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Sleep in Infancy: A Concept Analysis

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ABSTRACT

Problem: Sleep has historically been defined by adult standards that fail to recognize the dynamic physiologic process in the first year of life.
Eligibility criteria: A literature review and concept analysis were conducted to examine what is known about sleep in infancy. Studies were included if sleep was objectively measured and healthy infants 0 to 12 months old were the focus of the study.
Sample: Of 647 records identified, 348 were assessed for eligibility and 20 studies were included in the review of the literature.
Results: Sleep in infancy is a time of evolving sleep architecture, sleep consolidation, and extensive neural activity resulting in neurodevelopment.
Conclusions: It is imperative to recognize the critical role of sleep for optimal infant neurodevelopment on the part of healthcare providers and society at large.
Implications: Efforts should be made to protect sleep periods in both healthy and hospitalized infants. The proposed definition has the potential to improve the care of healthy and hospitalized infants by preserving and promoting neurodevelopment.

Introduction

Sleep is a process vital to physical, mental, and emotional health throughout the lifespan. It is instrumental to cellular and tissue renewal, immunity, cognition, and behavioral regulation – among other functions (Al-Samsam & Cullen, 2005; Graven & Browne, 2008; Hinds et al., 2007; Oliveira, Gomes, Bacelar Nicolau, Ferreira, & Ferreira, 2015; Stremler, Adams, & Dryden-Palmer, 2015). Sleep deprivation impedes these and other vital functions in both children and adults. Studies have investigated the impact of hospital-acquired sleep deprivation in adult and pediatric tertiary care environments. In the context of the hospital environment, sleep is disrupted by around-the-clock nursing care, procedures, light, noise, and an unfamiliar environment (Al-Samsam & Cullen, 2005; Kudchadkar, Aljohani, & Punjabi, 2014; Linder & Christian, 2011; Meltzer, Davis, & Mindell, 2012). This results in sleep fragmentation that could delay recovery and extend weeks beyond discharge (Al-Samsam & Cullen, 2005; Kudchadkar et al., 2014).

Despite the recognition of this problem, pediatric hospitals struggle to preserve sleep for children and infants. There is a culture within hospitals that views sleep as a low priority. Routines are in place for the convenience of the providers, rather than for the benefit of the patients (Kudchadkar et al., 2014; Stremler et al., 2015). Sleep quality and quantity are not regularly assessed (Stremler et al., 2015), nor are interventions routinely implemented to improve sleep in hospitalized children and infants (Kudchadkar et al., 2014).

How sleep is defined and viewed by children's caregivers strongly contributes to this culture. Sleep is often viewed from an adult perspective as a restorative, healing process. It is assumed that sleep can be resumed after disruption without having a negative developmental impact on infants. While sleep evolves throughout the lifetime, it is a rapidly changing physiologic process during the first year of life (Graven & Browne, 2008). During these changes, considerable neurodevelopment occurs in areas regulating cognition, motor skills, emotions, and language acquisition. Disruptions in sleep disrupt neurodevelopment.

Neonatal intensive care units (NICU) have adopted the theory of developmental care in an attempt to promote neurodevelopment, which emphasizes sleep preservation among other interventions (Altimier & Phillips, 2013). However, these practices are often limited to NICUs with varying success. Term infants in other hospital units are often subjected to the same disruptive routines as older children and adults. Al-Samsam and Cullen (2005) found that patients (mean age 9 months) in the pediatric intensive care unit (PICU) experienced noise, light, and care disturbances similar to those found in adult ICU environments, resulting in sleep fragmentation and decreased rapid eye movement (REM) sleep. This fragmentation can negatively impact developing brains.

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A lack of recognition by healthcare providers of sleep's importance at this age may stem from how sleep has been historically defined in adult terms. A new definition would differentiate the role of sleep in infancy from its role in adulthood and emphasize its importance in the minds of healthcare providers. The purpose of this concept analysis is to provide an age-appropriate definition of sleep in infancy. This definition should act as a starting point for multidisciplinary discourse regarding future research and practice.

Methods

The analysis follows the Walker and Avant method. A literature search was conducted using PubMed, CINAHL, and PsycINFO databases from 2007 to 2018 using the following search terms: sleep, development, infant, neonate, newborn, and baby. The following terms were used with the Boolean operator NOT: SIDS, SIDS prevention, maternal health, and maternal depression. The search was limited by English language, original research, peer reviewed, and human subjects. The databases were last searched on December 31st, 2018. A PRISMA flow diagram (Fig. 1) shows how the articles were screened for inclusion. Articles were excluded if sleep in infancy was not objectively measured; the outcome of the study focused on parents; subjects were medically ill or premature; subjects were older than 12 months of age during the study. Twenty original research articles were included in the full literature review. This review is summarized in the Appendix.

Findings

The Walker and Avant (2011) method of concept analysis involves a thorough examination of the use of a concept in the literature. From this examination a conceptual definition is synthesized including attributes, antecedents, consequences, exemplar cases, empirical referents, and implications for practice and research (Walker & Avant, 2011).

Definition and uses

Common definition

A standard and an idiom dictionary were consulted to analyze sleep in infancy in the vernacular. The way it is defined by the public is closely linked to how a society considers the concept. The Oxford English Dictionary (n.d.) defines sleep as a regularly recurring unconscious state in which neural activity is suspended so that the brain can rest. The idiom dictionary gives a more specific perspective on how sleep in infancy is generally viewed. The concept to sleep like a baby has come to mean a very deep, prolonged sleep in which an individual is quite difficult to arouse (Nagy, 2006). The general conceptualization of sleep in

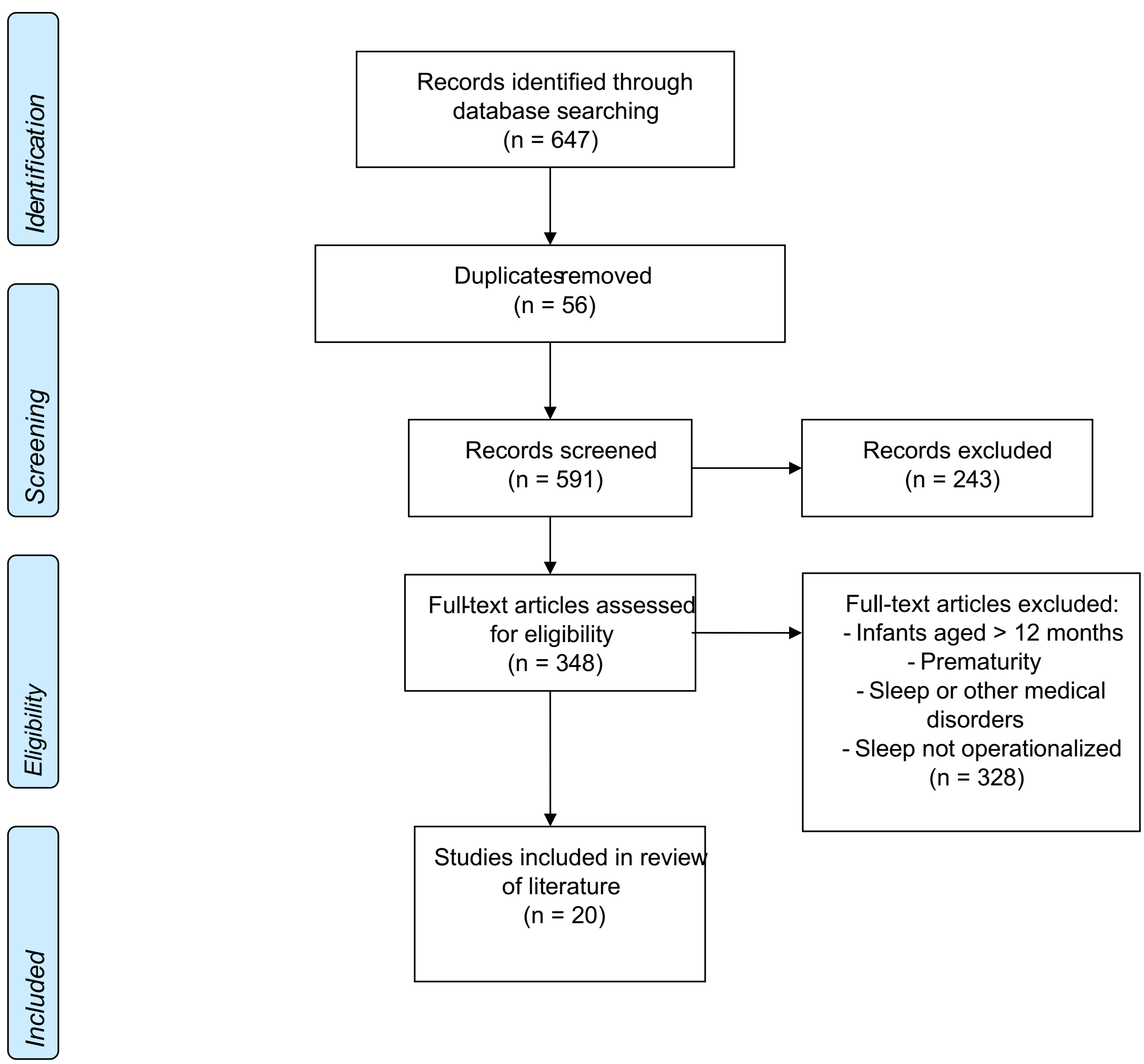

Fig. 1. PRISMA flow diagram of search strategy. Figure based on preferred reporting items of systematic reviews and meta-analyses (PRISMA) flow diagram (Liberati et al., 2009).

infancy is as a time of inactivity and rest. This is contrary to how it is viewed in the scientific literature.

Medical literature definition

The medical literature has defined sleep by the sleep stages seen throughout infancy (Fattinger, Jenni, Schmitt, Achermann, & Huber, 2014; Frasch, Zwiener, Hoyer, & Eiselt, 2007; Jakaite, Schetinin, & Maple, 2012; Milano et al., 2009; Terrill, Wilson, Suresh, Cooper, & Dakin, 2010). According to Milano et al. (2009), sleep is an oscillating pattern hallmarked by varying levels of arousal. Sleep in the neonatal period is predominantly active sleep (AS) that cycles frequently between quiet and indeterminate sleep stages (Frasch et al., 2007; Terrill et al., 2010). The frequency of changes between sleep stages diminishes and the amount of time spent in quiet sleep (QS) increases as the infant grows (Fattinger et al., 2014).

Developmental literature definition

The majority of the literature reviewed focused on infant development. These studies defined sleep by its contribution to the main task of infancy – development. It was viewed as a vital physiologic process needed for neural, motor, and behavioral development (Aparicio et al., 2007; Horvath, Hannon, Ujma, Gombos, & Plunkett, 2017; So, Adamson, & Horne, 2007; Spruyt et al., 2008); a period of vast neuroactivity and connectivity (Liu, Flax, Guise, Sukul, & Benasich, 2008), in which infants learn from and adapt to their environment (Taga, Watanabe, & Homae, 2018; Tarullo et al., 2016); a developmental milestone hallmarked by sleep consolidation at night that may interact with other developmental milestones (Atun-Einy & Scher, 2016; Henderson, France, Owens, & Blampied, 2010; Scher & Cohen, 2015; Tikotzky et al., 2010). While these definitions are varied – perhaps indicative of the impact of sleep on multiple processes – sleep in infancy is recognized as a process vital to physical and psychological health; and as such, must be protected (Anuntaseree et al., 2008; Cohen, Atun-Einy & Scher, 2016; Vijakkhana, Wilaisakditipakorn, Ruedeekhajorn, Pruksananonda, & Chonchaiya, 2015).

Conceptual definition

The conceptual definition put forth in this concept analysis is a synthesis of the above definitions and uses in the scientific literature. Sleep in infancy (0–12 months) is a dynamic physiologic process characterized by evolving sleep architecture, sleep consolidation, and neural activity that results in neurodevelopment.

Attributes

Attributes of a concept are the key characteristics that differentiate it from other concepts (Walker & Avant, 2011). The attributes of sleep in infancy are unique, evolving sleep architecture, a process of sleep consolidation, and neural activity.

Sleep architecture

Sleep is separated into stages defined by their electroencephalogram (EEG) characteristics. During infancy, sleep architecture evolves from less distinct patterns dominated by AS/REM to patterns resembling those seen in later life, dominated by QS/Non-REM (NREM). For the first two months of life, sleep is categorized as AS or QS (Terrill et al., 2010). As the precursor to REM sleep, AS is the dominant sleep stage initially (Terrill et al., 2010). As infants age, the percentage of time spent in AS, and later REM sleep, decreases and the time spent in QS increases. QS is characterized by slow waves and is the precursor to NREM sleep (Terrill et al., 2010). As the infant develops, sleep stages become more defined. By 2 months, sleep stages can be categorized as REM, NREM Stage 1, and NREM Stage 2 (Milano et al., 2009). NREM Stages 3 and 4 begin to appear by 4 months (Fattinger et al., 2014). By 12 months, NREM is the dominant sleep stage and sleep architecture begins to resemble adult-like patterns (Fattinger et al., 2014).

Sleep consolidation

While sleep architecture develops, infants begin to consolidate sleep during nighttime hours. Newborns spend approximately 16 h sleeping per day; this time spread almost evenly throughout the 24-hour period (So et al., 2007). Sleep consolidates rapidly in the first 6 months of life with more sleep occurring at night (Henderson et al., 2010; Tikotzky et al., 2010). By 3 months, most infants are capable of sleeping through the night (Henderson et al., 2010), due in part to the development of self-soothing behaviors (St. James-Roberts, Roberts, Hovish, & Owen, 2015). As infants sleep for longer periods at night, they are awake more during the day. Infants will continue to require daytime naps, but the amount of daytime sleep decreases as the child ages. These daytime naps are important for brain development, but should decrease in duration over time (Horvath et al., 2017). A longer duration of daytime naps has been associated with poorer neurodevelopmental outcomes (Spruyt et al., 2008).

Neural activity

Infants spend the majority of time in active periods of sleep, contrary to the adult pattern where NREM stages are predominant. According to Liu et al. (2008), this is a time of intense activity in which neural connectivity occurs. This connectivity appears to be primarily intrahemispheric or midline, unlike the interhemispheric connections seen during adult sleep (Liu et al., 2008). Infants may be building necessary neural pathways, whereas adults merely need to share information between hemispheres through established pathways (Liu et al., 2008).

Antecedents

Antecedents are the events or characteristics that must occur in order for the concept to occur (Walker & Avant, 2011). Sleep is preceded by a period of wakefulness characterized by growing sleep pressure and moderated by circadian rhythms. Both appear at 2 months and regulate the timing of sleep (Aparicio et al., 2007). The circadian rhythm is a homeostatic process that modulates the need for sleep based on the cycle of light and dark, changes in body temperature, changes in hormone levels, and food availability (Aparicio et al., 2007). Sleep pressure is a mechanism of homeostasis in which the need for sleep increases exponentially with time spent awake (Aparicio et al., 2007). This need builds during wakeful periods until the infant falls asleep again. Sleep pressure can be seen in the slope of slow wave sleep EEG tracings, where the slope is steeper at the onset and decreases over time (Fattinger et al., 2014).

Consequences

Consequences are the result or impact of the concept (Walker & Avant, 2011).

Neurodevelopment

Sleep in the first year of life results in extensive neurodevelopment. The active periods of sleep, when the brain is making neural connections, are vital to an infant's ability to learn, develop behavioral and motor skills, and regulate their emotions. Without sleep this development is delayed. Infants are capable of learning language and responding to their environment while asleep (Liu et al., 2008; Tarullo et al., 2016). Naps have been shown to improve memory in infants as young as 3 months (Horvath et al., 2017). Between 2 and 10 months of age, the brain's sensory inhibition response during sleep also begins to develop (Taga et al., 2018). Increased sleep is linked to better temperament as perceived by parents, including approachability, low distractibility, and adaptability (Spruyt et al., 2008). Conversely, less sleep consolidation and more daytime naps at 12 months are correlated with poorer emotional regulation and behavioral scores on the Bayley Scales of Infant Development II (Spruyt et al., 2008).

Exemplar cases

Cases are used in concept analysis to illustrate the concept in real-life situation (Walker & Avant, 2011). There are four types of cases: a model case exhibits all characteristics of the concept; a borderline cases contains some but not all characteristics of the concept; a contrary case examines the absence of all characteristics of the concept; and a related case is loosely associated with the concept, but lacks its characteristics (Walker & Avant, 2011).

Model case

Baby Isaac is a newborn. He spends most of every day sleeping. He wakes approximately every three to 4 h to eat and often goes back to sleep. In total, he sleeps 16 h per day. The majority of that time is spent in AS, although he cycles frequently between AS, QS, and indeterminate sleep stages. During this time, his brain is developing. At 2 months, his sleep stages begin to resemble those seen in adults. He experiences REM and the first two stages of NREM sleep. By 3 months, he has consolidated his sleep so that he spends most of the night asleep and more time awake during the day. His time awake increases his need for sleep so that by nighttime, he feels sleep pressure. This pressure is relieved as he sleeps. He still wakes in the night, but is now able to soothe himself back to sleep. These night wakings will continue through 12 months of age, but will become shorter and less frequent. During this time, he will continue to need daytime naps, but the duration of daytime sleep will decrease with age. By 4 months, he experiences all four stages of NREM, as well as REM sleep. The proportion of REM sleep is lessening so that NREM is becoming the dominant sleep state. His brain is busy while he is asleep, making much needed sensorimotor connections. These connections are helping Isaac to grow and develop many skills. It affects his temperament, motor skills, and behavioral patterns.

Contrary case: sleep deprivation

Baby Zoey has been crying intermittently for 10 h. Instead of cycling through sleep stages to allow her brain to develop, she has been awake. As a result of sleep deprivation, she is exhibiting poor temperament and motor organization. She is extremely irritable, unable to self-soothe or focus on usual comforts. She appears frantic as she shakes her head from side to side, wailing and arching. Without sleep her brain is deprived of the opportunity to make sensorimotor connections necessary for her cognitive, motor, and emotional development.

Borderline case: sedation

Baby Josiah has just had surgery. He is intubated and on continuous IV sedation. As a result, he appears to be asleep. His muscles are relaxed. His eyes are closed. His heart and respiratory rates are at the lower end of normal, indicating rest. However, he is not experiencing normal sleep. Many commonly used sedatives prevent an individual from progressing past the first two stages of NREM sleep (Carno & Connolly, 2005). In these lighter sleep stages he can easily be aroused by noise, light, or caregiving activities. He is unable to experience REM sleep or the deeper NREM sleep stages. Josiah is not experiencing the needed neural activity of sleep, even though he appears to be sleeping comfortably.

Related case: safe sleep

When sleep in infancy is addressed, the focus is often on safe sleep due to comprehensive public health campaigns. Sudden Infant Death Syndrome (SIDS) is a subcategory of Sudden Unexpected Infant Death, in which cause of death cannot be identified (Task Force on Sudden Infant Death Syndrome, 2016). The focus of SIDS prevention is to promote a safe sleeping environment for the infant, who may be unable to change position or react strongly enough to environmental conditions to prevent suffocation (Task Force on Sudden Infant Death Syndrome, 2016).

Maria takes great care to ensure that her baby, Ella, has a safe sleeping environment. She realizes that sleep can be a vulnerable time for infants, during which they may experience suffocation. Infants may be prevented from correcting their position or protecting their airway due to poor muscle tone (Task Force on Sudden Infant Death Syndrome, 2016). As a result, Maria makes sure that Ella always sleeps on a firm mattress with only a fitted sheet. She avoids placing toys, fluffy blankets, and crib bumpers in the bed. In fact, when Ella is put to sleep, she is put to sleep on her back, alone in the crib, and swaddled in a single blanket. Maria knows that when she nurses Ella at night, she must not fall asleep with the baby due to the risk of suffocation. Ella always sleeps in the safest place – her own crib.

Empirical referents

Empirical referents are the modalities used to measure a concept (Walker & Avant, 2011). Sleep can be measured both objectively and subjectively. Objective measures include polysomnography (PSG) and its components, as well as actigraphy. Subjective measures of sleep in infancy include parent-kept sleep diaries and the Brief Infant Sleep Questionnaire (BISQ).

Objective

PSG

Polysomnography is the gold standard of sleep measurement. It consists of electroencephalography (EEG), electromyelography, electrooculography, electrocardiography, and respiratory inductive plethysmography (Fattinger et al., 2014; Terrill et al., 2010). This method of studying sleep requires a significant amount of equipment, which in and of itself may interfere with sleep. However, the resulting data can be used to analyze sleep cycles as well as individual sleep stages.

PSG components

Because the gold standard of sleep measurement involves invasive, cumbersome equipment, effort has been made to measure sleep objectively with different components of PSG. Two-channel EEG has been used in infants to measure sleep in a less invasive manner (Bennet et al., 2016; Jakaite et al., 2012). EEG has been used to differentiate AS from QS in infants aged 22–48 days, but has not been thoroughly tested in other populations and age groups (Bennet et al., 2016).

Infant interbreath interval (IBI) is another component of PSG that has been used independently to measure sleep in infants. Terrill et al. (2010) used the IBI data from respiratory inductive plethsymography to characterize sleep stages in infants on the basis that respiratory patterns are characteristically different in AS and QS. With their algorithm they were able to accurately define a sleep stage as QS or AS (Terrill et al., 2010). This method would allow for the monitoring of sleep with less equipment, but has not been validated in various populations and age groups.

Videography

Videography can be used in conjunction with both objective and subjective measures. Low light cameras record the subject as they sleep (St. James-Roberts et al., 2015). While sleep stages cannot be recorded, researchers can determine from gross motor movements and eye opening if the subject is awake. However, there is a risk for misidentification of sleep and wake periods when videography is used alone.

Actigraphy

Actigraphy is a relatively new technology used to study sleep in infants. It consists of a wearable device, usually placed on an infant's calf or ankle, that calculates total sleep time, sleep efficiency, and sleep-wake patterns (Aparicio et al., 2007; Tikotzky et al., 2010). The device is non-invasive – often no bigger than a small bracelet. It can be utilized in a variety of settings, allowing an infant to be studied in the comfort of their home, rather than in an unfamiliar laboratory setting. Compared to the gold standard of sleep measurement, So et al. (2007) found that actigraphy had a 97% predictive value when predicting sleep in 6-month-old infants. However, it does not offer the in-depth data PSG does.

Subjective

Sleep diaries

Sleep diaries are a common subjective measure of sleep in infants. They are recorded by the infant's caregiver over a specified period of time. They can be separated into time intervals for the caregiver to note the infant's state (awake, asleep, crying). Other information in these diaries can include: time the infant is put to bed, sleep onset, wake times, and feeding schedule (Aparicio et al., 2007; Vijakkhana et al., 2015). They are often used to supplement the objective data of actigraphy (Cohen, Atun-Einy, & Scher, 2012).

Sleep diaries are limited by self-report. So et al. (2007) noted that while actigraphy and sleep diaries were in agreement during the day-time hours, sleep diaries overestimated sleep at night. At night infants may wake and soothe themselves back to sleep without ever waking their parents, as seen by St. James-Roberts et al. (2015).

BISQ

The Brief Infant Sleep Questionnaire (BISQ) is a standardized sleep tool that assesses the typical sleep patterns of an infant. It is a caregiver questionnaire with 11 items, excluding demographic information (Sadeh, 2004). The questionnaire evaluates sleep onset, nocturnal, diurnal, and total sleep durations, night wakings, and sleep setting (Sadeh, 2004). The tool defines poor sleepers as infants who wake more than 3 times per night; experience night wakings greater than 1 h; or have a total sleep time of less than 9 h (Sadeh, 2004). Sadeh (2004) demonstrated construct validity by comparing the tool with actigraphy and sleep diaries. Reliability for the various items ranges from $r = 0.82$ to $r = 0.95$ (Sadeh, 2004).

Discussion

Implications for research

There is much still unknown about sleep, especially considering the conceptual definition presented here. Research should continue to focus on healthy infants to determine the best interventions for supporting sleep, as well as evaluating how sleep in infancy affects sleep and neurologic outcomes in later childhood. Sleep should be studied in a variety of populations to assess cultural differences in how sleep is treated, promoted, and protected. Many studies in adults have demonstrated the negative effects of sleep deprivation during hospitalization. Research should focus on how the hospital environment impacts sleep and developmental outcomes of infants with a variety of chronic and acute conditions. It is possible that more harm is done by a disruptive hospital environment than is currently recognized.

Implications for practice

Sleep in the first year of life is documented in the literature as an important process necessary for growth and neurodevelopment. As such, efforts should be made in practice to protect and preserve sleep as much as possible. For healthy infants, this involves teaching parents the importance of sleep, as well as what to expect as sleep evolves. It is important for parents to help their infants develop self-soothing techniques, so that beginning at 3 months, infants can better consolidate sleep during the night.

Clinicians in hospital settings should look at the environment and routines to which infants in their care are subjected. All effort should be made to limit disruption of sleep as long as it is not at the expense of the infant's health. This may require flexibility in terms of nursing care, bathing routines, visitation, radiology and phlebotomy procedures, and even the timing of interdisciplinary rounds. Part of this will involve changing the attitudes of clinicians towards sleep – viewing it as a vital, active neurologic process, rather than a period of rest that can be resumed easily after disruptive care activities.

Conclusion

Sleep in the first year of life is a physiologic process different from sleep in adulthood. In infancy, sleep is a period of intense neural activity, evolving sleep architecture, and sleep consolidation vital to neurodevelopment. In light of this new definition, it is the responsibility of healthcare providers to reflect on how they view sleep in infants and how they treat sleep in their practice. By recognizing the critical role of sleep for optimal infant neurodevelopment, healthcare providers can prioritize safer, quality care through the preservation and promotion of sleep.

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Author contribution statement

A.S. conceived of the presented idea. AS developed the search strategy and performed the review of the literature. AS performed the analysis of the concept. AS wrote the manuscript in full.

Declaration of interest

The author reports no conflict of interest. The author above is responsible for the content and writing of this paper.

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