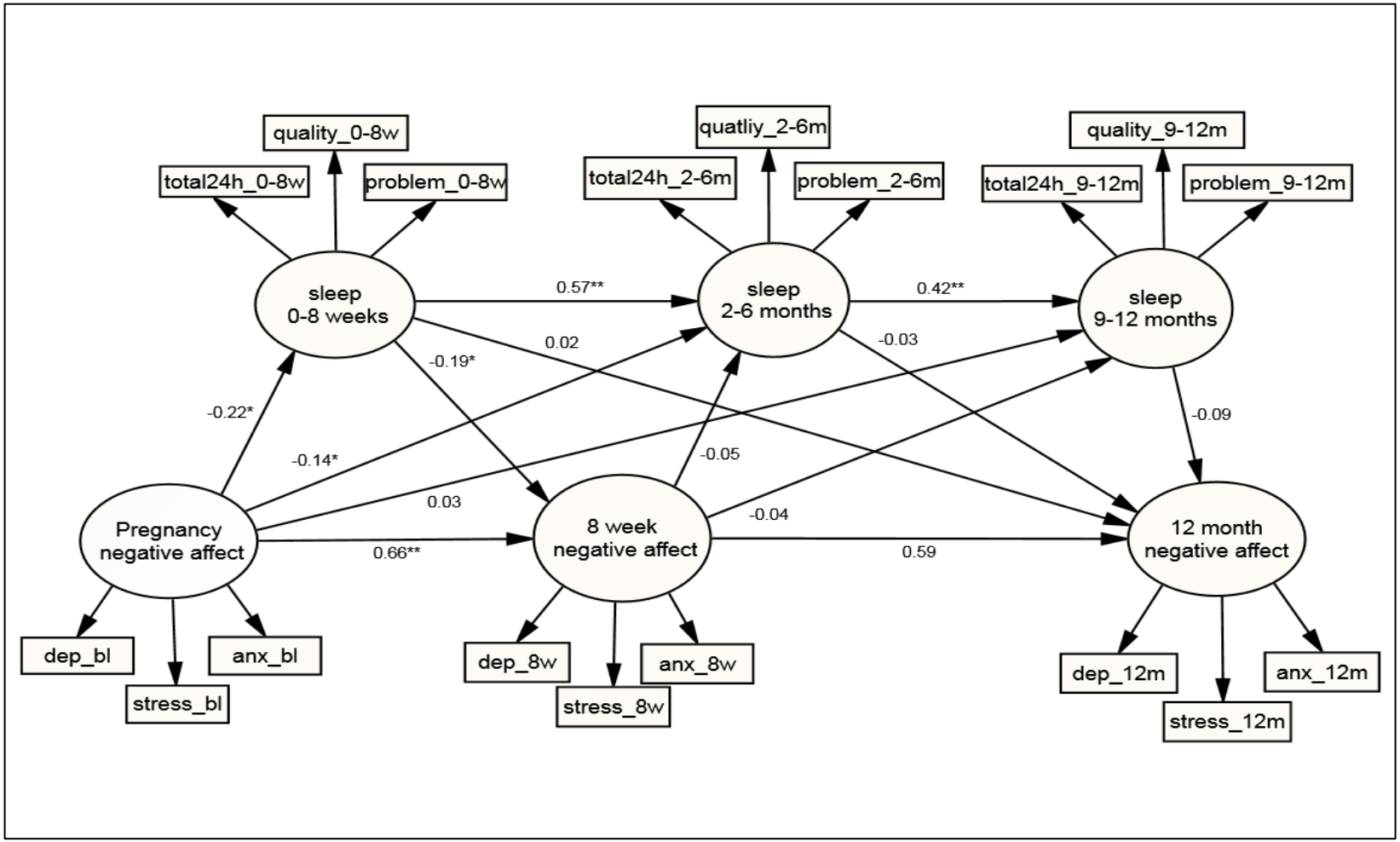
*p<0 .05, ** p< 0.01.

Figure 2. Regression weights for model 1: Infant sleep predicting maternal negative affect.



*p<0 .05, ** p< 0.01.

*Figure 3***.** Regression weights for model 2: Maternal negative affect predicting infant sleep.



* p<0 .05, ** p< 0.01.

Figure 4. Regression weights for model 3: Full bidirectional model; maternal negative affect and infant sleep predict each other.

3.6. Model 4: Proximal Bidirectional Relationships

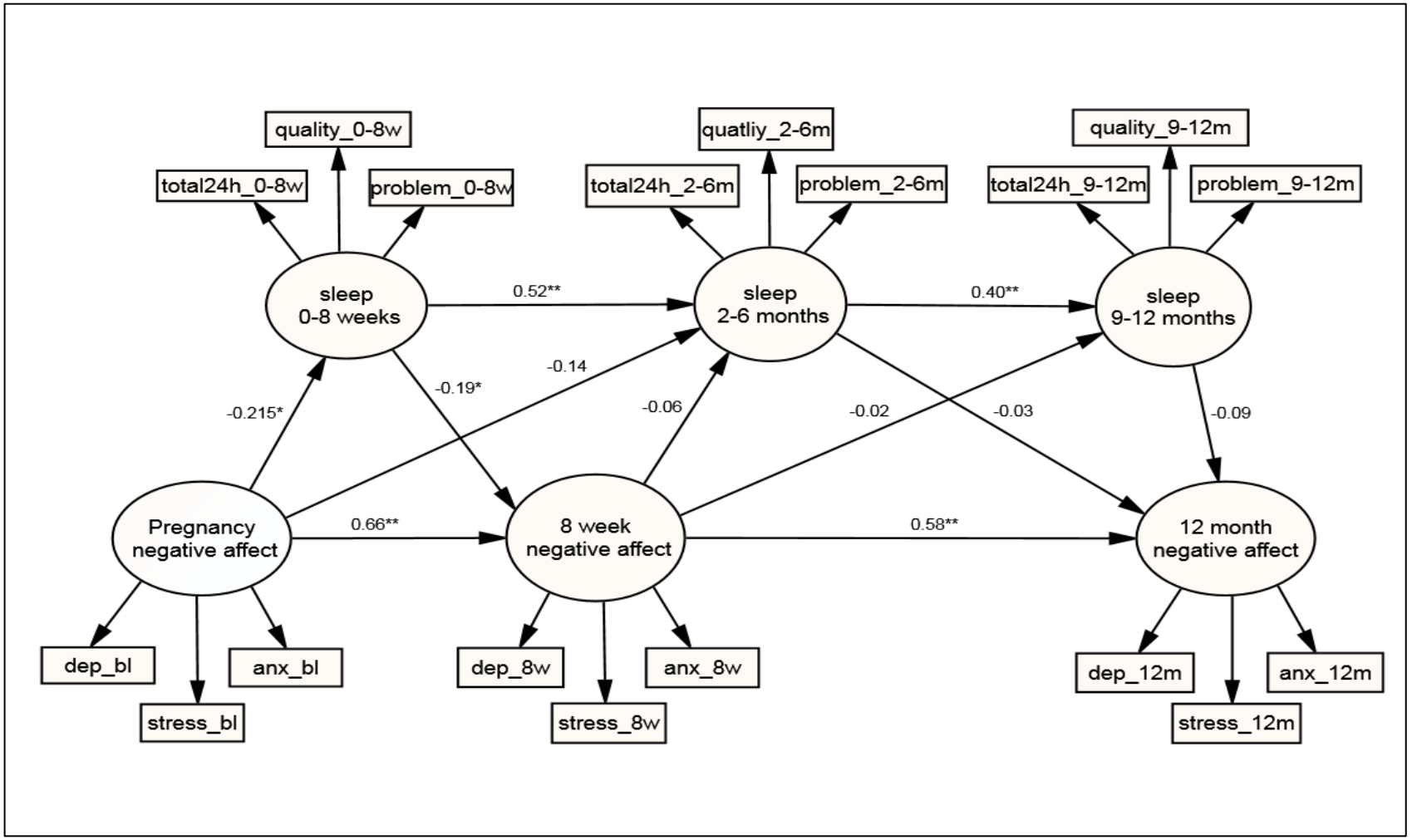
Given the previous models indicated that the predictive effect of both negative affect and sleep did not continue through the first year of life, a more parsimonious model was fitted which measured the proximal bidirectional relationships (i.e. to the next two consecutive time points). That is, the paths from pregnancy negative affect to sleep at 9-12-months, and from infant sleep at birth-8 weeks to negative affect at 12-months were excluded (see Figure 5). This model was the best fitting model (RMSEA = 0.052, RMR = 0.81, GFI, NFI, AGFI and CFI >0.9) although it was very similar to model 3 (full bidirectional). In this model significant pathways included that of maternal negative affect at pregnancy to infant sleep at birth-8 weeks (β = -0.215, p = 0.004) and infant sleep at 2-6 months (β = -0.141, p = 0.039), and infant sleep at birth-8 weeks to negative affect at eight weeks (β = 0.191, p = 0.002).

3.7. Model 5: Proximal Bidirectional Relationships with Confounds

The best fitting model (model 4) was then re-run, this time controlling for maternal years of education and number of biological children at the time of pregnancy. As Figure 6 shows, these variables were not significantly related to maternal negative affect during pregnancy and when controlling for these variables, all significant pathways from the previous model remained significant.

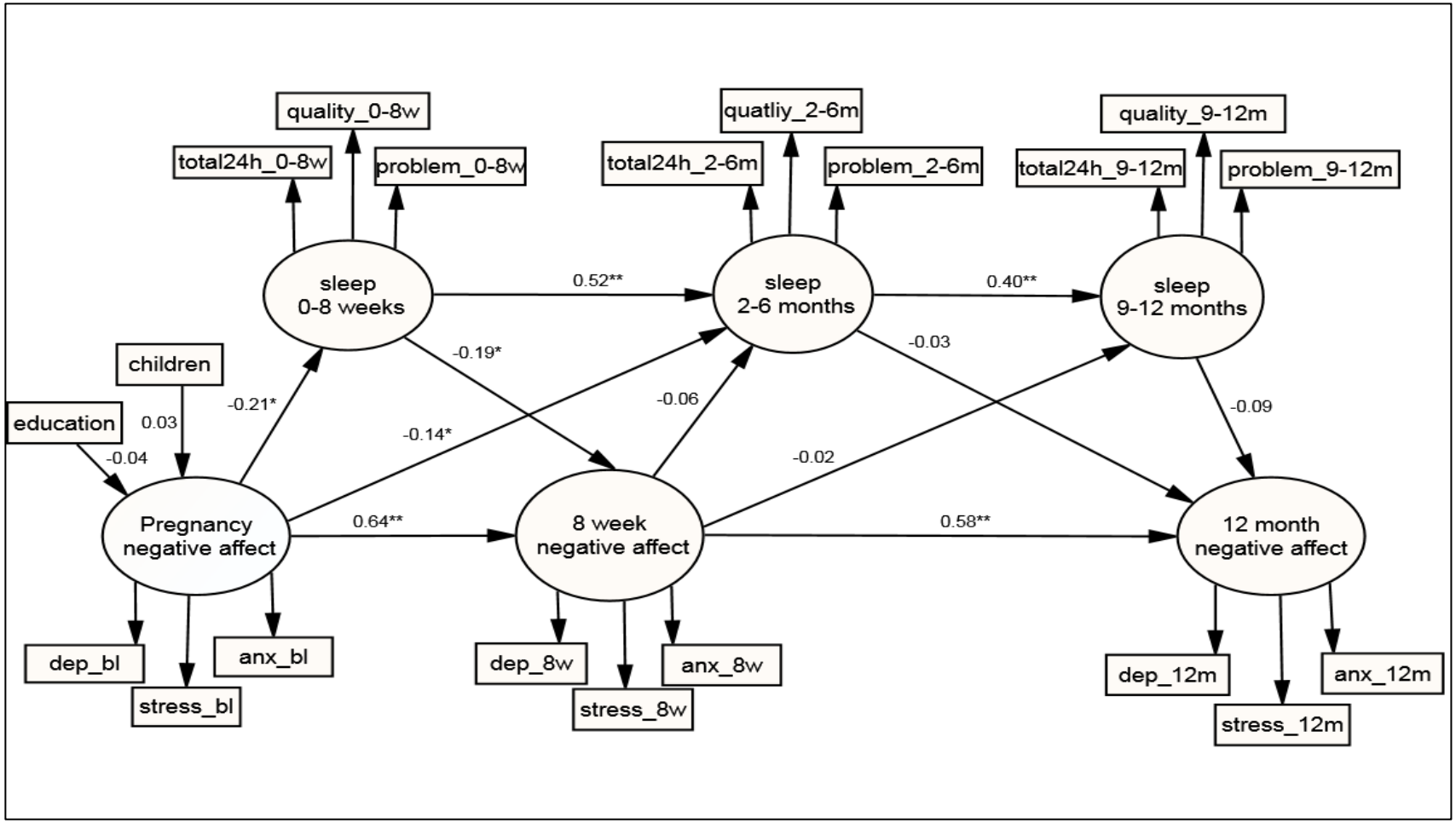
Although all models had reasonable fit, the best fitting were models 3 and 4, which measured the bidirectional relationship between maternal negative affect and infant sleep. Moreover, of these two models, the most parsimonious model was model 4 which examined the bidirectional relationships over shorter-periods of time. As a final check on the impact of data distribution, the best fitting models were re-analysed using un-weighted least squares, which takes into account deviation from normality (Schermelleh-Engel et al., 2003). This

analysis provided similar results, and supported model fit and standardized regression weights of significant pathways.



*p<0 .05, ** p< 0.01.

*Figure 5***.** Regression weights for model 4: Short-term bidirectional model.



* p<0 .05, ** p< 0.01.

Figure 6. Regression weights for model 5: Full bidirectional model with confounds.

4. Discussion.

The results of the current study support the idea that bidirectional relationships between maternal negative affect and infant sleep exist. Model 4 examined the short term bidirectional relationships between maternal negative affect and infant sleep. This model showed some of the strongest fit indices and the existence of bidirectional relationships. Specifically, maternal negative affect during pregnancy predicted poorer infant sleep at birth-8-weeks and 2-6-months, and poor infant sleep at birth-8-weeks predicted poorer maternal negative affect at 8-weeks. The final model, model 5, re-fit model 4 controlling for the effect of maternal education and pre-existing children on maternal negative affect during pregnancy. These factors have been known to be associated with maternal stress, depression and anxiety during pregnancy (Britton, 2008; Solem & Christophersen, 2011), and hence were important to be accounted for when considering the relationship between maternal negative affect and infant sleep. Results of model 5 were similar to model 4, and all significant pathways remained significant. This indicates that even when accounting for maternal education and other biological children, the bidirectional relationship between maternal negative affect and infant sleep in the early postnatal period remains. Results support the notion of assessing for maternal negative affect and infant sleep disruptions in the postnatal period, but also the importance of considering these constructs in the context of each other.

Taken together, the results of this study highlight the importance of assessing transactional models (Goldberg et al., 2012; Sadeh & Anders, 1993), which allow examination of infant sleep and maternal mental health in the context of one another (Armstrong et al., 1998). The current results also show the importance of the antenatal and early postnatal period for the wellbeing of the mother and the child. Specifically, we found the strongest predictor of maternal negative affect in the first year of the infant's life was

prior negative affect. This is consistent with previous research, which indicates that poor maternal mental health during pregnancy is indicative of poorer mental health postnatally (Armstrong et al., 1998). Furthermore, despite the fact that infant sleep patterns were somewhat changeable over time, the strongest predictor of sleep at 12-months was earlier reported sleep patterns. This is consistent with past research emphasizing the importance of the early postnatal period for the development of the child, as well as the wellbeing and health of mothers (Dawson, Ashman, & Carver, 2000; Gale, O'Callaghan, Godfrey, Law, & Martyn, 2004; Murgatroyd & Spengler, 2011). These results suggest that early education and preventative intervention may be of benefit where maternal mental health or infant sleep problems are detected.

4.1. Strengths and Limitations

Although this study used a large sample with infant sleep and maternal negative affect measured at multiple time points across the first year of life, there are some limitations. First, infant sleep and maternal negative affect were measured using maternal report rather than medical or biological measurement techniques and thus may have been subjected to social bias in responding in regards to sleep quality, as well as lack of parental knowledge regarding exact duration and frequency of sleep. However, the BISQ from which the questions were derived, has been validated against biological methods including actigraph studies, and has been shown to be a valid and accurate measure of infant sleep (Sadeh, 2004). Further, the DASS and EPDS have been shown to be psychometrically valid and reliable tools for the assessment and diagnosis of depression, anxiety and stress and are frequently used in clinical and research settings for this purpose (Cox et al., 1996; Crawford & Henry, 2003; Lovibond & Lovibond, 1995). Second, the current sample was drawn from New South Wales, and was also an advantaged sample, comprised of families from predominantly middle to high socio-

economic background. Replication in other geographical areas and socio-demographic groups is recommended to determine the generalisability of the findings.

4.2. Clinical Implications

The results of the current study clearly show evidence of bidirectional relations between maternal negative affect and infant sleep measured in a prospective pregnancy cohort throughout the first year of life. The results highlight the need for both constructs to be considered in the context of one another when assessing infant sleep problems and/or maternal mental health. Further, the results are consistent with a systemic model of the way a young infant interacts with its environment. Future research should expand on this, investigating possible mediators in this relationship (E.g. maternal sleep). The results further support the importance of early intervention for maternal mental health during pregnancy, as well as potential intervention for infant sleep problems in the early postnatal period. Indeed, the first eight weeks of life appear to be a period of heightened risk for the wellbeing of mothers and infants as demonstrated by the strength of the bidirectional relationships at this time. Education with mothers and families at this time may be helpful to create realistic expectations about the challenges of the transition post-birth and to normalise the natural variability in infant sleep patterns in the first year of life.

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STUDY 3

Target journal: Infant and Child Development

Title: Infant sleep in the first year of life: Prediction of infant development at 12-months of age

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Key words: *Infant sleep, infant development, cognition, language*

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Abstract

Introduction and Aims: The importance of sleep for young children has been well documented. Studies suggest that sleep quality plays a crucial role in the cognitive and physical development of a young child. To date most studies focus on the early post-natal period or the later pre-school years. Given the important role sleep plays in executive functioning, it is important to also study child sleep patterns in the critical early developmental window when a child often reaches important milestones such as walking and talking. The aim of the current study is to examine the predictive relationship between infant sleep patterns from birth to 12-months of age, on infant development at 12-months of age.

Design and Methods: Pregnant women were recruited through general antenatal services in New South Wales, Australia, and interviewed during pregnancy, at infant age 8-weeks, and infant age 12-months. Information was gathered from mothers on demographics, mental health (Depression Anxiety and Stress Scales and Edinburgh Depression Scale) and infant sleep (adapted from Brief Infant Sleep Questionnaire). When children were 12-months old the Bayley Scales of Infant and Toddler Development (BSID-III) was administered.

Results: Structural equation modelling examined the association between infant sleep from birth to 12-months and child scores on the BSID-III at 12-months of age. Infant sleep patterns from birth to 8-weeks were significantly related to infant cognitive and language development at 12-months, and remained when controlling for potential confounds.

Discussion and Conclusions: Taken together, the results of the current study present novel discoveries regarding infant sleep in the first year of life, and highlight the importance of sleep in the development of cognition and language in early infancy.

Key words: *Infant sleep, infant development, cognition, language*

1. Introduction.

1.1. Importance of Early Infant Development

Early infancy has been acknowledged as a critical time of development in a child's life, with immense neuronal interconnectivity occurring soon after birth (Chugani, 1998; DiPietro, 2000). In fact, neonates are born with an estimated 100 billion neurons, but connection (or interconnectivity) does not occur until the early years after birth (Herschkowitz, 1988). Although the brain of a young infant weighs only 25% of an adult brain, the infant undergoes such rapid maturation and development, that by age three, synapse interconnectivity is 50% greater than in the adult brain (DiPietro, 2000). Healthy development during this time has been associated with a myriad of positive outcomes through the life course (Barker, 2004; Lewis, Galbally, Gannon, & Symeonides, 2014). These include optimal physical health, psychosocial adjustment, academic achievement, and occupational success (Lewis, & Olsson, 2011; National Scientific Council on The Developing Child, 2007; World Health Organization, 2008). A recent review found that many characteristics of human development remain consistent over time and are strongly associated with later developmental trajectories and outcomes (Bornstein, 2010). Specifically, 50% of adult intelligence is developed by 4-years of age (Bloom, 1964) and IQ at age three predicts educational and occupational attainment at age 27 (McCall, 1977). Additionally, developmental performance in the first year of life, has shown strong associations with later motor skills, cognitive skills, language and communication, attention capacity, and educational and occupational outcomes (Piek, Gasson, Barrett, & Case, 2002; Rose-Jacobs, Cabral, Beeghly, Brown, & Frank, 2004). Numerous studies have found that performance on early developmental measures of cognition, language, and motor skills predict later development and performance on psychometric assessments (Bornstein, 2010). Specifically, scores on the Bayley Scales Mental Development Index (a component of the Bayley-II)

administered between four to 12-months of age, predict sores on the Reynell Developmental Language Scales at two, three, and four years of age (Siegel, 1992; Siegel, 1981), the Stanford Binet at three years of age, the McCarthy Scales of Children's abilities at four years of age, and the Wechsler Preschool and Primary Scale of Intelligence at four, five and six years of age (Bornstein, 2010; Wilson, 1978).

1.2. Sleep and Infant Development

Sleep allows the body to decrease activity, conserve energy, and aids the physical and mental health of young infants (Imeri & Opp, 2009; Maquet, 1995; Siegel, 2005). Further, sleep plays a crucial role in the development of the young infant brain (Dahl, 1996b). Sleep facilitates processes such as neural repair and growth, memory consolidation, and development of early sensory systems (Curcio, Ferrara, & De Gennaro, 2006; Fenn, Nusbaum, & Margoliash, 2003; Graven & Browne, 2008; Penn et al., 2002; Stickgold & Walker, 2005; Tarullo, Balsam, & Fifer, 2011). As intellectual functioning has been shown to be relatively consistent across the lifespan (DiLalla, Thompson, Plomin, Phillips, & et al, 1990; Freudigman & Thoman, 1993), early sleep quality is important given the significant role it plays in early brain development (Mindell et al., 2011). That is, the potential for infant sleep to promote or hinder infant development, may have a long lasting effect, which extends into later development and intellectual functioning. In fact, sleep wake states amongst 34 premature Israeli infants (32 and 36 weeks gestation) have been shown to be predictive of scores on the Mental Development Index of the Bayley Scales of Infant Development at 6-months of age. Specifically, lower duration of night sleep and high activity level at night were predictive of higher mental development scores at a chronological age of 6 months. These results suggest that early maturation of sleep patterns (as indicated by decreased amount of sleep and higher activity levels) is associated with later cognitive development (Gertner et al., 2002). Similarly, unconsolidated sleep and, poor sleep patterns (i.e.

fragmented and disrupted sleep), have been associated with decreased daily functioning, poor academic performance, decreased emotional regulation and increased behavioural problems and psychopathology in pre-schoolers and adolescents (Beebe, 2011; Dahl, 1996a; Dewald, Meijer, Oort, Kerkhof, & Bogels, 2010; Ednick, Cohen, & McPhail, 2009; Gibson, Elder, & Gander, 2012a; Sadeh, et al., 2015; Mindell et al., 2011). The child development literature suggests that sleep has an important influence on critical aspects of infant development, including cognition and language, and development of social-emotional and adaptive behaviour (Ednick et al., 2009; Freudigman & Thoman, 1993; Moore, Allison, & Rosen, 2006; Sadeh & Anders, 1993). Research on infant sleep in each of these developmental domains is described below.

1.2.1. Cognitive development.

Executive functioning refers to higher order cognitive processes such as set shifting, impulse control and working memory, all of which allow for self-monitoring and control, and are vital to the daily functioning of a child (Bernier, Carlson, Bordeleau, & Carrier, 2010; Garon, Bryson, & Smith, 2008; Zelazo, Carter, Reznick, & Frye, 1997). Cross-sectional studies on sleep and its relationship with cognition show that fragmented and disrupted sleep in infancy is associated with poorer executive functioning (Bernier et al., 2010; Randazzo, Muehlbach, Schweitzer, & Walsh, 1998; Sadeh, Raviv, & Gruber, 2000). These associations are also evident in longitudinal studies, with a recent study of 43 infants from Tel Aviv and Helsinki combined, finding that low qualtiy sleep in early infancy (at age 12-months) predicted poor executive fucntion and attention regulation skills at 3-4-years old (Sadeh et al., 2015). Further, cross-sectional studies of infant sleep at 10 and 12-months of age found that infants with disturbed sleep had lower mental developmental index scores on the Bayley Scales of Infant Development II (BSID-II)(A Scher, 2005; Spruyt et al., 2008). Moreover, sleep efficiency (total sleep time divided by time in bed) was positively associated with

development of problem solving skills in 12-month old infants (Gibson, Elder, & Gander, 2012). To date, most studies investigating infant sleep and cognitive development have been cross-sectional, and hence stability and predictability between the two constructs is difficult to ascertain.

1.2.2. Language development.

High sleep quality has consistently been associated with improved infant memory consolidation (Dearing, McCartney, Marshall, & Warner, 2001; Freudigman & Thoman, 1993; Scher, 2005; Touchette, Petit, Séguin, & Boivin, 2007) and higher order functioning (Porges, 1996). This in turn impacts the infant's ability to attend to and process language during social interactions (Dionne et al., 2011). One study found that sleep was necessary to the abstraction process, whereby infants are able to sustain sensitivity to exposed rules of language and generalise this to similar scenarios (Gómez, Bootzin, & Nadel, 2006). Further, one longitudinal study of 62 infants from Massachusetts, found that increased consolidation of sleep frequency and duration at seven and 19-months, has been associated with language development scores at 36-months (Dearing et al., 2001). However, it must be noted that parent-report for this study was based on surveys answered by both mothers (77%) and fathers (23%), although no analyses were conducted to determine if there were any reporting differences between the two groups. Further, only maternal demographic factors were controlled for, despite some measures being based on paternal report.

1.2.3. Motor development.

While sleep quality has been consistently associated with the development of procedural learning in adults (Walker et al., 2003; Walker, Brakefield, Morgan, Hobson, & Stickgold, 2002), studies with young children are scant. Some evidence suggests that parents of children with disturbed motor control report disturbed sleeping patterns in the child (Palm, Persson, Bjerre, Elmqvist, & Blennow, 1992), while other studies suggest motor development

is more closely linked to the physical position in which an infant sleeps than to sleep quality itself (Davis, Moon, Sachs, & Ottolini, 1998). Regardless, it is clear that more research examining the relationship between infant sleep and motor development is needed.

1.2.4. Social-emotional and adaptive behavioural development.

Clinical treatment studies have shown associations between sleep loss and emotional problems in children including depression, low self-esteem, anxiety and aggressive behaviour (Fredriksen, Rhodes, Reddy, & Way, 2004; Gregory, Van der Ende, Willis, & Verhulst, 2008; Vriend et al., 2013). Further, sleep loss and fragmented sleep, have been associated with decreased social skills and communication (Schreck, Mulick, & Smith, 2004), with clinically disturbed sleep (such as insomnia or delayed sleep latency) being a marker of disorders characterised by social deficits, such as Autism Spectrum Disorder (Richdale & Schreck, 2009). Moreover, disturbed sleep in children often manifests through behaviours similar to symptoms of Attention Deficit Hyperactivity Disorder (ADHD), such as difficulty concentrating, being organised, taking turns in social situations and controlling one's own physical movement and behaviour (American Psychiatric Association, 2013; Dahl, 1996b).

1.3. Gaps in the Literature and The Current Paper

In summary, the available research provides evidence that infant sleep is important for infant development across a range of domains. Yet, most studies have used cross-sectional designs to examine the concurrent association between infant sleep and developmental outcomes. There are comparatively few studies that have prospectively examined the extent to which sleep impacts on development, while controlling for potential background factors (e.g., infant gender and maternal factors) (Freudigman & Thoman, 1993; O'Brien, 2011). Further, of the studies that do take a longitudinal approach, most consist of pre-school aged children and focus on school performance or temperament (Sadeh et al., 2000), or have other methodological issues, as reported above. There is a lack of studies that investigate the

impact of infant sleep from the early postnatal period across the first year of life on early infant development (Freudigman & Thoman, 1993; Scher, 2000; Spruyt et al., 2008). This is important as sleep patterns are often established in the first year of life (Galland, Taylor, Elder, & Herbison, 2012; Teng et al., 2012). Likewise, it is a time when critical early developmental milestones are reached, such as walking and talking, and when neural growth is particularly rapid (Acebo et al., 2005; Chugani, 1998; DiPietro, 2000; Price et al., 2014). Finally, of those studies that have examined the relationship between infant sleep and development, few have used gold-standard batteries of development.

Taken together, the aim of the current paper was to investigate the extent to which infant sleep patterns across the first year of life predict development at 12-months of age on five key developmental domains. These domains were: cognition, language, motor, social-emotional and adaptive behaviour. These relationships were examined both before and following adjustment for infant physical characteristics (i.e birth weight, head circumference, gestational age, age at assessment and sex) and maternal demographic factors (i.e age, income, parity).

2. Method.

2.1. Participants

Data for this study were drawn from The Triple B Pregnancy Cohort Study, an NHMRC funded longitudinal study. See Study 1, section 2, for details regarding participants, recruitment, data collection, sample characteristics and ethics approval.

2.2 . Measures.

2.2.1. Infant sleep patterns.

Infant sleep patterns were measured at the 8-week and 12-month follow up interviews. Mothers were asked to answer questions about their infant's sleep in the first eight-weeks of the infant's life (8-week interview), when the infant was 2-6-months, and

when the infant was 9-12-months (both measured at 12-month interview). Questions about the frequency and length of daytime and night time sleeps were adapted from the Brief Infant Sleep Questionnaire (BISQ) (Sadeh, 2004) which has been validated against actigraph sleep studies as a screening measure for infant sleep (Lomeli et al., 2008; Sadeh, 2008). The length of day and night time sleeps were combined to calculate the total amount of sleep infants had over a 24-hour period. Mothers were asked to rate on a 10-point likert scale (1= poor/large problem, to 10 = excellent/no problem) the quality of their child's sleep, their own sleep pattern, and the extent to which they perceived their child's sleep as problematic.

2.2.2. Infant development.

When the infants reached 12-months of age they were assessed in the family home using the Bayley Scales of Infant and Toddler Development (BSID-III)(Bayley, 2005). Assessments were conducted by trained clinical research staff with high inter-rater reliability obtained on a random selection of 2.4% of all assessments conducted ($\alpha = 0.99$). The BSID-III provides assessment of the developmental functioning of infants and young children between one and 42-months of age and is derived from developmental research and theory on behaviour, which typifies normal and delayed development in young children. The BSID-III consists of five scales that assess infant development in five domains: Cognition, Language (Expressive and Receptive), Motor (Fine and Gross), Social-Emotional and Adaptive Behaviour. The first three scales are administered by an independent trained assessor, and the two remaining scales are based on caregiver self-report about their infant's behaviour, collected via questionnaire. The BSID-III has good reliability and validity and is the gold-standard measure of infant development (Simard, Luu, & Gosselin, 2012). Composite scores on each domain were used which have a mean of 100 and a standard deviation of 15. A score of 100 defines the average performance of the cohort (Bayley, 2005).

2.2.3. Background demographic and potential confounding factors.

Demographic variables with the potential to have a confounding effect on development were measured during pregnancy. These included maternal age, household income and number of other children in care. At the 8-week follow up, infant gender, birth weight, head circumference and gestational age were measured. Infant age at the date of the developmental assessment was also recorded. Univariate correlations were examined to determine the association of potential confounding variables with the individual developmental domains, and significant confounds were used in the main outcome analyses.

2.3. Statistical Analyses

SPSS (IBM Corp, 2013) was used to examine descriptive statistics and test statistical assumptions. Missing data on the social emotional (n = 6, 0.01%) and adaptive behaviour (n = 7, 0.02%) subtests were dealt with using mean substitution, such that the mean scale score for a participant was used to substitute the missing score for that participant. Structural equation modelling was used to investigate the extent to which infant sleep predicted the five developmental outcomes of interest (IBM SPSS Amos, 2012). Maximum likelihood estimation was used for all models.

2.3.1. Fit statistics.

The chi-square test assesses the magnitude of discrepancy between the sample and fitted covariance matrices and was used to assess global model fit, where small or non-significant values indicate adequate model fit (Hu & Bentler, 1995) As the chi-square test of fit is sensitive to large sample sizes (Hoyle, 1995; Kline, 1998; Schermelleh-Engel et al., 2003) other fit statistics were also used to assess model fit. Measures of fit included the root mean square error of approximation (RMSEA), the root mean square residual (RMR), goodness of fit index (GFI), the adjusted goodness of fit (AGFI), the comparative fit index (CFI) and the normed fit index (NFI). The RMSEA is a parsimony-adjusted index, which is often referred to as a “badness of fit” index, whereby values closer to 0 indicate best fit and

higher values indicate worse fit. Literature suggests that RMSEA values of less than 0.05 represent close approximate fit, and values between 0.05 and 0.08 suggest reasonable fit (Browne & Cudeck, 1992; MacCallum et al., 1996). The RMR is a measure of the mean absolute value of the covariance residuals, with a value of 0 meaning perfect model fit and higher values indicating worse fit. Values less than 1.0 are generally considered to indicate favourable model fit (Hu & Bentler, 1995; MacCallum et al., 1996). AGFI and GFI are measures of absolute fit, which assess how well an a-priori model reproduces the sample data. The CFI and NFI are incremental fit indexes, which assess the relative improvement in fit between the target model against the restricted baseline model (Hoyle, 1995; MacCallum et al., 1996). The GFI, AGFI, CFI and NFI result in values between 0 and 1, with values higher than 0.9 representing reasonable fit (Bentler, 1990; MacCallum et al., 1996; Schermelleh-Engel et al., 2003).

3. Results.

3.1. Developmental and Sleep Characteristics of Sample

The cohort generally fell in the average range across all domains on the BSID-III, with the highest composite scores on the cognition and social-emotional domains (see Table 1). Infant sleep patterns were consistent with those in international studies in which infants aged 12-months were sleeping between 12-14 hours in a 24-hour period, having between 1-2 night time sleeps and between 1-3 different day time sleeps (Galland et al., 2012; Teng et al., 2012) (see study 1 section 3.2).

3.2. Model 1 and 2: Measurement Models

A two-step approach was used, such that first the measurement model was verified before then fitting a structural model, which allowed for causal relationships between the latent variables. A theoretical measurement model was hypothesised by specifying the relationship between constructs and choosing indicator variables, which would produce the latent constructs of infant development and infant sleep. The construct variable of infant

sleep was developed using the indicator variables of total sleep over 24-hours, maternal rating of infant sleep quality and maternal ratings of the extent to which infant sleep was a problem. The latent construct variable of development was operationalized using the composite scores of all developmental domains on the BSID-III (see Figure 1). This first hypothesized model did not have adequate fit (see Table 4), and the indicator variables of development did not consistently account for a reasonable proportion of variance (see Table 2). This model was therefore not used for further analyses. The indicator variables for the latent constructs of infant sleep accounted for a reasonable proportion of variance in the construct variables (see Table 2). Further, when assessing model fit for a measurement model which only examined the latent construct of infant sleep, there was adequate fit (see Table 4).

Table 1
Descriptive Statistics for Bayley Results of Cohort (N = 448)

Composite Scores			**Frequencies**						
	Mean (SD)	**Range**	**Very Superior**	**Superior**	**High Average**	**Average**	**Low Average**	**Borderline**	**Significantly delayed**
Cognition	105 (11.18)	55-145	2%	13%	26%	54%	5%	1%	0%
Language	98 (10.41)	71-144	0%	3%	7%	67%	19%	3%	0%
Motor	97 (11.13)	49-127	0%	2%	14%	61%	16%	6%	1%
Social-emotional	106 (14.62)	70-140	13%	7%	17%	59%	4%	1%	0%
General adaptive	98 (11.69)	67-138	1%	6%	9%	61%	19%	3%	1%

Individual measurement models were then created using the latent constructs of infant sleep and each observed variable of composite scores on the BSID-III. This resulted in five separate structural models which examined the predictive effect of infant sleep separately on cognition, language, motor, social-emotional and general adaptive development (see Figure 2).

Table 2
Variance (R^2) in the Indicator Variables accounted for by the Outcome Constructs of Infant Sleep and Infant Development

	Model 1: Development measurement model			
	12 months			
Development				
Cognitive	0.64			
Language	0.42**			
Motor	0.71			
Social-emotional	0.16**			
General adaptive	0.30**			
	Model 2: Sleep only measurement model			
	0-8 weeks	2-6 months	6-9 months	9-12 months
Infant sleep				
Sleep over 24 hours	0.21**	0.35**	0.41**	0.35**
Quality rating	0.88**	0.88**	0.93**	0.95**
Problem rating	0.80**	0.90**	0.94**	0.96**

** $p < 0.01$.

3.3. Structural Models

The predictive effect of infant sleep on each individual developmental domain was measured in separate structural models. If significant pathways were identified, the structural model was then fitted again, controlling for potential confounds as identified by univariate analysis (see Table 3) to determine whether the predictive effect remained.

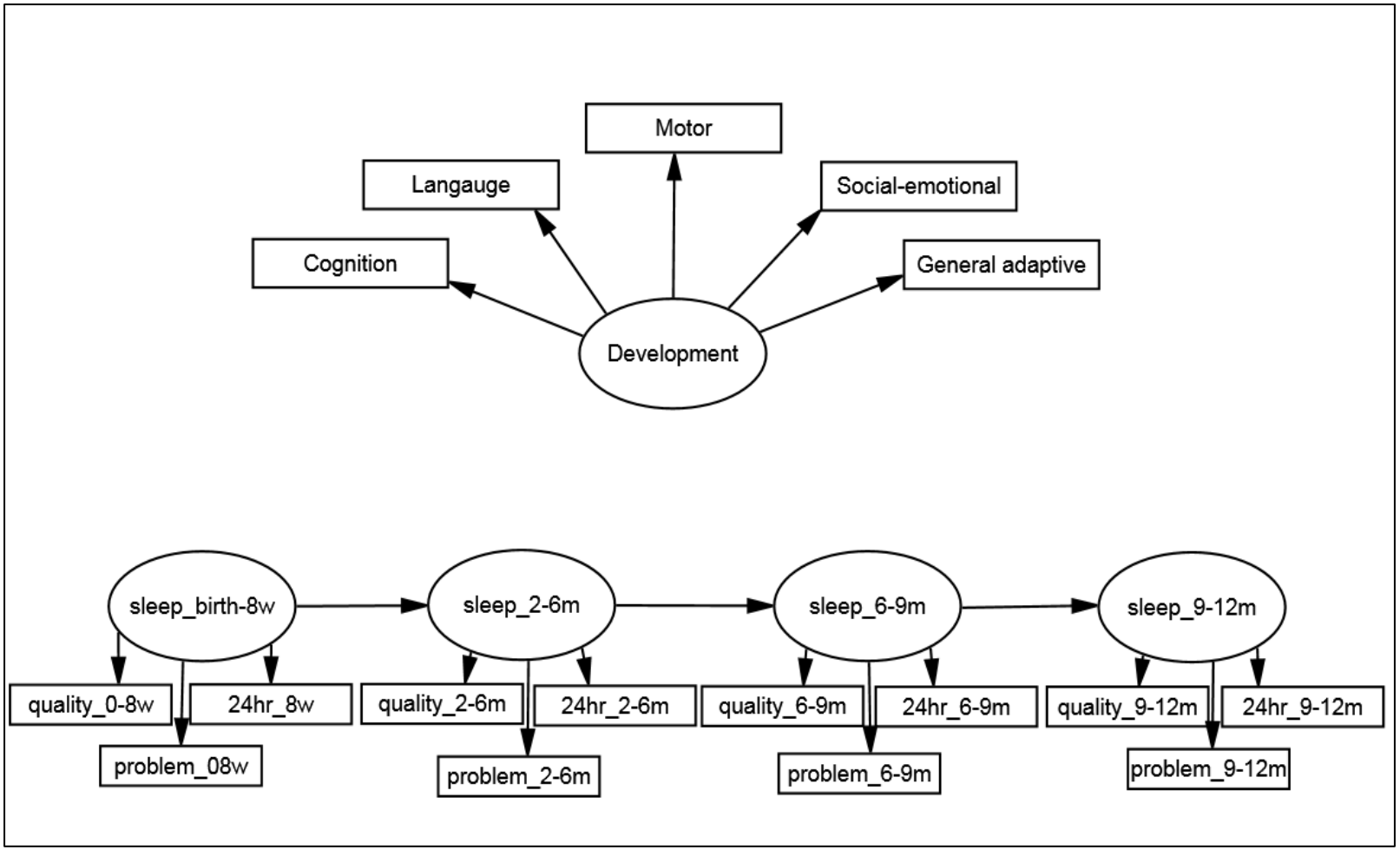


Figure 1. Measurement models 1 and 2**.**

Table 3
Univariate Correlation of Potential Confounds and Developmental Domains

	Cognition	Language	Motor	Socio-emotional	General adaptive
			Maternal factors		
Age	0.01	-0.04	-0.14**	0.01	-0.19**
Other children in care	0.09	-0.10*	-0.00	0.16**	-0.08
Income	0.037	0.01	0.05	-0.03	-0.01
			Infant factors		
Gestational age	0.05	0.03	0.11*	-0.05	.04
Age at assessment	-0.03	-0.06	-0.04	0.02	.03*
Sex	0.10*	0.17**	0.05	.02	.00
Head circumference	-0.18	-0.09	0.10*	-.01	.01
Birth weight	0.08	-0.05	0.13**	.08	.11*

*p<0.05, **p<0.001

3.4. Model 3 and 4: Sleep and Cognition

This model examined the extent to which infant sleep predicted cognitive development (see Figure 2). All paths in this model were non-significant except for the path between infant sleep at birth-8-weeks and cognition at 12-months ($\beta = 0.15$, $p < 0.05$). Fit statistics suggested adequate model fit (see Table 4). The model was then fitted again controlling for the confounding variable of infant sex. The path between infant sleep at birth-8-weeks and cognition remained significant ($\beta = 0.14$, $p < 0.05$) and model fit was similarly adequate.

3.5. Model 5 and 6: Sleep and Language

This model examined the extent to which infant sleep predicted language development (See Figure 3). All paths in this model were non-significant except for the path between infant sleep at birth-8-weeks and language at 12-months ($\beta = 0.15$, $p < 0.05$). Fit statistics suggested adequate model fit (see Table 4). The model was then fitted again controlling for the confounding variable of infant sex and parity. The path between infant sleep at birth-8-weeks to language remained significant ($\beta = 0.14$, $p < 0.05$) and model fit was similarly adequate.

3.6. Model 7: Sleep and Motor

This model examined the extent to which infant sleep predicted motor development. All paths in this model were non-significant (see Figure 4). Fit statistics suggested adequate model fit (see Table 4).

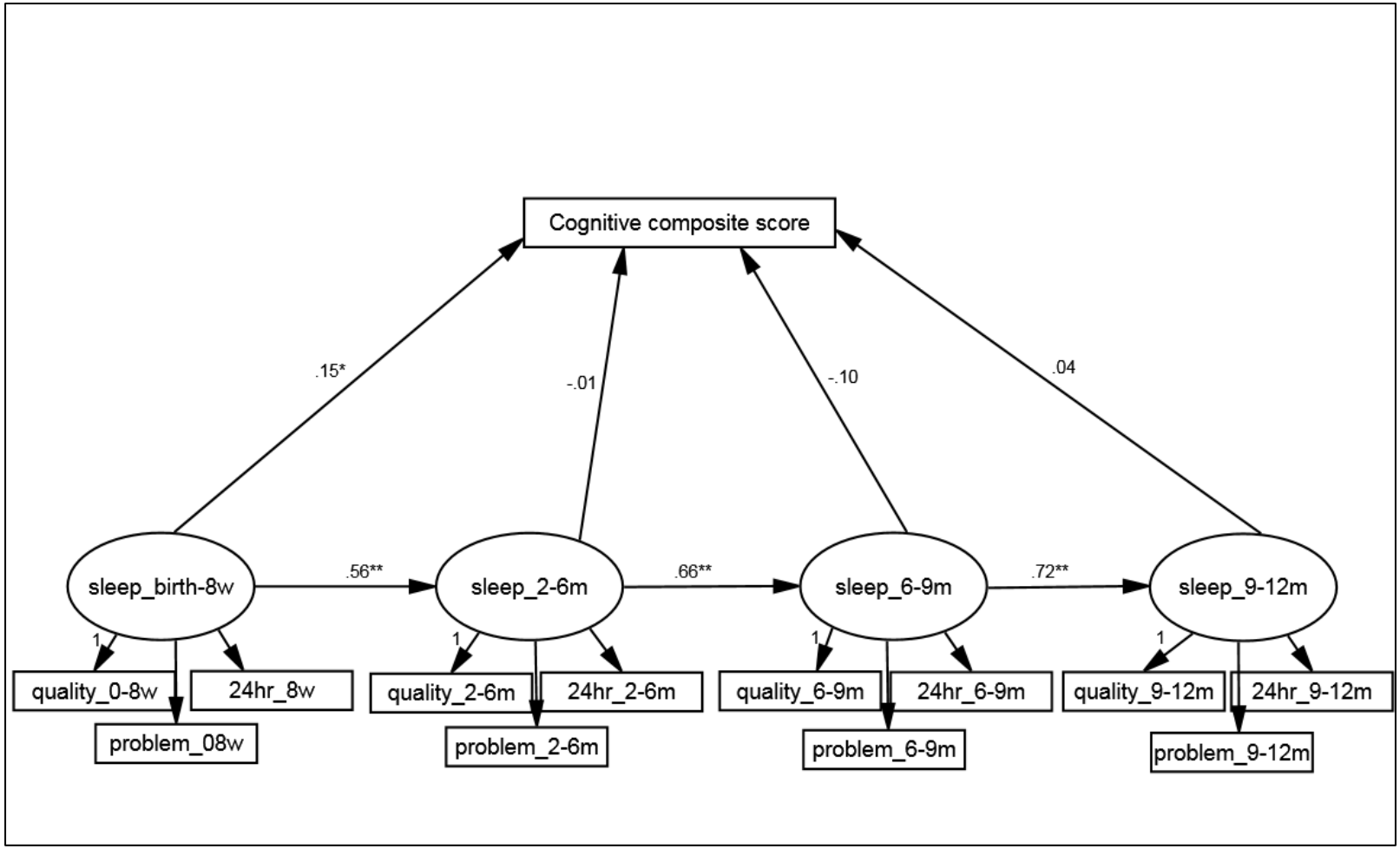
3.7. Model 8: Sleep and Social-emotional

This model examined the extent to which infant sleep predicted social-emotional development (see Figure 5). The path between infant sleep at birth-8-weeks and social-emotional development was significant ($\beta = 0.13$, $p < 0.05$), however did not remain

significant when controlling for parity. Fit statistics suggested adequate model fit (see Table 4).

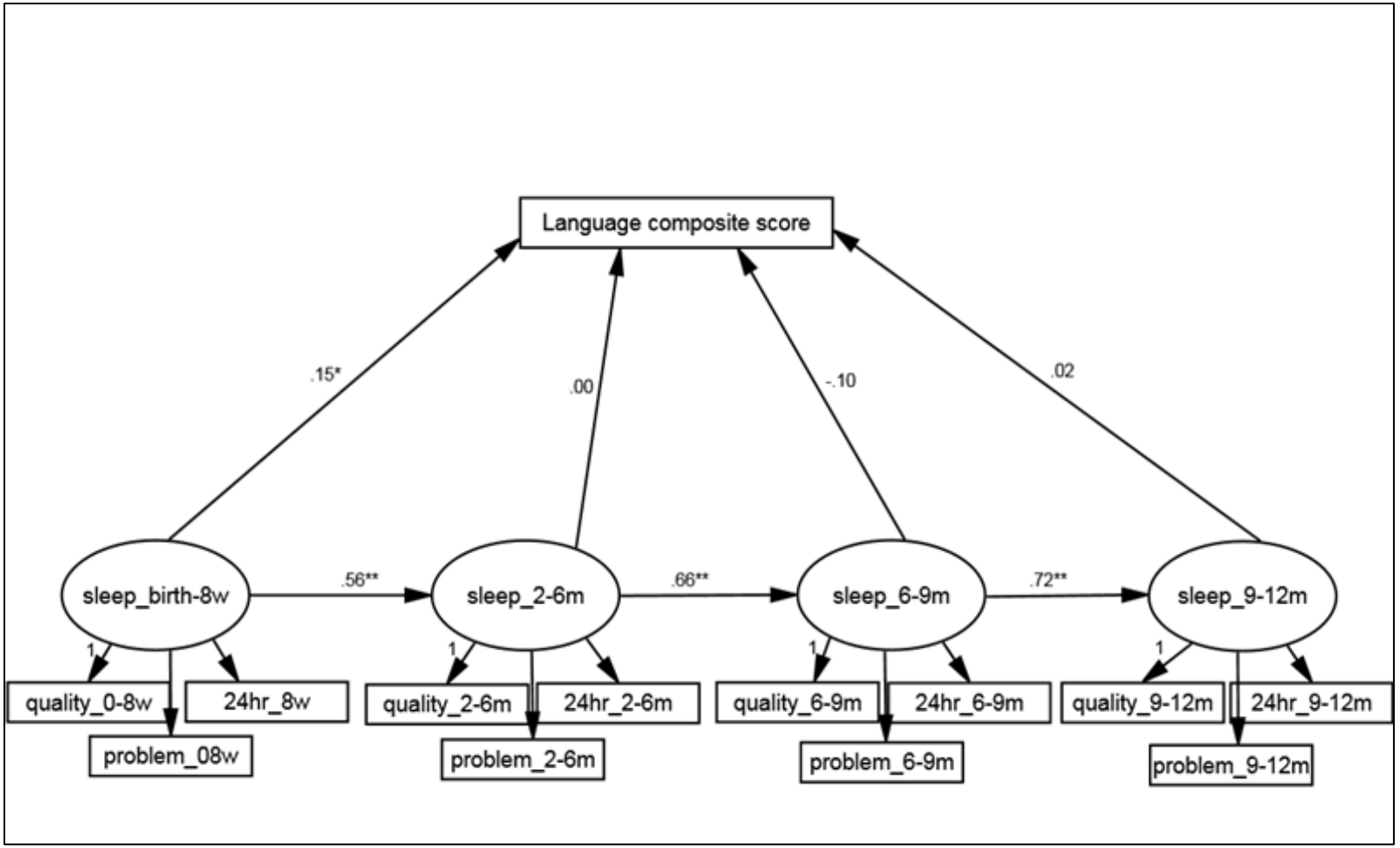
3.8. Model 9: Sleep and General Adaptive

This model examined the extent to which infant sleep predicted adaptive development (see Figure 6). All paths in this model were non-significant. Fit statistics suggested adequate model fit (see Table 4).



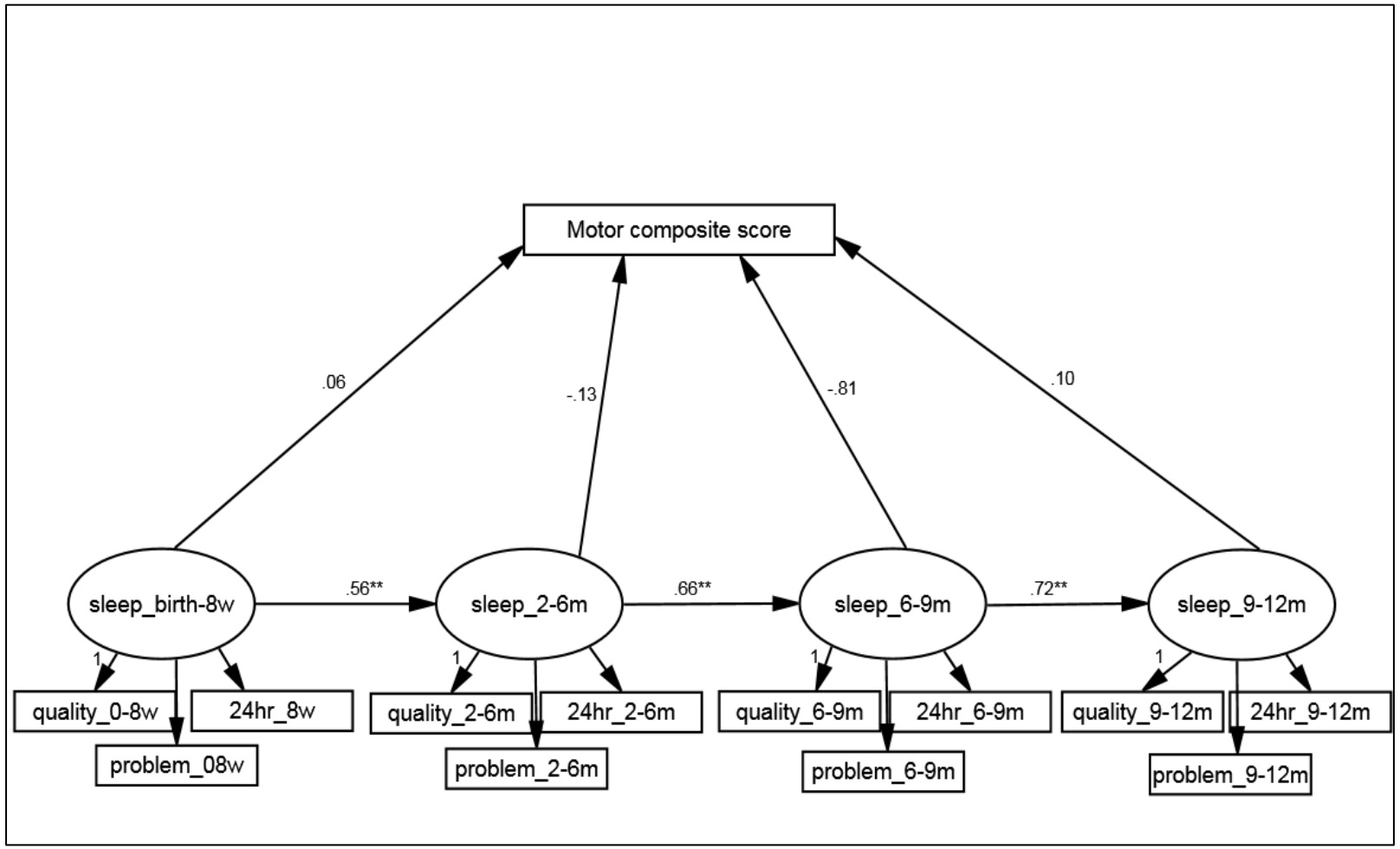
*p<0 .05, ** p< 0.01.

*Figure 2***.** Structural models examining predictive effect of infant sleep on cognitive development.



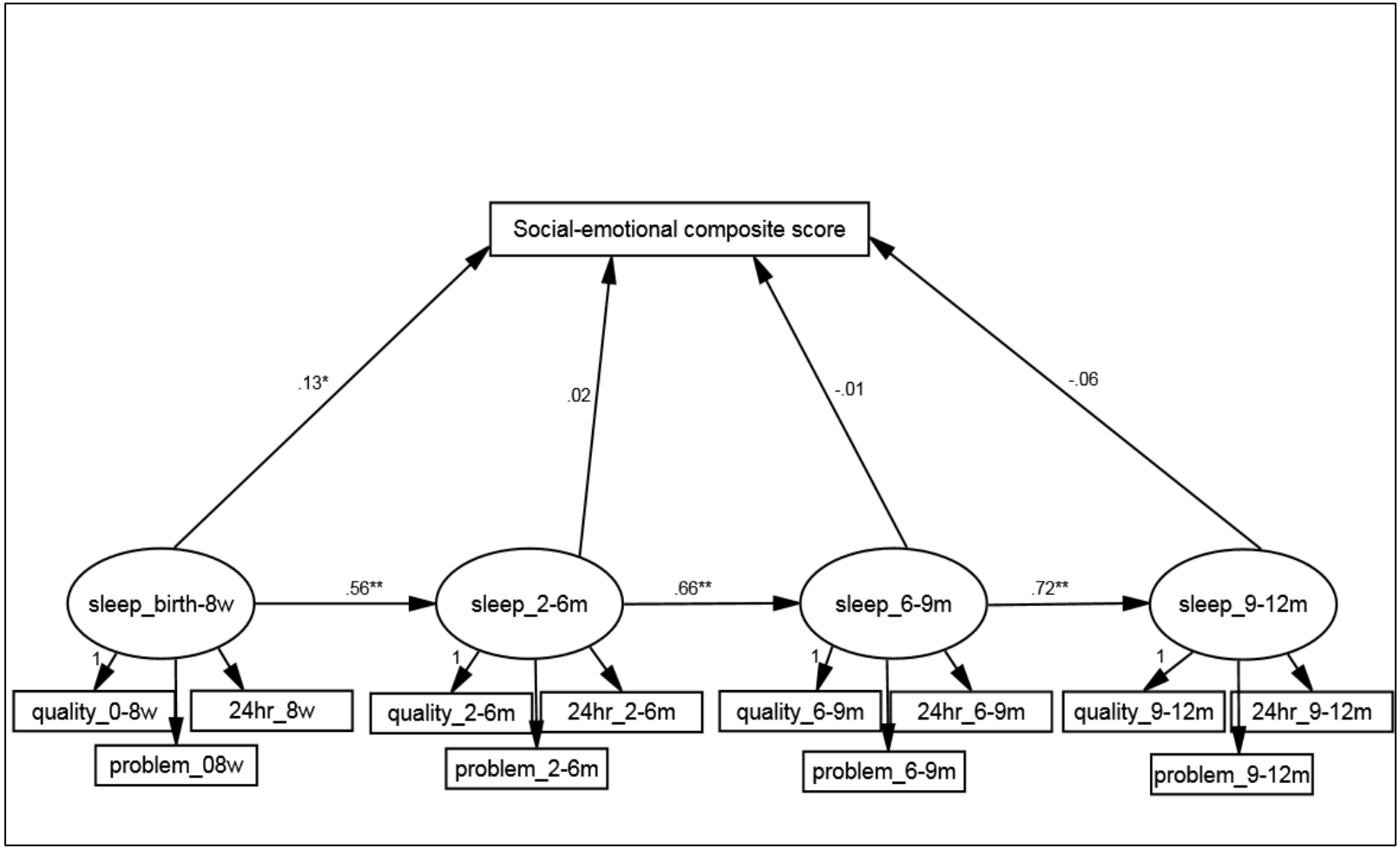
*p<0 .05, ** p< 0.01.

*Figure 3.*Structural model examining predictive effect of infant sleep on language development.



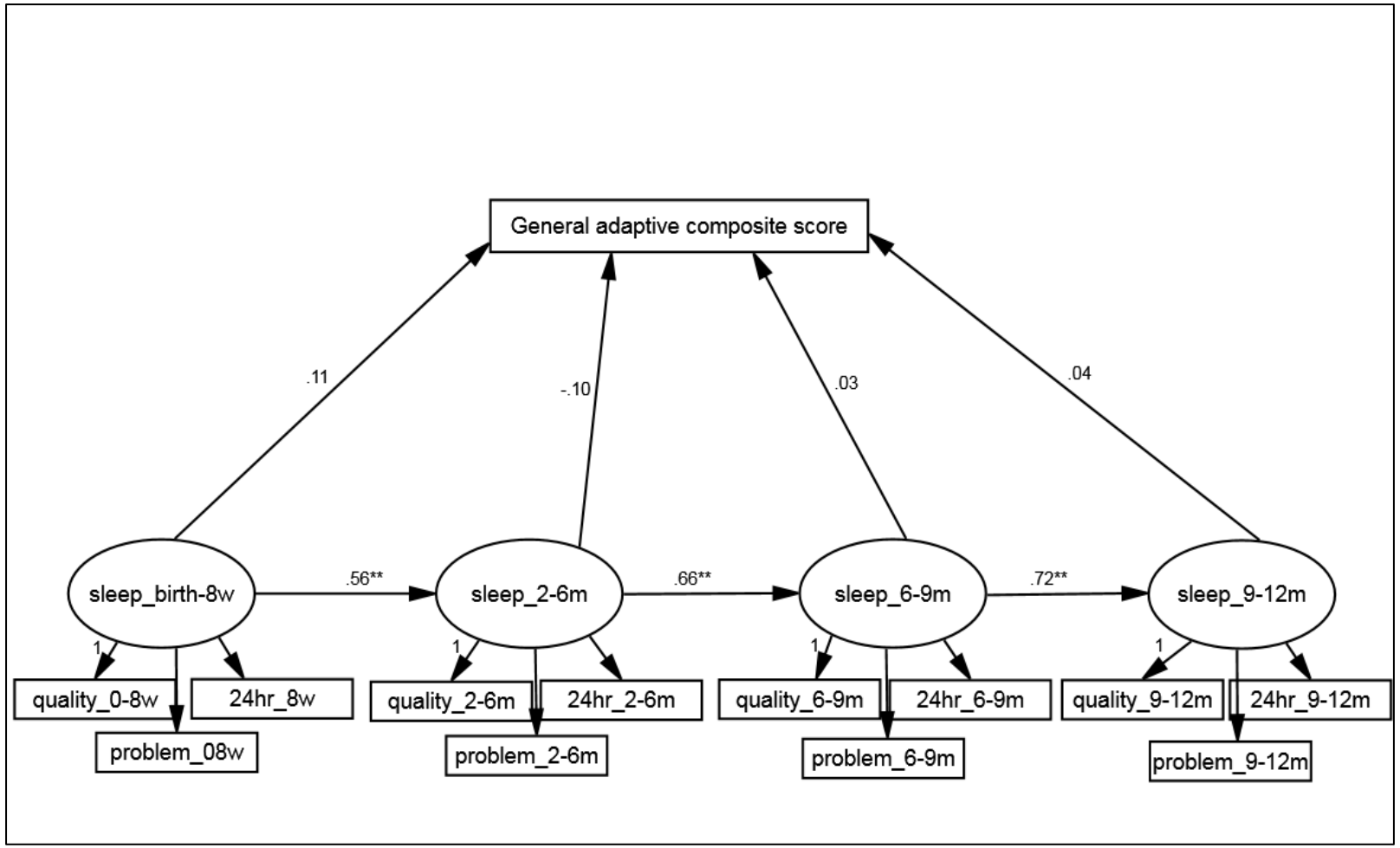
*p<0 .05, ** p< 0.01.

Figure 4. Structural model examining predictive effect of infant sleep on motor development.



*p<0 .05, ** p< 0.01.

Figure 5. Structural model examining predictive effect of infant sleep on social-emotional development.



*p<0 .05, ** p< 0.01.

Figure 6. Structural model examining predictive effect of infant sleep on general adaptive development.

Table 4.
Fit Indices for Measurement and Structural Models

	x^2 (df)	CMIN/DF	N	P	RMSEA	RMR	GFI	AGFI	CFI	NFI
Model 1: Measurement model	931.21 (116)	8.03	448	0.00	0.13	3.70	0.81	0.75	0.80	0.78
Model 2: Sleep only measurement model	152.94 (34)	4.50	448	0.00	0.09	0.28	0.95	0.89	0.97	0.96
Model 3: Cognition	162.15 (42)	3.86	448	0.00	0.08	0.35	0.95	0.90	0.97	0.96
Model 4: Cognition and confounds	225.82 (81)	3.38	448	0.00	0.07	0.33	0.95	0.90	0.97	0.95
Model 5: Language	158.94 (42)	3.78	448	0.00	0.08	0.36	0.95	0.90	0.97	0.96
Model 6: Language and confounds	213.00 (67)	3.18	448	0.00	0.07	0.33	0.95	0.90	0.96	0.95
Model 7: Motor	164.36 (42)	3.91	448	0.00	0.08	0.37	0.95	0.90	0.97	096
Model 8: Social-emotional	159.85 (42)	3.80	448	0.00	0.08	0.46	0.95	0.90	0.97	0.96
Model 9: General Adaptive	160.02 (42)	3.80	448	0.00	0.08	0.33	0.95	0.90	0.97	0.96

4. Discussion.

The aim of the current paper was to determine the effect of infant sleep patterns across the first year of life on infant development at 12-months of age. The results demonstrated some evidence of a predictive relationship between infant sleep and development. Specifically, it was found that infant sleep at birth-8-weeks predicted cognitive development at 12-months, after accounting for infant gender. That is, higher infant sleep duration and quality predicted higher cognitive development scores on the BSID-III. Similarly, infant sleep at birth-8-weeks predicted language development at 12-months, after accounting for infant gender and number of children in care. That is, higher infant sleep quality and duration predicted higher language scores on the BSID-III. It is interesting to note that these results suggest infant sleep in the early postnatal period is more important to development at 12-months, than sleep at 9-12-months. This is consistent with literature which indicates strong associations between early sleep and later life outcomes (Freudigman & Thoman, 1993), and may be explained by the important neurological changes that take place in the early postnatal period, which have a key impact on the development trajectory (Freudigman & Thoman, 1993). Specifically, the association between sleep and early memory consolidation (Dearing et al., 2001; Freudigman & Thoman, 1993; Scher, 2005; Touchette, Petit, Séguin, & Boivin, 2007) appears to have a significant role in an infant's later cognitive and language functioning (Ginette Dionne et al., 2011; Gomez, Newman-Smith, Breslin, & Bootzin, 2011; Porges, 1996). It could also be the case that after the first eight weeks of life, sleep patterns begin to consolidate and become more routine and hence tend to explain less of the variation in developmental scores. Additionally, as infants grow and mature, they are exposed to an increasing number of other psychosocial factors (such a day-care and changes in family situation), which may dominate the variance in infant development.

There was a significant relationship between infant sleep at birth-8-weeks and social-emotional development, with higher infant sleep quality and duration predicting social-emotional scores on the BSID-III. This significant relationship did not remain after controlling for parity, suggesting that the variance in social-emotional development may be better accounted for by social interactions with other children, rather than infant sleep. No significant relationships were found between infant sleep and motor or general adaptive development at 12-months. These results are somewhat surprising, given that research has previously identified associations between sleep and an infant's ability to self-regulate emotions and behaviour (Dahl, 1996b; Gregory & O'Connor, 2002). It is possible that limited variation in sleep patterns and developmental outcomes may have limited the power to detect significant relationships. A more diverse sample, with a wider range of sleep patterns and developmental performance may yield different results.

4.1. Strengths and Limitations

Although this study used a longitudinal design with a large sample, some limitations are important to note. First, measurement of sleep patterns was based on maternal-report, which may be subject to biases in reporting in regards to sleep quality, as well as lack of parental knowledge regarding exact duration and frequency of sleep. However, the BISQ has been validated against biological measurement tools of infant sleep, and hence any bias in reporting is likely to have been minimal (Lomeli et al., 2008; Sadeh, 2004). Second, the current sample was drawn from New South Wales, and was also an advantaged sample, comprised of families from predominantly middle to high socio-economic background. Replication in other geographical areas and socio-demographic groups is recommended to determine the generalisability of the findings. Third, as infant development was only measured at 12-months of age, it would be interesting to re-examine the relationship between infant sleep and development at a later age where individual behaviours and attributes may be

more stable. Finally, it is important to note that effect sizes of significant pathways were small (0.15 for cognition and 0.15 for language). Nevertheless, the existence of a significant relationship suggests that these are important areas in the development of an infant, and warrant the need for further investigation into these areas, and other contextual factors that may contribute to these relationships.

4.2. Clinical Implications

Taken together, the results of the current study present novel discoveries regarding infant sleep in the first year of life, and highlight the importance of sleep in the development of cognition and language in early infancy. Specifically, the results suggest that sleep in the first 8-weeks of life may be particularly important for infant cognitive and language development at 12-months of age. This is consistent with previous research which highlights the importance of the early postnatal period in later life outcomes (Freudigman & Thoman, 1993). Neurologically, the results suggest that sleep patterns that are considered as better in quality, and less fragmented, allow for the occurrence of higher order processes such as memory consolidation and executive functioning. This in turn, allows for the infant to process and apply modelled problem solving and language skills, building on these skills as they grow older and increase their exposure to cognitive demands and social interactions.

The fact that the impact of sleeping patterns carry over into developmental performance 10 months later, puts a spotlight on the fundamental way in which infant sleep can impact upon a young infant. To date, most research has focused on concurrent consequences of infant sleep and/or academic outcome of older children. The finding that development at a time when infants are learning vital communication and processing skills, may be strongly associated with the sleeping patterns of infants in their first 8-weeks of life, emphasises the need for the health and wellbeing of a young infant during this time to be of

absolute priority. As such, it raises further essential research opportunities in the field of infant sleep and consequential wellbeing. Specifically, if infant sleep in the first 8-weeks of life is significantly related to later cognitive and language development, it can be assumed essential to study these effects in more clinical samples, or in at-risk infants. For example, further research would do well to examine the effects sleep patterns have on later development, for infants who are required to spend time in intensive care or specialist care units after birth, or other situations which may affect a young infants sleep patterns. The results also pave the way for future studies by raising the question of whether strategies addressing problematic sleep patterns lead to changes in developmental outcomes. That is, intervention studies should address the effect of sleep treatments and family education programs on the improvement of developmental outcomes. As such, the current results pave the way for continued research into the role of infant sleep, and ways in which the health and wellbeing of developing infants can be promoted and nurtured.

Clinically, the results also promote the importance of assessment and treatment of sleep disturbances in early infancy given the apparent association between sleep patterns with developmental outcomes of infants. Understanding the link between infant sleep and development promotes the need for education for families around infant sleep patterns and ways in which families can best support their child's development during the first year of life. Further, it highlights the need for sleep patterns to be part of routine assessment during early infant health checkups, and the importance of follow up and referrals for intervention should infant sleep patterns appear to be problematic. Given the knowledge that infant sleep as early as 8-weeks old is related to development 10 months later, it appears imperative that any suspected disturbances or problems with infant sleep are assessed and treated as soon as possible, so as to prevent future harms.

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General Discussion.

1. Summary of Findings

The results of this thesis highlight the fundamental role sleep plays in the life of a young infant. This thesis contributes to our understanding of the role of sleep in the first year of an infant's life and the possible predictors and consequences of these patterns. Taken together, the results of all three studies converge to suggest that the wellbeing of a young infant in the first year of life is dependent on many factors, including sleep and maternal mental health. Further, the results empirically support the postulated link between infant sleep and development, and have implications for assessment, and prevention and intervention, as discussed below.

1. 1. Study one: Sleeping patterns in a cohort of Australian infants from 8-weeks to 12-months of age.

The first study examined the typical sleep patterns of infants across the first year of life using a sample of infants from New South Wales, Australia. The study investigated the way in which these patterns changed over time, their association with maternal sleep quality, and other maternal and infant demographic factors. While previous studies have shown that infant sleep generally decreases across the first year of life, there was a lack of Australian specific data available, particularly longitudinal data, which enables study of sleep over time. Study one found that across the first year of life infants significantly reduced their day sleeps from an average of 3.8 day sleeps at birth-8-weeks, to an average of 1.9 day sleeps by 9-12-months. Similarly, average night sleeps significantly reduced across the first year of life from 2.7 night sleeps at birth-8-weeks, to an average of 1.9 sleeps by 9-12-months. Total duration of sleep over a 24-hour period significantly decreased from an average of 14.4 hours at birth-8-weeks, to an average of 13.5 hours by 6-9-months. These patterns are consistent with data from other available infant samples in Australia and New Zealand, and with other

international samples (Galland et al., 2012; Teng et al., 2012). The relative consistency in infant sleep across the existing studies suggests that it may be possible to develop empirically based guidelines for typical infant sleep patterns, including information about optimal and sub-optimal sleep patterns for developing infants.

Study one also explored maternal reports of infant sleep quality. On average, mothers rated their infant's sleep as largely positive across the first year of life and there was a significant positive relationship between infant sleep and maternal sleep quality. Namely, the more positive mothers rated their infants sleep, the more likely they were to rate their own sleep as positive. This relationship is consistent with previous research, and highlights the important role that the sleep patterns of a young infant may have in maternal functioning and wellbeing (Armstrong, Van Haeringen, et al., 1998; Meltzer & Mindell, 2007). Finally, parity and lower maternal anxiety during pregnancy were significantly associated with more positive reports of infant sleep. Although these findings do not demonstrate a causal relationship between infant sleep and maternal sleep quality, the results are in line with Sadeh and Anders' (1993) model of infant sleep in which the systemic and transactional nature of infant sleep is described. Specifically, this model describes how infant sleep can be impacted by factors intrinsic to the infant (i.e., their own biology, treatment and health factors), proximal extrinsic factors (i.e., maternal psychopathology), and more distal extrinsic factors (i.e., family stress and siblings) (Sadeh & Anders, 1993).

1.2. Study two: Maternal negative affect and infant sleep: Investigating bidirectional relationships.

The second study examined the relationship between maternal negative affect and infant sleep patterns and aimed to determine whether this relationship was bidirectional. To date, the extant literature has focussed predominantly on the role that infant sleep patterns have in the mental health and wellbeing of mothers in the first year after birth. There is,

however, evidence that maternal negative affect may also predict infant sleep patterns during this time (Armstrong, Van Haeringen, et al., 1998; Bayer et al., 2011; Pinheiro et al., 2011). However, few studies have examined the potential bidirectional nature that may exist between infant sleep and maternal mood (Bayer, Hiscock, Hampton, & Wake, 2007; Giallo & Vittorino, 2011; Goldberg et al., 2012; Martin et al., 2007; Sadeh & Anders, 1993). Study two addressed this gap by using structural equation modelling to examine the bidirectional relationships between infant sleep and maternal negative affect over the first year of infant life. The results supported the notion that the relationship between infant sleep and maternal negative affect is bidirectional, particularly in the first eight weeks of life. Specifically, maternal negative affect during pregnancy predicted poorer infant sleep from birth-8-weeks and 2-6-months; reciprocally, poor infant sleep from birth-8-weeks predicted greater maternal negative affect at 8-weeks. These results remained significant when accounting for relevant psychosocial factors including maternal education and parity. The finding that a bidirectional relationship exists between infant sleep and maternal negative affect fits with a systemic model of infant sleep (Sadeh and Anders, 1993) and further highlights the importance of using transactional models to examine such complex and inter-related constructs. Finally, these results highlight the importance of considering both maternal mental health and infant sleep within the context of one another to best promote the wellbeing of both mothers and their infants.

1.3. Study three: The impact of infant sleep in the first year of life on infant development at 12-months of age.

The third and final study investigated the extent to which infant sleep across the first year of life predicted infant development at 12-months of age. Whilst there is agreement in the literature that infant sleep plays a key role in the development and functioning of a young infant, few studies have prospectively examined the predictive role sleep plays in early infant

development. Further, most studies that have examined the relationship between infant sleep and development have focussed on school functioning, academic achievement and temperament. Comparatively few have focussed on the early development of a young infant at a time when sleep patterns are being established, and when important developmental milestones (such as walking and talking) are being reached. Study three found that sleep in the first two months of life predicted infant development in two key domains at 12-months of age. Specifically, increased sleep duration and quality from birth-8-weeks, predicted significantly higher scores on cognitive development at 12-months, after accounting for infant gender and parity. Similarly, increased sleep duration and quality from birth-8-weeks, predicted significantly higher language development at 12-months, after accounting for infant gender and parity. Interestingly, infant sleep was not significantly associated with motor development or adaptive behaviour development, and significant pathways between infant sleep and social-emotional development did not remain after controlling for parity. Further research is needed to investigate whether a larger and more varied sample (i.e., with respect to socio-demographic background) would yield different findings in these latter domains.

The results of study three highlight the important role sleep plays for the growing infant and are consistent with a considerable body of research showing that significant neurological changes take place in the first 8-weeks of an infant's life (Freudigman & Thoman, 1993). In the context of Sadeh and Anders' (1993) model of infant sleep, the results of study three illustrate the systemic way in which infant sleep may impact on factors intrinsic to the infant (i.e., development and maturation). Additionally, the results further highlight the importance of assessment and intervention for infant sleep problems early in life, and how addressing poor infant sleep patterns early may result in subsequent improvements in infant development and wellbeing.

2. Limitations

There are four important limitations of the aforementioned studies which need to be considered when interpreting the findings of this thesis. First, it is important to acknowledge that the sample examined consisted of mothers and infants from New South Wales only. Second, the sample included families drawn from different socio-economic backgrounds, however, it had higher representation of somewhat advantaged families from middle to high socio-economic backgrounds. Furthermore, participants were a subsample drawn from a larger longitudinal study (The Triple B Pregnancy Study). A subsample was used for this thesis as at the time of analysis, data collection was still underway for the larger study and hence the full dataset was not available for analysis. Due to these two limitations in sampling, caution should be taken in generalising the findings. Importantly, replication of these findings in the larger sample and with participants drawn from other geographical areas and socio-demographic backgrounds is important to ensure the results are generalisable. Third, infant and maternal sleep and maternal negative affect were measured using maternal self-report rather than via medical or physiological measurement techniques, and thus may have been influenced by social bias in regards to sleep quality, as well as lack of parental knowledge regarding exact duration and frequency of sleep. Future validation studies may shed light on the reliability between maternal report and biological measures. Whilst social bias may have influenced the findings, these assessment tools have been demonstrated to be reliable and valid (Cox et al., 1996; Crawford & Henry, 2003; Parry & Piontek, 2002), and have also been validated against actigraph studies (Lomeli et al., 2008). Likewise, data was collected by experienced interviewers trained to interview in a non-judgemental way, to encourage truthful answers, and to ensure all participants understood that their results were confidential and would only be examined as aggregate, group data. Finally, findings from the three studies show that the sleeping patterns and developmental performance of infants, as well as the

mental wellbeing of mothers, were generally positive, and non-clinical in severity. A more diverse sample, with greater variation in infant sleeping patterns, development, and maternal affect, may yield more resolute conclusions.

3. Implications

The results of the thesis have important theoretical and clinical implications for researchers, health practitioners, and families, and are discussed below.

3.1. Theory.

The results of the three studies which comprise this thesis have important theoretical implications. Specifically, the results support the model of infant sleep proposed by Sadeh and Anders (1993), and the systemic and dynamic way in which a young infant interacts with their immediate and peripheral environment. That is, maternal mental health and infant sleep should not be considered as independent predictor or outcome variables only. The results of study two show that a bidirectional relationship exists, and that maternal mental health and infant sleep patterns may be predictive of each other. Study three builds on this idea, with the results suggesting that infant sleep plays a significant role in the development of a young infant. In combination, the results provide evidence that infant sleep may be both a predictor and critical outcome in a young infant's life.

3.2. Assessment and measurement.

The findings of the thesis underscore the need for adequate assessment of three major domains in infant and perinatal health assessments; infant sleep patterns, maternal negative affect from pregnancy onwards, and infant development. More specifically, study one revealed that infants begin to consolidate their sleep patterns across the first year of life, and that night wakings were common. Importantly, these results are consistent with previous national and international studies on infant sleep, providing a clearer understanding of 'normative' or typical patterns of infant sleep. Understanding what constitutes 'normal' or

typical sleep patterns is important when assessing infant sleep and/or development generally. As such, these findings provide a useful standard for assessment by psychologists, paediatricians, midwives and infant health workers more generally.

These results may also inform the development of formal guidelines for typical infant sleep, and well as deviations from these typical patterns (i.e., sub-optimal sleep, for example). This in turn may lead to reassurance for parents of infants with typical sleep patterns, and conversely, may provide clearer diagnostic guidelines for young children and infants who experience pathological sleep problems.

Study two and three highlight the important role that maternal mental health and infant sleep have in the wellbeing and development of young infants, as well as the importance of considering these factors together. Specifically, study two revealed that antenatal and postnatal maternal mental health significantly predicted infant sleep outcomes in the first 6-months of life, and vice versa. Moreover, study three revealed that infant sleep in the first eight weeks of life, plays a significant part in infant development at 12-months of age. Given the complex way in which these factors appear to interact, it is clear that they require evaluation in any assessment process. Findings from these studies suggest that it is therefore critical that hospital staff and maternal and infant health workers assess maternal mental health both antenatally and postnatally, and continue to assess infant sleep from birth onwards.

3.3. Prevention and education.

The three studies in this thesis each identified important aspects of infant sleep that could be disseminated to parents and/or health workers via education and prevention efforts. Study one provided further confirmation of what appear to be common or typical patterns of sleep for young infants, and how these patterns change over the first year of infant life. These data on infant sleep patterns, in conjunction with the existing literature, could be useful to

educate both parents and practitioners about how infants are likely to sleep in the first year of their life. This may lead to clearer and more realistic expectations from families regarding their young infant's sleep, and may be of particular interest for first time parents. Study two revealed the complex and dynamic way that infant sleep and maternal mental health interact. Providing education to families as to the way these two factors interrelate would likely help normalise periods of heightened stress. For example the finding that night waking was common in the first year of life, may normalise heightened maternal negative affect during this time, and allow for better adaption to sleep routine disruption, especially for first time mothers. Likewise, knowledge of the way infant sleep patterns can impact on infant development may help educate parents about the importance of infant sleep. Specifically, study three found that increased sleep quality and duration in the first eight weeks of life was associated with a significant increase in infant cognitive and language development at 12-months of age. It is interesting to note that most significant relationships between these factors occurred in the first eight weeks of life, suggesting that it is common for this time to be a period of change and fluctuation, with most routines and relationships appearing to settle from 6-months onwards. This information may be of importance to families, as it normalises periods of instability and strain during the first year after birth.

3.4. Intervention and treatment.

Finally, the results of the thesis have important implications for the intervention and treatment of problematic infant sleep and maternal mental health perinatally. The finding that infant sleep can be considered as both a predictor and outcome factor in the larger familial context aids in identifying areas which could be targeted to improve infant sleep or development, and/or maternal wellbeing. Specifically, study two found that maternal negative affect during pregnancy predicted poorer sleep from birth-8-weeks and 2-6-months, and poor infant sleep from birth-8-weeks predicted poorer maternal negative affect at 8-weeks.

Understanding these relationships, and which time points represent heightened risk for adverse outcomes for mothers and infants, allows for appropriate targeting of early intervention and treatment. For example, prevention programs that promote resilience and positive coping strategies for mothers during pregnancy may result in a decrease in maternal negative affect, and an improvement in subsequent infant sleep patterns in the first six months of life. Similarly, prevention programs which help families adjust to fluctuating infant sleep in the first eight weeks of life, may lead to an increase in positive sleep patterns, and a decrease in subsequent maternal negative affect in the first eight weeks, and potentially more favourable developmental outcomes for the infant at 12-months of age.

4. Conclusion

This thesis aimed to address gaps in the infant sleep literature by examining sleep patterns across the first year of life, the potential bidirectional relationship between infant sleep and maternal affect, and the relationship between infant sleep and development. Results of the thesis show a steady decline in sleep frequency and duration across the first year of life. That is, as infants grow and develop they require less night sleep and fewer daytime naps in the first year of life. The results also show that a significant bidirectional relationship exists between infant sleep and maternal negative affect, with both infant sleep and maternal mood influencing one another, particularly in the first 8-weeks of life when infant sleep can fluctuate considerably. Finally, the thesis found that infant sleep plays an important role in cognitive and language development in early infancy.

Taken together, the results improve our knowledge of infant sleep, and its predictors and consequences. Moreover, the results also highlight the importance of assessment, education, prevention, and treatment of poor sleep patterns and maternal mental health, and their related outcomes. Understanding the complex and important role of infant sleep, and the accompanying theoretical and health-related implications, will better allow families and

health care providers to care for, and support, young infants and mothers from pregnancy though the first year of life.

5. References

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Appendix A: Demographic Questions

SECTION A: Demographics

A1. What is your date of birth? _____

A2. How old are you now? _____ yrs

A3. Are you Aboriginal and/or Torres Strait Islander?

No ☐ 0
Yes ☐ 1
Not stated ☐ 9

A4. In which country were you born?

Australia ☐ 0
England ☐ 1
Italy ☐ 2
Greece ☐ 3
New Zealand ☐ 4
Vietnam ☐ 5
Scotland ☐ 6
Other ☐ 7 (*Please specify*_____)

A5. What is your highest level of education?

Did not complete Year 10 ☐ 0
Completed Year 10 ☐ 1
Completed Year 12 ☐ 2
Completed Tafe/technical ☐ 3
Completed University/college ☐ 4

A6. What is your **current employment status**?

☐ 1 Full time employment
☐ 2 Part time/casual employment
☐ 3 Unemployed (pension, unemployed)
☐ 5 Student
☐ 6 Home duties
☐ 9 Other: (*Please specify*_____)

A7. What is the *total (before tax)* of all wages/salaries, government benefits, pensions, allowances and other income the **HOUSEHOLD** and **YOU INDIVIDUALLY** *usually* receives?

Combined household	Mother

☐ 1 $2400 or more per week ($124,800 or more per year)
☐ 2 $2200 - $2399 per week ($114,400 - $124,799 per year)
☐ 3 $2000 - $2199 per week ($104,000 - $114,399 per year)
☐ 4 $1500 - $1999 per week ($78,000 - $103,999 per year)
☐ 5 $1000 - $1499 per week ($52,000 - $77,999 per year)
☐ 6 $800 - $999 per week ($41,600 - $51,999 per year)
☐ 7 $700 - $799 per week ($36,400 - $41,599 per year)
☐ 8 $600 - $699 per week ($31,200 - $36,399 per year)
☐ 9 $500 - $599 per week ($26,000 - $31,199 per year)

☐ 10 $400 - $499 per week ($20,800 - $25,999 per year)
☐ 11 $300 - $399 per week ($15,600 - $20,799 per year)
☐ 12 $200 - $299 per week ($10,400 - $15,599 per year)
☐ 13 $100 - $199 per week ($5,200 - $10,399 per year)
☐ 14 $50 - $99 per week ($2,600 - $5,199 per year)
☐ 15 $1 - $49 per week ($1 - $2,599 per year
☐ 16 Nil income
☐ 17 Negative income

A8. (If working) At what point in your pregnancy do you plan to stop working? _____ weeks

A9. Where are you currently living *(tick one only):*

Rented house or flat	☐ 1
Privately owned house or flat	☐ 2
Staying with family/friends	☐ 3
Other (*please specify*_____)	☐ 4

A10. What is your current marital status?

Never married	☐ 1
Widowed	☐ 2
Divorced	☐ 3
Separated but not divorced	☐ 4
Married	☐ 5

A11. Are you currently living with your partner?
Yes……☐ 1 No ……..☐ 0

C14. How many biological children do you have? _____ (if no children skip to *non-biological children* below)

C15. How many are currently in your care? _____

SECTION F: ABOUT YOUR INFANT

F1. What gender is your baby? (code silently if known) ..... Male…….. ☐0 Female ……☐1

F2 What is your infant's D.O.B? _____

F3 How old is your infant? _____ weeks

F4. How many babies did you have? E.g. twins (code silently if known)
1……☐ 1
2……☐ 2
3+……..☐ 3

F5 How many weeks gestation was your child when he/she was born?_____ weeks

F6 What was your baby's birth weight? (from blue book where possible) _____ kgs or _____ lbs

F7. What was your baby's length at birth? (from blue book where possible) _____ cms

Appendix B: Infant Sleep Patterns and Maternal Ratings of Infant Sleep

8-week follow up

F24. Please describe your infant's current sleep pattern.
(For question c/d/e/1= poor/large problem and 10 is no problem/excellent)

	a. DAYTIME (based on mother's definition)		b. NIGHTIME (based on mother's definition)		C .On a scale 1-10 rate your child's sleeping pattern	D: On a scale of 1-10 how much has their sleeping been a problem for you	E. on a scale of 1-10 rate your overall sleeping pattern
	Frequency (how many sleeps)	Duration (total hours of sleep during daytime)	Frequency (how many sleeps)	Duration (total hours of sleep during night time)			

12-month follow up

H2. Please describe your infants typical sleep pattern in the last 10 months.
(For question f /g/h/1= poor/large problem and 10 is no problem/excellent)

	a. DAYTIME (based on mother's definition)		b. NIGHTIME (based on mother's definition)		C .On a scale 1-10 rate your child's sleeping pattern	D: On a scale of 1-10 how much has their sleeping been a problem for you	E. on a scale of 1-10 rate your overall sleeping pattern
	Frequency (how many sleeps)	Duration (total hours of sleep during daytime)	Frequency (how many sleeps)	Duration (total hours of sleep during night time)			
2-6 months of age							
6-9 months of age							
9-12 months of age							

Appendix C: Maternal Negative Affect Questions

F2. Edinburgh 10-item DS –

Instructions: Please tick the answer box that comes closest to how you have felt <u>IN THE LAST 7 DAYS</u>, not just how you feel today.

1. I have been able to laugh and see the funny side of things:
   - ❑ 1. As much as I always could
   - ❑ 2. Not quite as much now
   - ❑ 3. Definitely not so much now
   - ❑ 4. Not at all

2. I have looked forward with enjoyment to things:
   - ❑ 1. As much as I ever did
   - ❑ 2. Rather less than I used to
   - ❑ 3. Definitely less than I used to
   - ❑ 4. Hardly at all

3. I have blamed myself unnecessarily when things went wrong:
   - ❑ 1. Yes, most of the time
   - ❑ 2. Yes, some of the time
   - ❑ 3. Not very often
   - ❑ 4. No, never

4. I have been anxious or worried for no good reason:
   - ❑ 1. No, not al all
   - ❑ 2. Hardly ever
   - ❑ 3. Yes, sometimes
   - ❑ 4. Yes, very often

5. I have felt scared or panicky for no very good reason:
   - ❑ 1. Yes, quite a lot
   - ❑ 2. Yes, sometimes
   - ❑ 3. No, not much
   - ❑ 4. No, not at all

6. Things have been getting on top of me:
   - ❑ 1. Yes, most of the time I haven't been able to cope at all
   - ❑ 2. Yes, sometimes I haven't been coping as well as usual
   - ❑ 3. No, most of the time I have coped quite well
   - ❑ 4. No, I have been coping as well as ever

7. I have been so unhappy that I have had difficulty sleeping:
   - ❑ 1. Yes, most of the time
   - ❑ 2. Yes, sometimes
   - ❑ 3 Not very often
   - ❑ 4. No, not at all

8. I have felt sad or miserable:
   - ❑ 1. Yes, most of the time
   - ❑ 2. Yes, quite often
   - ❑ 3. Not very often
   - ❑ 4. No, not at all

9. I have been so unhappy that I have been crying:
   - ❑ 1. Yes, most of the time
   - ❑ 2. Yes, quite often
   - ❑ 3. Only occasionally
   - ❑ 4. No, never

10. The thought of harming myself has occurred to me:
   - ❑ 1. Yes, quite often
   - ❑ 2. Sometimes
   - ❑ 3. Hardly ever
   - ❑ 4. Never

K5. DASS –

Please read each statement and circle a number 0, 1, 2 or 3 which indicates how much the statement applied to you over the past week. There are no right or wrong answers. Do not spend too much time on any statement.

		Not at all	**Some degree, or some of the time**	**Considerable degree, or a good part of time**	**Very much, or most of the time**
A	I found it hard to wind down	0	1	2	3
B	I was aware of dryness of my mouth	0	1	2	3
D	I experienced breathing difficulty (e.g. excessively rapid breathing, breathlessness in the absence of physical exertion	0	1	2	3
F	I tended to over-react to situations	0	1	2	3
G	I experienced trembling (eg, in the hands)	0	1	2	3
H	I felt that I was using a lot of nervous energy	0	1	2	3
I	I was worried about situations in which I might panic and make a fool of myself	0	1	2	3
K	I found myself getting agitated	0	1	2	3
L	I found it difficult to relax	0	1	2	3
N	I was intolerant of anything that kept me from getting on with what I was doing	0	1	2	3
O	I felt I was close to panic	0	1	2	3
R	I felt that I was rather touchy	0	1	2	3
S	I was aware of the action of my heart in the absence of physical exertion (eg, sense of heart rate increase, heart missing a beat)	0	1	2	3
T	I felt scared without any good reason	0	1	2	3

Appendix D: Thesis appendix Final ethics approval letter – Macquarie University

From: Ethics Secretariat <ethics.secretariat@mq.edu.au>
Date: Thursday, July 4, 2013 at 9:24 M
Subject: External Approval Accepted- Rapee (5201300396)
To: Prof Ron Rapee <ron.rapee@mq.edu.au>
Hannah Fiedler <Hannah.fiedler@students.mq.edu.au

Dear Ms Fiedler
Re: "Maternal stress and anxiety and child sleep patterns at 12 months of age" (Ref 5201300396)

Thank you for submitting the above externally approved ethics application. The above application was considered by the Executive of the Human Research Ethics Committee (Medical Sciences). In accordance with s 5.3 of the National Statement on Ethical Conduct in Human Research (2007) (the National Statement) the Executive has accepted the final approval from NSW Health Sydney Local Health District and your right to proceed under their authority.

The Executive noted that the Macquarie University supervisor on this project, Prof Ron Rapee, was not listed on the original application approved by NSW Health Sydney Local Health District. The Executive Officer from Ethics Review Committee (RPAH Zone), Ms Lesley Townsend, has granted permission for Prof Ron Rapee to access pooled, unidentifiable data for the purposes of supervising the above project.

Any modifications to the above study must be made by NSW Health Sydney Local Health District. A copy of the approved modification, progress reports or any new approved documents must be submitted to the Ethics Secretariat for the HREC's records.
Please do not hesitate to contact the Ethics Secretariat if you have any questions or concerns.
Please retain a copy of this email as this is your official notification of external approval being noted.
The HREC (Medical Sciences) wishes you every success in your research.

Yours sincerely
Dr Karolyn White
Director of Research Ethics
Chair, HREC (Medical Sciences)

Ethics Secretariat
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Appendix E: participant information sheet

Impact of Parental Substance Use on Infant Development and Family Functioning

The Triple B Study: Babies, Bumps and Beyond

Participant information sheet

You, your partner (if applicable) and your baby (when he/she is born) are invited to take part in a research study examining infant development and family functioning. The objective is to investigate the impact of environmental and demographic factors, social support and health care access on infant development and family functioning. This is the first large-scale Australian study to examine these issues. The study will improve knowledge of these effects to direct public health and treatment initiatives that improve the health and well-being of Australian children and families. The study is being conducted by the National Drug and Alcohol Research Centre at the University of New South Wales and the National Drug Research Centre at Curtin University of Technology.

The study involves a number of interviews during your pregnancy and when your baby is 12 months old. The first interview will take approximately one and a half to two and a half hours per person to complete (one interview each, that is one interview with yourself and one interview with your partner, if applicable), and will ask questions relating to demographics, substance use, general health and psychological well-being, health problems associated with pregnancy and your relationship with your partner.

You will be asked to complete two, brief 15-minute telephone interviews during your second and third trimester. This interview will again contain demographic questions and questions related to substance use. If you are first interviewed during your second or third trimester, these interviews can be conducted retrospectively.

After you have had your baby you will be asked to complete a brief survey which will ask questions relating to antenatal care received and birth outcomes. There will also be a short interview at eight weeks which will take approximately one hour to complete. At this time we would also like to collect a genetic sample from yourself, your partner (if applicable) and your child. A simple cheek swab is used to collect DNA. We are collecting DNA to see if genes influence how mothers and their babies react to events that happen during pregnancy. We also want to see if events during pregnancy change the way genes work. This will help us identify those mothers who may need special care during pregnancy. Our work may also lead to new ways of repairing faulty genes in the future. The genetic information will be de-identified and cannot be linked back to the donor or used in familial studies

You and your partner (if applicable) will be asked to complete the final follow-up interview when your baby is 12 months old. This interview will be similar in content to the baseline interview and includes a short list of word knowledge and general verbal ability.

Additionally, an infant development and observational assessment will be conducted. You will receive the results from this infant assessment. This final assessment will take approximately 3 hours to complete (for mothers)/1 hour (for partners if applicable). At this time we would also like to collect another cheek sample from your baby for genetic testing. This will allow us to investigate how events in the first year of life change the way genes work. This information holds considerable promise for finding new ways of treating common conditions of childhood in the future.

You will be reimbursed for your time and out-of-pocket expenses. You and your partner (if applicable) will each receive $50 for the first interview (provided in two instalments; $25 at the beginning and $25 at completion), $40 upon completion of the eight week interview and $50 at completion of the last interview.

Participation in this study is entirely voluntary. You do not have to take part in it. If you do take part, you can withdraw at any time without having to give a reason. Whatever your decision, please be assured that it will not affect your medical treatment or your relationship with the staff who are caring for you.

All information collected for the study will be treated confidentially, and only the researchers involved will have access to it. Researchers may be required to report a serious crime or disclose health information, or if they suspect harm to yourself or to another person, or if required by law, for example as a result of a court order.

The study has been approved by the Human Research Ethics Committee of Curtin University and the Ethics Review Committee (RPH zone) of the Sydney South West Area Health services. The study has been approved by the Ethics Committee for the Women and Infants Newborn Health Services, Perth. If you have any concerns or complaints regarding this study contact the Director of Medical services (tel: 08-93402222) and quote protocol number 1811/EW.

If you would like further information about this study please do not hesitate to contact Aurora on (08) 9266 1621.

Thank you for your time.

Appendix F: Participant consent forms

UNSW

NDRI national drug research institute | Curtin University

Impact of Parental Substance Use on Infant Development and Family Functioning

The Triple B Study: Bumps, Babies and Beyond

PARTICIPANT CONSENT FORM

I,.....
. [name]
of.....[
address]

have read and understood the Information for Participants on the above named research study

and have discussed the study with .....

I have been made aware of the procedures involved in the study, including any known or expected inconvenience, risk, discomfort or potential side effect and of their implications as far as they are currently known by the researchers.

I understand that my participation in this study will allow the researchers to have access to my medical record, and I agree to this.

I freely choose to participate in this study and understand that I can withdraw at any time.

I also understand that the research study is strictly confidential and any information will be disclosed only with my permission, except as required by law.

I hereby agree to participate in this research study.

Please tick the appropriate responses in the box below

	YES	NO
I would like to receive the results of the infant developmental assessment, which will be conducted when my child is 12 months old	☐	☐
I am happy to be contacted in future regarding future participation in this study. I understand that my participation, as with all aspects of this study, would be entirely voluntary and that I would be under no obligation to participate.	☐	☐
If I am randomly selected to have my interviews recorded, I agree to this. I understand that this is for quality and training purposes.	☐	☐

(Mothers only) If I am randomly selected to provide a confidential urine drug screen, I agree to this.	☐	☐

NAME:

SIGNATURE:

DATE:

NAME OF WITNESS:

SIGNATURE OF WITNESS: