

Risk Factors for Sleep-Related Infant Deaths in In-Home and Out-of-Home Settings

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abstract

BACKGROUND AND OBJECTIVE: Multiple environmental risk factors are associated with sleep-related infant deaths. Little is known about differences in risk factors for deaths occurring in-home and out-of-home. We sought to compare risk factors for in-home and out-of-home infant deaths.

METHODS: We conducted a cross-sectional analysis of sleep-related infant deaths from 2004 to 2014 in the National Child Fatality Review and Prevention database. The main exposure was setting (in-home versus out-of-home) at time of death. Primary outcomes were known risk factors: sleep position, sleep location (eg, crib), objects in the environment, and bed sharing. Risk factors for in-home versus out-of-home deaths were compared using the χ^2 test and multivariate logistic regressions.

RESULTS: A total of 11 717 deaths were analyzed. Infants who died out-of-home were more likely to be in a stroller/car seat (adjusted odds ratio, 2.6; 95% confidence interval, 2.1–3.4; $P < .001$) and other locations (adjusted odds ratio, 1.9; 95% confidence interval, 1.5–2.3; $P < .001$), and placed prone (adjusted odds ratio, 1.2; 95% confidence interval, 1.1–1.3; $P < 0.01$). Bed sharing was less common out-of-home (adjusted odds ratio, 0.7; 95% confidence interval, 0.6–0.7; $P < .001$). There were no differences in sleeping on a couch/ chair, or objects in the sleep environment.

CONCLUSIONS: Sleep-related infant deaths in the out-of-home setting have higher odds of having certain risk factors, such as prone placement for sleep and location in a stroller/car seat, rather than in a crib/bassinets. Caregivers should be educated on the importance of placing infants to sleep supine in cribs/bassinets to protect against sleep-related deaths, both in and out of the home.

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Dr Kassa conducted the initial analyses, interpreted the data, and drafted the initial manuscript; Drs Moon and Colvin conceptualized and designed the study, interpreted the data, and reviewed and revised the manuscript; and all authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

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WHAT IS KNOWN ON THIS SUBJECT: Multiple risk factors are associated with sudden infant death syndrome and other sleep-related infant deaths occurring in the infant's home. Education about sleep environment risk factors has resulted in a decline in infant deaths.

WHAT THIS STUDY ADDS: Little is known about risk factors specifically for out-of-home deaths. This study identifies risk factors for death in-home versus out-of-home. Pediatric providers should further educate infant caregivers regarding the importance of safe sleep environments, both in and out of the home.

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Sleep-related infant deaths are those that occur during sleep or in a sleep environment; these comprise a large majority of sudden and unexpected infant deaths (SUID).¹ Sleep-related infant deaths are generally understood to include sudden infant death syndrome (SIDS), accidental suffocation and strangulation in bed (ASSB), and other ill-defined deaths, and account for ~3500 infant deaths in the United States each year.²

Risk factors for sleep-related infant deaths include both intrinsic biological factors and aspects of the sleep environment.³ Risk factors related to the sleep environment are well established and include side and prone sleep position, sleeping on surfaces other than cribs/bassinets, soft and loose bedding, and bed sharing.¹ However, because most of these deaths occur in the infant's home, very little is known about risk factors for deaths occurring outside of the infant's home. Most of the data available about out-of-home infant deaths are for those that have occurred in child care settings.^{4,5} Infants dying in child care were more likely to die during the first week of child care and were more likely to be last placed or found prone, when the usual sleep position is nonprone.⁴ One additional study with data about out-of-home deaths is a case-control study from Germany, which found that the risk of SIDS was higher when the infant slept at a relative's home compared with the parental home, although no analysis of risk factors by setting was conducted.⁶ In this study, we sought to identify risk factors for sleep-related infant death occurring in a broad range of settings outside of the parental home. We hypothesized that, because the usual sleep location (eg, crib, bassinet) may not be available outside of the home, deaths in out-of-home settings are more likely to be in unsafe locations (eg, adult beds, sofas).

METHODS

Data Source

After receiving approval from the National Center for Fatality Review and Prevention (NCFRP) and consent from 45 states participating in the NCFRP, we received a de-identified dataset of infant deaths occurring in 2004 to 2014. This dataset included demographic information on the child, caregivers and primary supervisors at the time of death, setting (ie, child's home, relative's home, or child care) and other known risk factors, such as sleep position, sleep location (eg, crib), and presence of items in the sleep location.^{7,8} The NCFRP dataset has been previously described.^{9,10}

Study Subjects

We included all deaths of infants (ie, <12 months old) that occurred during sleep or in a sleep environment. Deaths due to non-sleep-related medical conditions, homicide, or for which the setting was missing or unknown were excluded. On the basis of data regarding cause of death determination, cases were assigned to 1 of 3 causes of death: SIDS/SUID, ASSB, and unknown/ undetermined. This study was deemed exempt by the institutional review boards of Children's National Medical Center and the University of Virginia.

Setting of Death

Deaths were classified as occurring at the child's home ("in-home") or outside of the child's home ("out-of-home"). Out-of-home deaths included those at friends' or relatives' homes (regardless of duration of stay), licensed or unlicensed child care centers, vehicles, temporary housing, jails, hotels/motels, and public spaces.

Sleep Location, Position, and Other Risk Factors

We classified sleep location as follows: crib, bassinet and playpen, car seat/stroller, adult bed or on a person, couch or sofa, other (eg, floor, futon, pillow, and bean bag), and unknown.

Additional risk factors included bed sharing and the presence of objects, such as pillows, quilts and other items, in the sleep environment. The sleep position in which infants were placed and found was categorized as supine, side, and prone.

Other Study Definitions

Infant demographic characteristics included age, sex, and race/ethnicity. Infant age was classified as 0 to 3 months, 4 to 6 months, and 7 to 11 months, because our previous studies have found that the importance of specific risk factors differ in these age categories.⁷ Race/ethnicity was classified as non-Hispanic white, non-Hispanic black, Hispanic, and other. The primary caregiver and supervisor at the time of death were classified as parent, relative/friend, foster parent, licensed or unlicensed child care provider (which included babysitters), or other.

Data Analysis

Data were analyzed by using Stata, version 11.2 (Stata Corp, College Station, TX) and SPSS, version 21 (IBM SPSS Statistics, IBM Corporation, Armonk, NY). As previously described,^{7,9} the Markov Monte Carlo method was performed to impute missing data. Descriptive statistics were used to describe demographic and sleep environment risk factors among infants who died in-home versus out-of-home. We compared the presence of risk factors by group (in-home versus out-of-home) using the χ^2 test and used multivariate logistic regression, adjusting for age, race/ethnicity, and sex, to calculate the odds of a risk factor in the out-of-home setting compared with the in-home setting.

RESULTS

Population Characteristics

There were 13 471 infant deaths included in the dataset. A total of 11 717 (87.0%) met the inclusion criteria and were included in the

TABLE 1 Characteristics of the Study Population

Characteristics	Total (N = 11 717)	In-Home (N = 9364) ^a	Out-of-Home (N = 2353) ^a	<i>P</i> ^b
Infant age category at time of death (N, %)				<.001
0–3 mo	8135 (69.4)	6632 (70.8)	1503 (63.9)	
4–6 mo	2631 (22.5)	2025 (21.6)	606 (25.8)	
7–11 mo	951 (8.1)	707 (7.6)	244 (10.4)	
Sex of infant (N, %)				.22
Boy	6793 (58.0)	5455.4 (58.3)	1337.6 (56.8)	
Girls	4924 (42.0)	3908.6 (41.7)	1015.4 (43.2)	
Race and ethnicity of infant (N, %)				<.01
Hispanic	2055.4 (17.5)	1658.2 (17.7)	397.2 (16.9)	
Non-Hispanic white	5232.2 (44.7)	4107 (43.9)	1125.2 (47.8)	
Non-Hispanic black	3714 (31.7)	3033 (32.4)	681 (28.9)	
Other	715.4 (6.1)	565.8 (6.1)	149.6 (6.4)	
Diagnosis (N, %)				.03
SUID/SIDS	3215 (27.4)	2526 (27.0)	689 (29.3)	
ASSB	3361 (28.7)	2730 (29.1)	631 (26.8)	
Unknown/undetermined	5141 (43.9)	4108 (43.9)	1033 (43.9)	
Primary caregiver (N, %)				.04
Parent/guardian	11325 (96.7)	9212.6 (98.4)	2112.4 (89.6)	
Relative/friend	178.4 (1.5)	74.4 (0.8)	104 (4.4)	
Foster care	116.6 (1.0)	20.6 (0.2)	97.6 (4.1)	
Babysitter	61.2 (0.5)	31.8 (0.3)	29.4 (1.2)	
Other	35.8 (0.3)	24.6 (0.3)	11.2 (0.5)	
Primary supervisor at time of death (N, %)				<.001
Parent/guardian	9991.6 (85.2)	8726.6 (93.2)	1255 (53.3)	
Relative/friend	865 (7.4)	456.6 (4.9)	408.4 (17.4)	
Foster care	108.2 (0.9)	21.8 (0.2)	86.4 (3.7)	
Babysitter/child care provider	687.2 (5.9)	122.4 (1.3)	564.8 (24.0)	
Other	75 (0.6)	36.6 (0.4)	38.4 (1.6)	
Setting				—
Child's home	9364 (79.9)	9364 (100)	—	
Relative/friend's Home	1415 (12.1)	—	1415 (60.1)	
Child care/babysitter's	524 (4.5)	—	524 (22.3)	
Traveling/temporary	126 (1.1)	—	126 (5.4)	
Foster home	124 (1.1)	—	124 (5.3)	
Other	164 (1.4)	—	164 (7.0)	

By study definition, out-of-home deaths were not in the child's home. Therefore, those cells are empty (as indicated with an em dash) and the χ^2 test was not performed for Setting.

^a Decimal points of counts exist due to averaging over 5 independent imputations during the multiple imputation process.

^b *P* values reflect χ^2 tests comparing in-home and out-of-home groups for each demographic characteristic.

analysis. The majority of deaths (79.9%) occurred in-home (Table 1). Most (69.4%) of these deaths occurred before 4 months of age, and the majority (58.0%) of infants were boys. Non-Hispanic whites were the largest racial/ethnic group (44.7%). The cause of death was unknown/undetermined for 43.9% of cases, with SIDS/SUID and ASSB being the cause for 27.4% and 28.7% of cases, respectively. Parents were most frequently the supervisor (85.2%) at the time of death.

Comparing in-home and out-of-home deaths, a higher percentage of infants

who died in-home were <4 months of age (70.8% in-home vs 63.9% out-of-home; $P < .0001$). A higher percentage of non-Hispanic white infants died out-of-home compared with in-home (47.8% out-of-home vs 43.9% in-home), whereas non-Hispanic black infants were more likely to die in-home (32.4% in-home vs 28.9% out-of-home; $P < .01$). In infants' homes, 93.2% of primary supervisors were parents, compared with 53.3% in the out-of-home setting ($P < .001$). In the out-of-home setting, a higher percentage of primary supervisors at the time of

death were licensed and unlicensed child care providers (24.0% vs 1.3%) and relatives (17.4% vs 4.9%; $P < .001$). The majority of out-of-home deaths occurred at relatives' homes (60.1%), followed by child care settings (22.3%), including licensed and unlicensed child care and babysitters' homes.

Sleep Environment Risk Factors: Bivariate Analyses

Overall, 9.0% of infants had no sleep environment risk factors present. This percentage was similar among deaths occurring in out-of-home (10.1%) and in-home settings (8.7%). The plurality of all infants were placed for sleep supine (42.4%), on an adult bed or a person (51.9%), and was bed sharing (54.7%) at the time of death (Table 2). One or more objects were present in the sleep environment of one-third of all infants. Differences in risk factors existed by setting. In-home deaths were more likely to occur on an adult bed or while held by a person (53.4%) compared with those that occurred in out-of-home settings (45.7%; $P < .001$). Bed sharing was also more likely to be present in in-home (57.1%) than out-of-home (45.3%) deaths ($P < .001$). Infants who died out-of-home were more likely to be found in the prone position (43.1% vs 38.8%; $P < .001$). Differences in change in position were of statistical significance, with a slightly higher percentage of out-of-home infants being found prone after being placed to sleep in the supine or side position. There was no difference in the presence of objects in the sleep environment.

Multivariate Models for Sleep Environment

After adjusting for infant age, race/ethnicity and sex, children who died out-of-home had approximately twice the odds of being in a car seat/stroller or other location (eg, floor, futon, pillow, and bean bag) than infants who died in-home (Table 3.) Out-of-home infants had 30% lower

TABLE 2 Sleep Environment Risk Factors Occurring In-Home and Out-of-Home

Risk Factor	Total (N = 11 717)	In-Home (N = 9364) ^a	Out-of-Home (N = 2353) ^a	P ^b
Sleep location (N, %)				<.001
Crib, bassinet, playpen	3268.2 (27.9)	2605.2 (27.8)	663 (28.2)	
Car seat/stroller	311.2 (2.7)	189.2 (2.0)	122 (5.2)	
Adult bed/person	6076.2 (51.9)	4999.8 (53.4)	1076.4 (45.7)	
Couch/chair	1507 (12.9)	1190.6 (12.7)	316.4 (13.4)	
Other	555.4 (4.7)	379.2 (4.1)	175.2 (7.4)	
Bed sharing (N, %)				<.001
No	5303 (45.3)	4016 (42.9)	1287 (54.7)	
Yes	6414 (54.7)	5348 (57.1)	1066 (45.3)	
≥ 1 Objects (N, %)				.46
No	7853 (67.0)	6261 (66.9)	1592 (67.7)	
Yes	3864 (33.0)	3103 (33.1)	761 (32.3)	
Sleep position: placed (N, %)				<.001
Supine	4973 (42.4)	3974.4 (42.4)	998.6 (42.2)	
Prone	2632 (22.5)	2048 (21.9)	584 (24.8)	
Side	1530 (13.1)	1201.4 (12.8)	328.6 (14.0)	
Unknown	2582 (22.0)	2140.2 (22.9)	441.8 (18.8)	
Sleep position: found (N, %)				<.001
Supine	3306 (28.2)	2660.6 (28.4)	645.4 (27.4)	
Prone	4647 (39.7)	3632.8 (38.8)	1014.2 (43.1)	
Side	1428.6 (12.2)	1163.6 (12.4)	265 (11.3)	
Unknown	2335.4 (19.9)	1907 (20.4)	428.4 (18.2)	
Change in sleep position (N, %)				<.001
Supine/side to supine/side	4058.4 (34.6)	3260 (34.8)	798.4 (33.9)	
Supine/side to prone	1935.6 (16.5)	1522.8 (16.3)	412.8 (17.5)	
Prone to supine/side	242.2 (2.1)	200.4 (2.1)	41.8 (1.8)	
Prone to prone	2202 (18.8)	1697 (18.1)	505 (21.5)	
Position placed or found unknown	3278.8 (28.0)	2683.8 (28.7)	595 (25.3)	

^a Decimal points of counts exist due to averaging over 5 independent imputations during the multiple imputation process.

^b P values are for the χ^2 tests comparing in-home and out-of-home groups for each risk factor.

TABLE 3 Adjusted Odds Ratios of an Out-of-Home Death (Compared With In-Home Deaths) Occurring in the Presence of a Sleep Environment Risk Factor

Sleep Environment Risk Factor	Out-of-Home aOR (95% CI) ^a	P
Sleep location		
Car seat/stroller	2.6 (2.1–3.4)	<.001
Adult bed/on person	0.9 (0.8–1.0)	.04
Couch/chair	1.1 (0.9–1.3)	.28
Other	1.9 (1.5–2.3)	<.001
Crib/bassinet/playpen	Reference	
Bed sharing		
Yes	0.7 (0.6–0.7)	<.001
No	Reference	
Any object in sleep location		
Yes	1.0 (0.9–1.0)	.31
No	Reference	
Sleep position: placed		
Prone	1.18 (1.05, 1.32)	<.01
Side	1.15 (0.996, 1.32)	.06
Unknown	0.82 (0.72, 0.93)	<.001
Supine	Reference	
Sleep position: found		
Prone	1.13 (1.01, 1.27)	.03
Side	0.94 (0.80–1.1)	.42
Unknown	0.91 (0.79, 1.05)	0.18
Supine	Reference	
Position change		
Back/side to stomach	1.06 (0.93, 1.22)	.38
Stomach to back/side	0.85 (0.60, 1.21)	.36
Stomach to stomach	1.23 (1.08, 1.40)	<.01
Position placed or found unknown	0.88 (0.78, 0.99)	0.04
Back to back	Reference	

aOR, adjusted odds ratio; CI, confidence interval.

^a Adjusted for age category, race/ethnicity, and sex.

odds of bed sharing at the time of death. Out-of-home infants were also slightly more likely to have been placed to sleep in the prone position (odds ratio, 1.18; 95% CI, 1.05–1.32; $P < .01$). There were no differences between the 2 groups for objects found in the sleep environment.

DISCUSSION

In this analysis of 11 717 deaths, there were important differences in sleep environment risk factors for infants who died out-of-home. Infants who died out-of-home had higher odds of dying in a location other than a crib, bassinet, or playpen, such as a car seat/stroller, futon, pillow and bean bag. Our findings also suggest that out-of-home, infants have higher odds of having been placed in the prone position at the time of death.

The American Academy of Pediatrics recommends that infants be placed for sleep in the supine position in a crib or bassinet.¹ Although the current study could not provide reasons for sleep location, out-of-home settings are often temporary or transient situations, because they may occur while the family is traveling, living in temporary housing, or visiting friends or relatives. It is possible that many infants who were out-of-home did not have a portable crib either because of cost or inconvenience, and were therefore placed in locations other than a crib/bassinet. Car seats/strollers may be convenient locations for infants to sleep if the family is traveling or in an otherwise transient situation. However, they are not recommended for routine sleep because of the potential risk of upper airway obstruction.¹ One review of US Consumer Product Safety Commission records of deaths involving sitting and carrying devices included 31 deaths in car seats and 3 in strollers. A total of 48% of car seat deaths and all 3 stroller deaths were attributed to positional asphyxia; the

other car seat deaths were attributed to strangulation from straps.¹¹ More research will be needed to better understand the epidemiology and mechanism of these deaths to better inform families.

After adjusting for age, race/ethnicity, and sex, we also found that infants who died out-of-home were more likely to be placed prone. This may be at least partly due to having nonparental caregivers when out-of-home. Although parents were the majority of supervisors among in-home and out-of-home deaths, child care providers and relatives/friends comprised a higher percentage of supervisors for out-of-home deaths than for in-home deaths. Studies of sleep practices in child care settings have found that many child care providers place infants prone for sleep.^{4,5,12} Although public health campaigns targeting parents and primary caregivers in the home setting and at licensed child care settings improve knowledge about safe sleep practices^{13,14} and have resulted in a significant decline in the risk of sleep-related deaths among infants,¹⁵ the findings of this study suggest continued gaps in practices to prevent sleep-related infant deaths, particularly in out-of-home settings and in settings with nonparental caregivers. Unfortunately, for many parents who need to re-enter the work force after the birth of a child, the care of infants outside of the home is not a choice, but an unavoidable economic necessity. Providing those who care for children outside of the home, including nonparental caregivers (eg, relatives and babysitters) and licensed and unlicensed child care providers, with education regarding safe sleep practices is critical. In addition, informing parents about the need to maintain safe sleep practices while traveling (eg, traveling with portable cribs) and ensuring that individuals who are caring for their children out-of-home implement safe sleep practices, such as supine

sleeping, will be important. Programs that distribute portable cribs may also be helpful in disseminating information about the need for safe sleep practices in all settings.¹⁴

The reasons for risk factor differences identified in this study deserve further investigation and the findings should be interpreted in light of several limitations. There are limitations inherent in the NCFRP database. Each state determines which child deaths are investigated and thus which deaths are included in the database. Therefore, the NCFRP database may not include all child deaths within each state, and consequently the data cannot be compared 1-to-1 with vital statistics data.¹⁰ There may also be a selection bias. In addition, rates cannot be calculated from the data unless there is a well-defined denominator and, without detailed analysis, the data cannot be assumed to be a representative sample of all deaths. Furthermore, we were unable to adjust for some important factors contributing to the risk of sleep-related death in infants, including maternal age, breastfeeding status, known biological risk factors, exposure to tobacco smoke, and birth weight or prematurity.¹⁶ It is unknown if inclusion of these factors would alter our findings. In particular, there may be differences in infants who were cared for out-of-home that may be associated with a history of prematurity or the family's socioeconomic status. Finally, because data about risk factors were largely collected through caregiver interviews, recall bias is another important limitation of this study and thus, some risk factors may have been underreported. Nonetheless, our findings provide insight into the differences in risk factors for sleep-related deaths occurring out-of-home. This information will help to direct resources and education about providing safe sleep environments in out-of-home settings. Future studies can further explore the reasons

behind the differences found in this study and determine the contribution of important factors that we were unable to examine.

CONCLUSIONS

Among infants with sleep-related deaths, known risk factors, such as sleep location and position, were more likely to be present in out-of-home settings compared with infants' homes. Education of parents and nonparental caregivers regarding the necessity of cribs/bassinets and supine sleep position to protect against sleep-related deaths both in-home and out-of-home is needed.

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ABBREVIATIONS

ASSB: accidental suffocation and strangulation in bed
NCFRP: National Center for Fatality Review and Prevention
SIDS: sudden infant death syndrome
SUID: sudden unexpected infant death

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Hilina Kassa, Rachel Y. Moon and Jeffrey D. Colvin

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