

# Nocturnal Video Assessment of Infant Sleep Environments

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abstract

**BACKGROUND AND OBJECTIVE:** Reports describing factors associated with sleep-related infant death rely on caregiver report or postmortem findings. We sought to determine the frequency of environmental risk factors by using nocturnal sleep videos of infants.

**METHODS:** Healthy, term newborns were recruited for a parent study examining the role of parenting in the development of nighttime infant sleep patterns. For 1 night at ages 1, 3, and 6 months, video recordings were conducted within family homes. Videos were coded for sudden infant death syndrome risk factors in post hoc secondary analyses after the parent study was completed.

**RESULTS:** Among 160 one-month-olds, initially 21% were placed to sleep on nonrecommended sleep surfaces and 14% were placed nonsupine; 91% had loose/nonapproved items on their sleep surface, including bedding, bumper pads, pillows, stuffed animals, and sleep positioners. Among 151 three-month-olds, 10% were initially placed on a nonrecommended sleep surface, 18% were placed nonsupine, and 87% had potentially hazardous items on their sleep surface. By 6 months, 12% of the 147 infants initially slept on a nonrecommended surface, 33% were placed to bed nonsupine, and 93% had loose/nonrecommended items on their surface. At 1, 3, and 6 months, 28%, 18%, and 12% changed sleep locations overnight, respectively, with an increased likelihood of bed-sharing and nonsupine position at the second location at each time point.

**CONCLUSIONS:** Most parents, even when aware of being recorded, placed their infants in sleep environments with established risk factors. If infants were moved overnight, the second sleep environment generally had more hazards.



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**DOI:** 10.1542/peds.2016-1533

Accepted for publication Jun 27, 2016

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PEDIATRICS (ISSN Numbers: Print, 0031-4005; Online, 1098-4275).

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**WHAT'S KNOWN ON THIS SUBJECT:** Risk and protective factors for sleep-related infant death, including sudden infant death syndrome, have been established by epidemiologic studies. These reports are typically limited by subjective reporting by parents/caregivers or postmortem findings and may underestimate the prevalence of these factors.

**WHAT THIS STUDY ADDS:** Most parents placed their infants in sleep environments with established risk factors. When infants were moved to a different sleep environment in the middle of the night, the new sleep environment often included more unsafe elements.

**To cite:** Batra EK, Teti DM, Schaefer EW, et al. Nocturnal Video Assessment of Infant Sleep Environments. *Pediatrics*. 2016;138(3):e20161533

Sleep-related infant deaths, the most common cause of postneonatal infant mortality,<sup>1</sup> are defined as deaths occurring during sleep or in a sleep environment, and include sudden infant death syndrome (SIDS), accidental suffocation and strangulation in bed, and ill-defined deaths. Risk factors that have been associated with sleep-related deaths include, but are not limited to, side and prone sleeping, soft sleep surface, loose bedding, bed-sharing, tobacco use, and not breastfeeding.<sup>2</sup> Efforts to eliminate risk factors began in 1992 in the United States, when the American Academy of Pediatrics (AAP) recommended against prone positioning.<sup>3</sup> Subsequent AAP guidelines,<sup>4,5</sup> the most recent published in 2011,<sup>2</sup> have also recommended avoidance of “soft materials in the infant’s sleeping environment” and room-sharing without bed-sharing.

Despite substantial publicity for these recommendations and public education campaigns, many of these recommendations are not fully followed by parents. Data from the National Infant Sleep Position Study (NISPS) report that 73% of parents placed their infants in a nonsupine position for sleep in 2010,<sup>6</sup> that rates of bed-sharing doubled from 6.5% in 1993 to 13.5% in 2010,<sup>7</sup> and that 55% of parents continue to use loose bedding in the infant sleep environment, despite recommendations to the contrary by the AAP.<sup>8</sup> Data also show that soft bedding and bumpers continue to be found in the cribs of infants who died in sleep-related deaths.<sup>9</sup> However, publications describing parental practice have been limited by their methods. They have typically been based on either parental self-report or death scene investigations. Some studies have used video recording to analyze the safety of sleep environments,<sup>10,11</sup> but none used direct observation to quantify modifiable risk factors

in infant sleep environments. To overcome previous limitations, the present study analyzed nocturnal sleep videos collected from a parent, longitudinal study of infant sleep arrangements, maternal endorsement of these arrangements, and their association with emotional and marital difficulties.<sup>12</sup> The aim of this secondary analysis was to determine the frequency of known risk factors for sleep-related infant deaths by using these objective data in the 6 months after birth.

## METHODS

### Participants

The parent study was an observational evaluation of families whose newborns were delivered at 2 hospitals in central Pennsylvania. Mothers were approached within 48 hours of delivery by project staff, who described the study and provided contact information on a handout. Those participating were healthy, term newborns. All mothers were aged  $\geq 18$  years, of any ethnicity, fluent in English, and living with their infants as an independent family unit. Interested mothers were called at home within 3 weeks of discharge, and a home visit was scheduled 4 to 6 weeks after delivery. All participating mothers provided informed consent before enrollment, and they completed a baseline demographic questionnaire.

This study was approved by the Penn State University’s Office of Research Protections and the secondary analysis was approved by Penn State College of Medicine’s Human Subjects Protection Office.

### Study Procedures

At infant ages 1, 3, and 6 months, research staff visited each family to set up video equipment in the area(s) of the home where the infant commonly slept. The equipment consisted of a Bosch Divar XF 8 channel digital video recorder

(Bosch, Fairpoint, NY), Infrared Color Couple Charged Device (ML) Cameras (Spectral Instruments Inc, Tuscan, AZ), Channel Vision 5014 Microphones (Channel Vision Technology, Costa Mesa, CA), and an Audiovox D9000 Portable DVD/CD Player (Voxx Electronics Corp, Hauppauge, NY). All cameras were wired directly to the digital video recorder by using Mini coaxial cable television cables with an option of a wireless setup by using a Video Transmitter Kit from Videocomm Technologies (Burlington, ON, Canada). Up to 3 more cameras were placed for each family depending on parental reports of bedtime or sleep locations. For all families, 1 camera and microphone setup were suspended on a boom stand above the infant’s primary sleep location to provide a clear view of the infant’s head, body, and primary sleep surface. Other cameras were set up to provide alternate views or in alternative sleep locations. Infrared illuminators were set up to provide bounce lighting to illuminate the infants’ room if needed. At each study time point, video recordings were initiated by parents 1 hour before the start of bedtime. Recordings continued throughout the night until the infant was fully awake in the morning.

### Video Analysis

After downloading the recordings to an external hard drive, the videos were viewed by using Bosch Divar XF/700 Software 3.33. Videos were reviewed and coded by 1 of 2 research assistants with data entered, including sleep location(s), surface(s), position(s), and other objects on or around the sleep surface. For purposes of assessing inter-rater reliability, a total of 56 videos (25 at 1 month, 16 at 3 months, and 15 at 6 months) were coded by both research assistants, and Cohen’s  $\kappa$  statistic was calculated.<sup>13</sup> The  $\kappa$  statistics indicated

**TABLE 1** Study Baseline Participant Demographic Characteristics (N = 162)

Variable	Value
Child sex	
Male	77 (48)
Female	85 (52)
Maternal demographic characteristics	
Age, y	29.3 ± 5.3
Race/ethnicity	
White	135 (84)
Black	6 (4)
Asian	5 (3)
Hispanic/Latina	9 (6)
Other	5 (3)
Education	
High school graduate or less	22 (14)
Some college	30 (19)
College graduate or more	110 (68)
Marital status	
Single	4 (2)
Single, cohabitating with partner	22 (14)
Married, cohabitating with partner	132 (82)
Father involved, living separately	4 (2)
Paternal demographic characteristics	
Age, y	32.0 ± 5.9
Race/ethnicity	
White	124 (85)
Black	5 (3)
Asian	5 (3)
Hispanic/Latino	7 (5)
Other	5 (3)
Education	
High school graduate or less	23 (15)
Some college	26 (17)
College graduate or more	100 (67)
Family income, thousands of dollars, median (interquartile range)	60 (37–90)

Unless otherwise indicated, data are presented as *n* (%) or mean ± SD.

perfect or near perfect agreement, with values of 1.00 for sleep surface and position, 0.94 for sleep location, and 0.87 to 0.95 for each individual object on or around the sleep surface. For statistical analysis, data coded from video recordings were summarized and/or described by using frequency counts and percentages for categorical variables and means, SDs, medians, and ranges for continuous variables.

## RESULTS

### Demographic Characteristics

Of the 167 infants enrolled in the study, 162 (97%) had at least 1 video and comprised our analysis sample. Of these, 142 (88%) had videos from all 3 time points. One hundred sixty of the infants were observed at 1

month of age (median, 1.2 months; range, 0.9–1.9 months), 151 at 3 months (median, 3.1 months; range, 2.3–4 months), and 147 at 6 months (median, 6.1 months; range, 4.8–7.3 months). Forty-eight percent of the infants were male (Table 1). The median age of mothers and fathers was 29 and 32 years, respectively. Eighty-four percent of the mothers and 85% of the fathers were white, and most parents attended at least some college. More than 80% of mothers were married and living with their partner. Exclusive breastfeeding was reported for 59%, 52%, and 18% of infants at 1, 3, and 6 months, respectively. Regarding attrition, there were no demographic differences between those who did and did not complete the 6-month observation period. Those who

dropped out were less likely to breastfeed at 1 and 3 months, compared with those who remained in the study for 6 months.

### Sleep Position and Environment

#### 1-Month Videos

Fifty-eight percent of 1-month-old infants began the night in their parents' room, and the majority (79%) were on an AAP-approved sleep surface (eg, crib, cradle, bassinet, playpen) (Table 2). A playpen is defined as a portable play yard that conforms to standards set by the US Consumer Product Safety Commission.<sup>14</sup> Although 86% were initially placed supine, 12 (8%) and 7 (4%) were placed in the side and prone positions, respectively. Nearly all (91%) participants had a loose/nonapproved item on their sleep surface. The most common items were loose bedding, bumper pads, pillows, stuffed animals, and sleep positioners.

Forty-five (28%) infants slept in at least 2 locations at the 1-month observation; 91% of infants ended up on a nonapproved sleep surface (eg, adult bed, sofa, car seat, co-sleeper, or swing) for the second sleep location. Only 64% were placed in a supine position at this second location, and 67% shared their sleep surface with another person (Table 3). When the entire night was considered, 36% of the cohort of 160 infants were placed nonsupine, and 28% shared a sleep surface at some point in the night.

#### 3-Month Videos

About one-half (52%) of 3-month-old infants began the night in their own room, and 90% were on an AAP-approved sleep surface. Eighty-two percent began the night supine, with 10% and 8% being placed on their side and prone, respectively, and 87% had loose/nonapproved items in their sleep environment.

Twenty-seven (18%) infants slept in at least 2 locations, with an increase in unsafe sleep risk factors in the

second location; the proportion of infants sleeping in a crib, bassinet, or playpen decreased from 93% to 11%, only one-third were placed supine, and 81% shared their sleep surface with another person. When the entire night was considered, 35% of the cohort of 151 infants were placed nonsupine, 22% shared a sleep surface, and 89% slept with loose and nonapproved items at some point during the night.

### 6-Month Videos

Two-thirds (69%) of 6-month-old infants began the night in their own room, and 88% were on an AAP-approved sleep surface. Sixty-seven percent were placed supine in their initial sleep location, with 15% and 17% being placed on their side and prone, respectively, and 93% had loose/nonapproved items in their sleep environment.

Eighteen infants (12%) slept in at least 2 locations, with an increase in unsafe sleep risk factors in the second location; there was a decrease in the proportion of infants sleeping in a crib, bassinet, cradle, or playpen from 78% to 17%, a decrease in supine sleep position (50% to 22%), and an increase in the sleep surface being shared with another person (17% to 67%). When the entire night was considered, 44% of the 147 infants with 6-month videos were placed nonsupine, 16% shared a sleep surface, and 93% had a loose or nonapproved item in their sleep environment at some point during the night.

## DISCUSSION

Our data show that most parents, even when they were aware of being recorded, placed their infants in sleep environments with established risk factors for sleep-related infant deaths. In addition, infants being moved in the middle of the night were often moved to more unsafe sleep environments than where they began the night. These objective findings overcome the

**TABLE 2** Initial Sleep Location, Surface, Position, and Sleep Environment According to Age

Variable	1 Month (n = 160)	3 Months (n = 151)	6 Months (n = 147)
<b>First sleep location</b>			
Parent room	93 (58)	68 (45)	38 (26)
Own room	54 (34)	78 (52)	101 (69)
Other room	13 (8)	4 (3)	7 (5)
<b>Sleep surface</b>			
Crib (crib, cradle, bassinet, playpen)	127 (79)	136 (90)	130 (88)
Adult bed or mattress	13 (8)	10 (7)	11 (7)
Car seat	10 (6)	3 (2)	2 (1)
Swing	4 (3)	0	0
Other	3 (2)	1 (1)	1 (1)
Bedside co-sleeper ("sidecar")	2 (1)	1 (1)	1 (1)
Sofa	0	0	2 (1)
<b>Position placed on first sleep surface</b>			
Supine	138 (86)	123 (82)	98 (67)
Side	12 (8)	15 (10)	22 (15)
Prone	7 (4)	12 (8)	25 (17)
Indeterminate (not supine)	3 (2)	1 (1)	2 (1)
<b>Loose/nonapproved items on sleep surface</b>			
Loose bedding	134 (84)	112 (74)	101 (69)
Bumper pads	39 (24)	64 (42)	70 (48)
Pillow/cushion	31 (19)	29 (19)	30 (20)
Stuffed animal/pillow-like toy	26 (16)	39 (26)	49 (33)
Sleep positioner/wedge	22 (14)	11 (7)	1 (1)
Another person	14 (9)	9 (6)	12 (8)
Other	11 (7)	8 (5)	5 (3)
Mobile/hanging toy within child's reach	6 (4)	7 (5)	11 (7)
Hard toy	5 (3)	5 (3)	18 (12)
SIDS monitor	5 (3)	4 (3)	2 (1)
Bottle	3 (2)	1 (1)	8 (5)
Loose cord/electrical wire	3 (2)	2 (1)	2 (1)
Pet	1 (1)	1 (1)	3 (2)
<b>Is first sleep location shared with another person?</b>			
No	145 (91)	142 (94)	135 (92)
Yes; parent	14 (9)	9 (6)	11 (7)
Yes; other	0	0	1 (1)

common limitations for research on sleep-related infant deaths and risk factors, as they are not self-reported, and suggest that current public education and health care provider guidance related to safe infant sleep are not being carefully adhered to, even in a relatively educated, affluent patient population. Although the parent study that supported this analysis was not designed or originally intended to serve as an evaluation of SIDS risk factors, these findings are a reminder that efforts to improve parent education and understand real-world parent practices must continue.

These objective data may help to explain some of the discordance in reporting of risk factors in the

sleep environment for healthy living infants and for infants who have died suddenly and unexpectedly. The NISP, an annual cross-sectional telephone survey conducted from 1992 to 2010, provided parent-reported data about infant sleep practices and reported that approximately three-quarters of infants were both placed supine<sup>6</sup> and in a crib or bassinet.<sup>7</sup> This finding is consistent with our data for initial position and placement. However, when we included subsequent position and placement in the middle of the night, 38% of infants were ever placed nonsupine during the night, and 91% of 1-month-old infants who were moved during the night ended up in an unsafe environment. These findings are more consistent with

**TABLE 3** Sleep Location, Surface, Position, and Sleep Environment for Infants Moved to a Second Location

Variable	1 Month (n = 45)		3 Months (n = 27)		6 Months (n = 18)	
	Location 1	Location 2	Location 1	Location 2	Location 1	Location 2
<b>Sleep location</b>						
Own room	7 (16)	3 (7)	7 (26)	1 (4)	7 (39)	4 (22)
Parent room	34 (76)	34 (77)	20 (74)	25 (93)	9 (50)	13 (72)
Other room	4 (9)	7 (16)	0	1 (4)	2 (11)	1 (6)
<b>Sleep surface</b>						
Crib (crib, cradle, bassinet, playpen)	36 (80)	4 (9)	25 (93)	3 (11)	14 (78)	3 (17)
Adult bed or mattress	3 (7)	23 (51)	2 (7)	20 (74)	2 (11)	10 (56)
Sofa	0	2 (4)	0	0	1 (6)	0
Car seat	1 (2)	4 (9)	0	1 (4)	0	3 (17)
Bedside co-sleeper ("sidecar")	1 (2)	0	0	0	1 (6)	0
Swing	2 (4)	6 (13)	0	1 (4)	0	0
Other	2 (4)	6 (13)	0	2 (7)	0	2 (11)
<b>Position child placed in</b>						
Supine	39 (87)	29 (64)	21 (78)	9 (33)	9 (50)	4 (22)
Side	3 (7)	9 (20)	6 (22)	7 (26)	5 (28)	6 (33)
Prone	0	2 (4)	0	0	3 (17)	4 (22)
Other	1 (2)	0	0	0	0	0
Indeterminate (nonsupine)	2 (4)	5 (11)	0	11 (41)	1 (6)	4 (22)
Items on bed excluding pacifier, mean $\pm$ SD	1.8 $\pm$ 1.3	2.5 $\pm$ 1.3	1.7 $\pm$ 1.0	2.7 $\pm$ 1.0	2.1 $\pm$ 1.3	2.4 $\pm$ 1.6
Shared sleep surface	4 (9)	30 (67)	1 (4)	22 (81)	3 (17)	12 (67)

Unless otherwise indicated, values are given as n (%).

data from Child Death Review teams, which reported that in sleep-related deaths, 38% of infants were found on their stomach, and only 28% of infants were found in a crib, bassinet, or playpen.<sup>15</sup>

We also found higher rates of bed-sharing and loose bedding in the environment than studies relying on parental report have noted. The most recent report from NISP demonstrated that 13.5% of families usually shared a bed.<sup>7</sup> Our observations found that a sleep surface was shared by 28%, 23%, and 16% of infants during a single night's observation at 1, 3, and 6 months, respectively. Importantly, <10% at each time point were observed sharing a surface at the beginning of the night, but this scenario increased overnight. Interestingly, Colvin et al<sup>15</sup> reported that 69% of infant deaths reviewed by Child Death Review teams occurred while the infant was sharing a sleep surface. Similarly, NISP reported a lower rate (55%) of soft or loose bedding use,<sup>8</sup> compared with ~75% in our observations. However, this difference may be partially explained by how bedding was defined in the 2 studies. NISP did

not include thin blankets (as thin as or thinner than a receiving blanket) or sheets, whereas these items were included in our count.

Approximately 90% of infants had loose or soft bedding, including loose blankets, stuffed animals, pillows, bumper pads, and sleep positioners, in their sleep areas. Some of these items were found on shared sleep surfaces, which is not surprising. Adult beds frequently have parental bedding (eg, blankets, pillows); in addition, many parents who sleep with their infant use bedding to build a barrier in the belief that the bedding will protect the infant from falling off the bed or from rollover accidents.<sup>16</sup> We also found that the majority of cribs contained soft or loose bedding. Many parents use soft bedding because of concerns about infant warmth and comfort, and to prevent infants from hurting themselves, and they may not be aware that soft bedding in the infant sleep environment creates a hazard. However, soft bedding in the sleep environment is the most common risk factor seen in sudden and unexpected infant deaths that occur in infants aged  $\geq 4$  months.<sup>15</sup>

There are 2 likely reasons that utilization of nocturnal videos resulted in the finding of higher rates of unsafe sleep environments than have been previously reported. First, objective video observations eliminate the bias inherent in self-reporting. Participants may be reluctant to admit to behaviors, particularly when they are inconsistent with infant care recommendations. In addition, videos allowed us to view the infant sleep environment throughout the entire night. This approach is in contrast to surveys, in which questions about sleep position, sleep location, and bedding are often asked in isolation, and the entire sleep environment may not be considered holistically. Furthermore, many parents may assume that the question refers only to initial placement at the beginning of the sleep period and not to changes occurring during the night. Indeed, we found that 28%, 18%, and 12% of participating infants slept in >1 location during the night at 1, 3, and 6 months, respectively. When the infant was moved in the middle of the night, there was a higher likelihood that the infant was placed in an



unsafe sleep environment. We found that for all 3 observation times, the second sleep environment was more hazardous than the initial setting in terms of sleep location, sleep position, and sharing the surface with another person.

These findings have important implications for public health messaging regarding both initial placement and handling of the infant in the middle of the night. Although safe sleep messages have been emphasized for years, our data suggest that parents are not strictly adhering to the guidance on safe sleep environments. This lack of adherence may be at least partly because of persistent cultural norms and beliefs. For instance, decorative bedding products displayed at and sold in retail establishments (and shown in parenting magazines) have influenced what is seen as appropriate by parents.<sup>17</sup> In addition, infant comfort, which includes longer sleep duration, is a priority for many parents, and this goal often results in prone and side positioning<sup>18–26</sup> and sharing of sleep surfaces.<sup>27,28</sup> Health care providers should be aware of these influences on parental decision-making so that appropriate guidance can be given.

It is also important for health care providers to realize that the

nighttime sleep environment is not static, but fluid, with potentially several changes during the course of the night. Kendall-Tackett et al<sup>29</sup> found that when parents were asked about infant sleep location at the beginning of the night, 31% reported bed-sharing, compared with 59% when parents were asked about sleep location at the end of the night. It is possible that well-intentioned parents consider safe sleep guidelines to be those that are applicable for the onset of sleep but less so in the middle of the night. It is therefore prudent for health care providers to ask about sleep environment for the entire night and provide anticipatory guidance accordingly. In addition, future epidemiologic studies should consider the fluid nature of the sleep environment.

We acknowledge that this study has limitations. Our cohort was largely white, with socioeconomic and educational levels higher than the norm. These results may therefore not be generalizable to other demographic groups. In addition, parents were aware that they were being videotaped. It is thus possible that we underestimated the proportion of families who did not adhere to safe sleep guidelines. Nonetheless, our direct observations revealed high rates of nonadherence

with safe sleep guidelines. Future studies in other populations will be needed to confirm this.

## CONCLUSIONS

This longitudinal study of infant sleep environments using videotaped observations found that among a predominantly highly educated, white population, infants were frequently placed in unsafe sleep environments, both with initial placement and during the course of the night. Our study found a higher proportion of sleep environment risk factors than have been reported in previous studies. Additional research on parental beliefs and understanding of when safe sleep guidelines are applicable and on barriers to safe sleep will be important, with the goal of developing more effective educational materials and interventions.

## ABBREVIATIONS

AAP: American Academy of Pediatrics  
NISP: National Infant Sleep Position Study  
SIDS: sudden infant death syndrome

**FINANCIAL DISCLOSURE:** The authors have indicated they have no financial relationships relevant to this article to disclose.

**FUNDING:** Supported by National Institutes of Health grant R01HD052809-01 and the Ashley Nicole Shellenberger SIDS Research Fund at the Penn State College of Medicine. Funded by the National Institutes of Health (NIH).

**POTENTIAL CONFLICT OF INTEREST:** The authors have indicated they have no potential conflicts of interest to disclose.

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*Pediatrics* 2016;138;

DOI: 10.1542/peds.2016-1533 originally published online August 15, 2016;

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