

# Infant Deaths in Sitting Devices

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abstract

**BACKGROUND AND OBJECTIVES:** Annually, several hundred infant deaths occur in sitting devices (eg, car safety seats [CSSs] and strollers). Although American Academy of Pediatrics guidelines discourage routine sleeping in sitting devices, little is known about factors associated with deaths in sitting devices. Our objective was to describe factors associated with sleep-related infant deaths in sitting devices.

**METHODS:** We analyzed 2004–2014 National Center for Fatality Review and Prevention data. The main outcome was sleep location (sitting device versus not). Setting, primary caregiver, supervisor at time of death, bed-sharing, and objects in the environment were compared by using  $\chi^2$  tests and multivariable logistic regression. Descriptive statistics of additional possible risk factors were reviewed.

**RESULTS:** Of 11 779 infant sleep-related deaths, 348 (3.0%) occurred in sitting devices. Of deaths in sitting devices, 62.9% were in CSSs, and in these cases, the CSS was used as directed in <10%. Among all sitting-device deaths, 81.9% had  $\geq 1$  risk factor, and 54.9% had  $\geq 2$  risk factors. More than half (51.6%) of deaths in CSSs were at the child's home. Compared with other deaths, deaths in sitting devices had higher odds of occurring under the supervision of a child care provider (adjusted odds ratio 2.8; 95% confidence interval 1.5–5.2) or baby-sitter (adjusted odds ratio 2.0; 95% confidence interval 1.3–3.2) compared with a parent.

**CONCLUSIONS:** There are higher odds of sleep-related infant death in sitting devices when a child care provider or baby-sitter is the primary supervisor. Using CSSs for sleep in nontraveling contexts may pose a risk to the infant.

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**WHAT'S KNOWN ON THIS SUBJECT:** Each year, a number of infant deaths are associated with sitting devices (eg, car safety seats, strollers, and infant seats). The American Academy of Pediatrics recommends against routine sleeping in sitting devices for infants.

**WHAT THIS STUDY ADDS:** Using sitting devices for sleeping purposes in nontraveling contexts may pose a risk to the infant.

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Sleep-related infant death is a categorical term that includes sudden infant death syndrome (SIDS), accidental suffocation and strangulation in bed (ASSB), and other ill-defined deaths.<sup>1</sup>

Approximately 3700 infants annually suffer sleep-related infant death, making this the leading cause of postneonatal (28 days–1 year old) infant mortality.<sup>2</sup>

In an effort to decrease the rate of sleep-related deaths, the American Academy of Pediatrics (AAP) has released recommendations for a safe infant sleep environment.<sup>1</sup> Those recommendations include placing the infant in a supine sleep position, using a firm sleep surface, room-sharing without bed-sharing, avoiding the use of soft bedding and overheating, and particularly regarding sitting devices, refraining from the use of sitting devices, such as car safety seats (CSSs) and strollers for routine sleep.<sup>1</sup>

Sitting and carrying devices (such as CSSs, strollers, infant seats, bouncers, and swings) were initially designed primarily for the transporting, feeding, and play of infants and young children. Despite the intended purpose of these devices (eg, transportation, feeding, and playing), infants spend a significant amount of time in sitting devices for other reasons. One observational study of 187 infants found that the mean time an infant spent in a sitting device was 5.7 hours (range 0–16 hours) per day.<sup>3</sup> In some cases, these devices are used as a sleep alternative to a crib or bassinet.<sup>3–6</sup>

When placed in a sitting device for a reason other than its intended purpose (ie, not being used for transportation, feeding, or playing), infants are at risk for injury, including falls from the devices, falls from elevated surfaces on which the device has been placed, and injuries when the device flips over on a soft surface.<sup>7–10</sup> Additionally, in 1

retrospective study of sleep-related deaths of young (<2 years old) children occurring in sitting devices, many parents used the device as a place for their children to sleep; 16 of the 18 deaths involving a CSS occurred outside a motor vehicle, suggesting use of the CSS other than for its intended purpose.<sup>5</sup> Similarly, a UK study of 14 CSS-related infant deaths between 1999 and 2011 found that most deaths occurred when the CSSs were not being used to transport an infant in a motor vehicle and that most of these deaths occurred in infants <2 months of age.<sup>4</sup>

Reports of infant deaths in sitting devices have thus far included a limited number of deaths and primarily focused on the intended use of the sitting device at the time of death. Little is known about other factors surrounding infant deaths in sitting devices. In this study, we analyzed data from a large US case-reporting system to better understand the factors associated with sleep-related infant deaths in sitting devices.

## METHODS

### Data Source

Data for this study were obtained from the National Center for Fatality Review and Prevention (NCFRP). The NCFRP, funded by the Maternal and Child Health Bureau, Health Resources and Service Administration, US Department of Health and Human Services (UG7MC28482), and US Centers for Disease Control and Prevention, is a Web-based system used for systematically collecting, analyzing, and reporting data on infant and child deaths.<sup>11</sup> After approval and consent from the 45 states participating in the NCFRP, we received a deidentified data set of infant deaths occurring during sleep or in a sleep environment from 2004 to 2014. The NCFRP Child Death Review Case

Reporting System has been previously described.<sup>11–13</sup>

### Study Subjects

The NCFRP provided data on all infant ( $\leq 365$  days of age) deaths occurring during sleep. Deaths that could be explained by nonsleep-related causes, such as homicide or infection, and deaths missing sleep location were excluded. By using data regarding cause-of-death determination, cases were assigned to 1 of 3 causes of death: SIDS or sudden unexpected infant death (SUID), ASSB, and unknown or undetermined.

### Sleep Location and Setting of Death

We categorized sleep location as the location in which the infant death occurred; deaths were dichotomized into those in sitting devices (CSSs, strollers, bouncers, swings, and other infant seats) or not in sitting devices (crib, bassinet, playpen, adult bed, and couch or chair). Infant slings and carriers and nursing pillows were not categorized as sitting devices. Setting of death was defined as the environment in which the infant death occurred and was categorized as follows: child's home; relative's or friend's home; foster home; child care center or baby-sitter's home; vehicle in motion or temporarily stopped or parked; shopping or errands or car seat or stroller on a walk; motel, recreational vehicle or trailer, or park; and other.

### Primary Caregiver and Primary Supervisor

The primary caregiver was defined as the person who was responsible for the infant on a daily basis and was categorized as a parent or guardian, foster parent, relative or friend, or other. Primary supervisor was defined as the person who was responsible for the infant at the time of death and was categorized as a parent or guardian, relative, friend, child care provider (licensed or unlicensed), baby-sitter, other, or unknown.

## Data Analysis

Data analysis was performed by using SAS (SAS Institute, Inc, Cary, NC) and SPSS (IBM SPSS Statistics, IBM Corporation, Armonk, NY). As previously described,<sup>12,13</sup> multiple imputations using the Markov chain Monte Carlo method were performed to impute missing data, and subsequent analyses were performed by using pooled imputed data. The maximum missing data that were imputed for any variable was 2.2% (setting and race and/or ethnicity).  $P < .05$  was considered significant. First, any available narratives and free-text variables were reviewed to determine if the sitting device was being used as directed at the time of death. CSS use guidelines stipulate that they be used for transport in a vehicle (either parked or in motion).<sup>14</sup> However, CSSs are now being marketed to also be used for transport other than in a vehicle (eg, stroller and shopping cart). Hazard patterns noted in case series of injuries and deaths associated with CSSs<sup>5,8</sup> suggest that many injuries and deaths are associated with improper buckling of CSS straps. Thus, we defined “as directed” use of a CSS as the infant being strapped into an appropriately sized CSS while the infant was being transported in a vehicle (either parked or in motion.) For deaths in sitting devices, we determined the number of risk factors present at the time of death<sup>15</sup> and categorized them as follows: (1) infant risk factors (estimated gestation age <37 weeks; birth weight <2500 g; intrauterine exposure to illicit drugs, heavy alcohol use, or misuse of over-the-counter medications; infant disability or chronic health condition; and maternal pregnancy complications), (2) supervision risk factors (supervisor impaired because of alcohol or illicit drugs, supervisor with a history of drug or alcohol abuse, or supervisor absent, asleep, or distracted), and (3) sleep-environment risk factors (new sleep

environment, item in the sleep environment, or exposure to secondhand smoke). Bed-sharing and sleep position were not included as risk factors given their relative rarity in or irrelevance to deaths occurring in sitting devices. Narratives available for deaths in CSSs ( $n = 24$ ) were also examined to identify hazards not included as variables in the data set. Those hazards were described separately for deaths in which the CSS was and was not used as directed. Second, using the  $\chi^2$  test, we compared risk factors by sleep location (in a sitting device versus not in a sitting device) and by whether the CSS was used as directed. Multivariable logistic regression, adjusting for age, race and/or ethnicity, and sex, was used to calculate the adjusted odds ratios (aORs) of the cause of death, primary supervisor, bed-sharing, and any objects being present in the sleep environment.

## RESULTS

### Characteristics of Deaths in Sitting Devices

Of 11 779 sleep-related infant deaths that were included in the analysis, 348 (3.0%) occurred in sitting devices (Table 1). The majority of deaths in sitting devices occurred in CSSs (219; 62.9%), followed by bouncers, swings, and other (122; 35.1%) and strollers (7; 2.0%). The median age of infants dying in sitting devices was 2.0 months (interquartile range 1.0–4.0 months). The sitting device was not used as directed in nearly two-thirds of deaths (62.9%). Among the 219 deaths in CSSs, <10% ( $n = 20$ ) occurred in the context of the CSS being used as directed (ie, the infant being strapped into an appropriately sized CSS while the infant was being transported in a vehicle, either parked or in motion) or when it was unclear if the CSS was being used as directed. Among all deaths in any sitting device, more than three-quarters (81.9%) had a least 1 risk factor, and more than half (54.9%) had 2 or more risk factors. Among deaths in any sitting device in which

the device was used as directed or when it was unclear whether it was being used as directed ( $n = 131$ ), the most common risk factors were the supervisor being asleep ( $n = 44$ ; 33.6%), maternal pregnancy complications ( $n = 32$ ; 24.4%), infant exposure to secondhand smoke ( $n = 30$ ; 22.9%), and having an estimated gestational age <37 weeks ( $n = 30$ ; 22.9%). Other risk factors that were present in >15% of deaths in which the sitting device was being used as directed or when it was unclear whether it was being used as directed include the following: item present in the sleep environment ( $n = 26$ ; 19.8%), new sleep environment ( $n = 23$ ; 17.6%); and low birth weight ( $n = 21$ ; 16.0%). A risk factor was present in approximately half of each of the 3 domains: infant risk factors (46.6%), supervision risk factors (48.9%), and sleep-environment risk factor (48.1%). Half of the deaths (50.4%) had risk factors in at least 2 of the 3 domains.

We also examined risk factors associated with the subset of deaths occurring in CSSs when they were used as directed and compared those to risk factors in deaths when the CSS was not used as directed. Although the comparison was likely underpowered, the only significant difference was for a supervisor being asleep at the time of death (CSS used as directed 6.3% versus CSS not used as directed 32.0%;  $P = .044$ ; Appendix Table). This association was no longer significant in logistic regressions adjusted for age and sex.

Among deaths in CSSs, additional information was available from narratives (of variable length) for 24 of the deaths, 7 of which occurred when the CSS was used as directed and 17 occurred when the CSS was not used as directed. Among deaths in which the CSS was used as directed, the entire CSS was covered with a blanket in 2 deaths; 1 infant was loosely buckled or not fully buckled into the CSS and was overheated, and 1 infant was left alone in a car in the CSS for a prolonged period of time. In

**TABLE 1** Characteristics of the Study Population by Location of Death

Characteristics	Total (N = 11 779), n (%)	Not a Sitting Device (n = 11 431), n (%)	Sitting Device (n = 348), n (%)	P
Age at the time of death, mo				
0–3	8190 (69.3)	7951 (69.6)	239 (68.7)	.29
4–6	2638 (22.4)	2551 (22.3)	87 (25.0)	
7–11	951 (8.1)	929 (8.1)	22 (6.3)	
Infant sex				
Male	6823 (57.9)	6623 (57.9)	200 (57.5)	.84
Female	4956 (42.1)	4808 (42.1)	148 (42.5)	
Race and/or ethnicity of infant				
Hispanic	2032 (17.3)	1968 (17.2)	64 (18.4)	.63
Non-Hispanic white	5272 (44.8)	5112 (44.7)	160 (46.0)	
Non-Hispanic African American	3733 (31.7)	3626 (31.7)	107 (30.8)	
Other	742 (6.3)	725 (6.3)	17 (4.9)	
Cause of death				
SUID or SIDS	3278 (27.8)	3151 (27.6)	127 (36.5)	<.0001
ASSB	3407 (28.9)	3349 (29.3)	58 (16.7)	
Unknown or undetermined	5094 (43.3)	4931 (43.1)	163 (46.8)	
Primary caregiver at time of death				
Parent or guardian	11 458 (97.3)	11 118 (97.3)	340 (97.7)	.80
Relative or friend	182 (1.6)	179 (1.6)	<sup>a</sup>	
Foster parent	102 (0.9)	99 (0.9)	<sup>a</sup>	
Other	37 (0.3)	35 (0.3)	<sup>a</sup>	
Primary supervisor at time of death				
Parent or guardian	9004 (76.5)	8743 (76.5)	261 (75.0)	.0007
Relative	662 (5.6)	649 (5.7)	13 (3.7)	
Friend	85 (0.7)	82 (0.7)	<sup>a</sup>	
Baby-sitter	398 (3.4)	375 (3.3)	23 (6.6)	
Child care provider	157 (1.3)	145 (1.3)	12 (3.5)	
Other	45 (0.4)	44 (0.4)	<sup>a</sup>	
Unknown	1425 (12.1)	1390 (12.2)	35 (10.1)	
Setting				
Child's home	9444 (80.2)	9221 (80.7)	223 (64.1)	<.0001
Relative's or friend's home	1423 (12.1)	1365 (11.9)	58 (16.7)	
Foster home	123 (1.0)	121 (1.1)	<sup>a</sup>	
Child care center or baby-sitter's home	511 (4.3)	480 (4.2)	31 (8.9)	
Motel, RV, trailer, or park	112 (1.0)	103 (0.9)	9 (2.6)	
Vehicle in motion or temporarily parked	20 (0.2)	<sup>a</sup>	19 (5.5)	
Shopping or errands (not in vehicle), restaurant, or on walk in stroller	8 (0.1)	<sup>a</sup>	<sup>a</sup>	
Other	138 (1.2)	136 (1.2)	<sup>a</sup>	
Bed-sharing				<.0001
Yes	6604 (56.1)	6589 (57.6)	15 (4.3)	
No	5175 (43.9)	4842 (42.4)	333 (95.7)	
≥1 object in sleep environment				<.0001
Yes	3954 (33.6)	3883 (34.0)	71 (20.4)	
No	7825 (66.4)	7548 (66.0)	277 (79.6)	

RV, recreational vehicle.

<sup>a</sup> Frequency suppressed because cell size <6.

the 3 other deaths in which the CSS was used as directed, there were no obvious hazards noted, although 1 infant had a history of extreme prematurity (<28 weeks estimated gestational age) and extremely low birth weight (<1000 g). Among the deaths in which the CSS was not used as directed, 4 deaths

occurred when the infant was loosely buckled or not fully buckled into the CSS, 2 occurred while the entire CSS was covered by a blanket, and in 1 death, the CSS had shifted position in a dangerous manner. In 8 deaths in which the CSS was not used as directed, there were no obvious hazards, although in all but 3 of

these deaths, the infant had a risk factor present: supervisor asleep (*n* = 3); intrauterine exposure to illicit drugs, heavy alcohol use, or misuse of over-the-counter medications (*n* = 2); prematurity (*n* = 1); and an item present in the sleep environment (*n* = 1).

## Comparison of Deaths in Sitting Devices to Deaths Not in Sitting Devices

A higher proportion of infants who died in sitting devices had SUID or SIDS or an unknown or undetermined cause of death compared with infants who did not die in sitting devices ( $P < .0001$ ; Table 1). The majority of deaths occurring both in sitting devices and not in sitting devices occurred in the child's home. Nearly two-thirds (64.1%) of deaths in sitting devices, including 74.3% of deaths in strollers and more than half (51.6%) of deaths in car seats, occurred in the child's home. Among deaths in sitting devices, higher percentages of deaths in CSSs occurred at a relative's or friend's home (21.9%) and at a child care center or baby-sitter's home (12.3%) than deaths in strollers and bouncers or swings (total percentage at both locations 11.5%;  $P < .0001$ ).

After adjusting for age, sex, and race and/or ethnicity and in comparison with deaths that did not occur in a sitting device, deaths in sitting devices had higher odds of occurring under nonparental supervision, such as baby-sitters (aOR 2.0; 95% confidence interval [CI] 1.3–3.2) and child care providers (aOR 2.8; 95% CI 1.5–5.2), than deaths occurring under parental supervision (Table 2). Relative to infants who died while not in sitting devices, infants who died in a sitting device were half as likely to have an object in the sleep environment (aOR 0.5; 95% CI 0.4–0.6) or to have a cause of death of ASSB (aOR 0.4; 95% CI 0.3–0.6; reference = SIDS and SUID).

## DISCUSSION

In this large data set of 11 779 infant sleep-related deaths, 3% occurred in a sitting device, consistent with other published data.<sup>6,16</sup> The majority of deaths in sitting devices were in CSSs. The overwhelming majority of infants who died in sitting devices died at home and under the supervision of their parent or guardian. Because there are no data available on the

**TABLE 2** Multivariable Analysis of Risk Factors of Infant Deaths in Sitting Devices Compared With Deaths Not Occurring in a Sitting Device

Characteristics	Odds Ratio (95% CI) <sup>a</sup>	P
Primary supervisor at the time of death		
Relative	0.7 (0.4–1.2)	.16
Friend	1.1 (0.4–3.7)	.83
Baby-sitter	2.0 (1.3–3.2)	.002
Child care provider	2.8 (1.5–5.2)	.002
Other	0.7 (0.1–5.2)	.75
Unknown	0.8 (0.6–1.2)	.35
Parent or guardian	Reference	—
Cause of death		
ASSB	0.4 (0.3–0.6)	<.001
Unknown or undetermined	0.8 (0.7–1.1)	.14
SUID or SIDS	Reference	—
Bed-sharing		
Bed-sharing	0.03 (0.02–0.05)	<.001
Not bed-sharing	Reference	—
≥1 object in sleep environment		
Item present	0.5 (0.4–0.6)	<.001
No item present	Reference	—

—, not applicable.

<sup>a</sup> Adjusted by age category, sex, and race and/or ethnicity. Reference is death not occurring in a sitting device.

relative amount of time infants spend sleeping in cribs, bassinets, sitting devices, and other locations, this study cannot compare the relative risk of sleeping in a sitting device compared with other locations. However, these results do serve as a reminder that sleep-related infant deaths do occur in sitting devices, including CSSs.

CSSs are a safe and effective way of transporting an infant and should always be used when transporting an infant in a motor vehicle, whether the infant is awake or asleep. The AAP notes that CSSs are designed as safety devices to be used in motor vehicles and not as general infant sitting devices<sup>14</sup> and advises that they be used only for travel.<sup>14,17</sup> If a child falls asleep in a CSS while actively traveling in a motor vehicle, they should remain in the CSS until they are no longer traveling. If they are still asleep when they are no longer traveling, they should then be placed in a crib or bassinet. Thus, theoretically, few deaths in sitting devices should occur outside of traveling contexts. However, our findings indicate that in the great majority of deaths in sitting devices,

the infant was not being transported. Although parents and other caregivers may put an infant in a sitting device with the intent of sleep, the AAP recommends against this because of safety concerns. Although we cannot ascertain from this study all of the circumstances surrounding the infant at the time of death, we believe that it is prudent for parents and caregivers to remove the infant from the sitting device when they fall asleep and place them in a bassinet or crib when they are not transporting the infant in a motor vehicle. After leaving the motor vehicle, infants should be moved to a flat, firm surface when it is practical to do so.<sup>1</sup> At a minimum, infants should not sleep in these devices unsupervised. Although this data set did not provide detail regarding buckling, a previous study found that several infants who died in sitting devices had not been properly buckled,<sup>5</sup> and we agree that infants should also always be buckled with a 5-strap harness, even when asleep, to reduce the risk of strangulation and positional asphyxia. Pediatricians should encourage parents and caregivers to include a portable crib or bassinet when traveling for use

once they reach their destination if it is likely that their infant will be asleep.

Despite AAP recommendations, infants often spend prolonged periods of time in CSSs when not traveling, and the CSS frequently is used as an alternative to a crib or bassinet.<sup>3-6</sup> This may in part be because CSSs are ubiquitous and because they are convenient for parents and caregivers to use. Indeed, our analysis revealed that nearly two-thirds of deaths in sitting devices occurred in the context of a sitting device that was not being used as directed or for its intended purpose. This is consistent with US Consumer Product Safety Commission injury data that estimate that >8000 infants are evaluated each year in hospital emergency departments for injuries associated with CSSs that are sustained outside of a motor vehicle.<sup>8</sup>

It is likely that caregivers find CSSs and other sitting devices to be a convenient means of temporarily holding a child while the caregiver is busy with other tasks. Caregiver confidence in the safety of CSS also is likely an important driver of the behavior. Knowing that CSSs are for safety and are “approved,” some caregivers may also believe that the use of CSSs for purposes outside of travel are also safe. Additionally, financial constraints may play a role in the inappropriate use or overuse of sitting devices for sleeping purposes. Although this study did not look at the motive behind placing an infant in a CSS for nontransportation reasons, it is worth considering that some caregivers might have been unable to afford a portable crib or other flat sleeping surface and used a CSS instead.

Although the majority of deaths in sitting devices were at home and under the supervision of a parent or guardian, when compared with other deaths, infants dying in sitting devices had higher odds of having a child care provider or baby-sitter as the primary supervisor at the time of death

(compared with a parent or guardian). Nonparental caregivers should be advised not to keep infants in sitting devices for sleep. Additionally, environments such as a relative’s or friend’s home may not be well equipped to safely accommodate the infant during sleep. In such cases, the use of a portable crib or bassinet should be arranged. Recent campaigns to educate child care providers on safe sleep-environment practices have been successful in improving knowledge and safe sleep practices.<sup>18</sup> However, these findings suggest that there are still gaps in the public knowledge regarding the appropriate usage of sitting devices for infant care and that all caregivers, including nonparental caregivers, must be educated in this regard.

This study has several limitations. Despite the NCFRP being a large case-reporting system, not every state participates, and only infant deaths reviewed by infant and child fatality teams are generally reported. Therefore, the NCFRP may not include all infant deaths in the participating states. Without denominator data, it is not possible to compare the collected data with vital statistics. As a result, it is not possible to determine the relative risk of infant sleep in a sitting device compared with a crib or bassinet. Additionally, some data items were collected from caregiver interviews, and thus, recall bias and missing data are limitations. Furthermore, the quality of data is dependent on the reporter’s experience and personal interpretation, and there may have been variability in how data were reported. In our examination of deaths in sitting devices, it is possible that some supervisors whom we deemed as being impaired because of distraction, illness, or disability were still capable of supervising the infant; however, these deaths comprised a small minority of the deaths in sitting devices. In addition, not all risk factors included in our analysis of

deaths in sitting devices (eg, maternal pregnancy complications) have been definitely linked to a heightened risk of infant sleep-related mortality. Finally, the absence of narratives and character limits on the narratives and other free-text variables posed another challenge in fully understanding the context in which an infant died in a sitting device.

## CONCLUSIONS

Deaths in sitting devices comprise ~3% of all infant sleep-related deaths, with the majority of these deaths occurring in CSSs. The majority of sitting-device-related infant deaths occur in nontraveling situations. Although our study does not examine why these factors are associated with infant death in sitting devices, our findings underline the significance of educating caregivers about the importance of using sitting devices only for their intended purpose, such as using CSSs only for transportation. Sitting devices are not an acceptable substitute for a crib or bassinet. Using CSSs for sleep in nontraveling contexts may pose a risk to the infant.

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## ABBREVIATIONS

AAP: American Academy of Pediatrics  
aOR: adjusted odds ratio  
ASSB: accidental suffocation or strangulation in bed  
CI: confidence interval  
CSS: car safety seat  
NCFRP: National Center for Fatality Review and Prevention  
SIDS: sudden infant death syndrome  
SUID: sudden unexpected infant death

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**POTENTIAL CONFLICT OF INTEREST:** In 2016, Dr Moon testified as a paid expert witness in a case of sleep-related infant death; Mr Liaw and Drs Han and Colvin have indicated they have no potential conflicts of interest to disclose.

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