Developmental Psychology
2012, Vol. 48, No. 6, 1511–1528

0012-1649/12/$12.00 DOI: 10.1037/a0027680

Patterns of Developmental Change in Infants' Nighttime Sleep Awakenings from 6 through 36 Months of Age

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Nighttime sleep awakenings and infant and family characteristics were measured longitudinally in more than 1,200 infants when the infants were 6, 15, 24, and 36 months old. By 6 months of age, the majority of children slept through the night, awakening their mothers only about once or twice per week. However, not all children followed this predominant developmental pattern. Using growth mixture modeling, we identified 2 distinct developmental patterns. One group, labeled *Sleepers*, included 66% of the children. These children showed a flat trajectory of sleep awakenings from 6 through 36 months, with mothers reporting their infant awakening from sleep about 1 night per week. The second group, labeled *Transitional Sleepers*, included 34% of the infants. These children had 7 reported nights of awakenings per week at 6 months, dropping to 2 nights per week at 15 months and to 1 night per week by 24 months. Compared with Sleepers, Transitional Sleepers were more likely to be boys, score higher on the 6-month difficult temperament assessment, be breastfed at 6 and 15 months old, and have more depressed mothers at 6 months old. Using 2-group structural equation modeling, we examined individual differences at different points on the individual infants' sleep trajectories. For infants in both groups, reported sleep awakenings were associated with difficult temperament measured at 6 months, breastfeeding, infant illness, maternal depression, and greater maternal sensitivity. Infant–mother attachment measures were not related to these sleep awakenings.

Keywords: infant sleep awakenings, breastfeeding, temperament, maternal sensitivity, attachment

The most common parental concerns reported to pediatric practices are those relating to initiating and maintaining sleep in infants (Anders & Eiben, 1997; Anders, Halpern, & Hua, 1992; Dollinger, 1982). A large minority of children have problems with awakenings during the night at some time in the first 4 years of life, with estimates ranging from 15% to 54% (Gaylor, Goodlin-Jones, & Anders, 2001; Hiscock & Wake, 2001; Jenni, Fuhrer, Iglowstein, Molinari, & Largo, 2005; Kataria, Swanson, & Trevathan, 1987; Pollock, 1992; Sadeh & Anders, 1993). For both pediatricians and developmental psychologists, sleep awakenings and their trajectories are of interest because they disrupt the emotional life and schedules of parents and siblings.

This article was published Online First March 26, 2012.

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This study was directed by a steering committee and funded by the National Institute of Child Health and Human Development (NICHD) through a cooperative agreement (5 U10 HD027040), which calls for scientific collaboration between the grantees and the NICHD staff. Early drafts of this paper were authored by the members of the Phase 1 and Phase 2 NICHD Early Child Care Research Network; all data were collected as part of that network. We express our appreciation to the many ECCRN investigators for their work designing this study, study coordinators at each site for supervising data collection, the research assistants for collecting data, the teachers and caregivers for completing forms, and the families who welcomed us into their homes and cooperated willingly with our repeated requests for information.

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At the same time, sleep awakenings are normative during infancy. Healthy babies cycle through sleep stages, waking several times during the night. Generally, babies soothe themselves and return to sleep without alerting their parents (Anders et al, 1992; Goodlin-Jones, Burnham, Gaylor, & Anders, 2001). When babies are not able to return to sleep on their own, they may *signal* their awakening to their parents. This signaling may take the form of either crying or calling out, and it alerts the parents to the child's awakening. This signaling can be disruptive to parents (Karraker & Young, 2007) and considered a sleep "problem." Some researchers see these sleep awakenings reported by parents to be *sleep continuity problems* (e.g., Sadeh & Anders, 1993). Although not all parents experience infant signaling upon awakening as problematic (Karraker & Young, 2007), describing and understanding sleep awakenings poses an important challenge for developmental psychologists. Research suggests that difficulties with sleep awakenings may foreshadow later problems with physiological, emotional, and behavioral self-regulation (Dahl, 1996; Dearing, Taylor, & McCartney, 2004; Frank, Issa, & Stryker, 2001; Gregory et al., 2005; Karraker, 2008; Lozoff, Wolf, & Davis, 1985; Richman, 1981; Thunström, 2002).

By 3 months old, most infants appear to sleep through the night (Jenni et al, 2005). That is, they may awaken, but they return to sleep uneventfully. The percentage of infants reported as having excessive sleep awakenings declines over the first few years of life (Goodlin-Jones et al., 2001; Lozoff et al., 1985; Richman, 1981; Scher, 1991; Scher, Zukerman, & Epstein, 2005; Thome & Skuladottir, 2005; Tikotzky and Sadeh, 2009; Touchette et al., 2005; Zuckerman, Stevenson, & Bailey, 1987), but not all infants show this characteristic decline. For example, Scher (1991) reported that signaling upon night waking was not uncommon throughout the infant's first year of life, with some parents reporting increased sleep awakenings around the age of 9 months. Jenni et al (2005) in a study of both pre- and full-term Swiss infants, found that night waking reports increased from the time the infants were 3 months old until 4 years of age. In an Internet questionnaire study, Sadeh (2004) found nonlinear, age-related trends in parent reports of night waking, with as many as 30% of infants and toddlers continuing to have multiple or prolonged night awakenings. Research has also pointed to groups of children for whom difficulties with sleep awakenings continue through early childhood or for whom problems recur even after intervention (Lam, Hiscock, & Wake, 2003; Thome & Skuladottir, 2005; Wolke, Meyer, Ohrt, & Riegel, 1995).

Most of the research on predictors of infant sleep awakenings has examined individual differences at particular infant ages, rather than individual differences in patterns over time. Although it is generally assumed that signaling upon sleep awakenings tends to decrease over the first 3 years of life, this may not be the case for all infants, and focusing on measures of central tendency at any given age may give only a partial picture of infant and toddler sleep. Burnham, Gaylor, and Williamson (2009) suggested that variability in sleep patterns across time needs to be acknowledged and understood in order for pediatricians and developmental psychologists to fully assess and diagnose sleep disorders. To do this, longitudinal data from large, normative samples are needed.

Several heuristic models have been offered for understanding individual and developmental differences in infant sleep awakenings. Using a systems perspective, Sadeh and Anders (1993) proposed a transactional model of sleep–wake regulation that acknowledges the role of the distal extrinsic context, including cultural norms, family socioeconomic factors, and experiences in the caretaking environment. Their model takes into account the role of the proximal extrinsic context (parental emotional characteristics), intrinsic infant characteristics (health, temperament, and developmental factors), and the parent–child relationship and interactions. Similarly, Beebe (2008) proposed a heuristic model that assumes both bidirectional and mediational relations among intrinsic and extrinsic child factors. Karraker (2008) proposed an integrative perspective that emphasizes parent–infant behavioral contingencies and developmental and transactional processes that might affect night waking. In all three models, intrinsic factors, such as infant temperament, health, and separation issues, as well as extrinsic factors, such as parental behaviors and characteristics, the family context, and the child's relationships with others, are assumed to affect parental reports of sleep awakenings.

Although the current literature implicates both biological and environmental factors in sleep awakenings, the underlying causes of infant sleep awakenings are not well understood. Building on Borbély's (1982) two-process model of sleep, Jenni and LeBourgeois (2006) suggested that frequent night waking may occur when homeostatic and circadian processes are misaligned. However, the issue underlying parental reports of sleep awakenings appears to be one of infant signaling—that is, alerting their parents upon their awakening—rather than one of actual awakening. That is because most children who awaken return to sleep on their own. Thus, understanding infants' capacity and propensity for self-soothing in particular and self-regulation more generally may be key to understanding most parental reports of infant sleep awakenings.

Some researchers have attributed repeated infant awakenings to repeated parental responses to infant normative sleep awakenings. Parental responses may interfere with the infant's developing ability to self-soothe and return to sleep independently (Goodlin-Jones et al., 2001; Karraker, 2008; Touchette et al., 2005; Warren, Howe, Simmens, & Dahl, 2006). At the same time, pre-existing infant problems with self-soothing (Burnham, Goodlin-Jones, Gaylor, & Anders, 2002) and possibly self-regulation in general (Dahl, 1996) may elicit more solicitous parenting behavior. Infant difficulties in self-soothing may elicit parental responsiveness to awakenings, which in turn reinforces infant's signaling behavior on awakening and further delays the infant's abilities to self-soothe and return to sleep quietly (Karraker, 2008). A negative circular pattern can arise when well-intentioned or exhausted parents attempt to intervene on behalf of infants who struggle to soothe themselves back to sleep. More involved mothers may have children with more awakenings because they respond more quickly to their children's awakenings (e.g. Tikotzky & Sadeh, 2009), and their children fail to learn self-soothing.

In particular, babies who breastfeed may find it difficult to soothe themselves and return to sleep in the middle of the night because they have become accustomed to falling asleep while nursing (e.g. Karraker, 2008). Early in infancy, breastfed babies may awaken more frequently throughout the night than formula-fed infants (e.g. Elias, Nicholson, Bora & Johnston, 1986) because breast milk is digested more quickly; later in infancy, breastfed infants may awaken more frequently, not because they are hungry but because they have difficulty returning to sleep without the customary nursing (Karraker, 2008; Middlemiss, 2004).

As capacity for self-regulation in the second and third years of life increases, most children resolve their early difficulties with sleep awakening (Bronson, 2000; Tikotzky & Sadeh, 2009). Self-soothing, infants no longer need to signal upon awakening. However, the normal capacity for self-soothing may be challenged in infants with temperamental difficulties; unusual health problems such as normative or excessive ear, gastrointestinal, or respiratory illnesses; insecure attachment; instabilities in the family situation; maternal depression; or parental behavior surrounding sleep.

In this article, we examine whether different prototypic patterns of sleep awakening can be identified over the course of infancy and whether specific intrinsic or extrinsic factors are associated with these prototypic sleep patterns. We also examine individual differences in sleep awakenings at three points across infancy, trying to understand not only patterns of sleep but also intrinsic and extrinsic factors that may affect developmental changes in processes related to infant sleep regulation. The identification of patterns of sleep awakenings over time may help inform pediatric practice, provide useful guidance to parents, and provide insight into the origins of sleep–wake regulation.

Intrinsic Variables Related to Sleep Awakenings

Gender

Gender does not appear to play a consistent role in sleep awakenings (e.g., Burnham, Gaylor, Williamson & Wei, 2009; Germo, Goldberg, & Keller, 2009; Iglowstein et al., 2003; Touchette et al., 2005). The gender differences that have been reported may be culture specific. In Israel, girls were reported to have more sleep problems than boys (Scher et al., 1995); in the United States, boys have been reported to have more sleep problems than girls (Goodlin-Jones et al., 2001; Weissbluth, David, & Poncher, 1984). Even though research does not show a clear role for gender in early sleep awakenings, it seems premature not to examine sex differences in infancy as a possible entry into maladaptive sleep patterns.

Temperament

Difficult temperament appears related to sleep awakenings and sleep problems in general (Jimmerson, 1991; Minde et al., 1993; Morrell & Steele, 2003; Scher et al., 2005; Touchette et al., 2005; Weissbluth et al., 1984). According to Sadeh & Anders (1993), infants who are irritable and hypersensitive and have lower sensory thresholds may sleep for shorter periods and nap irregularly. Morrell and Steele (2003) suggested that difficult infants may elicit more active parent comforting, which may perpetuate night awakenings. Longitudinal studies have shown positive associations between behaviorally assessed temperament and subsequent sleep problems (Keefe, Kotzer, Froese-Gretz, & Curtin, 1996; Snow, Jacklin & Maccoby, 1980) but not between maternal perception of temperament and subsequent sleep problems (Halpern, Anders, Garcia-Coll, & Hua, 1994).

Breastfeeding

Several studies have associated problems with sleep awakenings with factors related to breastfeeding—being nursed to sleep, having parental presence until sleep onset, or being fed on awakening (Lam et al., 2003; Touchette et al., 2005). Elias, Nicholson, Bora, and Johnston (1986), following babies for 2 years, reported that sleep awakenings were common in breastfed infants throughout the first 2 years of life; few studies have disputed this finding.

Attachment

Sadeh and Anders (1993) suggested that examining the association between the parent–child attachment system and sleep disturbances might be especially fruitful. Because going to bed can be a time of "heightened anxiety and uncertainty" (p. 28), children with a secure attachment to a parent might be less likely to have sleep problems. Evidence that attachment might be related to sleep disruptions has been accumulating. DeLeon and Karraker (2007) reported that mothers' ratings of the intensity of their 9-month-old infants' separation distress correlated positively with reported night awakenings. McNamara, Belsky, and Fearon (2003) found that 15-month-old infants with ambivalent attachments were reported to have more awakenings than infants with avoidant attachments and later showed more clinical sleep problems than infants with an avoidant attachment profile. According to Morrell and Steele (2003), ambivalent attachment correlated with sleep problems in infants at 12 months old and predicted persistent problems at 2 years old. However, Morrell and Steele emphasized that this association is still in question for two reasons. First, the association observed in their study was quite small. Second, the researchers noted that the majority of infants with persistent sleep problems did not show ambivalent attachment. Thus, it is not entirely surprising that in their analysis of data from more than 10,000 infants in the Early Childhood Longitudinal Study–Birth Cohort (ECLS–B), Burnham, Gaylor, Williamson, and Wei (2009) found that infants with frequent night waking at 9 months were more likely to be rated as securely attached at age 2 years than infants not rated as secure. The relations between sleep awakenings and attachment require further investigation.

Child Illness

Health problems may affect the infant's ability to sleep through the night. Inability to breathe due to respiratory difficulties, gastric discomfort, or pain accompanying ear infections can awaken infants much as it awakens adults, though it has rarely been studied in investigations of infant sleep. Although few infants suffer from obstructive sleep apnea syndrome (Thiedke, 2001), the possibility exists that infant illnesses, even transient ones, can affect sleep awakenings.

Maternal and Environmental Variables Related to Night Awakenings

Maternal Depression

Several researchers have reported that maternal depression is associated with infant sleep awakenings or sleep problems (Hiscock & Wake, 2001; Karraker & Young, 2007; Lam et al., 2003; Lozoff et al., 1985; Richman, 1981; Zuckerman et al., 1987). To untangle the nature of the relation between infant sleep awakenings and maternal depression, Warren, Howe, Simmens, and Dahl

(2006) examined the relation between maternal depressive symptoms and duration and frequency of infant sleep awakenings using longitudinal data from the National Institute of Child Health and Human Development Study of Early Child Care and Youth Development (NICHD SECCYD). They found that child awakenings did not predict maternal depressive symptoms; instead, higher maternal depressive symptoms predicted increased duration, but not frequency, of child awakenings across the 15- to 24-month and 24- to 36-month periods. These findings indicate that the mother's emotional characteristics, particularly her depression, may have a direct effect on her child's sleep.

Maternal Sensitivity

Although parental sensitivity is generally related to all things optimal in infants (e.g., Davis & Logsdon, 2011), it is not clear that maternal sensitivity, as typically measured, reduces sleep problems. Indeed, there is reason to suspect that parental sensitivity to infant awakenings may be related to more sleep awakenings and later sleep problems (Keller, Buckhalt, & El-Sheikh, 2008). Specifically, rather than allow infants to self-soothe and return to sleep on their own, parents who respond to awakenings with attempts to comfort or feed may interfere with their infant's growing ability to self-soothe and return to sleep independently. Karraker (2008) explained, "Parent responsiveness to infant night waking may reinforce infants' signaling behavior following awakening and teach them to expect parental interventions. Alternately, a lack of parent responsiveness can eventually. . .extinguish the signaling behaviors" (p. 114). Findings support this notion. According to Touchette et al. (2005), feeding after an awakening was the factor most strongly associated with infants not sleeping through the night at 5 months, and parental presence until sleep onset was the factor most strongly associated with sleep awakening at 17 and 29 months. At later ages, issues related to parental limit setting may be more predictive of sleep awakenings and persistent sleep problems than parental sensitivity (Touchette et al., 2005). Similarly, Tikotzky and Sadeh (2009) found that more parental involvement at bedtime, as well as greater parental sensitivity to infant distress, was correlated with more infant night waking in children up to 1 year old. The success of interventions aimed at limiting parental responsiveness to infant calls for attention around bedtime and awakenings (e.g. Ferber, 1985) suggests that parental efforts to comfort and placate young children who struggle with going to sleep may contribute to sleep difficulties through the second year of infancy.

A recent study supports the importance of mothers' emotionally sensitive attempts at limit-setting behavior during bedtime. Teti, Kim, Mayer, and Countermine (2010) showed that mothers' *emotional availability* at bedtime positively predicted infants' sleep quality. Emotionally available mothers were those "who prepared their infants for bed using positive, quiet, soothing bedtime routines that gently guided infant toward sleep" (p. 311). Although highly sensitive, these mothers were careful not to initiate new interactions and avoided high-volume, intrusive talk. In their rating scheme for sensitive mothers, Teti and his colleagues allowed the highly sensitive mother category to include those mothers who did *not* respond to their infant's calls after the infant had been put down to sleep or who delayed as much as 1 min before responding to distress cries, since the goal of the bedtime interaction was to gently guide the child to sleep. Thus, *not* responding to infant distress calls specifically at bedtime may be associated with better infant sleep quality.

Environmental Variables Related to Night Awakenings

Father's Presence

No studies have focused on the father's direct role in sleep problems, but fathers' presence may affect the mother's responsiveness and emotions about sleep awakenings. Sadeh, Flint-Ofir, Tirosh, and Tikotzky (2007) reported that fathers were more likely than mothers were to endorse imposing bedtime limits on infants. To the extent that a partner in the home objects to interruptions caused by awakenings and encourages the mother's limit setting, infants in two- parent households may be *less* likely to experience multiple sleep awakenings than infants in single-parent households. Alternatively, it is possible that more than one adult caregiver in the home could lead to *more* responsiveness to infant waking. That is, if one parent does not wake up, the other one might.

Child Care and Birth Order

There is limited evidence that sleep problems are related to child care attendance (Hauseman, Weinraub, & McCartney, 1993; Jimmerson, 1991) and birth order (Scher et al., 1995). Child care may affect children in a number of ways. It could increase children's tolerance for environmental interruptions during sleep. Alternatively, child care may increase sleep disturbance by making children more vigilant and stressed at bedtime. Center care, with lower teacher-to-child ratios, may create more stress in children than other forms of nonmaternal care. Birth order may be related to increased parental experience with sleep awakenings, or it could create more distractions and stress at bedtime.

Current Study

In this study, we examined child, parent, and environmental factors that have been implicated in affecting—or that have been hypothesized to affect—the developmental course of sleep awakenings, focusing on those factors that may place children at risk for later sleep problems. We considered child characteristics (e.g., difficult temperament, breastfeeding, attachment to the mother, birth order, and health problems), maternal characteristics (e.g., depression, sensitivity), and environmental factors (presence of a spouse or partner in the household, amount of time in nonmaternal care, family poverty status, and partner's health). We also examined the effects of maternal and paternal health as they may affect parental responsiveness to infant sleep awakenings. Finally, we considered marital conflict because research has suggested that marital conflict may disrupt children's sleep in middle childhood (El-Sheikh, Buckhalt, Mize, & Acebo, 2006), and we also added a measure of harsh parenting/maternal acceptance, as parental harshness and lack of acceptance may more directly affect younger children's sleep.

With a large and diverse sample of families from 10 different locations across the United States, the NICHD SECCYD longitudinal data set is ideal for examining changes from 6 to 36 months in infant sleep awakenings and their relations to family experiences. Using these data, three other sets of researchers have provided interesting findings regarding correlates of sleep awakenings at particular ages. Karraker and Young (2007) examined the relations between maternal depression and infant awakenings at 6 months, Warren et al. (2006) examined the relations between maternal depressive symptoms and duration and frequency of infant sleep awakenings over the first 3 years of infancy, and McNamara et al. (2003) compared anxious and avoidant attached infants' sleep at ages 15 and 24 months. In this report, we modeled individual differences in infant sleep trajectories over the entire first 3 years of infancy, and we examined the factors that may account for individual differences in these developmental patterns that may be related not only to maternal depression and infant attachment but also to other variables concerning family health and family risk.

We had three aims. The first was to estimate the developmental trajectories of infant sleep awakenings. Cross-sectional studies and the theoretical literature suggested that a small number of developmental patterns characterize the large majority of infants between 6 and 36 months old. Because sleep is critical for good health and normal development, it seemed likely that the largest group of children would show very low levels of sleep problems throughout this period. At the same time, because there are numerous conditions that could disrupt sleep, we expected to identify a second group of infants who would show early sleep difficulties but whose sleep problems would abate with time and with the increasing capacity for self-regulation. We also considered the possibility that there could be a third and relatively small group of infants for whom sleep awakenings would continue and possibly increase over time. These babies, we hypothesized, might have constitutional problems with self-soothing that are aggravated by environmental conditions or health problems.

The second aim was to identify important processes associated with the developmental trajectories by examining relations of the trajectories with intrinsic child factors—temperament, breastfeeding experiences, attachment security, and health problems—and with extrinsic factors—those relating to familial and environmental risk factors. Previous research suggested that early in infancy, infants with difficult temperament and infants who were breastfed might have more awakenings than other infants. Later in infancy, separation distress, insecure attachment, and infant respiratory, ear, and intestinal illnesses might account for variation in sleep awakenings in children. Children with the most reported sleep awakenings, we hypothesized, would reside with a mother with high levels of depressive symptoms, as Karraker and Young (2007) and Warren et al. (2006) had reported. It also seemed that children with high levels of sleep awakenings might have a mother with who is highly sensitive and particularly responsive to their distress. Family poverty was added because families living in poverty might be likely to be more stressed and also because parents in poverty might be likely to sleep in closer proximity to their infants than more affluent parents. For completeness, we examined possible associations between infant sleep awakenings and child gender, birth weight, and the quantity of nonmaternal child care children experienced.

A third aim was to examine individual differences in sleep awakenings at specific points across infancy. We were interested in exploring whether the predictors of awakening early in infancy—at 6 months of age—might be different from those later in infancy. Examining individual differences in addition to patterns may help illuminate developmental changes in processes related to infant sleep regulation.

Method

Sample

We recruited participants for the study in 1991 from hospitals at 10 data collection sites: Little Rock, Arkansas; Irvine, California; Lawrence, Kansas; Boston, Massachusetts; Philadelphia and Pittsburgh, Pennsylvania; Charlottesville, Virginia; Seattle, Washington; Hickory and Morganton, North Carolina; and Madison, Wisconsin. Recruitment and selection procedures are described in detail in several publications (NICHD Early Child Care Research Network [ECCRN], 1994, Vandell, 1996). Of the initial pool of eligible mothers contacted for participation, 1,364 completed the 1-month home visit and became study participants. These 1,364 families were very similar to the eligible hospital sample on major demographic characteristics (years of maternal education, ethnicity, and presence of partner in the home). The resulting sample was diverse, including 24% ethnic minority children, 11% mothers who had not completed high school, and 14% single-parent mothers (percentages not mutually exclusive). Mothers had an average of 14.4 years of education (SD = 2.49 years), and 51.7% of the children were boys. Eligibility requirements specified that mothers be 18 years or older, speak English, plan to be in the geographic area for the next 3 years, not have known or acknowledged substance abuse, and have infants who had not been hospitalized at birth for more than 7 days and did not have any obvious disabilities. This had the effect of screening out very low birth weight, severely premature, or sick infants from the study. The sample was not designed to be nationally representative. However, the sample was similar to families in the census tract records and the nation as a whole on key demographic variables (household income and ethnicity).

We considered data from each subject complete if data from at least two assessment points were available. With this criterion, complete sleep data were available from more than 88% of the initial sample: 1,276 mothers and their infants at 6 months, 1,243 at 15 months, 1,206 at 24 months, and 1,215 at 36 months. The sample was approximately half male at each age. Compared with children for whom we had insufficient sleep data for analyses, children with sleep data at two or more of the assessment points appeared to be less likely to be from a minority ethnic group (analysis sample: 23%; excluded sample: 35%, p = .44), and more likely to have more educated mothers (14.29 vs. 13.15 years of education, p = .34), but these differences were not statistically significant. For measures of gender, birth weight, birth order, and minority status, we had complete data from 1,364 subjects. The measure with the fewest data points was the health of the mother's husband/partner, since some mothers did not have a husband or partner living in the home. For that measure, we had only 1,016 reports of husband's/partner's health when the child was 36 months old.

Mothers included in these analyses had an average of 14.3 years of education (SD = 2.49 years), and 13.3% were single parents. Although average family income was 3.66 times the poverty threshold ($SD = 3.10$), 31% of the infants were from low-income families (Federal income-to-needs level 2 or below), and no more than 81% of the children at any assessment period were non-Hispanic White.

Procedure

Research assistants visited mothers and children at home when the children were 1, 6, 15, 24, and 36 months old and made telephone contacts at intervening 3-month intervals. At each face-to-face visit, mothers completed questionnaires about themselves, the child, and their family, and responded to a standardized demographic interview. Children and their mothers came to the universities' laboratories when children were 15, 24, and 36 months old. At these visits, research assistants administered standardized assessments to the children and observed mothers and children playing together. When the infants were 15 months old, we videotaped them with their mothers in the Strange Situation.

Measures

Nighttime sleep awakenings. During a standardized interview, research assistants asked mothers five questions about their child's nighttime sleep in the previous week. We selected these questions, listed in Table 1, to mirror the most common measures of infant problems in use at the time data collection for the study began (Lozoff et al., 1985; Richman, 1981; Zuckerman et al., 1987). We used the number of nights mothers reported sleep awakenings after sleep onset (NIGHTS SA) in the preceding week as the main sleep measure, and we collected this measure when the infants were 6, 15, 24 and 36 months old. This measure is comparable to the measures of fragmented sleep that have been collected in more recent longitudinal studies of sleep (e.g. Jenni et al., 2005; Tikotzky & Sadeh, 2009; Touchette et al., 2005). Parent questionnaire measures of sleep awakenings appear to be highly correlated with measures obtained from actigraphs and parent sleep diaries (Tikotzky & Sadeh, 2009). We present the distribution of infants with sleep awakenings for 1through 7 nights at each age in Table 2.

Problem sleep. For validity purposes, we examined the mother's responses to the question concerning how much of a problem the child's sleep awakenings were for her and her family (see Question 5, Table 1). Mothers' responses were rated on a 1–3 scale, ranging from *not much* to *quite a bit*.

Standardized report of sleep problems. When the children were 24 and 36 months old, mothers completed the Child Behavior Checklist (CBCL 2–3; Achenbach, 1992), a widely used screening checklist with demonstrated test–retest validity as well as concurrent and predictive validity. The CBCL requires mothers to answer *not true*, *somewhat or sometimes true*, or *very true or often true* for each of 100 behavioral items, and we assigned scores 0, 1 or 2, respectively, for these responses. Included among these 100 items were the following items concerning the child's sleep: (a) Doesn't want to sleep alone, (b) Has trouble getting to sleep, (c) Has nightmares, (d) Resists going to bed at night, (e) Sleeps less than most children during day and/or night, (f) Talks or cries out in sleep, and (g) Wakes up often at night. We summed these scores to create a total sleep problems score. Available only when the infants were 2 and 3 years old, the CBCL total sleep problems score was used to test the validity of the NIGHTS SA scores collected at those points.

Child gender, birth weight, birth order, and minority status. Research assistants obtained maternal reports of child gender, birth weight, and birth order, and race/ethnicity from interviews when the infant was 1 month old. Birth order was categorized as first-born or not. Infants categorized by their mothers as "White/European, not Hispanic" were considered "not minority." All others were considered minority.

Difficult temperament. To measure difficult infant temperament, we used 39 six-point items selected from the 55 items on the Infant Temperament Questionnaire (Medoff-Cooper, Carey, & McDevitt, 1993) that mothers completed at the 6-month home visit. We created a composite score representing difficult temperament from the mean of items from the Approach, Activity, Intensity, Mood, and Adaptability subscales (with appropriate items reflected). Higher scores represented more difficult temperament (e.g., "My baby is fussy or cries during the physical examination by the doctor"). Cronbach's alpha for the items administered to this sample was .81.

Breastfeeding. Mothers reported whether their infant was breastfeeding at the 6- and 15-month assessment periods. We entered each of these variables into separate analyses, one at a time, as a categorical variable.

Attachment. Trained, reliable research assistants administered the Strange Situation when the infants were 15 months old according to standard procedures (Ainsworth, Blehar, Waters, & Wall, 1978). Videotapes of the Strange Situation episodes from all sites were shipped to a central location and rated by a team of experienced and reliable coders. We used three measures coded from these videotapes. The first measure is a categorical rating of the child's secure/insecure attachment. We categorized infants as securely attached if they sought comfort from their mothers when they were distressed or greeted their mothers without ambivalence when they were reunited. The second was a categorical measure of attachment style—secure, avoidant, ambivalent–resistant, and disorganized (Main & Solomon, 1990). The third measure was a categorical measure of the child's separation distress during Episode 6 of the Strange Situation, when the child was left alone in the strange situation room. Video viewers coded separation distress, using a 5 point scale—*none*, *mild*, *moderate*, *strong*, and *extreme*. For data analyses, we collapsed these ratings into a categorical yes/no variable. If separation distress was coded as strong or extreme, then distress was scored as yes; if coded as none, mild, or moderate, then distress was scored as no. Details of the coding and characteristics of infant attachment security in the sample are described in NICHD ECCRN (1997, 2006).

Table 1
Sleep Questions Mothers Answered at the 6-, 15-, 24-, and 36-Month Infant Assessments

1. Has your child wakened you during the night in the last week?
2. How many nights during the last week?
3. How many times each night did your child awaken you?
4. If so, for how long was your child awake?
5. How much of a problem was this for you and your family?

Note. Rated on a scale ranging from 1 (*not much*) to 3 (*quite a bit*).

Table 2
Percentage of Infants at Each Age Awakening From 1 to 7 Nights Per Week

Nights/week	6 months %	6 months N	15 months %	15 months N	24 months %	24 months N	36 months %	36 months N
0	29.58	378	33.07	411	35.57	429	37.94	461
1	13.54	173	17.94	223	19.49	235	21.48	261
2	15.02	192	16.81	209	17.08	206	14.98	182
3	5.95	76	10.46	130	9.37	113	8.81	107
4	4.15	53	3.94	49	4.31	52	4.53	55
5	3.99	51	2.98	37	3.23	39	4.12	50
6	3.29	42	2.74	34	1.99	24	1.73	21
7	24.49	313	12.07	150	8.96	108	6.42	78
Missing	86		121		158		149	

Child illnesses. When the infants were 6, 15, 24, and 36 months old, mothers reported whether in the preceding 3 months their child had experienced any of the following health problems: respiratory illnesses, ear infections, or intestinal illnesses. We summed these scores for a child illness measure. These scores could range from 0 (*no illnesses*) to 3 at each assessment.

Maternal depression. When the infants were 6, 15, 24, and 36 months old, mothers completed the Center for Epidemiological Studies Depression Scale (CES–D; Radloff, 1977). Cronbach's alphas for the CES–D across the five data collection points ranged from .88 to .91. The depression scores were moderately stable over time (*rs* = .46–.58).

Maternal sensitivity. We videotaped mother–child interaction in semistructured 15-min observations at each age. The observation task at 6 months had two components. In the first 7 min, mothers were asked to play with their child using any toy or object available in the home or none at all; for the remaining 8 min, mothers were given a standard set of toys they could use in play with their infants. When the infants were 15, 24, and 36 months, the observation procedures followed a three-boxes procedure in which mothers showed their children age-appropriate toys in three containers in a set order. The mother was instructed to have her child play with the toys in each of the three containers and to do so in the order specified. Independent coders rated maternal–child interactions from videotapes. Details of the procedure, coding, and reliability are described in NICHD ECCRN (1999, 2001, and 2006).

At each infant age, we constructed a maternal sensitivity composite based on three of the ratings. At 6, 15, and 24 months, it comprised the sum of three 4-point ratings: sensitivity to nondistress, positive regard, and intrusiveness (reversed). At 36 months, we composited three 7-point ratings: supportive presence, respect for autonomy, and hostility (reversed). Intercoder reliability on the composite was .87 at 6 months, .83 at 15 months, .85 at 24 months, and .84 at 36 months. Internal consistency was .75, .70, .79, and .78, respectively. The composite scores were moderately stable across time (*rs* ranged from .39 to .48). We computed composites across age periods (6–36 months and 24–36 months) by standardizing the scores at each age and averaging them across time.

Acceptance/No Harsh Parenting. Acceptance/No Harsh Parenting is a subscale of the Early Childhood Home Observation and Measurement Environment Inventory (Caldwell & Bradley, 2003) administered at the 36-month home visit. The Early Childhood version of the inventory is composed of 55 items designed to measure the quality and quantity of stimulation and support available to a child in the home environment. The focus is on the child in the environment, the child as a recipient of inputs from objects, events, and transactions occurring in connection with the family surroundings. HOME is one of the most widely used of home environment measures; it affords information about a number of different aspects of caregiving in the child's family environment. Prior to collecting data, all assessors trained at a central location passed a certification evaluation, attaining at least a 90% level of agreement in scoring with gold-standard tapes. The certification process was repeated every 6 months during active data collection. Acceptance/No Harsh Parenting score was created by summing four observations ("mother does not scold," "no physical restraint," "no slaps or spanking," "no physical punishment"). Scores could range from 0 through 4.

Maternal health. When the infants were 6, 15, 24, and 36 months old, research assistants asked mothers to describe their health compared with other women their age on a 4-point Likert scale ranging from *poor* (1) to *excellent* (4).

Second parent/partner in the home. When the infants were 6, 15, 24, and 36 months old, mothers reported whether or not there was a second parent or maternal partner in the home. We entered this variable into the analyses categorically for each assessment period.

Family size. When the infants were 6, 15, 24, and 36 months old, mothers reported how many children and adults were in the home. Families with more than five members of the household (children and adults) were considered large. This categorical variable was entered at each assessment period.

Father's or partner's health. When the infants were 6, 15, 24, and 36 months old, research assistants asked mothers to describe their husband's or partner's health compared with other people their age on a 4-point Likert scale ranging from *poor* (1) to *excellent* (4).

Poverty. Using the mothers' reported family income when the infant was 6, 15, 24, and 36 months old, we computed income-to-need ratio scores using the parents' family income, the number of individuals the mother reported to be in the household, and the

U.S. census poverty levels at the time of the measurement. We averaged these income-to-need scores over the four assessments. We categorized families with average income-to-need ratios below 2 as poor; all others we considered not poor. We entered the variable into the analyses as a categorical measure.

Maternal education. At the first visit with the mother, when the child was 1 month old, mothers reported whether they had completed high school, some training beyond high school, college, or postcollege education; these scores were then transformed into scores representing corresponding numbers of education years. The number of years of maternal education was used in the analyses.

Child care. We examined two quantity measures of nonmaternal care at each assessment point. For *amount* of nonmaternal child care, we used the mother's report of the number of hours per week that her child was cared for on a regular basis by someone other than herself. To smooth out some of the inherent variability in this measure (e.g. child not in care due to illness), we averaged the report for a given time point with reports of assessments immediately adjacent to that report. Thus, the analysis used averaged reports from when the infant was 5, 9, and 12 months old (for the 9-month child care measure), 18, 21, and 24 months old (for the 21-month measure), and 30, 33, and 36 months old (for the 33-month measure). For *percentage of time in center* child care, we counted the percentage of total nonmaternal child care periods that the mother reported that the child spent in center-based care. Due to the larger infant-to-adult ratios in center care, we thought this type of care might be more stressful to infants and might affect their sleep. Detailed information on these child care measures can be obtained from NICHD ECCRN (1997, 2002).

Marital conflict. When infants were 1 month old, mothers completed the Conflict subscale of the Love and Relationships Questionnaire (Braiker & Kelly, 1979), five items designed to tap mothers' experiences of conflict with their spouse or partner. A sample question is: "How often do you and your partner argue?" Answers are given on a 9-point Likert scale that ranges from *very little or not at all* to *very much or extremely*. Scores across the 5 items were averaged.

Data Analyses

Preliminary to the major data analyses, we examined whether nighttime sleep awakenings (NIGHTS SA) are a valid measure of sleep problems in infancy by computing Pearson product-moment correlation coefficients among NIGHTS SA scores, maternal report of infant sleep problems, and CBCL sleep scores at each assessment point. These correlations are presented in Table 3.

Data analysis proceeded in three stages. In the first stage, we identified developmental trajectories of sleep awakenings (NIGHTS SA) with growth mixture modeling. We estimated an unconditional growth model using data collected at four time points (6, 15, 24, and 36 months old) across the period of study. Multiple random start values for parameter estimates were used to assure a global maximum was reached. We used a simple polynomial growth model to identify the developmental trajectories found in the sleep awakening data. Based on preliminary examination of the raw data, the model included a random intercept and linear slope with a fixed quadratic term. We held the latter term fixed to identify the model and make it estimable. The mixture component of the growth mixture model allowed us repeatedly to estimate the model each time with a different specified number of latent classes to ascertain the best possible latent class portrayal of the growth trajectories supported by the data. Within every estimated model, each latent class had its own mean latent growth model estimated, perturbed by individual random variation within the class. This fits the general approach to mixture modeling—beginning with a single class model and gradually adding classes to the specification and re-estimating the model until evidence is accumulated to determine the best model in terms of the number of latent classes. This approach of adding additional classes is constrained by identifiability constraints imposed by the complexity of the data. We used the suggested method for determining the number of latent classes in the mixture model (Nylund, Asparouhov, & Muthén, 2007)—finding the convergence of several sources of evaluation including Bayesian information criterion (BIC) statistics and likelihood ratio tests, followed by checking the solution quality and substantive interpretability. The likelihood ratio tests provides a statistical test indicating whether the addition of the last class is necessary; the BIC statistics enable comparisons

Table 3
Means and Correlations Among Sleep Awakenings (NGTSA), Maternal-Reported Problems With Sleep (Problm), and Child Behavior Checklist (CBCL) Scores From 6 Months Through 36 Months

Scoring	Mean	*SD*	1	2	3	4	5	6	7	8	9
1. NGTSA06	2.89	2.79									
2. NGTSA15	2.14	2.34	0.33**								
3. NGTSA24	1.90	2.17	0.23**	0.28**							
4. NGTSA36	1.72	2.04	0.15**	0.19**	0.34**						
5. Problm06	1.32	0.55	0.28**	0.1**	0.07	0.06					
6. Problm15	1.30	0.55	0.15**	0.29**	0.14**	0.1**	0.31**				
7. Problm24	1.31	0.57	0.08	0.07	0.37**	0.11**	0.18**	0.25**			
8. Problm36	1.34	0.59	0.03	0.04	0.12**	0.37**	0.11**	0.27**	0.29**		
9. CBCL24	3.24	2.71	0.17**	0.22**	0.47**	0.22**	0.03	0.12**	0.39**	0.11**	
10. CBCL36	3.68	2.60	0.09**	0.12**	0.29**	0.34**	0.04	0.14**	0.25**	0.21**	0.58**

Note. *N*s for each correlation varied from 544 to 1,278 depending on the nonmissing data available for each pair.
$^{*}p < .05$. $^{**}p < .01$.

across possible models, with lower values indicating better fit. Finally, we compared the identified models to the predicted ones.

In Stage 2, we validated the mixture groups uncovered by the growth mixture model by examining group differences across a wide variety of covariates. We did this by predicting mixture group membership from a set of independent variables with a multivariate analysis of variance (MANOVA), followed up by a series of analyses of variance. The independent variables used to test for group differences between the mixture groups included child gender, birth weight, birth order, difficult temperament, breastfeeding at 6 and 15 months, attachment security, attachment style, separation distress, child illnesses, maternal depression, maternal sensitivity, maternal and husband/partner health, husband/partner presence in the home, poverty, maternal education, and child care hours.[1]

In the third stage, we employed multiple group structural equation modeling to identify variables (child, mother, and family characteristics listed in the Methods section) associated with individual differences in NIGHTS SA over time and at each age that were captured by the latent growth trajectory groups found in Stage 1 and validated in Stage 2. The estimation method (robust maximum likelihood with a response variable model for the ordered categorical outcome variables, sleep awakenings) used for fitting this model allowed us to accommodate continuous, ordered categorical, and binary variables simultaneously in the model.[2]

We tested a multiple-group structural equation model that maintained the distinction between the latent class models; this allowed us to formally test whether the covariates of interest operated differently within the groups. We tested the effects of both time invariant (i.e., child gender, birth weight, difficult temperament, breastfeeding at 6 and 15 months, poverty, and attachment or separation distress) and time-varying (i.e., child illness, maternal depression, maternal sensitivity, maternal and husband/partner health, hours in nonmaternal care, and presence of a husband/partner in the home) covariates on children's sleep awakening intercepts and linear slopes. Because a large complex structural model that simultaneously regressed the sleep awakening growth model parameters on estimated covariate growth model parameters whose growth models also were included in the model proved to be inestimable with our data, we had to take a two-stage approach. We initially estimated separate growth models for each time-varying covariate and output each individual's estimated intercept and linear slope for these covariates. These estimated intercepts and slopes were then used as covariates along with the time-invariant covariates in a multivariate multiple regression of the sleep awakening growth parameters. Thus the full structural equation model fit a model in which both random intercept and slope parameters from the sleep awakening growth model were regressed on the full set of time-invariant covariates and time-varying, covariate model-estimated, random intercept and slope parameters.

Finally, since the sleep awakenings growth models contained a (fixed) quadratic term, the effects of the covariates on the intercept and linear slope were not stable across the entire period modeled. The results of statistical tests of estimated coefficients and the coefficients themselves would change depending on the time point that testing was specified for which depended on at what point time was coded to be zero. We chose to specifically examine the effects of the covariates at 6 months (the beginning of our study window), 21 months (the center of our window), and 36 months (the end of our window) by estimating the model three times with the zero point for time set to 6, 21, and then 36 months.

We conducted Stage 2 analyses, data manipulation, and descriptive statistics using SAS Version 9 (SAS Institute, 2010). We estimated both the Stage 1 growth mixture model and Stage 3 multiple groups structural equation model using Mplus Version 6 (Muthén & Muthén, 1998–2010) using maximum likelihood methods for missing data (Allison, 1987; Little & Rubin, 2002). This method yields unbiased estimates assuming any missing dependent variable data is either missing completely at random or simply at random. Missing exogenous covariate data lead to listwise deletion. However, by including the covariate estimation in the model, this maximum-likelihood missing data approach that keeps all the data in the modeling regardless of some missing dependent variable data can be extended to the covariates as well. We used this approach for four covariates (separation distress, breastfeeding, difficult temperament, and maternal sensitivity at 6 months) that had higher rates of missing data and that otherwise would have resulted in the exclusion of additional cases from the analysis.

Results

Descriptive Data

All participants with sleep awakening (NIGHTS SA) data for at least one of the four data points were included. Significance tests to determine whether there were differences between those included and those excluded showed no significant differences on child gender, maternal education, maternal depression, or minority status.

Table 3 presents the means and standard deviations for each sleep measure and the intercorrelations among each measure. NIGHTS SA scores were correlated over age and were significantly correlated with maternal ratings of how much of a problem the child's sleep was for the mother and the family within all ages. CBCL sleep scores at 24 and 36 months were correlated with each other and correlated with corresponding NIGHTS SA scores. These results indicate that the NIGHTS SA measure is associated with maternal perceptions of her child's sleep waking as a problem for her or the family and with maternal reports of sleep problems on the standardized child behavior checklist. Subsequent growth trajectory modeling was performed only on the NIGHTS SA scores.

Modeling Developmental Change

The growth mixture model was specified and estimated iteratively with one, two, and three latent classes as hypothesized. Subsequent examination of the three-class model and additional attempts to fit it determined this model as unidentified. Table 4 provides several fit statistics used to identify the most appropriate

[1] A table of the means, sample size, standard deviations, and ranges for each variable used in these analyses is available from the authors on request.

[2] Because the quadratic model is attempting to capture asymptotic trajectories at 36 months, the linear slopes and associations between them and the covariates at 36 months are uninterpretable (and are thus not reported at 36 months).

Table 4
Growth Mixture Model Fit and Model Quality Statistics for One, Two, and Three Latent Classes

No. of latent classes	Lo, Mendell, & Rubin (2001) nested LR test *p*	Bootstrap LR test *p*	BIC	Smallest class size[a]	Entropy	Posterior probability range
1			15977	—	—	—
2	<.00005	<.00005	15905	34%	.383	.73–.85
3	.1110	1.0000	15913	<1%	.620	.58–.85

Note. LR = likelihood ratio; BIC = Bayesian information criterion.

number of latent classes needed to model our data. Both the nested likelihood ratio test (Lo, Mendel, & Rubin, 2001) and the bootstrap likelihood ratio test (McLachlan & Peel, 2000) indicated a two-class model is a better fit than the one-class model. In addition, the BIC statistic for the two-class model was lower, indicating it is a better solution. Although we attempted repeatedly to fit a three-class model and obtained a solution, the parameters estimated did not present an interpretable model. The software had a difficult time finding a solution for the three-class model and had to fix two parameters to make the model identifiable. The fit statistics obtained by this model and likelihood ratio tests all pointed to the two-class model as better than the one-class model; we do not consider the three-class model viable for valid comparison because of the uninterpretable nature of the estimated model parameters.

The quality of the two-class solution is shown by two indicators. The smallest class is 34%, so the solution is not fitting an extremely rare class. The posterior probabilities (average class probability for the assigned class) are .73 for the smaller class and .85 for the larger class. Both model fit statistics and testing point to the two-class solution that seems to be of acceptable quality. Table 5 contains descriptive information by the two-class solution, and Figure 1 presents the mean trajectories for the two groups. The trajectories in this figure are the mean model-estimated trajectories for the two-class solution; they are not based on actual raw data. The model shows the Sleepers group, comprising 66% of the sample, maintaining a fairly steady 1 night per week with sleep awakening across the study period from 6 to 36 months. There is a slight rise to an apex at about 24 months, falling back off after that. We use the label *Sleepers* because this group has relatively few nights of awakenings. The second group, composed of the remaining 34% of the sample, starts off at 6 months according to the model with nightly sleep awakenings, dropping fairly steeply until it joins the Sleepers group with 1 night per week with sleep awakening at about 18 months. The quadratic model is capturing some asymptotic behavior occurring in the 24- and 36-month data, which it does by dropping a bit lower at 30 months and then rising back up to the same level at 36 months. A flat line between 24 and 36 months would be a truer representation of this group's data in this portion of the study period. We use the label *Transitional Sleepers* for this group because though they have many sleep awakenings in their first year; by the time they reach 18 months old, we estimate that they became indistinguishable from the Sleepers.

Table 5
Means and Standard Deviations for the Number of Nights Per Week With Awakenings at Four Ages, Broken Down by the Two Latent Class Groups and the Full Data Set

	Sleepers			Transitional Sleepers			Full data set		
Child age	*N*	*M*	*SD*	*N*	*M*	*SD*	*N*	*M*	*SD*
6 months	842	1.3	1.6	436	6.0	1.9	1,278	2.9	2.8
15 months	818	1.9	2.1	425	2.7	2.7	1,243	2.1	2.3
24 months	800	1.9	2.1	406	1.9	2.4	1,206	1.9	2.2
36 months	806	1.8	2.0	409	1.7	2.1	1,215	1.7	2.0

Factors Differentiating the Two Trajectory Groups

To examine factors related to the trajectory groups and establish the validity of the two groups, we tested group differences between the Sleepers and Transitional Sleepers mixture groups on a large group of variables (gender, birth weight, birth order, minority status, difficult temperament, breastfeeding at 6 and 15 months, attachment and separation distress, child illness, maternal educa-

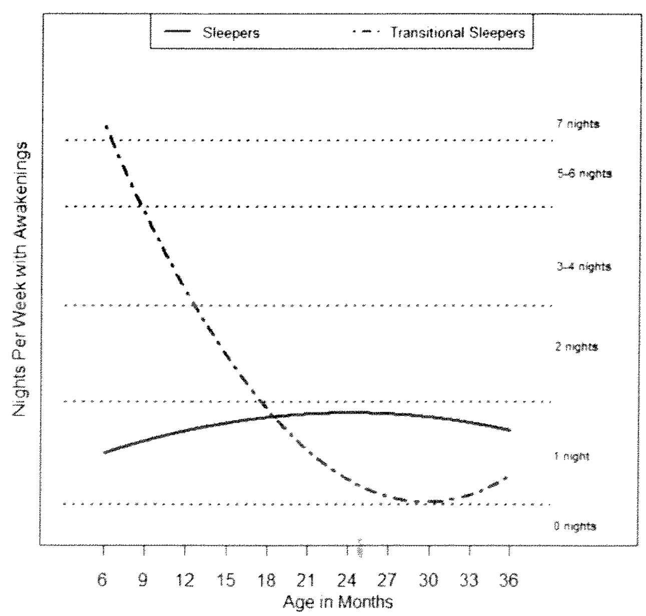

Figure 1. The two class growth mixture model solution for the NIGHTS SA (number of nights mothers reported infant sleep awakenings after sleep onset) scores at 6, 15, 24, and 36 months. There are five horizontal lines that display the thresholds levels between response categories 0, 1, 2, 3 or 4, 5 or 6, and 7 nights per week with child awakenings. Some categories (3 or 4, and 5 or 6) were combined due to small cell counts.

tion, maternal depression, maternal sensitivity, acceptance/harsh punishment, maternal health, paternal health, husband's/partner's presence in the home, family size, marital conflict, poverty, number of hours of nonmaternal child care, and percentage of time in center care) using a MANOVA with the latent class assignment as the independent variable. The MANOVA was significant, $F(48, 642) = 2.36$, $p < .0001$. On average, compared with the Sleepers, the Transitional Sleepers were more likely to be male, $F(1, 1303) = 9.20$, $p = .003$, and more likely to be breastfed at 6 months, $F(1, 1277) = 33.01$, $p < .001$, and at 15 months, $F(1, 1240) = 19.21$, $p < .001$. They also had higher scores on difficult temperament at the 6-month assessment, $F(1, 1277) = 6.47$, $p = .011$; had a mother with a higher depression score at 6 months, $F(1, 1276) = 7.83$, $p = .005$; and had a mother with a husband or partner with health problems at 6 months, $F(1, 1098) = 4.86$, $p = .028$, 24 months, $F(1, 1031) = 8.79$, $p = .003$, and 36 months, $F(1, 1014) = 5.88$, $p = .016$. Finally, they were more likely to come from a large family, $F(1, 1303) = 7.20$, $p = .007$, and to be in child care fewer hours per week at 9 months, $F(1, 1299) = 5.13$, $p = .024$. Means and effect sizes for each of these variables with effect sizes larger than .01 are presented in Table 6. Because the sleep awakening trajectories for the two groups differed primarily in the first year and a half of infancy, coming to nearly identical trajectories in the third year of life, it is not surprising that most of the variables on which the two mixture classes differed represent characteristics or circumstances also occurring early in infancy.

Identifying Correlates of Individual Differences in Sleep Awakenings Over Time

Having established group-level differences, we then sought to examine the relations between the covariates and children's individual sleep trajectories. Initial structural equation modeling (SEM) contained a simultaneous regression of the sleep awakening growth model intercepts and slopes on a set of time-invariant covariates and the random intercepts and slopes of time-varying covariate growth models. Initial findings were null for the prediction of sleep awakening intercepts and linear slopes from covariate slopes, so these predictor variables were removed from the final model. We used a nested likelihood test to determine whether we could impose equality constraints across our two groups (Sleepers and Transitional Sleepers) on the regressions of the sleep awakening growth model parameters on the covariates. The constrained model fit the data adequately for all three intercept models, 6 month, $\chi^2(22, N = 1,298) = 27.95$, $p = .18$; 21 month, $\chi^2(22, N = 1,259) = 12.59$, $p = .94$; and 36 month $\chi^2(22, N = 1,301) = 13.31$, $p = .92$. Fit statistics for the final model tested at each of three time points indicated a reasonably good fit in each case. For the model fit at the 6-month time point, the comparative fit index (CFI) = .97, Tucker–Lewis index (TLI) = .95, root-mean-square error of approximation (RMSEA) = .054 (90% confidence interval [CI] [.040, .068]), and standardized root-mean-square residual (SRMR) = .024. The 21-month model had CFI = .653, TLI = .386, RMSEA = .043 (90% CI [.027, .058]), and SRMR = .020; the 36-month model had CFI = .983, TLI = .971, RMSEA = .042 (90% CI [.027, .057]), and SRMR = .021. Although the CFI and TLI at 21 months might not indicate as good a fit as one might hope for, the RMSEA and SRMR for this model still show acceptable fit (Hu & Bentler, 1999; MacCallum, Browne, & Sugawara, 1996).

The estimated path coefficients with statistical significance indicators for the three SEM models, with the sleep awakenings intercepts respectively set at 6 months, 21 months, and 36 months, are found in Table 7. The top of Table 7 provides the constrained multiple regression estimates for the two groups; the bottom provides the unconstrained estimated growth model means, variances, and covariances for each of the two groups.

These results show that 6-month breastfeeding and difficult temperament were associated with more sleep awakenings through the middle of the study period (i.e., 21 months); at the beginning of the study period (i.e., 6 months), children who were breastfed or had a difficult temperament also had sleep awakening linear slopes that were decreasing faster than those in other children. Throughout the study period, children who experienced more illness or had mothers with more depression or sensitivity also experienced more sleep awakenings; at 6 months, these effects were also associated with sleep awakenings that were decreasing faster than in other children. Maternal health and hours in child care had isolated instances of association. R^2 values for the two growth parameter outcomes show that the models predicted 5%–8% of the variance in random intercepts of Sleepers and 4%–5% of Transitional Sleepers across the three time points tested. The models do slightly less well accounting for variance among the random slopes, accounting for 2%–5% of Sleepers' variance in slopes, and 3%–5% of the Transitional Sleepers' slope variances. We calculated effect sizes for the covariates using a t statistic to Cohen's d transformation. Significant effects on the random intercepts were generally in the .2–.4 range. The effects of covariates measured earlier (i.e., difficult temperament and breastfeeding both at 6 months) tended to decrease over time. The same variables that predicted sleep awakenings in the Transitional Sleepers group also predicted sleep awakenings in the Sleepers group. Each of the effect sizes was larger for measures predicting variation in the Transitional Sleeper group than in the Sleeper group.

Table 6
Mean Scores and Effect Sizes for Variables That Differed Between Sleeper and Transitional Sleep Groups

Variable	Sleepers	Transitional Sleepers	Effect size
Child gender (male)	0.49	0.58**	.01
Difficult temperament at 6 months	3.16	3.22**	.01
Breastfeeding at 6 months	0.23	0.38***	.03
Breastfeeding at 15 months	0.04	0.10***	.02
Maternal depression at 6 months	8.51	9.88**	.01
Health of mother's partner at 24 months	3.29	3.16*	.01
Health of mother's partner at 36 months	3.27	3.16*	.01

* $p < .05$. ** $p < .01$. *** $p < .001$.

Discussion

Using a large, normative sample, we demonstrated that signaling upon sleep awakening has a clear developmental course over the first 3 years of life. By 6 months of age, the majority of children are awakening their parents no more than 1 or 2 nights per week. The frequency of awakenings drops over time, so that by the

Table 7
Multiple-Group Structural Equation Modeling Estimates and Effect Sizes for Models Fit at Ages 6, 21, and 36 Months

	Dependent variable (NIGHTS SA Growth Model)									
	6 months				21 months				36 months	
Sleepers & Becoming Sleepers	Random intercept	ES-S[a]/ES-TS[b]	Random slope	ES-S[a]/ES-TS[b]	Random intercept	ES-S[a]/ES-TS[b]	Random slope	ES-S[a]/ES-TS[b]	Random intercept	ES-S[a]/ES-TS[b]
Structural regression coefficients										
Gender (male)	.02	.08/.12	−.01	−.06/−.09	.02	.08/.12	−.00	−.01/−.01	.02	.07/.10
Difficult temperament	.08**	.21/.30	−.03**	−.25/−.35	.05*	.15/.22	−.01	−.08/−.11	.04	.08/.12
Breastfeeding at 6 months	.09**	.26/.38	−.03**	−.28/−.40	.06**	.21/.31	−.02	−.14/−.20	.03	.07/.10
Separation distress	.02	.07/.10	−.01	−.08/−.11	.02	.07/.10	.00	.00/.00	.02	.05/.07
Child illness at 6, 21, & 36 months	.19**	.29/.42	−.05**	−.25/−.36	.16**	.38/.54	.01	.05/.07	.12**	.29/.42
Maternal depression at 6, 21, & 36 months	.06**	.26/.37	−.02**	−.27/−.39	.05**	.24/.35	.01	.11/.15	.08**	.24/.34
Maternal sensitivity at 6, 21, & 36 months	.07**	.26/.37	−.02**	−.21/−.31	.05**	.21/.30	.01	.07/.10	.09**	.20/.28
Maternal health at 6, 21, & 36 months	.01	.02/.03	−.01*	−.14/−.21	−.00	−.01/−.01	.01	.10/.14	.02	.05/.07
Child care hours at 9, 21, & 36 months	−.02	−.08/−.12	.00	−.01/−.01	−.00	−.11/−.16	.03**	.08/.11	.05	−.05/−.07
Poverty	−.02	−.04/−.05	.00	.01/.02	−.02	−.08/−.11	−.02	−.11/−.16	−.06	−.13/−.19
Parent with partner at 6, 21, & 36 months	−.00	−.07/−.11	.00	.00/−.01	−.00	−.01/−.01	.00	.19/.28	−.00	.11/.16
Intercepts, variances, & covariances										
Sleepers										
Intercept	−.064		−.050		−.099		−.052		−.178	
Variance	.111**		.013		.066**		.032		.207**	
Covariance intercept with slope	−.031**		—		−.001		—		.149**	
R^2	.068**		.052**		.075**		.025**		.048**	
Transitional Sleepers										
Intercept	.334**		−.248**		−.099		−.052**		−.215	
Variance	.156**		.013**		.104**		.026**		.251**	
Covariance intercept with slope	−.040**		—		.002		—		.147**	
R^2	.052**		.053**		.053**		.026**		.043**	

Note. NIGHTS SA = number of nights mothers reported their infant experienced sleep awakenings after sleep onset.
[a] ES-S = Cohen's d measures of effect size–Sleepers. [b] ES-TS = Cohen's d measures of effect size–Transitional Sleepers.
* $p < .05$. ** $p < .01$.

end of infancy, the majority of children are not signaling upon awakening or are signaling only about 1 night a week. Over all infants, the percentage of children awakening their parents more than 6 or 7 nights a week drops from approximately 25% at 6 months old to less than 10% at 36 months old. These findings are consistent with the findings of other researchers who have studied children cross-sectionally or over smaller periods of time within the infancy period (e.g. Jenni et al., 2005; Tikotzky & Sadeh, 2009).

More interesting, however, are our findings that there appear to be two distinct patterns over the first 3 years of life that characterize the sleep awakenings of healthy, community-living children. Two thirds of children, those we identify as Sleepers, show little evidence of elevated sleep awakenings at any point from 6 through 36 months. On average, they signal their awakenings consistently less than 2 nights a week during this entire period. In contrast, about one third of the children, those we call Transitional Sleepers, show early difficulties with sleep awakenings, signaling upon awakening from approximately 6 or 7 nights per week at 6 months to just under 3 nights per week at 15 months. By approximately 18 months and certainly by 24 months, Transitional Sleeper children have about the same low levels of awakenings as do children in the Sleeper group. Findings obtained with growth mixture modeling suggest that nights of sleep awakenings diminish in these Transitional Sleepers in a nonlinear fashion, with rate of night awakenings declining more strikingly in the period between 6 and 21 months of age than in the period between 21 and 36 months of age. Although approximately 6% of the children were still awakening every night at 36 months old, the analyses showed no evidence for our hypothesized third small group of infants for whom nights with sleep awakenings would continue and possibly increase over time. For most of the infants, nights with sleep awakenings declined significantly by the third birthday.

The two groups of children we identified—Sleepers and Transitional Sleepers—appear to represent meaningful and distinct longitudinal patterns with regard to the developmental course of sleep. In the first year of life, membership in the two groups is predictable from both intrinsic and extrinsic child characteristics. Compared with infants categorized as Sleepers, infants in the Transitional Sleepers group are more likely to be male, breastfeeding at 6 and 15 months old, and described by their mothers as having difficult temperament at 6 months old. The mothers of Transitional Sleepers are more likely to be depressed, and their husbands/partners are more likely to have health issues. Transitional Sleepers are more likely to come from a large family, and they spend fewer hours in child care at 9 months old.

At the same time, there are many important characteristics hypothesized to correlate with sleep awakenings that we did not find different between the two groups. The Transitional Sleepers did not differ from the Sleepers on any of our measures of attachment, separation distress, or maternal sensitivity. They were not different on demographic variables such as child gender, birth weight, birth order, poverty, or single-parent household status. Indeed, by 18 months old, not only are Transitional Sleepers able to sleep through the night without awakening their parents, but they are indistinguishable from the children who, from the beginning, had frequently slept through the night without signaling.

Although the developmental patterns of sleep differ across infants, the individual predictors of sleep awakenings within each group do not differ. Across all children, difficult temperament, breastfeeding, child illness, maternal depression, and maternal sensitivity predict more signaling upon awakening at all points across the infancy period.

It is hard to know whether the appearance of slightly larger effect sizes in the predictors of the Transitional Sleeper group reflects the greater sensitivity of these children to internal and external factors or whether the larger effect sizes simply mirror the greater variability in the Transitional Sleeper group. It is worthwhile to speculate whether Transitional Sleepers are likely to be different from Sleepers in other ways as they move through childhood. Will they show more labile sleep patterns in the face of anxiety-producing events? Will they show evidence of greater variability in learning patterns? We are investigating these empirical questions using the longitudinal data set.

The finding that difficult temperament is related to sleep awakenings replicates the findings of other studies (Jimmerson, 1991; Minde, et al., 1993; Morrell & Steele, 2003; Sadeh & Anders, 1993; Scher et al., 2005; Touchette et al., 2005). Sadeh and Anders (1993) suggested that infants who are irritable and hypersensitive and have lower sensory thresholds might sleep for shorter periods and nap irregularly. With these data, we show that mothers of infants with difficult temperaments also report that these infants signal upon awakening from sleep more frequently than other infants. The suggestion by Morrell and Steele (2003) that difficult infants may elicit more active parent comforting that may perpetuate night awakenings does not gain support from our findings. If this were the case, we might not have found the steep decline of awakenings in infants with difficult temperaments that we did find.

These findings replicate and extend previous findings that sleep awakenings early in infancy are related to breastfeeding (Elias et al., 1986; Karraker, 2008), but they do not resolve the problem of whether these awakenings are more likely to be caused by internal cues to hunger or by difficulties in self-soothing related to being put to bed while nursing. However, the finding that infant awakenings decline steeply with declining incidence of nursing suggests that it may not be, as suggested, that breastfeeding contributes to diminished capacity to self-soothe, or we would have found that breastfeeding early in life continued to contribute to sleep awakenings even after the incidence of breastfeeding diminished. Indeed, the Transitional Sleepers who are distinguished by higher frequencies of breastfeeding at 6 and 15 months old show incidence of sleep awakenings at 18 months that mirror those of the Sleeper infants at that age.

These findings may shed some light on the discrepancy among studies examining gender differences in sleep. Our finding that male infants were more likely to be Transitional Sleepers than female infants suggests that in the first year of life, boys may have more difficulty settling after awakening. However, for neither group was being male a predictor of awakenings at any given age. This somewhat contradictory finding is congruent with other findings suggesting inconsistent results regarding early gender differences in sleep (for an early review, see Maccoby & Jacklin, 1974). That the difference we observed is very small may explain why gender differences in sleep have been found inconsistently. Gender differences in sleep may only be detected consistently with large samples and detected more frequently when they are examined in children in the first year of life.

The role of maternal sensitivity in predicting more sleep awakenings over the entire 3-year period is contrary to other findings in the general literature regarding maternal sensitivity. Most studies generally show that that maternal sensitivity is related to optimal and more desirable or advanced developmental infant outcomes (Davis & Logsdon, 2011). Here, we found that greater sensitivity was related to *more* awakenings at each assessment period. Infants whose mothers display sensitivity during play and structured interactions are more likely to continue to awaken more frequently than infants whose mothers are less responsive. One explanation may be that generally sensitive mothers during the day are also more inclined to intervene when the infant shows signs of struggling with sleep. This may support Karraker's (2008) suggestion that when mothers attempt to assist their children in returning to sleep, their responsiveness reinforce behaviors in the child that run counter to self-soothing and self-regulation. Because developing capacities for self-soothing seem important for regular sleep, the tendency of mothers to intervene may have the unintended consequence of slowing the child's progression in the area of self-soothing. One counter to this interpretation is that we find this relation between infant signaling upon awakening and maternal sensitivity as early as 6 months old, a time when infants might not be as sensitive to instrumental learning as after 9 months (Bell & Ainsworth, 1972). Alternatively, it may be that mothers who are more sensitive are more likely to hear their children signaling upon awakening, and they are therefore more likely *to report* these awakenings. Their behavior may not be instrumental in interfering with children's self-soothing at all. More observational research is needed to differentiate between these interpretations of the relation of maternal sensitivity and infant nighttime awakenings.

One interpretation of the finding that the effects of temperament and breastfeeding diminish with age is that the factors most strongly connected to early differences in sleep patterns are different from the factors most strongly connected to later sleep difficulties. As infants mature, they may be more likely to sleep through the night, and sleep on any given night may become more dependent upon situational factors and family circumstances. However, it is also possible that the explanation for the decline in the relation between temperament and sleep awakenings is the increasing distance in time between the temperament measure, which was only collected at 6 months, and the sleep awakening reports collected later in infancy when the infants were 36 months old.

These findings, while far from definitive, suggest several things about the developmental course of sleep awakenings. First, genetic or constitutional factors such as those that might be reflected in difficult temperament appear to be implicated in early sleep problems during infancy. Early on, sleep awakenings may be related to children's difficult temperament, breastfeeding experiences, and child illnesses as well as to mothers' depression and sensitivity. Second, family contextual factors and parenting practices also appear implicated in sleep awakenings, and these continue throughout the infancy period. Although the mechanisms by which depression affects infant awakenings has yet to be defined, it is possible that maternal depression, shown to be causally related to sleep awakenings (Warren et al., 2006), may operate directly on infant constitutional factors. New evidence is emerging that maternal depression may affect infants prenatally, via the mother's hypothalamic–pituitary–adrenal system (Field, 2011). The mechanism involved in maternal depression and sleep awakenings may involve both maternal stress and cortisol concentrations during pregnancy. In a recent study, Bergman and her colleagues (Bergman, Sarkar, Glover, & O'Connor, 2010) showed that cortisol during pregnancy was related to later infant cognitive development depending upon mother–infant interactions and infant attachment classification. It is possible that the mothers in our study who were more depressed when their infants were 6 through 36 months old also were more depressed during pregnancy, and this prenatal depression may have affected fetal neurodevelopment and infant sleep awakenings in the first 6 months of life. At the same time, we also acknowledge that sleep deprivation also can exacerbate maternal depression, especially in the first 6 months after childbirth (see Karraker & Young, 2007). Future research on sleep awakenings will benefit from a more thorough prenatal history and biological assessment. In contrast, family adversity related to low income, single-parent status, or poor maternal health do not seem to be related to sleep awakenings, at least not in this group of approximately 1,200 infants drawn from across the United States.

The absence of associations between sleep problems and variables related to the infant–mother attachment system are of concern because of the failure of our study to replicate findings of other researchers, even those using subject children from the same NICHD data set. McNamara et al. (2003) reported that infants with insecure–resistant attachments had significantly greater numbers of night awakenings and longer mean duration of night-awaking episodes than insecure–avoidant infants. However, in their analyses, McNamara et al. compared only insecure-resistant and insecure–avoidant infants, and they used a different measure of sleep awakenings—awakenings occurring more than three times per night or lasting longer than an hour, or the mother reports of "severe disruption." Including secure attachment types in our comparisons, we did not find any differences across the sample in the number of night per week of sleep awakenings, despite our attempt to use measures of attachment security and separation distress. Thus, it might be that attachment and sleep awakenings are not related unless the sleep awakenings occur more frequently in the night, last longer than an hour, and are part of a larger, more generalized sleep problem.

Our findings further suggest that the measure of the number of nights per week in which infants awakened after sleep onset may be a useful indicator of individual differences in infant sleep patterns. It is an easy measure to collect, it is relatively stable over 6-month periods, and it correlates well with maternal reports of difficulties around sleep. This measure also correlates with the sleep factor score from the CBCL, another more standardized measure of sleep problems that we obtained later in the infancy period. That the sleep awakenings measure correlated with the CBCL measure of more general sleep problems in addition to awakening after sleep onset raises two possibilities. The first possibility is that signaling upon awakening is a sleep *problem*, not just an artifact of more sensitive mothers being more likely to hear and report awakenings, and the second, that sleep awakenings early in life may foreshadow difficulties that may persist in affecting sleep and possibly self-regulation as children mature. Other studies from our laboratory are examining this possibility.

Limitations

Findings from this study are limited by their reliance on data obtained from maternal report. We have no independent measures of infants' sleep (e.g., polysomnography or observation) other than maternal report. In addition, we did not have direct measures of sleep routines or bedtime conditions that might affect nighttime sleep awakenings. Although other research suggests that maternal report is reasonably reliable and correlates with laboratory observations of infant sleep (Sadeh, Lavie, Scher, Tirosh, & Epstein, 1991; Tikotzky & Sadeh, 2009), our findings regarding the relations among variables may be confounded by the shared variance attributable to maternal report. It has been suggested that maternal reports of infant temperament and sleep awakenings are themselves related. Infants with many sleep awakenings could have been perceived as having difficult temperament. However, the fact that of the 39 items on the temperament measure used in this study, none specifically addressed the issue of sleep awakenings partially mitigates this possibility.

Findings are also limited by their reliance on the nature of the sleep maternal report—the number of nights per week that infants awakened. It is possible that using number of times per night averaged over each week or the duration of the awakenings might yield different results. Each of these measures was available for these analyses; we selected nights per week of awakenings because it was correlated with the number of awakenings per night and duration and seemed more conservative a measure of sleep awakenings, one less likely to be affected by short-term difficulties. Similar analyses with these other measures might yield different findings; preliminary analyses that we conducted using other measures of sleep awakenings suggest that that is not the case.

The findings are also limited by the restricted sample recruited for the NICHD study, a sample recruited from mothers and infants who were all healthy at birth. No premature infants, twins, or low-birth-weight infants were included in the initial sample. Nevertheless, although the incidence of maternal-reported sleep problems was low, the incidence is similar to those reported by earlier researchers (e.g., Jenni et al., 2005; Richman, 1981; Zuckerman et al., 1987).

Readers may also be aware of problems inherent to trajectory modeling (Bauer & Curran, 2004; Sampson & Laub, 2005). The groups we identified may be relatively unstable and will need to be replicated with other samples and validated over time. In addition, as this is a correlational study, issues of cause and effect are difficult to untangle. It is possible that sleep awakenings are responsible for mothers rating children as having difficult temperament and may even contribute to continued breastfeeding. However, Warren et al. (2006) noted that depression contributed to child awakenings, not vice versa. Analyses similar to those used by Warren and her colleagues would have to be undertaken to resolve many of the correlational findings in this report.

Finally, because the sample is large, many of the findings, though significant and characterized by acceptable power estimates, are nevertheless modest in magnitude. For measures that differed between the two groups, the effect sizes ranged from .01 to .03. For measures that predicted variability in sleep awakenings at any given age, the effect sizes ranged from .02 to .08. Our study of large groups enables us to identify even these very small effects. Critics might question these small effect sizes. However, although these effect sizes are small, they are nevertheless important. In 1990, Robert Rosenthal noted that the small effects we psychologists sometimes dismiss are often larger than effects in the medical field that are taken very seriously by medical researchers and the general public. The effect sizes of our findings compare favorably with those in the literature demonstrating the relation between passive smoking at work and lung cancer (effect size approximately .02) and with the measures of self-examination and extent of breast cancer (effect size below .01; Bushman & Anderson, 2001).

Practical Implications

These findings suggest that parents and primary health care providers should be aware that some infants who are generally healthy and typically developing might nevertheless have mothers who report sleep awakenings that extend into their infant's second year of life. Those infants more predisposed to early sleep problems are also those who are reported by their mothers to have difficult temperaments and to be breastfeeding. However, for nearly all healthy infants, sleep awakenings tend to abate by the middle of the second year. Because our study mothers described infants with many awakenings per week as creating problems for themselves and other family members, parents might be encouraged to establish more nuanced, carefully targeted routines to help babies with self-soothing and to seek occasional respite (Karraker, 2008).

For families who report continuing sleep awakenings in infants older than 18 months old, interventions may be necessary. Our findings are indeterminate in regards to supporting specific expert recommendations for optimal infant sleep patterns concerning greater bedtime ritualization, discouragement of parental intrusion, and encouragement of infant self-soothing to promote sleep that is more continuous. Future research should be directed to exploring sleep problems in high-risk samples and the effectiveness of interventions with high-risk samples and to investigating whether these early, normative patterns of sleep disruptions have implications for later cognitive and social developments that require self-regulation.

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Received January 2, 2011
Revision received December 29, 2011
Accepted January 9, 2012 ■