Sleep

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Glossary

Actigraph – A wristwatch-like device that records movements for extended periods. The information derived from actigraphy (activity-based recording) can be used to assess sleep–wake patterns. Actigraphy enables sleep assessment in the child's natural sleep environment.

Electroencephalogram (EEG) – Recordings of electrical signals from electrodes attached at different locations on the skull. The information represents brain activity, and wave forms from which sleep stages can be assessed.

Polysomnography (PSG) – A laboratory assessment of sleep including recording of electrical signals representing brain and muscle activity, eye movements, breathing patterns, and related information.

Quiet sleep – A sleep period that is characterized by relative tranquility, lack of gross body movements, and regular breathing.

Rapid eye movement (REM) sleep – Refers to the sleep state which is characterized by rapid eye movements, irregular breathing, twitches and jerky limb movements, and facial grimaces. This state is also called 'dream sleep' because it is assumed that most dreaming occurs during this period.

Settling – The sleep initiation process in infants and young children that includes overcoming problems such as bedtime resistance or difficulty falling asleep.

Introduction

The formation of sleep research as a unique scientific field has been associated with the discovery of rapid eye movement (REM) sleep in humans. Interestingly, this discovery, reported by Kleitman and Asherinsky in 1953, was based on observations of sleeping infants. This historic fact provides a special context for the interest in sleep in early development. Another important historical milestone was the publication of the manual for newborn and infant polysomnography (PSG) by Anders, Emde, and Parmelee in 1971.

The evolution of sleep–wake patterns is one of the most striking phenomena in early childhood and particularly in the first year of life. During infancy and early childhood, children spend more time in sleep than they spend in wakefulness. In infancy, the most prevalent parental concerns are related to feeding and sleep. Sleep problems in early childhood are very prevalent and disruptive to family life. The aims of this review are (1) to introduce the topic of sleep from a scientific perspective; (2) to describe the development of sleep–wake patterns; (3) to provide knowledge on factors influencing sleep and domains that are affected by sleep; and (4) to describe common sleep problems in early childhood: their effects and the means to manage these problems.

What is Sleep?

At first, the definition of sleep appears quite intuitive. However, scientific efforts to define sleep have led scientists to the realization that the definition of sleep is quite elusive. Definitions based on reduced awareness and responsiveness of the individual to the environment are appealing and are commonly used but they have their limitations. When we fall asleep, our awareness and responsiveness to the environment are indeed dramatically reduced. However, research has shown that when we sleep, our brain continues to process external information and our responsiveness to the environment is dependent upon the relevance and the intensity of the external stimulation. For instance, it has been shown that individuals are more likely to respond during sleep to auditory stimulation when their own name is used in comparison to other nonrelated words. Unique phenomena such as night terrors or sleepwalking also challenge these simple definitions, because they present mixed states of sleep and wakefulness. Therefore, it is not easy to sharply define the exact time when wakefulness ends and sleep starts and vice versa. Despite these limitations the reduced awareness and responsiveness to the environment are the core features of the definition of sleep.

The scientific definition of sleep is based on specific features manifested in electroencephalographic (EEG) recordings of brain activity. Specific EEG markers of brain activity have been associated with a sharp decrease in awareness and responsiveness to the environment and they are used to identify sleep stages.

Assessing Sleep

Parents are a very valuable source of information about their child's sleep–wake patterns. Young children usually require attention when they are awake and therefore parents usually know if their child is asleep or awake. Most of the research and the clinical work in this area are based on parental reports in the form of sleep questionnaires or sleep diaries.

However, research has shown that parental reports have serious limitations. For instance, if a child wakes up in the middle of the night and remains quiet his parents are less likely to know that their child was awake during the night. Considering this and other major limitations of parental reports, more sophisticated and objective methods have been developed to assess sleep–wake patterns. The gold-standard of sleep research and sleep medicine has been polysomnography (PSG). PSG is based on extensive assessment of sleep that includes attaching the child to multiple electrodes that document her brain activity, muscle activities, eye movement, and breathing efforts. These measures are required for assessing sleep stages, breathing patterns, and sleep disruptions. PSG is usually conducted in a sleep laboratory and not in the child's natural environment. It is therefore the most elaborate way to assess sleep, but this assessment does not necessarily reflect the child's natural sleep patterns.

In an attempt to capture sleep in a more naturalistic manner, additional methods have been developed. These methods include video recordings and activity-based monitoring, or actigraphy. The first method is based on video recording of infants in their crib and assessing sleep–wake patterns based on visual scoring of these recordings. Actigraphy is based on a small wristwatch-like device that can be attached to the child's ankle or wrist for extended periods (of days or weeks). The monitor records activity levels every predefined interval (e.g., 1 min) and stores them in its internal memory. Based on the unique characteristics of activity patterns during sleep and wakefulness, sleep–wake patterns are assessed in the natural environment of the child for extended periods with minimal disruptions. Based on video recordings and actigraphy it has been shown in different studies that infants often wake up during the night and resume sleep without signaling (e.g., crying) their parents. The findings of these studies revealed that self-soothing (the ability to resume sleep without crying) is a major developmental capacity that distinguishes infants reported to have sleep problems from those who do not.

The Main Rhythms of Sleep

Observation of sleeping infants led to the discovery of REM sleep in the early 1950s. As indicated earlier, this discovery was considered to be the starting point of the modern science of sleep research. Researchers interested in the phenomenon of eye movements observed that when babies fell asleep their eyes started moving rapidly and this phenomenon was associated with jerky limb movements, facial grimaces, smiles, and irregular breathing. After a short period this active sleep (the early infancy equivalent to REM) was replaced by different manifestations of quiet sleep, which is characterized by a very calm body, steady breathing, and the disappearance of REMs. These active and quiet periods of sleep alternate throughout the night in a cyclic manner. The active REM sleep was later associated with dream recollection and was also named 'dream sleep'. Furthermore, REM sleep has been associated with intense brain activity, information processing, and memory consolidation. The other type of sleep was later subdivided into four sleep stages, from stage 1 to stage 4, according to the depth of sleep and EEG correlates, where sleep stages 3 and 4 were defined as deep-sleep stages (slow-wave sleep), during which the individual is the least likely to respond to external stimuli or to wake up spontaneously.

The other major rhythm associated with sleep is the circadian rhythm that refers to the fact that sleep is a naturally recurring phenomenon, which alternates with wakefulness with a certain cyclic pattern. As diurnal animals, human sleep is mostly concentrated at night-time. The circadian rhythm relates to our internal biological clock and brain mechanisms that determine our preference to sleep at night and maintain wakefulness during the day. This repetitive 24-h cycle evolves during early childhood and is influenced by environmental and biological factors.

Development of Sleep–Wake Patterns

There are three main maturational changes in sleep–wake patterns across development. The first and most rapid maturational process is the concentration and consolidation of sleep during the night. The second change is the change in sleep architecture and mainly the significant reduction in REM sleep. The third developmental trend is the gradual decrease in total sleep time.

Consolidation of Nocturnal Sleep

Newborns spend an average of 18 h in sleep that is distributed into a number of sleep episodes (4–6) during the 24-h period (see **Figure 1**). This finding has been reported in studies over the last few decades with no substantial change. One of the most striking developmental features of the evolving sleep–wake system is the consolidation of sleep to one main episode during the night. This process is very rapid during the first 6 months of life, and in most infants, a clear preference

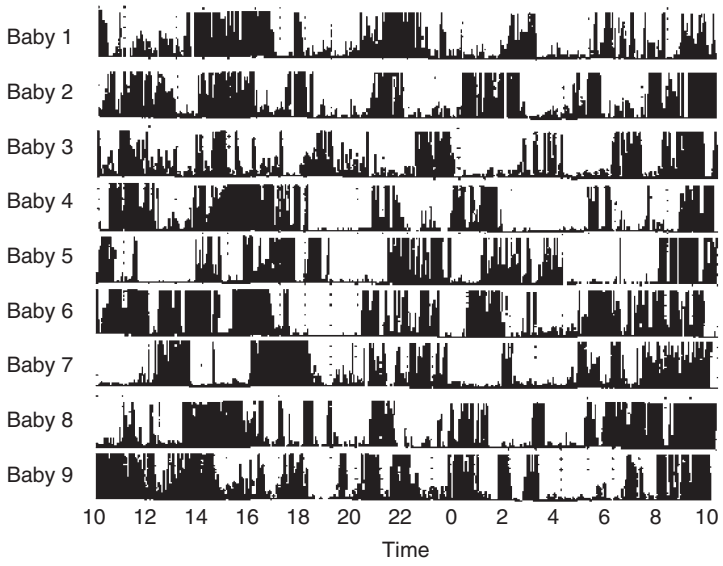

Figure 1 Sleep–wake patterns of newborn babies. The presentation is based on raw actigraphy data of nine babies. Each bar represents 24 h of specific baby. Dark lines represent activity level each minute. Dark condensed areas represent wakefulness periods. Areas with no activity or with very low activity levels represent periods of sleep.

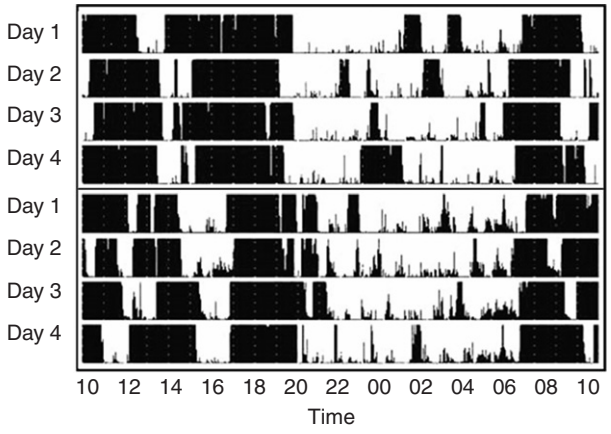

Figure 2 Sleep–wake patterns of 6-month-old babies. The presentation is based on raw actigraphy data of two infants, each for four consecutive nights. Each bar represents a 24-h period. Dark lines represent activity level each minute. Dark condensed areas represent wakefulness periods. Areas with no activity or with very low activity levels represent periods of sleep.

for night-time sleep is seen at 6 months of age (see Figure 2). It is estimated that by the end of the first year of life most infants are capable of sleeping through the night which means having a consolidated sleep period of at least 5–6 h at night (Figure 3).

As sleep becomes extended and consolidated during the night, daytime sleep decreases. As children grow they tend to have fewer and shorter naps. This trend continues until school age (5–6 years) when daytime naps become very rare. It should be noted however, that one mid-day nap (siesta) is a lifestyle choice in some cultures.

The consolidation of sleep during the night is significantly dependent on the environment. Caregivers usually encourage sleep at night by creating a quiet and dark environment for the infant and by discouraging and limiting night-time interactions. Biological processes also appear to play a major role in this process. The maturation of the pineal body in the brain during the first 6 months of life leads to adult-like secretion pattern of melatonin. Melatonin is a hormone secreted mostly during dark hours. Its secretion sharply rises in the evening hours and this rise is considered to be the time cue for other brain systems to prepare for sleep. It has been shown that daytime light exposure, and settings that provide an appropriate light–dark environment that is compatible with night–day differentiation, facilitate the consolidation of nocturnal sleep and circadian rhythms. Links between the sleep–wake system and melatonin secretion have been demonstrated. For instance, one study assessed the maturation of sleep patterns and melatonin secretion in 20 infants (age range: 26–37 weeks). Sleep was assessed using actigraphy for 1 week, and melatonin secretion was assessed by collecting samples of a metabolite of melatonin in the urine (saved in disposable diapers). Immature melatonin secretion patterns were associated with more fragmented sleep and an increase in evening melatonin level was associated with earlier bedtime.

Although the consolidation of sleep during the night is a very rapid and solid developmental trend, many infants exhibit difficulties in developing consolidated sleep. This topic is further addressed in the sleep problems section.

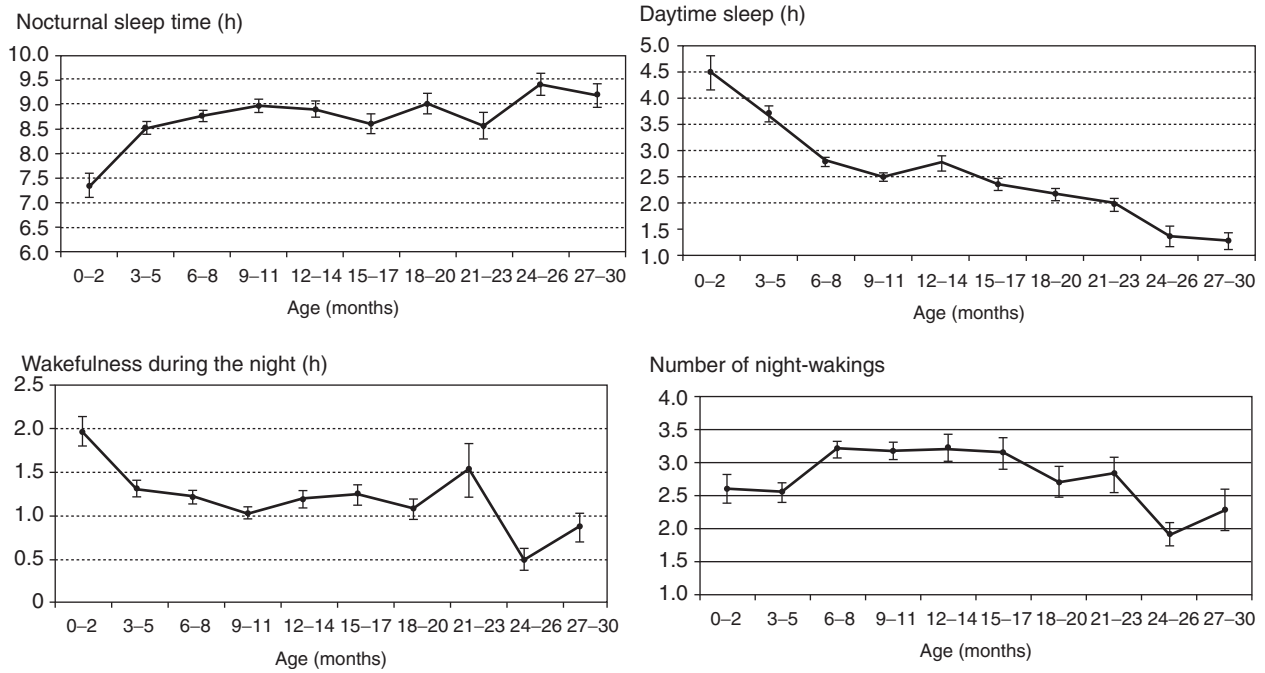

Figure 3 Sleep patterns across development: based on parental reports of more than 1000 babies. From Sadeh A (2004) A brief screening questionnaire for infant sleep problems: Validation and findings from an Internet sample. *Pediatrics* 113: e570–e577.

REM and Non-REM Sleep

Newborns spend about 50% of their sleep time in active sleep. This averages to about 8 h a day in REM sleep with its unique characteristics. During early development, the amount of time spent in REM sleep drops sharply. Actually, most of the developmental decrease in sleep time is related to the reduction in REM sleep.

Another phenomenon that is associated with the increased need for REM sleep in early infancy is that newborns and infants move directly into REM sleep as soon as they fall asleep. In later development the first REM sleep episode appears after the child spends some time in non-REM sleep stages. This delay between sleep onset and the first REM sleep episode is also called REM latency.

One of the most intriguing questions is what is the role of REM sleep in early development or why babies spend so much time in this unique sleep state. We know that during REM sleep the brain is very active although the infant is disconnected from the environment and is generally not responsive to external stimulation. From animal research, we know that there is a strong correlation between maturity of the newborn brain in each species and the amount of time that newborns of each species spend in REM sleep. Species born with a very mature brain (highly independent newborns) spend very little time in REM sleep in comparison to species born with immature brain (like the human newborn, born with about 30% of the adult brain size). Therefore, one strong hypothesis is that the intense activation of the brain during this early developmental period is needed for brain maturation, increasing the number and connectivity of neurons. Animal studies also suggest that during REM sleep, stereotypic behaviors are programmed and practiced. For instance, the famous French neurophysiologist and sleep researcher Michel Jouvet investigated what happens to cats when the area of their brainstem that is responsible for muscle paralysis during REM sleep is damaged. He reported that when these cats entered REM sleep they performed complex behaviors associated with sexual, aggressive, and explorative behaviors. The first smiles of the baby appear in REM sleep and demonstrate this activation of neurologically preprogrammed behaviors.

It has been shown in human adults and animal studies that REM sleep is directly related to information processing and consolidation of long-term memory. For instance, studies have demonstrated that selective deprivation of REM sleep led to compromised memory for new tasks learned prior to sleep. Modern research using brain mapping techniques has demonstrated that specific brain areas that were activated during a specific learning task in wakefulness turn on again during REM sleep episodes. Considering this, it appears reasonable to hypothesize that increased REM sleep time is needed in early childhood for the processing and absorption of enormous amounts of information that bombards the infant.

Decrease in Total Sleep Time

The maturational process is also clearly manifested in the total amount of time spent in sleep. From the newborn

period, with an average of 16 sleep hours per day, to adulthood, with an average of 7–8 h, sleep time gradually decreases. This reduction in sleep time is mostly based on the disappearance of daytime sleep and the gradual delay of sleep onset time.

One of the common question that parents ask is "Do my child get enough sleep?" or "How long should she sleep considering her age?" Unfortunately, there is no simple answer to this question. Although information on average sleep times for different age groups exists, there are wide individual differences in sleep needs. For instance, some newborns spend 20–22 h in sleep during their first days of life, whereas others spend only 10–12 h in sleep at this time. When children get older these individual differences narrow, but they can still be quite significant, thus precluding a simple assertion as to how much sleep is appropriate for a given child at a given age. The decision is usually based on the evaluation of the child's daytime functioning. If a child is a short sleeper but functions well and does not show any signs of sleepiness or fatigue during the day, he is probably getting enough sleep. In contrast, if the child is a long sleeper but still shows signs of daytime sleepiness and fatigue he might be suffering from an undiagnosed sleep disorder that makes his sleep ineffective.

From a broader perspective, it has been claimed that because of changes in lifestyle, particularly in Western countries, including the long working hours of many parents and evening attractions such as television and the Internet, the length of sleep is gradually decreasing. Some experts suggest that the US, for instance, is a 'sleep-deprived nation' and that chronic sleep deprivation has become a common mode of living. Evidence for these claims exist for adults, teenagers, and school-age children; however, it has not yet been shown in younger children.

Factors Influencing Sleep in Early Childhood

The development of sleep in early childhood and its complex links to multiple factors could be considered from a transactional perspective. Many biological and environmental factors influence sleep but infant sleep patterns may also significantly affect the environment. Figure 4 summarizes the transactional model proposed for infant sleep. The transactional model is based on systems dynamics and the notion that child development is influenced by bidirectional or multidirectional effects or transactions by which the parents influence their child and the child and her personal attributes affect her parents.

As demonstrated in this model, there are multiple distal and proximal factors that influence, or are influenced by, infant sleep in a transactional manner. Infant

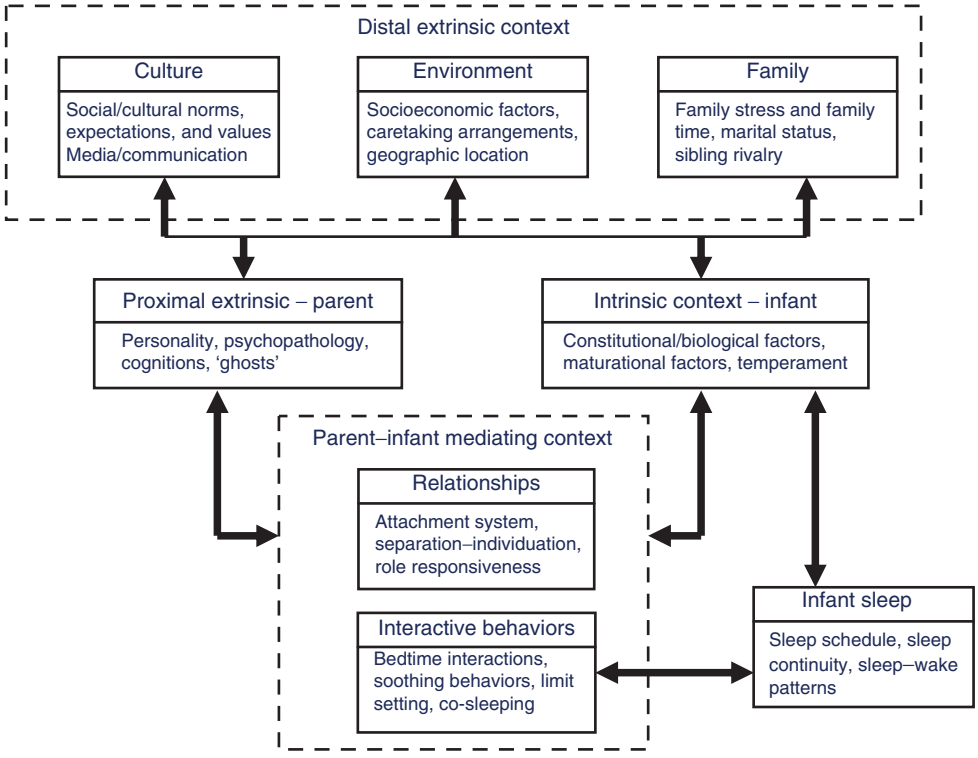

Figure 4 A transactional model of infant sleep: factors that influence and are influenced by infant sleep. After Sadeh A and Anders TF (1993) Infant sleep problems: Origins, assessment, intervention. *Infant Mental Health Journal* 14: 17–34.

sleep is influenced by infant factors such as temperament or biological and maturation factors. The parents play a role in shaping infant sleep by their sleep-related interactions with their infant (e.g., bedtime rituals, soothing techniques). Infant sleep could be a major source of family stress and shape parental behaviors in a reciprocal manner. Parental psychopathology and ghosts from their past (traumatic or stressful events) may underlie certain parental attitudes and behaviors that regulate infant sleep. For instance, parents who experienced traumatic neglect or abandonment in their childhood may be oversensitive to separation issues around bedtime and may overreact to the child. Such excessive involvement may lead to persistent sleep disruptions.

More remote factors play a more indirect role in shaping infant sleep. For instance, cultural traditions and expectations may determine what an acceptable bedtime routine or sleeping arrangement is. Co-sleeping with parents is a traditional and accepted choice in some societies (mostly in developing, non-Western, less-industrialized countries), whereas solitary sleep is the preferred choice in other societies (mostly Western industrialized societies). The socioeconomic status and the educational level of the parents appear to have significant effects on the way they address sleep-related issues and on their children's sleep. It also affects living conditions, including factors such as environmental noise level, home temperature, and sleeping arrangements, which can directly influence sleep.

The following sections address some of the factors that have been consistently associated with sleep in early childhood. In these sections, unless specified differently, the terms 'poor sleep' and 'sleep problems' usually refer to difficulty falling asleep (also addressed as settling problems) and multiple and prolonged night-wakings.

Medical and Biological Factors

Sleep is a very sensitive barometer to the physical well-being of the child. Even the most common colds or a congested nose may lead to significant sleep disruptions. Most of these conditions are transient and the associated sleep disruptions are usually resolved once the condition has run its course.

Many medical conditions have been linked to night-waking problems. Among the frequent ones are allergies, including cow-milk allergy, atopic dermatitis, colic, ear infection, gastroesophageal reflux. For instance, it has been shown that infants with persistent sleep problems, who fail to respond to behavioral interventions, suffered from cow-milk allergy. When these infants were put on a milk-free diet, their sleep improved significantly. Another study found that infants with a history of colic (excessive crying and fussing in infants, which is often associated with pain and muscle tightness) had poorer and shorter sleep compared to babies with no history of colic, between the ages of 4 and 8 months. It is quite clear that any medical problem that causes physical distress to the child is likely to interfere with sleep.

However, research suggests that some common problems or parental concerns may have been overemphasized as a potential source for sleep problems. Teething, for instance, is considered by many parents as a major cause for persistent night-waking problems. Nevertheless, studies on teething indicate that for most infants teething can cause distress for only a few days before and after tooth eruption. Therefore, it is unlikely that teething is a source of persistence and long-term sleep problems. Another major parental concern is that insufficient feeding and infant hunger are major causes for night-wakings. However, studies have shown that in normal, healthy infants, an enriched diet before bedtime does not improve sleep. Furthermore, excessive feeding during the night may serve as a reward and increase night-wakings and dependency on parents following night-wakings.

Temperament studies have suggested that perhaps infants who develop sleep problems have a certain biological vulnerability. For instance, studies have shown that children with poor sleep tend to have, according to their parents' reports, a difficult temperament, including a low sensory threshold. Low sensory threshold refers to the child's increased sensitivity to sensory stimulation, such as noise, touch, temperature, smells, and tastes. This link between poor sleep and reported low sensory threshold led to the hypothesis that this increased sensitivity of the child is the underlying cause for the sleep problem. For instance, if the child is hypersensitive to auditory stimulation he may have a difficult time falling asleep with background noise or wake-up more easily to external sounds during sleep. However, this hypothesis has never been supported by any experimental study or objective measures of both sleep and sensory reactivity.

In this context it is important to address swaddling – the technique of tightly wrapping the infant's body in tissue cloths, sheets, or light blankets. This old infant care practice is believed to reduce crying and improve sleep. Recent well-controlled studies demonstrated that indeed swaddling leads to reduction in crying and to a more consolidated sleep with fewer arousals. Another important finding was that swaddled infants required less intense auditory stimuli to arouse from REM sleep. This finding is in line with other research suggesting that sudden infant sleep syndrome (SIDS) is less likely to occur in swaddled infants.

Parenting and Infant Sleep

The most direct and consistent factor that has been associated with infant sleep is related to the parents. Poor

sleep has often been associated with excessive parental involvement and interactions with the infant during the night.

Settling and night-waking problems in early childhood have been associated with specific parental characteristics and psychopathology. The most persistent finding is related to the links between maternal depression and sleep problems in early childhood. Infants and young children of depressed mothers are more likely to have sleep problems. Postpartum depression has been linked to infant sleep problems. Maternal depression also increases the likelihood of persistence of a sleep problem in early childhood. Maternal depression is also a predictor of persistence of sleep problems in young children. Studies have shown that interventions aimed at the prevention of infant sleep problems improve maternal well-being and reduce the likelihood of depression. Taken together, these studies suggest that maternal depression could be a factor in the development of sleep problems in early childhood. Furthermore, infant sleep problems may affect or exacerbate maternal depression because of the resultant maternal stress, sleepiness, and fatigue. It has been suggested that the toll of caring for a sleep-disturbed infant and the related exhaustion may make some mothers more vulnerable to postpartum depression. This area of research exemplifies how difficult it is to interpret cause and effect from findings of studies demonstrating associations between two domains. This is particularly true: there are good theoretical and intuitive rationales for both interpretations (infant sleep disruptions increase maternal depression and vice versa).

Parental sleep-related interactions with a young child appear to play a major role in determining sleep patterns. Going to sleep is a major separation for young children. During the day, the child is constantly attended to by his caregivers who are happy to respond to most of his wishes and needs. However, at night, the child is suddenly expected to separate from his attachment figures and social environment and go to sleep, often alone, in a separate dark room. As much as this separation is difficult for the child, it is often complicated for the parents to separate, and if the child protests and cries, they often feel like they are abandoning their child and this stimulates very intense and strong negative feelings. One of the measures used by many parents to alleviate this separation is the bedtime ritual. Bedtime rituals can include a bath, rocking, singing, storytelling, and other enjoyable activities around bedtime. These rituals make the transition to bed easier for many children and their parents. Studies show that in most cases, with maturation, children require less assistance to fall asleep. They usually develop their own self-soothing activities in bed and require less parental presence and assistance. However, many infants and their parents develop a falling asleep ritual that is very dependent on parental assistance. These infants fall asleep only if and while they are being nursed, rocked, held, bottle-fed or carried around the house. Research in this area has consistently shown that infants who require parental involvement to fall asleep are more likely to wake up more often during the night and require similar assistance each time they wake up. It has also been shown that the major difference between infants who are considered good sleepers and those defined as problematic is related to the infant's self-soothing capacity. Infants who possess the ability to sooth themselves to sleep do wake up during the night (2–3 times on average) but they are able to fall back to sleep without crying and requiring parental attention. Often, the parents are not even aware that their child wakes up at night and resume sleep without their involvement.

Another area of research has focused on parental attitudes, beliefs, and attributions regarding the child's behaviors and needs, summarized under the term parental cognitions. It is assumed that parental cognitions on topics related to the child reflect an underlying cognitive structure that drives specific parental behaviors and responses to the child. These, in turn, play a major role in shaping the child's behavior, development, and psychopathology. Translating this notion to developmental sleep research, it was found that infant sleep problems were associated with negative maternal sleep-related cognitions, including difficulty with limit-setting, anger toward the child, and doubts about self-competence. Another study that assessed both maternal and paternal cognitions found that when both parents have difficulties related to limit-setting, their infant is more likely to suffer from poor sleep. These correlational studies demonstrate the links between infant sleep and parental cognitions. These links are assumed to be bidirectional and further studies are needed to assess causal interpretations.

It is important to note that although most research findings relate to mothers, this does not necessarily indicate that fathers do not play a role in this area. This bias reflects the fact that most studies do not include fathers. This in contrast to the strong belief that fathers do play a significant role in child development and have influence on the child's evolving sleep patterns.

Culture and Co-Sleeping

Co-sleeping or bed-sharing with parents is a common practice in many cultures and societies. Anthropologists claim that sleeping together with parents is a more natural sleep mode in primates and in traditional human societies. In the Western industrialized world, solitary sleep has been encouraged and favored.

Co-sleeping could be a lifestyle choice favored by parents because of their cultural or family tradition or their emotions about the topic. Very often, parents who do

not consider it as their preferred lifestyle choice resort to co-sleeping because they are too tired to cope with their sleepless child and the need to visit the child's room numerous times during the night.

Studies in the US reveal that co-sleeping is very prevalent in different sections of the culture. For instance, in an urban sample, co-sleeping was reported as a routine practice in 35% of the white families and in 70% of the black families. In both racial groups co-sleeping was associated with a parental approach that emphasized parental involvement and body contact.

Surveys on co-sleeping suggested that when it is the lifestyle choice of parents, co-sleeping is not necessarily associated with an increase in reported sleep problems. However, in societies that favor solitary sleep, co-sleeping is indeed associated with increased prevalence of sleep problems. As suggested above, it is not clear from these studies if co-sleeping is a cause or an exacerbating factor for the sleep problems or just a mere reflection of the efforts (or surrender) to solve the problems at night.

It has been suggested that co-sleeping could serve as a protective factor for SIDS (see later). This provocative claim has never been established. On the contrary, it has been demonstrated that co-sleeping is associated with fatal accidents and infant deaths because of trapping between or underneath parents, suffocation, and other accidents that tend to happen in parental beds (that are not appropriate for infant sleep). Recently, pediatric organizations have reached a consensus calling parents to refrain from co-sleeping with infants because of the increased risk for accidents and deaths. However, this does not mean that parents and babies should sleep in separate rooms. Infant sleeping in a crib in the parents' room does not pose a risk problem and many professionals encourage this arrangement, particularly during the first months of infancy.

From a scientific perspective, it is interesting to note that the issue of co-sleeping vs. solitary sleep was examined in sleep laboratories. These studies revealed that when infants sleep with their mothers in the same bed they sleep worse than when they sleep in separate beds. While co-sleeping, both mothers and infants wake up more often, and tend to stimulate and awaken each other.

Stress

The links between sleep and stress in early childhood are more complex than could have been expected. It is well established that stressful events produce a biobehavioral alarm response, mediated by the activation of the sympathetic adrenergic system, which lead to increased vigilance, arousal, fear, or aggression. This response is part of the preparation for coping with the source of stress and is incompatible with sleep. Indeed, sleep could be considered as the most unsafe behavior or state under dangerous circumstances.

Research on the effects of stressful events on sleep in infants and children reveals that indeed sleep can be disrupted under stressful circumstances. For instance, a few studies explored the impact of mother–child separation on the child's sleep patterns. The separations were either due to the mother's need to deliver another baby, or due to her business trips. These studies showed that in response to separation, young children exhibited increase in crying, negative affect, activity level, heart rate, and night wakings. When the mother returned, opposite trends were noted. These responses are compatible with the stress-activation theory that emphasizes the negative effect of stress on sleep. However, other studies in infants and children have shown that under diverse stressful situations, the effects of stress on sleep could be entirely different. For instance, studies in infants who undergo stressful event like circumcision or children exposed to prolonged stress periods have shown that under such unique circumstances children spend more time in deep sleep or they extend their sleep period. This response is compatible with the withdrawal-conservation hypothesis that suggests that under circumstances of uncontrollable, prolonged stress, it is best for the organism to preserve energy and to resort to inactivity or sleep. It has also been suggested that under such circumstances sleep is an escape from stress.

Studies on stress and sleep in adults reflect a similarly inconsistent picture. It has been suggested that these contradictions could be resolved if the nature of the stressor and the coping style of the individual are considered. Individual and maturational differences may be partly responsible for the biobehavioral strategy adopted to cope with stressors: the 'alarm' response, which lead to alertness, hypervigilance, and preparedness, or the 'escape' response, which leads to sleep. In accordance with stress theories, it is also conceivable that a sudden, intense stressor would lead to an 'alarm' response and alertness, whereas prolonged or chronic uncontrollable stress would lead to 'exhaustion' and to flight to sleep.

In summary, it appears that complex links exist between sleep and stress. These relationships are mediated by the type of stressor, its durability, the coping strategy of the child, and probably by other factors that are yet to be explored.

Sleep Problems and Related Interventions

Sleep problems are very prevalent during early childhood. Surveys suggest that 20–30% of all infants and young children suffer from sleep difficulties. As described in

previous sections, many factors can disrupt sleep or cause severe sleep problems. Roughly, sleep problems may be divided in reference to the predominant causal factors: (1) medical/physical factors; (2) behavioral and psychosocial factors; and (3) different combinations of these factors.

The common medical problems that lead to severe sleep disorders in young children are those related to breathing difficulties during sleep. However, the most common problems are difficulty falling asleep and night-wakings that are mostly attributed to nonmedical factors. The following sections briefly review the most prevalent problems and common interventions.

Settling and Night-Waking Problems

The most prevalent sleep-related complaint during the first two years is related to night-waking. As sleep–wake patterns evolve, the child is expected to 'sleep through the night' which means having a consolidated and undisrupted sleep (of at least 5 h) during the night. However, despite a strong maturational trend in this direction, many infants exhibit significant difficulties in developing consolidated sleep during the night. This problem could be manifested in the form of multiple night-wakings, or in the form of extended night-wakings, or both. These night-waking problems are a source of great distress to the parents whose help is required repeatedly during the night. Based on surveys conducted in many countries, it is estimated that 20–30% of all infants suffer from some difficulties associated with night-wakings and difficulties falling asleep. With maturation, infants who have difficulty with sleep consolidation may overcome these problems. However, research has shown that these problems, if not treated, tend to be persistent in more than 50% of all children, when they are revisited 1 or 2 years later. It has also been suggested that the roots of chronic insomnia in adults could often be traced back to early untreated childhood sleep problems.

As indicated earlier, settling and night-waking problems have been repeatedly linked to family affairs and excessive parental involvement in sleep-related interactions with their child. These links are the basis for popular and effective interventions. The most common interventions for settling and night-waking problems are behavioral methods aimed at training infants and young children to fall asleep in their own bed and resume sleep in bed with minimal parental assistance. The parents are trained to convey the message to the child that they are near by, but wean the child from their intense involvement. If the child is old enough to understand, rewards and incentives are used to encourage the child to accept the new arrangements. It has been repeatedly demonstrated that most sleep-disturbed infants and young children improve their sleep rapidly and dramatically once their parents decrease their involvement and interaction with the child during the settling process and during night-wakings.

The use of objective means such as video recordings and actigraphy has significantly contributed to the understanding of important phenomena related to these problems and interventions. For instance, it has been demonstrated that many infants wake up during the night without their parents' awareness, because these infants are able to soothe themselves back to sleep without crying and requiring parental help. Furthermore, it has been shown that during behavioral interventions (such as those described above), many infants continue to wake up during the night but resume sleep without parental attention. As far as the parents are concerned, their baby learned to sleep through the night; whereas in reality, their baby may have learned to soothe himself back to sleep when he wakes up.

Sleep-inducing drugs are often used to help young children with settling and night-waking problems. However, studies have shown that although these drugs could be effective in improving sleep their effect is often limited to the period of administration. Because most parents and professionals share strong reservations about medicating young children for extended periods, medication is usually not a recommended treatment for common night-waking problems. The efficiency of behavioral interventions makes them the preferred treatment of choice.

Nightmares

Nightmares are very common as sporadic events during childhood. Studies indicate that more than 80% of all children report having scary dreams. When a young child is having a nightmare, she usually wakes up screaming or crying. The child usually responds to caregivers' attempts to console and relieve the fear. Verbal children can report a scary dream but young children may have difficulty in distinguishing between dreams and reality. When these episodes are infrequent and the child does not show any signs of stress or anxiety during the day, the practical advice is usually to calm the child during the event and help her restore sleep.

Clinical research suggests that repeated and persistent nightmares could be a sign of post-traumatic stress disorder (PTSD). Even minor stressful events or periods could lead to a surge in nightmares. Therefore, if the child suffers from very frequent and persistent nightmares, professional help should be sought for further psychological assessment and intervention.

Night Terrors

When a young child is having a night terror (pavor nocturnus), he usually wakes up with a piercing scream, he

may sit in his crib with his eyes open (or closed). He looks like he is being tormented, his breathing is irregular, his heartbeat is racing, and he may be sweating. With this terror appearance, the child is not responsive to his caregivers' attempts to calm him down. He may actually struggle against such attempts. This episode can last minutes or up to an hour if not interrupted. Once the episode is completed, or the parents manage to fully awaken the child, he usually resumes sleep with no recollection of the event. It is important to reassure the parents that these episodes are normal during development and are usually not associated with any known disorder or negative consequences. The main parental role is comforting and reassuring the child if it helps in shortening the episodes.

Night terrors are disturbances of arousal and usually occur during quiet or non-REM sleep. Night terrors can occur in very young infants even during the first year of life. Usually, these events are sporadic and although they are very scary for the parents, they are considered normal phenomena with no known adverse consequences. If these events become frequent and persistent, they may indicate that the child is undergoing a stressful period and this issue should be further explored. Insufficient sleep can also contribute to an increased frequency of night terrors. Therefore, assessment of the child's sleep needs and trials of sleep extension could also serve as a measure to reduce them.

Rhythmic Behaviors and Head Banging

Most infants and young children use some forms of rhythmic behaviors for self-soothing while they calm down and fall asleep. These rhythmic behaviors can include body rocking, sucking, and head banging. It is assumed that these behaviors often replace parental rhythmic soothing techniques, such as rocking and tapping on the child's back. However, in some children these behaviors become very intense and even alarm the parents,who worry about possible physical damage, as in the case of intense head banging.

In most cases, it is assumed that rhythmic behaviors serve a positive purpose and therefore they should not be disturbed. Usually, as the child matures these behaviors are spontaneously discarded. In the event that these behaviors are very fierce and alarming, it is usually recommended to the parents to protect the child from possible self-injury (i.e., by putting a soft surface against which the child can continue her head banging).

There are no established clinical interventions for persistent and fierce rocking or head banging. However, these issues are often resolved by working with parents on issues related to developing alternative soothing techniques for the child.

Breathing-Related Sleep Problems

As described earlier, any cold, even a congested nose, can lead to difficulty breathing during the night that leads to sleep fragmentation, and to reduced sleep quality and daytime alertness. However, more serious and sustained problems are also common in children. These problems are associated with blocked airways due to enlarged tonsils and adenoids, due to the anatomy of the airways, the tongue, and other tissues, or because of some inflammation in these areas. During sleep, when muscle tone is reduced and breathing is under automatic control, blocked airways could lead to a reduction in oxygen level and to an arousal response initiated by the brain. In mild cases, blocked airways lead to greater breathing efforts, snoring and breathing with an open mouth during sleep. In more severe cases, they may lead to repeated arousals (sometimes dozens during each hour of sleep) and seriously compromise sleep and its revitalizing function. When there are significant breathing cessations during sleep, the disorder is defined as sleep apnea syndrome (SAS). Sometimes, SAS can result from a failure of some central brain mechanisms that control breathing during sleep. Young infants often have brief breathing pauses that are considered normal because of their immature control systems.

Snoring is very common in young children. Prevalence rates of snoring of up to 26% have been reported in infants. The older professional belief that snoring without apnea is a benign condition has been recently replaced by a more negative perspective. Snoring is associated with poorer sleep quality and reduced daytime alertness. A significant number of studies have demonstrated that children who snore are more likely to present symptoms of attention problems and hyperactivity as well as other neurobehavioral deficits. Snoring in infants has been associated with a bad mood.

There are two medical options for the treatment of sleep apnea and related disorders. One option is to eliminate the source of airways obstruction by surgically removing enlarged tonsils, adenoid, or other excessive tissue. These procedures are very common in young children and they are considered relatively safe and successful. Sometimes it is recommended to wait because the child is too young to have the surgery or some maturational changes are expected to potentially resolve the problem. An alternative treatment for severe cases is using a little compressor that creates positive air pressure that helps the air travel through the blocked airways. The child sleeps with a mask on his face and the airflow comes from a machine. This treatment does not solve the sleep apnea problem but it enables having a very reasonable sleep under otherwise very poor breathing conditions. This is a very common treatment for adults suffering from sleep apnea. For young children it is usually only a temporary treatment before other measures are taken to resolve the problem.

Sleep Schedule Disorders

Earlier the development of the circadian rhythm and the consolidation of sleep during the night were described as a strong characteristic of the early maturational process. However, these processes should not be taken for granted and there are specific disorders that reflect the disruption of these processes.

Sleep schedule disorders characterize individuals who are often good sleepers. Given the opportunity to go to sleep and get up when they want, their sleep quality is usually quite good. However, when these individuals are expected to adhere to normal environmental clock (i.e., a reasonable bedtime in the evening and rise-time in the morning), they have difficulty adjusting and are often unable to fall asleep when expected, or to stay asleep during night-time hours.

Typical sleep schedule disorder could be manifested in the form of delayed sleep phase syndrome that refers to the inability to fall asleep before very late hours after the age-appropriate bedtime. These children fall asleep very late at night and have serious difficulty waking up at a reasonable time in the morning. Another manifestation is the advanced sleep phase syndrome, which refers to the opposite picture of a child who falls asleep very early in the afternoon and gets up very early (sometimes in the middle of the night). Other manifestations of schedule disorders are related to a non-24 h sleep–wake schedule, which means that the child's biological clock is changing from day to day and 'permitting' sleep at a different hour every day.

The understanding of schedule disorders has evolved in the last two decades. It is still not very clear how these disorders evolve or interfere with the normal maturation of the biological clock. However, it has been shown that children who suffer from pervasive developmental disorders (with assumed underlying brain dysfunction) are more likely to develop sleep schedule disorders. Sleep schedule disorders are also affected by light exposure as daylight (or the light–dark cycle) is the major regulatory information for the brain vis-a-vis the 24-h sleep–wake schedule. It has been suggested that insufficient light exposure could also delay or interfere with proper development of the biological clock and the related sleep–wake schedule, in early childhood.

Sudden Infant Death Syndrome

SIDS refers to a sudden, unexpected death of a baby during sleep without an identified medical explanation. This is the major nightmare of many parents during infancy. Needless to say, this is not considered to be a sleep disorder but because it is a sleep-related event it does have significant impact on sleep research and sleep medicine. SIDS occurs during the first year of life, peaking in prevalence between 2 and 4 months of age. Intense research has focused on trying to understand and prevent these tragic events. The results of these studies have identified a number of risk factors. SIDS is significantly more likely to occur in babies sleeping in a prone position. Smoking (during pregnancy and after delivery), high room temperature, prematurity, and soft or loose bedding or objects in crib, are considered to be significant risk factors. The main risk factor established in the last decade has been the prone sleeping position. The Back to Sleep campaign that has educated caregivers to put babies to sleep on their back (and not on their tummy or side) has led to a significant reduction in the incidence of SIDS. Recently, it has been suggested that the use of a pacifier can also serve as a protective factor.

Because one of the underlying assumption in SIDS research is that SIDS victims have a problem with their arousal mechanism, research focused on evaluating the potential risk factors, often using the auditory arousal threshold paradigm to assess these factors. The arousal threshold paradigm is based on exposing infants to white noise at increasing volumes until they wake up. High arousal threshold relates to infants who require a high noise level to wake up. This may reflect a problem with their arousal response that is assumed critical for survival and SIDS prevention. Using this methodology, research identified that infants sleeping on their tummy have a higher arousal threshold which could be related to the increased risk for SIDS in this sleeping position. It has been found that the use of a pacifier may lower the arousal threshold and therefore may serve as a protective factor as well.

Sleeping in a supine position (on the back) appears to be a strong protective factor. However, research has validated parental experience that infants sleeping on their back wake up more often and are sometimes more resistant to sleep in this position. This may pose a difficulty for parents to adopt the 'back to sleep' recommendation. Nevertheless, in light of the strong data that supports this recommendation, it is mandatory to encourage parents to adhere to this practice. Since sleeping on the back may delay, to some extent, the ability of the infant to stretch and strengthen the neck and shoulder muscles, it is also recommended to put the infant on his tummy when he is awake, with supervision.

The Impact of Sleep Disorders and Insufficient Sleep

Sleep disorders that disrupt the restorative function of sleep, and insufficient sleep, may lead to significant functional impairments. Most of the experimental studies on sleep restriction and sleep deprivation have been conducted with adults. A few studies have been performed with school-age children. These studies have shown that sleep restriction leads to reduced alertness

and compromised neurobehavioral functioning as manifested on attention, memory, and learning tasks.

Many studies have focused on the correlates of poor sleep quality and other sleep-related problems (e.g., snoring) in children. These studies have shown that poor sleep quality and sleep-related breathing problems are associated with reduced alertness, compromised cognitive performance, and behavior problems that have been associated with the diagnosis of attention deficit hyperactivity disorders (ADHD). These behaviors include restlessness and fidgetiness, poor concentration, poor sustained attention, and poor emotional regulation. Furthermore, it has been shown in research and case studies that when proper treatment resolves a major underlying sleep disorder, the negative behavioral correlates are alleviated.

In infants and young children, poor sleep has been associated with a difficult temperament. It has been argued that insufficient or poor sleep could compromise behavior regulation and therefore leads to a more moody child with a low frustration tolerance. The child is usually described as more difficult to manage. Research findings have not been very consistent but the overall picture does suggest that young sleep-disturbed children are perceived more negatively by their parents (usually their mothers) than their non-sleep-disturbed peers. It is not entirely clear if these findings indicate that these children present more problem behaviors because they are sleep deprived, or that their mothers have negative perceptions because the mothers themselves are sleep-deprived. In a study of children aged 4–5 years, poor sleep was associated with compromised behavioral adjustment in preschool.

There is very little information on the long-term effects of insufficient sleep or sleep disorders on child development. One study found that infants who suffered from reported sleep problems were more likely to be diagnosed with ADHD as they grow older. Other studies have shown that infants with delays in the maturation of sleep patterns are more likely to be diagnosed with other neurological disorders. Notwithstanding these studies, there is still insufficient knowledge how chronic insufficient sleep or sleep disorders interfere with brain maturation during the crucial years of early development.

Summary and Conclusion

Sleep–wake patterns evolve rapidly during early development and their development is determined by brain maturation and environmental influences. The evolution of sleep–wake patterns often involves difficulties and delays that are manifested in the form of sleep problems that may cause significant distress to the family.

Maturational trends and the significant individual differences in sleep needs and sleep patterns should be considered when questions like "Is my child getting enough sleep?" or "How many night-wakings are considered a sleep problem?" are asked.

A variety of cultural and parenting factors play a role in shaping children's sleep patterns. These factors should always be evaluated when a specific sleep problem is addressed.

Insufficient or disrupted sleep may have negative impact on other domains of child development particularly in the areas of behavior and attention regulation.

Some childhood sleep problems (e.g., night terrors, head banging) tend to disappear with maturation and usually require no intervention. However, other early childhood sleep problems (e.g., difficulty falling asleep, frequent night-wakings) respond well to brief behavioral interventions and therefore should be detected and treated as early as possible to improve the child's sleep and to alleviate parental distress.

See also: ADHD: Genetic Influences; Colic; Demographic Factors; Depression; Discipline and Compliance; Fear and Wariness; Imagination and Fantasy; Independence/Dependence; Newborn Behavior; Routines; SIDS; Stress and Coping; Temperament.

Suggested Readings

Acebo C, Sadeh A, Seifer R, Tzischinsky O, and Carskadon MA (2000) Sleep/wake patterns in one to five year old children from activity monitoring and maternal reports. *Sleep* 23: A30–A31.

Anders TF, Halpern LF, and Hua J (1992) Sleeping through the night: A developmental perspective. *Pediatrics* 90(4): 554–560.

Bates JE, Viken RJ, Alexander DB, Beyers J, and Stockton L (2002) Sleep and adjustment in preschool children: Sleep diary reports by mothers relate to behavior reports by teachers. *Child Development* 73: 62–75.

Kuhn BR and Weidinger D (2000) Interventions for infant and toddler sleep disturbance: A review. *Child & Family Behavior Therapy* 22(2): 33–50.

Lam P, Hiscock H, and Wake M (2003) Outcomes of infant sleep problems: A longitudinal study of sleep, behavior, and maternal well-being. *Pediatrics* 111(3): e203–e207.

Mindell JA (1993) Sleep disorders in children. *Health Psychology* 12(2): 151–162.

Mirmiran M, Maas YGH, and Ariagno RL (2003) Development of fetal and neonatal sleep and circadian rhythms. *Sleep Medicine Reviews* 7(4): 321–334.

Sadeh A (1996) Stress, trauma, and sleep in children. *Child and Adolescent Psychiatric Clinics of North America* 5(3): 685–700.

Sadeh A (2004) A brief screening questionnaire for infant sleep problems: Validation and findings from an Internet sample. *Pediatrics* 113: e570–e577.

Sadeh A and Anders TF (1993) Infant sleep problems: Origins, assessment, intervention. *Infant Mental Health Journal* 14: 17–34.

Thoman EB (1990) Sleeping and waking states in infants: A functional perspective. *Neuroscience and Biobehavioral Reviews* 14(1): 93–107.