

I. SLEEP AND DEVELOPMENT: INTRODUCTION TO THE MONOGRAPH

Mona El-Sheikh and Avi Sadeh

ABSTRACT Literature on sleep and child development is growing rapidly in exciting new directions across several disciplines and with this comes a need for guiding conceptual principles and methodological tools. In this introductory chapter, the importance of sleep for child development across multiple domains is highlighted. The aims of this monograph are presented and pertain to the need to consider and integrate theory and research across multiple disciplines and use state-of-the-art methodologies. A developmental ecological systems perspective adapted to sleep illustrates the multiple levels of influence and their importance in the study of child sleep and development. A focal aim is to provide examples of longitudinal studies linking sleep with child development, which are presented in seven chapters of this volume.

Sleep plays a major role in child development. This statement is based on a number of scientific pillars: (a) Children spend more time in sleep than in wakefulness during the entire first decade of their life (Galland, Taylor, Elder, & Herbison, 2012; Iglowstein, Jenni, Molinari, & Largo, 2003); (b) Sleep is linked to multiple key domains in child development including brain maturation (Feinberg & Campbell, 2011; Mirmiran & Vansomeran, 1993); learning and memory (Astill, Van der Heijden, Van Ijzendoorn, & Van Someren, 2012); academic achievement (Dewald, Meijer, Oort, Kerkhof, & Bogels, 2011); adjustment problems (Gregory & Sadeh, 2012); physical growth/puberty (Carskadon, Vieira, & Acebo, 1993; Sadeh, Dahl, Shahar, & Rosenblat-Stein, 2009; Sassin et al., 1969); temperament (Ednick et al., 2009); and physical health including metabolism and body mass index (Knutson, 2012; Leproult & Van Cauter, 2010); and (c) Sleep problems are among the leading parental concerns and reasons for seeking professional help in early childhood (Byars, Yolton, Rausch, Lanphear, & Beebe, 2012; Mindell, Kuhn, Lewin, Meltzer, & Sadeh, 2006; Wake et al., 2006). The growing

Corresponding author: Mona El-Sheikh, Human Development and Family Studies, 203 Spidle Hall, Auburn University, AL 36849-5214, email: elshemm@auburn.edu

multidisciplinary literature on sleep and development has revealed the need for integrative conceptual frameworks, organizing principles on definition and measurement of key constructs, and additional longitudinal research. These issues are addressed in this monograph.

What sleep is, how best to operationalize it, and what defines sufficient and good quality sleep are matters of continuing dialogue. There are many sleep parameters of potential importance for children's development. While sleep duration is a key parameter and most frequently studied, other significant sleep/wake domains include sleep quality (e.g., efficiency, continuity), schedule (e.g., consistency across the week or weeknight/weekend differences), chronotype (e.g., time of optimal arousal), daytime sleepiness, bedtime routines, and daytime naps. One important dimension of sleep is the distribution of sleep and wake episodes around the 24-hr day-night continuum or the light-dark cycle. These rhythms of sleep-wake episodes tend to recycle every (about) 24-hr period and are therefore also termed circadian rhythms. Thus, the number of sleep-wake episodes and their distribution around the clock are significant manifestations of the sleep-wake system. When sleep concentrates in the dark (nocturnal) hours it can be manifested as consolidated sleep (with no intermittent wake episodes) or as fragmented sleep. Hence, sleep consolidation or sleep continuity is a major characteristic of the sleep-wake system, which is manifested in the number and duration of night-wakings. Another common way to quantify sleep continuity is using the estimated sleep efficiency, which is the percent of true sleep from the total sleep period that includes true sleep and time spent in wake episodes in-between (for more details, see Chapter III on sleep assessment).

Sleep-wake patterns and behaviors represent a complex process determined by a wide range of biological, behavioral, social, and cultural factors, which can be well considered from a developmental ecological systems perspectives adapted to sleep (e.g., see Figure 1; Bronfenbrenner, 1979; Bronfenbrenner & Ceci, 1994). This view is espoused in this monograph and is explicated later in the chapter.

Monograph Aims

The monograph's three major aims are to present: (1) contemporary conceptual and methodological issues that need to be considered to integrate knowledge of sleep and child development across multiple disciplines and accelerate the pace and enhance the quality of research (Chapter II); (2) examples of longitudinal studies, which are scant in this developing area of inquiry, that utilize objective sleep assessments and demonstrate linkages between various sleep parameters and child development across multiple domains (Chapters IV-X); and (3) sleep assessment methodologies including

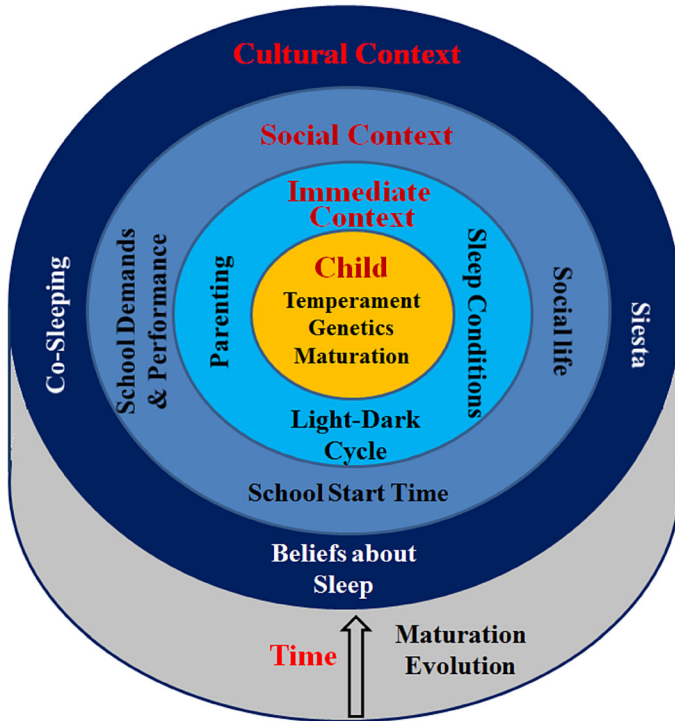


FIGURE 1.—Systems perspective on sleep and development.

their advantages and disadvantages (Chapter III). Although most studies presented pertain to infants and young children, issues addressed apply to development throughout adolescence, and our reference to “children” applies to infants through adolescents. All empirical studies presented were conducted using community samples of typically developing children.

Chapter II summarizes discussions from an SRCD-sponsored forum on sleep and development that included scholars from multiple disciplines, and presents its guiding recommendations for research priorities. This chapter highlights the need for integrative conceptual frameworks that incorporate the multidisciplinary nature of the field, promote consensus on definitions and measurement of pertinent constructs, and represent best practices in research methods. Themes addressed that influence sleep and development include biobehavioral mechanisms; family processes, and sociocultural factors with a focus on economic adversity. In addition, open questions, recommendations, and best practices for sleep assessment, statistics and research design are presented. Some readers will be more familiar with some

topics than others (e.g., those from the pediatric sleep field may be more familiar with sleep assessments whereas developmentalists may be more familiar with longitudinal methodologies and developmental issues) and we adopted a wide lens in writing this monograph.

Monograph chapters presenting empirical studies provide examples of relations between sleep and some of the many individual and familial factors that influence and are influenced by sleep. All empirical studies presented (Chapters IV–X) have the following common features: (1) They have a longitudinal element in their designs, a feature that is not common in the literature, yet one that is pivotal for understanding child development; (2) They demonstrate linkages between various sleep parameters (schedule, duration, quality, sleeping arrangements) and other key developmental domains (e.g., crawling, attachment, parenting, marital interactions); (3) They utilize objective assessments of sleep derived from actigraphy in the assessment of sleep duration or quality (i.e., with the exception of Chapter X where sleep arrangements and not sleep duration or quality were assessed); objective assessments have been underutilized and are important for examining children’s sleep (discussed further in Chapter III); and (4) They all include “typically” developing children.

A Developmental Ecological Systems Perspective Adapted to Sleep

The evolution of sleep–wake patterns during childhood is linked to multiple developmental and environmental micro- and macro-systems, many of which evolve bidirectionally and dynamically over time (e.g., with child’s age and maturation, and social and cultural changes). In this monograph, our underlying conceptual perspective is that of a systems model, which is adapted to sleep based on: (a) the perspective of Bronfenbrenner’s ecological systems theory (Bronfenbrenner, 1979; Bronfenbrenner & Ceci, 1994); and (b) the transactional (systems) model of development introduced by Sameroff (Sameroff, 1989, 2000; Sameroff & Fiese, 1990) as adapted to sleep development (Sadeh & Anders, 1993).

Figure 1 illustrates some of the systems related to child sleep and the links between these systems. Note that we use the “Child Context,” “Immediate Context,” “Social Context,” and “Cultural Context” to refer to the various levels of influence on children’s sleep. A critical dimension is time, reflected in the model by the child’s maturation. By extending the time perspective, we can address the role of evolution in shaping our cultures, societies, and our specific sleep ecology. For instance, the introduction of artificial light has dramatically transformed our reliance on the natural light–dark cycle. Advances in technology offer more and more attractions that compete with sleep time. As a result, children’s sleep time has been steadily decreasing over many decades (Matricciani, Olds, & Petkov, 2012). In the following sections

we briefly review some examples of these links and introduce how the studies included in this monograph can be integrated into this complex systems model.

The monograph cannot be exhaustive either in its presentation of studies demonstrating all levels presented in Figure 1 or in identifying all developmental outcomes associated with sleep. Rather, we hope that this collective and selective presentation will illustrate the many sleep parameters that can be examined in relation to numerous child developmental outcomes in several contexts, mostly the family setting.

The Child Context

Individual characteristics of infants and children can impact their sleep development. The sleep–wake system undergoes a dramatic process during the first few months of life. The average newborn spends 16 hr in sleep distributed to a number (5–6) of episodes around the clock. By 6 months-of-age (or even earlier), most infants attain one prolonged and relatively consolidated sleep episode during the nighttime hours and most wakefulness occurs during the daytime hours. This process is related to brain maturation and functioning of the pineal body, which secretes melatonin and represents the environmental light–dark cycle (secreted during dark hours and eliminated by light) and is closely linked to the evolving sleep–wake patterns throughout life (Crowley, Acebo, Fallone, & Carskadon, 2006; Haimov et al., 1994; Sadeh, 1997; Tzischinsky, Skene, Epstein, & Lavie, 1991). Development of the pineal body is also related to the massive maturational changes associated with puberty and the related sleep phase delay (Carskadon et al., 1993, 2002; Sadeh et al., 2009).

Another major maturational change associated with brain activity during sleep is the dramatic reduction in REM sleep from about 8 hr per day in newborns to about 1.5–2 hr in adults (Roffwarg, Muzio, & Dement, 1966), which mostly occurs during the first 3 years that are characterized by rapid growth of synaptic number and connectivity. Another major change is associated with the localization, distribution, and coherence of brain activity from early childhood to late adolescence. For example, it has been demonstrated that slow wave activity during sleep shifts from posterior to anterior brain regions with maturation (Kurth et al., 2010), and the intrahemispheric coherence of EEG activity increases in both left and right hemispheres (Tarokh, Carskadon, & Achermann, 2010). Furthermore, it has been consistently demonstrated that non-REM slow wave activity is decreasing during adolescence (Campbell et al., 2011; Feinberg & Campbell, 2011; Jenni & Carskadon, 2004). It is assumed that these processes reflect some aspects of brain organization and synaptic pruning occurring around the adolescence period (Feinberg & Campbell, 2011; Feinberg, Higgins, Khaw, & Campbell, 2006; Spear, 2000).

The child domain includes many other parameters including common medical issues such as digestive problems, respiratory problems, allergies, headaches, ear infections, and practically any physical discomfort can disrupt sleep patterns for brief or extended periods (Bruni, Russo, Violani, & Guidetti, 2004; Bursztein, Steinberg, & Sadeh, 2006; Gaultier, 1999; Gozal, 2008; Kahn, Mozin, Rebuffat, Sottiaux, & Muller, 1989; Kahn et al., 1987; Koinis-Mitchell, Craig, Esteban, & Klein, 2012). Furthermore, difficult temperament has been implicated in early childhood sleep problems (Ednick et al., 2009). However, the impact of sensory stimulation (emanating from the body or the environment) on sleep is still a relatively unexplored territory. Chapter IV in this volume on reactivity and sleep in infants addresses the role of infant sensory reactivity across different modalities (touch, light, sound) during wakefulness and during sleep in the evolving infant sleep patterns during the first year of life.

According to the dynamic systems perspective, developmental milestones are often associated with temporary reorganization of different psychological systems (Thelen, 1995). For instance, the onset of separation distress around the end of the first year of life can lead to sleep problems as sleep represents a major separation for both the parents and the infant (DeLeon & Karraker, 2007; Scher & Blumberg, 1999). This illustrates the dynamic nature of influence between sleep and other developmental processes. Moving to a different domain, motor development is a self-generated process driven by brain maturation (Counsell et al., 2008; Gilmore et al., 2012; Peterson et al., 2003). Children's ability to crawl or walk has striking influences on their perception of the world, their ability to interact with their environment and to regulate proximity to their caregivers. The onset of crawling is a key milestone in motor development. The study presented in Chapter V of this volume explores the impact of the onset of crawling on infant sleep. Furthermore, Chapter VI in this volume illustrates the importance of interactions among individual differences in physiological reactivity indexed by respiratory sinus arrhythmia, family conflict, and prior sleep regulation in the prediction of older children's sleep duration and quality over time. Thus, this chapter encompasses multiple levels of influence and interactions among them in the prediction of children's sleep.

The Immediate Context

Children's sleep is strongly affected by agents in their immediate context. Family caregivers play a primary role in creating conditions conducive to children's sleep during the night and wakefulness during the day (e.g., through regulation of light exposure, caffeine consumption, and through parental monitoring of bedtimes and wake times). Several studies in this monograph address issues related to parenting and child sleep. Illustrative of transactional dynamics, parents and caregivers influence infant sleep (e.g.,

through their cognitions and bedtime behaviors), but infant sleep is also a key factor in family adjustment and parental sleep (Tikotzky & Sadeh, 2009). For example, decisions regarding sleeping arrangement (e.g., room-sharing, bed-sharing, or solitary sleep) are determined by family factors, cultural norms and housing options (Ball, Hooker, & Kelly, 2000; McKenna et al., 1993; Mindell, Sadeh, Wiegand, How, & Goh, 2010; Thoman, 2006). Sleeping arrangement may not only have a direct impact on infant sleep (McKenna, Mosko, Dungy, & McAninch, 1990; McKenna et al., 1994), but also on maternal functioning. The study presented in Chapter X examines the links between infant sleeping arrangements and mothers' marital and emotional adjustment. Further, the study presented in Chapter VII examines bidirectional links between maternal and infant sleep, and the role of paternal involvement in caregiving during the first six months postpartum. In addition, sleep is an important separation challenge for children and their parents. The study presented in Chapter VIII addresses the links between toddlers' attachment to their mothers and toddlers' sleep. The study presented in Chapter IX focuses on bedtime routines in children and the associations of bedtime routines with both parenting behavior and children's sleep duration and quality. Finally, parental marital aggression has been associated with disruptions in children's sleep, and the effect of marital aggression on children's sleep as moderated by physiological reactivity (a child domain variable) is discussed in Chapter VI.

The Social Context

Although not a focus of the individual studies in this volume, the larger social context of children's sleep is critical when examining links between sleep and development (discussed in Chapter II). This context includes key factors such as peers/friends and associated social pressures and romantic relationships; school with its schedules, demands, and challenges to children's alertness and learning skills; and the need to work to support the family. Using the transactional system perspective, it is easy to understand how these factors may both influence children's sleep-wake problems and are influenced by sleep. For instance, school start time has a direct influence on children's sleep schedule and sleep duration (Hansen, Janssen, Schiff, Zee, & Dubocovich, 2005; Owens, Belon, & Moss, 2010). Homework and school-related extracurricular activities play an increasing role in affecting sleep patterns as children progress through higher grades. Relations are bidirectional since insufficient or poor sleep has important adverse effects on cognitive performance and school behavior. As early as 1913, scientists reported associations between sleep and school performance and cognitive abilities in children (Terman & Hocking, 1913). More recent research has demonstrated that insufficient or poor quality sleep has significant adverse effects on cognitive performance and school achievement (Astill et al., 2012;

Dewald et al., 2011; Sadeh, Gruber, & Raviv, 2003). Other Social Context factors bearing on child sleep are the use of multiple media formats (e.g., television, video games, cell phones; Dworak, Schierl, Bruns, & Struder, 2007; Johnson, Cohen, Kasen, First, & Brook, 2004; Munezawa et al., 2011; Paavonen, Pennonen, Roine, Valkonen, & Lahikainen, 2006; Van den Bulck, 2007) and consumption of caffeinated beverages (Ludden & Wolfson, 2010; Pollak & Bright, 2003)—both of which increase with age.

The Cultural Context

This context shapes perceptions, expectations, and norms about sleep, sleep arrangements, and potential interventions for sleep problems. Cultural influences include preferences for sleeping alone, co-sleeping, or room/sleep surface sharing; distribution of sleep over 24 hr (e.g., endorsement of naps for both children and adults); the need to work to support the family; and poverty and its correlates (e.g., bedding, noise, exposure to allergens, crowded housing). Notably, many of these variables constitute sociocultural influences.

Many studies have shown significant cultural or racial/ethnic differences in sleep patterns in infants, children, and adolescents (e.g., Bronstein & Montgomery, 2013; Galland et al., 2012; Gradisar, Gardner, & Dohnt, 2011; Pan, Chou, Zhang, & Liu, 2012; Shochat, 2013; Worthman & Brown, 2013). For example, in predominantly Asian countries, most infants and toddlers sleep in the same room with their parents whereas in predominantly Caucasian countries, most children beyond the first few months sleep in a separate room (Mindell, Sadeh, Wiegand et al., 2010). This study also demonstrated striking cultural differences in sleep patterns of children during the first 3 years of life (e.g., with Japan identified as the country where infants and young adults sleep less than in many other countries; see also Steptoe, Peacey, & Wardle, 2006). It is not clear if these differences reflect cultural differences in sleep needs or in the attitudes toward sleep and competing behaviors.

If we examine the issue of culture as an example of the dynamic systems perspective, research data demonstrate the effects of culture on many levels of the system. If we return to the large cross-cultural study of sleep in early childhood (0–3 years), significant cultural differences (predominantly Asian versus predominantly Caucasian countries) were found in: (a) Parental sleep-related choices and behaviors (Mindell, Sadeh, Kohyama, & How, 2010); (b) Parental perceptions of children's sleep problems (Sadeh, Mindell, & Rivera, 2011); and (c) Parent-reported sleep patterns in children. Importantly, although group differences were observed across all of these domains, the internal links between the domains were strikingly similar, suggesting that the transactional relations between parental behaviors and child's sleep are quite robust. Any significant change introduced to a specific

culture or society can downstream and affect many domains associated with sleep (see Figure 1). For instance, the availability of electricity (and the related options for artificial light and other technological appliances and media exposure) has significant impact on sleep schedule and quality (Nag & Pradhan, 2012; Peixoto, da Silva, Carskadon, & Louzada, 2009), and could trigger changes across multiple levels of the model.

The Transactional Nature of Sleep and Development

Finally, some of the most interesting and informative processes are those that manifest interconnections across the levels represented in the Figure (e.g., the aforementioned example regarding the availability of electricity). Complex interactions across levels occur as development progresses. Just as individual maturation is characterized by dynamic change, all of the other levels change simultaneously and/or over time: family structure changes inevitably and the social and cultural contexts evolve. The studies presented in this monograph illustrate some of this complexity by examining different levels of influence longitudinally (mostly at the child and immediate context levels). Although studies presented in this monograph were not directed specifically to ascertain the influence of cultural context factors, an important feature of the monograph is that it presents studies conducted in three countries and includes studies of children from cultural minorities and those exposed to economic adversity; samples underrepresented in the literature at large. This monograph demonstrates that progress will require trans-disciplinary developmental research across multiple levels of influence—with increasing recognition that sleeping and waking processes are intertwined in complex ways.

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