Unsafe Sleep Practices and an Analysis of Bedsharing Among Infants Dying Suddenly and Unexpectedly: Results of a Four-Year, Population-Based, Death-Scene Investigation Study of Sudden Infant Death Syndrome and Related Deaths

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ABSTRACT. *Background.* **Prone sleep and unsafe sleep surfaces increase the risk of sudden infant death. Recent epidemiologic studies also suggest that when an infant's head or face is covered by bedding, or when a sleep surface is shared with others, the risk of dying increases. The inference of a causal role for these risk factors is supported by physiologic studies and by the consistent finding that fewer infants die when risk factors are reduced. The prevalence of most of these risk factors in infant deaths in the United States is uncertain.**

Objective. **To describe the prevalence of several important risk factors related to sleep practices among a defined population of infants dying suddenly and unexpectedly.**

Methods. **In this population-based study, we retrospectively reviewed death-scene information and medical examiners' investigations of deaths in the city of St Louis and St Louis County between January 1, 1994 and December 31, 1997. Because of the potential for diagnostic overlap, all deaths involving infants <2 years old with the diagnoses of sudden infant death syndrome (SIDS), accidental suffocation, or cause undetermined were included.**

Results. **The deaths of 119 infants were studied. Their mean age was 109.3 days (range: 6–350). The diagnoses were SIDS in 88 deaths, accidental suffocation in 16, and undetermined in 15. Infants were found prone in 61.1% of cases and were found on a sleep surface not designed for infants in 75.9%. The head or face was covered by bedding in 29.4%. A shared sleep surface was the site of death in 47.1%. Only 8.4% of deaths involved infants found nonprone and alone, with head and face uncovered.**

Conclusions. **Using detailed death-scene descriptions, we found that similar unsafe sleeping practices occurred in the large majority of cases diagnosed as SIDS, accidental suffocation, and cause undetermined. Considering these diagnoses together may be useful in public health campaigns during a time when there may be diagnostic overlap. Regardless of the diagnosis, recommendations that infants sleep supine on firm sleep surfaces that lessen the risk of entrapment or head covering have the potential to save many lives. Campaigns are needed to heighten awareness of these messages and of the risks of dangerous bedsharing.** *Pediatrics* **2000; 106(3). URL: http://www.pediatrics.org/cgi/content/full/106/3/e41; *sudden infant death syndrome, sleep, child, consumer product safety, suffocation.***

ABBREVIATIONS. SIDS, sudden infant death syndrome; ME, medical examiner.

Epidemiologic studies identifying risk factors and public health campaigns to reduce these risks have been followed by large reductions in the rates of sudden infant death syndrome (SIDS) in many countries.[1–10] In Reduce the Risk public health campaigns, priority has been given to risk factors that may be causally related to SIDS.[11,12] In addition, priority has been given to risk factors that are readily correctable and at the same time acceptable to care providers and parents.

Many studies, including several recent reports receiving widespread attention, have documented that infants dying unexpectedly are often found entrapped by bedding or by sleep surfaces.[13–17] Adult beds and couches are often involved.[16–18] Because these sleep surfaces are often shared, the possibility of entrapment by a bedmate (or overlying) has also been raised.[17,19] Recent studies like these in the United States of beds and bedsharing have been criticized because the denominators for the results have not been defined, so the relative frequencies of particular death scenarios are not known. The results reported here are population-based. Furthermore, they are drawn from urban and suburban municipalities in our metropolitan area that reflect the economic diversity of this country. Thus, the results are not limited to the urban poor.

Covering a 4-year period during the US Reduce the Risk campaign (Back-to-Sleep), the present study uses postmortem and death-scene data to determine the frequency of certain risk factors among infant deaths. This is not a study to establish risk associated with certain sleep practices or to compare infants dying with the general population. Rather, we describe the frequency with which well-established risk

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factors are evident from the death-scene investigation.[4,10,18,20,21] This study has focused on 4 sleep practices as risk factors: position when found,[22] presence of bedding or other materials covering the infant's face or head,[18,20] sharing a sleep surface with others,[23–29] and the use of sleep surfaces other than those recommended for infants.[14,15,17] In addition to the strong consensus regarding their effect on risk, we have focused on these 4 sleep practices because the death-scene data provided detailed information about them, and because these risk factors might be eliminated through information campaigns.

We have considered all infant deaths with the diagnoses of SIDS, accidental suffocation, and cause of death undetermined, because there can be much overlap among these diagnoses.[30] The possibility of overlap, or diagnostic drift, has given rise to general concern in recent years that some deaths that would have been diagnosed as SIDS as recently as 10 years ago are now labeled as cause of death undetermined or accidental suffocation.[30,31] This is the first study to scrutinize these diagnoses together, in terms of sleep practices common to all 3. Unlike several large recent epidemiologic studies,[18,32] we used a detailed and direct inspection of the death scene to document the specific circumstances of death.[33] In most cases, an infant mannequin was particularly helpful in clarifying the relationship among the victims, beds and bedding, and others sharing the bed, if any.

Ultimately, this study had 2 purposes: first, to document avoidable risk factors apparent at the death scene as a way of developing a rough estimate of the number of preventable deaths; and, second, to use death-scene data to indicate, where possible, specific pathophysiologic mechanisms that might explain the increased risk associated with certain practices, such as bed sharing or use of couches[24] and other nonstandard sleep surfaces.

METHODS

Selected records from the offices of the medical examiners (MEs) were reviewed retrospectively. All records for infants dying at <2 years of age were considered. The deaths occurred in the city of St Louis or in St Louis County between January 1, 1994 and December 31, 1997. The city of St Louis is a single municipality in which the population is 393 109 (1990 census), with a separate ME office. St Louis County includes 90 municipalities in the state of Missouri that surround the city of St Louis; it has central court offices, including the ME office; its population is 993 508 (1990). During the 4-year study, the average number of births per year in the city of St Louis City and St Louis County were 6051 and 13 263, respectively; on average, there were 3918 black infants born annually in the city, and 3051 black infants born in the county. The demographics of the city of St Louis and St Louis County, taken together, reflect the economic diversity of most US metropolitan areas, with large middle class neighborhoods, urban and suburban neighborhoods with low per-capita income, and affluent urban and suburban neighborhoods.

By law in Missouri, all deaths of children <18 years old are reviewed by a Child Fatality Review Program panel. Two of the authors (R.M.P. and M.C.) are active members of their local Child Fatality Review Program panel. In the city of St Louis and St Louis County, the panels meet monthly, and information is reviewed from police records, the ME offices, the courts, and the Division of Family Services. The final decision on cause of death of the ME, thus, reflects input from many agencies with mandates to investigate child fatalities.

The official cause of death was noted for all infants <2 years old. All cases for which the cause of death was SIDS, positional asphyxia, suffocation, or undetermined after a complete medicolegal investigation[34] were reviewed in detail. Deaths in infants >1 year of age are not designated as SIDS in either ME office. Deaths were diagnosed as accidental suffocation if it was clear from the scene investigation that the infant would have had marked difficulty with respiratory movements or gas exchange before death and there were physical obstacles preventing escape from the asphyxiating environment (Fig 1). Undetermined was the diagnosis if the death was unexplained by a complete autopsy and scene investigation but minor findings raised important questions about the circumstances of death.[34] For example, in both ME offices, if another infant from the same family had died mysteriously or if there were unexplained superficial injuries on postmortem examination, the diagnosis of undetermined would be possible. Undetermined was also the diagnosis if circumstances of death strongly indicated the possibility of accidental suffocation but the scene investigation could not confirm compression of the thorax or compromise of the external airway. SIDS was the diagnosis if neither the autopsy nor the scene investigation suggested foul play or other cause of death. This included infants found with head or face covered, provided there were no obvious physical obstacles to the infant obtaining access to fresh air.

The ME files included a copy of the police report, and records from paramedics and a hospital emergency department, if either was involved. An important source of information was the Death-Scene Investigative Checklist for Child Fatalities, developed by the Missouri Child Fatality Review Program.[35] The scene investigators completed this checklist. It includes time of death, who found the infant, specific description of scene of death and the infant's position,[33,36] bedding near the infant, whether others were on the sleep surface with the infant and how they had been lying in relation to the infant, evidence that the infant was injured either intentionally or accidentally, mother's age, and infant's medical history. The scene description also included sleep surface on which the infant was found, whether the nose and mouth were covered, and whether the infant was entrapped or movement limited in a way that would prevent escape from an asphyxiating

Fig 1. The infant mannequin used for death-scene reconstruction is shown where the 5-month-old infant was found. This death was attributed to accidental suffocation. The infant was found hanging between the loosened crib rails and the mattress. This death occurred in 1995.

environment. In the majority of cases, a photograph of the scene (with or without an infant mannequin in the position found) was part of the ME records.[33,36] When the infant was found dead while sharing a sleep surface, the investigative checklist asks whether there was any evidence that part of the infant's body was covered by a bedmate. Findings suggesting entrapment of the head, thorax, and abdomen, so that they might not be moved by the infant or by the person finding him or her, were sought in all cases, as well as whether wedging was mentioned.[16]

All death-scene investigations were conducted first by the police and within 36 hours by the ME scene investigators from the city of St Louis or St Louis County. Additional data, reported in our results, were gathered from the narrative reports within each file. Unusual circumstances of death, such as cases where the infant had fallen from a bed into a dangerous microenvironment, were tabulated.

All descriptive statistics are mean ± standard deviation. Nominal data are compared by using χ^2 analysis.

RESULTS

During the study, the deaths of 241 infants <2 years old were referred to the 2 ME offices. Records of 119 infant deaths were reviewed in detail (49.4% of total number of infants <2 years old referred to ME; Table 1). This represents all infants <2 years old whose deaths were attributed to SIDS (88 cases), positional asphyxia or suffocation (15 cases), or undetermined after a complete investigation (15 cases).[34] In addition, we have included the 1 death recorded as being attributable to overlying. All infants with these diagnoses were <1 year old. Sixty-seven infants were from the city of St Louis, and 52 were from St Louis County.

Information on maternal smoking was recorded for less than one half of the death-scene reports and, therefore, was not analyzed. Victims from the city and county shared similar sociodemographic characteristics; a detailed analysis of these results and their implications are beyond the scope of this report.

Sleep Position, Face or Head Covered, and Sudden Death

Regardless of diagnosis, prone position was common when an infant was found dead. Sixty-six infants were found dead in the prone position (61.1% of cases with data available); 10 were on their side (10.2%); and 31 supine (28.7%). Information on position found was missing in 12 of 119 cases (10.1%). Of the infants found prone, the diagnosis was SIDS in 55, suffocation in 7, and undetermined in 4. Of those found on their side, 6 were diagnosed as SIDS, 2 suffocation, and 2 undetermined. Among infants found supine, the diagnosis was SIDS in 20, suffocation in 7, and undetermined in 4. The position found, per se, did not seem to have a significant effect on eventual diagnosis ($\chi^2 = 5.95$; $P = .20$).

The records in 25 cases indicate that prone infants had their nose and mouth down and into bedding when found[36] (Fig 2). Nose and mouth down position was indicated by a photographic reconstruction using the victim or an infant mannequin (16 of 25 cases) or by explicit recorded statements (9 of 25 cases).

Fig 2. The corpse of a 2-month-old infant is shown in the position in which she was found dead. Her mother, who found the infant, helped with the reconstruction. Her nose and mouth were down in a bassinet mattress. The lumbosacral area has several mongolian spots, and the shoulders have some livor mortis that collected after the infant was found dead and turned supine. Her death was attributed to SIDS.

Bedding covered the entire head of 10 infants (8.4%). Of these, 6 were found prone, 4 supine, and none lying on their side; 5 were called SIDS, and 5 accidental suffocation.

Bed, Furniture, or Other Surface on Which Death Occurred

Data are available on the sleep surface on which the infant was found in 111 of 119 cases (Table 2). Only 29 infants died in cribs or bassinets (24.1% of cases with data available describing bed or other sleep surfaces). Six infants died in playpens.

Fifty died on adult beds and 19 died on a chair or sofa (Fig 3). Five of 19 deaths on chairs or sofas were diagnosed as accidental suffocation, the rest were diagnosed as SIDS; 4 SIDS victims were found with their face into the underlying chair surface. Photographs showed that 17 of 19 chairs and sofas had thick cushions (>4 in thick); for the other 2 cases, death on a sofa is documented, but the surface is not further described. When deaths occurred on beds that were folded out from couches (hide-a-beds), these deaths were categorized as occurring on adult beds.

Among makeshift beds used as sleep surfaces (7 cases; Fig 4) were blankets, comforters, and pillows

TABLE 1. General Information on Infant Deaths ($n = 119$)

Age (d)	109.3 ± 65.4 (range: 6–350)
African American	81
Gestation <37 wk	29
Maternal age (y)	18.6 ± 3.9
Female	48

TABLE 2. Sleep Surface of Last Sleep

Crib/bassinet	29
Playpen	6
Adult bed	50
Couch/sofa/cushioned chair	19
Makeshift bed	7
Unknown	8

Fig 3. The infant mannequin is positioned where a 2-month-old infant was found dead on a couch. The cushion and back were covered with a coarse burlap cover. The infant had moved into the space between the cushion and back. He had been sleeping on the couch with a sibling. His death was attributed to accidental suffocation.

Fig 4. The infant mannequin is positioned where a 4-month-old infant was found on a makeshift bed in a hotel room. The infant was found face near straight down, with nose and mouth down into blankets placed on a carpeted floor. This was the first time this infant had been placed prone for sleep. The proximity of pillows had the potential to make it difficult to get access to fresh air by head lifting and turning. The death was attributed to accidental suffocation.

on the floor (4 cases), a foam pad placed on the floor (1 case), and adult mattresses placed on the floor (2 cases).

Entrapment by Furniture or Bedmate

The deaths of 10 infants were associated with entrapment by a bed or other sleep surface. That is, the infant was found in a potentially asphyxiating microenvironment and in a position that prevented the infant from extricating himself or herself. The word wedging was often used to describe these deaths in the reports of the MEs.[13,37] Of the total of 10 cases of partial entrapment, the sleep surfaces involved were adult beds (3 cases), crib (2 cases), chair or sofa (4 cases; Fig 3), and 1 makeshift bed. Both deaths in cribs with entrapment involved crib rails that had come loose, and the cribs were, thus, defective (Fig 1). Three infants had fallen from a sleep surface without rails (adult beds) before being found dead. One infant fell into a plastic-lined wastebasket, a second onto a plastic bag filled with clothes, and the third fell and became entrapped between "the bed, wall, and stereo cabinet."

Seven additional records showed evidence of entrapment by the body of a bedmate, as suggested by part of the infant's head, thorax, or abdomen being covered by the bedmate.[19] In 5 of 7, the position of the deceased infant beneath the bedmate was found by a third person. The narratives prepared by the ME investigators for these 7 cases included the following statements: 1) "The father . . . looked onto the bed and noted that the 2-year-old was laying across the deceased." 2) ". . . The mother . . . stated . . . her 7-year-old son came into the room, and told her that she was lying atop the deceased child, and at this time, she discovered it was not breathing." 3) ". . . When he (the father) awoke, he found the child with most of its body under a pillow, on which the father's arm was resting." 4) ". . . He (the father) had arrived home at approximately 7:00 AM, and discovered the baby beneath the mother. On pulling the child out from beneath the lady the father noted that the infant was not breathing and called 9-1-1." 5) "Father . . . fed the deceased, and fell asleep (in a chair) with the deceased in his arms . . . Grandmother who discovered deceased in father's arms, says when she found the baby her face was blue . . . her head was turned . . . against the arm of a chair. The father was holding her in his right arm." The chair was a cushioned easy chair and the death was attributed to accidental suffocation. 6) "The baby was completely covered up by a blanket that was being used by (the mother) and the deceased . . . . The baby was laying next to the lower part of the mother's back." The infant died on an adult bed, and the position of the mother next to him likely limited his access to one route of escape from beneath the blanket. 7) "The mother awoke . . . and discovered the deceased lying supine in bed, with the 2-year-old lying on the deceased's stomach. The deceased was unresponsive and not breathing."

Deaths Occurring While Sharing a Bed or Other Sleep Surface

Nearly one half (56) of the infants (47.1%) died while sharing a sleep surface with one or more bedmates (1.4 ± .7; range: 1–4 bedmates; Table 3). For the majority, deaths while bedsharing were diagnosed as SIDS, but for 13 the diagnoses were suffocation or undetermined (23.2% of bedsharing deaths). All deaths occurred on sleep surfaces that were not designed specifically for infant sleep. In 13 cases (23.2%), the scene investigation showed evidence for entrapment of the infant, either by a bedmate or by the sleep surface. In 18 cases (33.0%), the bedsharing infant was found dead on a pillow or comforter, items specifically identified in earlier studies as bedding that increases risk for sudden death when used by infants.[18,36,38] The pillows and comforters were on the shared sleep surface and the infant had been placed on top of them.

Analysis of Deaths That Were Potentially Preventable

It was possible to consider each death within 1 of 6 groups, based on the death-scene investigation and in terms of how preventable the deaths might have been (Table 4). The 5 categories of potentially preventable deaths in Table 4 comprise 84.0% of the 119 deaths studied. By definition, deaths diagnosed as accidental suffocation were likely preventable, whereas it is less clear, for example, how deaths occurring with the infant supine with face, nose, and mouth unencumbered might be prevented. However, Table 4 implies that supine, face-uncovered deaths, among infants found alone on the sleep surface, account for only 10 cases (8.4%).

Three deaths were designated undetermined because the investigation raised suspicion of foul play that could not be proved. If these deaths were infanticide,[39] they may have been preventable, but, obviously, not by changing sleep practices.

DISCUSSION

We report sleep practices evident at the death scene in 119 infant deaths from the city of St Louis and St Louis County, Missouri. These deaths occurred after the beginning of the Back-to-Sleep campaign. Twenty-five SIDS victims were found prone with their nose and mouth into underlying bedding.[36] The face-down position is associated with a high odds ratio for death (11.2).[10] Another 16 of the deaths were attributed to accidental suffocation. We assume that supine sleep on firm sleep surfaces designed for infants could have prevented most of the 41 deaths in these 2 groups that make up our first 2 categories in Table 4[14,15,40] (Figs 1–4).

Five of the deaths attributed to SIDS occurred with the infant's head completely covered by bedding. Like the face-down position, this scenario causes rebreathing of exhaled air[20,41] and significantly increases the adjusted odds ratio for dying to 2.18.[4] It seems likely that some of these types of unexpected deaths can also be prevented.

Thirty-five infants were found prone with face to side. It is difficult to predict how many of these deaths would have been prevented because a separate population-attributable risk for the prone face-to-side position has not been reported. Regardless of how many infants in this category would have avoided sudden death, there is international agreement that they would have been at reduced risk if they had slept supine.[40] And there is at least a statistical likelihood that many would not have died, with possible explanations provided by the fact that arousal mechanisms and airway protective reflexes are more robust among supine than among prone infants.[42,43]

Our results suggest the extent of the problem of sudden death among infants using unsafe sleep practices in St Louis. Eighty-four percent of the victims in this series (Table 4) had a diagnosis of accidental suffocation, or were prone and face down or to the side, or were found with head covered, or while sharing a sleep surface. For each of these circumstances, a case has been made, or could be made, that the sleep practice in question is causally associated with sudden death. This suggests that the deaths may not have occurred if certain high-risk sleep practices had been avoided, and that the majority of deaths were preventable. Although it is certainly true that infants continue to die suddenly and unexpectedly in the Back-to-Sleep era, it is apparent from this series that only a small minority (8.4%) were found alone in bed, in a nonprone position, with external airway unencumbered. This finding, in particular, highlights the need to continue to emphasize safe sleep practices.[44]

The impact of bedsharing on risk for sudden infant death remains controversial. Three case–control studies suggest that bedsharing increases risk for sudden death,[24,26,45] but the risk is lessened when the high rate of maternal smoking in these studies is considered. In England, in particular, the rate of

TABLE 3. Deaths Occurring Among 56 Infants Who Shared a Sleep Surface With Parent or Other Person(s) at the Time of Death

Diagnosis	
SIDS	43
Suffocation	10
Undetermined	3
Sleep surface	
Adult bed	34
Couch/sofa/chair	13
Makeshift bed	4
Unknown	5
Evidence for entrapment by	
Bedmate	7
Sleep surface or items on sleep surface	6
Found on pillow or soft comforter	18

TABLE 4. Potentially Preventable Deaths Among 119 Infant Deaths*

Category	Type	No.	%
1	Accidental suffocation	16†	13.4
2	Prone face down	25	21.0
3	Head covered, diagnosis SIDS	5	4.2
4	Prone with face to side	35	29.4
5	Shared surface, excluding 1–4	19	16.0

* For 9 deaths, the position found was not recorded. Percents shown were calculated using 119 as the denominator.
† Includes 1 death attributed to overlying.

smoking among mothers whose infants died while bedsharing is so high that the risk for nonsmoking mothers cannot be calculated from the data.[24] In the United States, a case–control study[27] from Washington, DC showed increased risk especially when black infants bedshare. Finally, preliminary results from the Chicago Infant Mortality Study, a large, recent case–control study, strongly indicate an effect of bedsharing that is independent of smoking.[46] There are no recent published results addressing risk for infants sleeping alone outside of cribs, but data from the US Consumer Products Safety Commission suggest that the risk may be high, particularly for accidental suffocation, and data substantiating this risk have been presented in a preliminary report.[47]

Strategies in addition to Back-to-Sleep are needed to avoid deaths in sleep environments known to be dangerous. For example, all would agree that every infant deserves access to a safe bed. Nevertheless, designing and manufacturing safe cribs are only part of a strategy, because only one quarter of our victims (29 of 119) were placed to sleep before death on surfaces designed for infant sleep. Only 2 of our cases of accidental suffocation involved infant cribs. More than one half of all deaths in all categories (Table 2) involved adult beds, cushioned chairs, or sofas,[24] including 13 of 16 accidental suffocation cases. Strategies, such as moving the infant so his or her feet are at the foot of the bed,[18] will not be effective for the majority of infants in the United States who die outside of cribs. Although separate risk calculations have not been made for use of sleep surfaces other than those meeting standards for infant safety, the case against this practice seems compelling.[13–17,47,48]

Most deaths on adult beds, chairs, and sofas occurred while the infant was sleeping with another person (68.1%). It is difficult to imagine a shared sleep surface used in the United States that would be as safe as standard cribs, in good repair, in preventing falls and entrapment. Therefore, although it is controversial whether bedsharing per se increases risk for sudden death, there seems little question that the sleep surfaces used by infants dying while bedsharing fail to meet widely recognized standards of safety.[16,17] It is also apparent that shared sleep surfaces themselves are softer and more likely to cause entrapment and, perhaps, rebreathing.[49] Eighteen bedsharing infants were found dead on pillows or comforters, and 6 of 10 cases of entrapment by sleep surfaces were during bedsharing.[28] Twenty-two of 56 of deaths (39.3%) while bedsharing fit into 1 of the first 3 categories in Table 4, indicating that factors clearly to be avoided are present in many bedsharing deaths. If bedsharing is to be accepted as a safe sleep practice in the United States, guidelines are urgently needed regarding the firmness of the shared sleep surface, avoidance of pillows and soft comforters, and ways to avoid falls and entrapment of the infant.[16,50] Finally, some of the deaths while bedsharing in our series probably involved exposure to tobacco smoke, a factor that greatly increases the risk associated with bedsharing.[26,51]

In this series, nearly one quarter of deaths (23.2%) while bedsharing were diagnosed as suffocation or undetermined. If our findings can be generalized, then the potential risk attributable to bedsharing in sudden unexpected deaths should not be assessed from SIDS data alone, but also from cases with closely related diagnoses, eg, accidental suffocation. This is particularly important during times when new mechanisms for death are being discussed, and diagnostic drift may occur. The potential for confusion and diagnostic drift is further evident in other reports. For example, in a large recent study from England, among infants diagnosed as SIDS, 1 victim was found under a parent and there were 4 cases where the infant was "wedged between the parent and the back of the sofa."[24] Why these deaths were diagnosed as SIDS and not accidental suffocation seems arguable and would require more specific information about the death scene.

Many reasons point to the possibility that entrapment by a bedmate is more common than is documented in our study (7 of 56 deaths while sharing a sleep surface). In 5 of 7 cases (71%) another family member discovered the entrapment of the deceased infant. Without a third-party observer, the bedmate may have changed position without being aware that the infant was once beneath part of his or her body. The bedmate may also deny the possibility of entrapment, for obvious reasons, if he or she finds the infant has died. Therefore, it seems plausible that the rate at which entrapment is documented would increase if more infants dying while sharing a sleep surface were discovered by a third party.[52] Finally, of 29 infants dying supine with nose and mouth uncovered, 19 (65.6%) died while bedsharing, suggesting that bedsharing may lessen the benefits of non prone sleep among high-risk groups.

Sixty-five of the deaths reviewed (categories 2, 3, and 4) occurred in positions and microenvironments in which rebreathing of exhaled air, perhaps with associated thermal stress, is believed to be an important contributory mechanism.[32,53] Another important potential mechanism, namely delayed or blunted airway protective reflexes, is suggested by the 10 deaths occurring with the infant's head completely covered, a finding that causes marked increases in odds ratio for dying.[4,20] At this time, there is only preliminary information describing what infants can do to obtain access to fresh air when their heads and external airways are covered, and the range of skills among young infants and the timing of their appearance during postnatal development are incompletely understood.[41,54] Nevertheless, as was the case in studies of prone deaths, risk associated with being found with head covered has been established by epidemiologic studies,[4,20] and potential lethal mechanisms have been explored in studies involving animals, mechanical models,[55] and human infants.[20,41] Epidemiologic and physiologic studies, thus, strongly suggest that avoiding loose bedding, particularly if bulky, could prevent head-covered deaths.

Of the 10 deaths with head covered, 5 were diagnosed as SIDS and 5 suffocation. This points out the strong potential for overlap between these 2 diagnoses in head-covered deaths. To resolve this diag-

nostic quandary, more must be learned about what infants can and cannot do, on average, when their heads and external airways become covered. It may be that some head-covered deaths are similar to wedging deaths, because the infant cannot use its developing repertoire of behaviors to escape from a suffocating environment.

Increasing supine sleep can prevent some deaths diagnosed as SIDS. By broadening our analysis to related sudden deaths, including those attributed to accidental suffocation and those for which a cause is undetermined, we have shown that most infants with these 3 causes for death either died prone or were using other sleep practices that should be discouraged. Our findings suggest that the Back-to-Sleep message should be intensified and that risks from sleep surfaces other than standard cribs, particularly those used during bedsharing, should be included in future public health messages. Combining Back-to-Sleep with refined messages about safe sleep zones should further reduce the rate of SIDS and related causes of infant death.

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