Sleep Environment and the Risk of Sudden Infant Death Syndrome in an Urban Population: The Chicago Infant Mortality Study

Fern R. Hauck, MD, MS*; Stanislaw M. Herman, PhD*; Mark Donovan, MS*; Solomon Iyasu, MBBS, MPH‡; Cathryn Merrick Moore, CDA*; Edmund Donoghue, MD§; Robert H. Kirschner, MD§† and Marian Willinger, PhD‖

ABSTRACT. *Objective.* **To examine risk factors for sudden infant death syndrome (SIDS) with the goal of reducing SIDS mortality among blacks, which continues to affect this group at twice the rate of whites.**

Methods. **We analyzed data from a population-based case-control study of 260 SIDS deaths that occurred in Chicago between 1993 and 1996 and an equal number of matched living controls to determine the association between SIDS and factors in the sleep environment and other variables related to infant care.**

Results. **The racial/ethnic composition of the study groups was 75.0% black; 13.1% Hispanic white; and 11.9% non-Hispanic white. Several factors related to the sleep environment during last sleep were associated with higher risk of SIDS: placement in the prone position (unadjusted odds ratio [OR]: 2.4; 95% confidence interval [CI]: 1.7–3.4), soft surface (OR: 5.1; 95% CI: 3.1–8.3), pillow use (OR: 2.5; 95% CI: 1.5–4.2), face and/or head covered with bedding (OR: 2.5; 95% CI: 1.3–4.6), bed sharing overall (OR: 2.7; 95% CI: 1.8–4.2), bed sharing with parent(s) alone (OR: 1.9; 95% CI: 1.2–3.1), and bed sharing in other combinations (OR: 5.4; 95% CI: 2.8–10.2). Pacifier use was associated with decreased risk (unadjusted OR: 0.3; 95% CI: 0.2–0.5), as was breastfeeding either ever (OR: 0.2; 95% CI: 0.1–0.3) or currently (OR: 0.2; 95% CI: 0.1–0.4). In a multivariate model, several factors remained significant: prone sleep position, soft surface, pillow use, bed sharing other than with parent(s) alone, and not using a pacifier.**

Conclusions. **To lower further the SIDS rate among black and other racial/ethnic groups, prone sleeping, the use of soft bedding and pillows, and some types of bed sharing should be reduced.** *Pediatrics* **2003;111:1207–1214;** ***sudden infant death, infant care, blacks, sleep, risk factors.***

From the *Loyola University Chicago Stritch School of Medicine, Maywood, Illinois; ‡Centers for Disease Control and Prevention, Atlanta, Georgia; §Office of the Medical Examiner of Cook County, Chicago, Illinois; and ‖National Institute of Child Health and Human Development, Bethesda, Maryland.

Received for publication Oct 2, 2002; accepted Dec 4, 2002.

†Deceased.

Dr Hauck is currently with the University of Virginia Health System, Charlottesville, Virginia; and Mr Donovan is currently with Covance, Princeton, New Jersey. Dr Iyasu is currently with the Food and Drug Association, Rockville, Maryland.

Reprint requests to (F.R.H.) Department of Family Medicine, University of Virginia Health System, Box 800729, Charlottesville, VA 22908-0729. E-mail: frh8e@virginia.edu

ABBREVIATIONS. SIDS, sudden infant death syndrome; OR, odds ratio; CI, confidence interval.

Sudden infant death syndrome (SIDS), the leading cause of postneonatal mortality in the United States, currently accounts for approximately 3000 deaths per year.[1] In the past 2 decades, SIDS rates among blacks consistently have been more than twice that of whites. On the basis primarily of research conducted in other countries,[2] national interventions were developed to reduce prone sleeping and other factors associated with SIDS.[3] Despite the success of these interventions that resulted in a decline of prone sleeping and SIDS rates among all racial/ethnic groups,[4] the black-to-white ratio for SIDS still exceeds 2.0.[1]

The Chicago Infant Mortality Study was designed to examine risk factors for SIDS and other sudden infant death with the principal goal of gathering information to aid in eliminating disparities in postneonatal mortality between blacks and whites. This population-based case-control study, which took place in Chicago between 1993 and 1996, investigated sociodemographic, behavioral, and medical characteristics of the family and infant; characteristics of the home environment; and the circumstances of death. This article presents a comprehensive picture of SIDS risk in a primarily black urban population, giving particular attention to hazards in the sleep environment.

METHODS

Case Selection and Data Collection

This study included all 260 Chicago resident infants whose death between November 1993 and April 1996 was determined by the Office of the Medical Examiner of Cook County, Illinois, to be caused by SIDS, resulting in 100% case ascertainment. A comprehensive death scene investigation included approximately 400 questions detailing the circumstances before death; the sleep environment of the child when last put down and found; the infant's and family's medical history; the mother's prenatal alcohol, tobacco, and drug use history; and other factors pertinent to determining the cause of death.[5–17] Photographs were taken to indicate the location and position of the infant when found. A scene investigation, autopsy, and review of the medical history were conducted for all 260 case infants, as specified by the SIDS definition used in this study: "The sudden death of an infant under 1 year of age, which remains unexplained after a thorough case investigation, including performance of a complete autopsy, examination of the death scene, and review of the clinical history."[18]

Two weeks after the death, a standardized follow-up interview with the primary caregiver was conducted. This interview con-

sisted of 235 questions addressing issues not included in the scene investigation, such as routine sleep habits of the infant, social stressors and supports, and access to and satisfaction with health care. The follow-up interview was conducted for 198 (76%) of the case infants; this was with the mother for 95% of the infants, 3% with the foster parent or legal guardian, and 2% with other relatives. Participants and nonparticipants in the follow-up interview were similar in race/ethnicity, marital status, parity, education, adequacy of prenatal care, and infant's age at death. Reasons for nonparticipation were also similar by race/ethnicity.

Selection of Controls

One living control infant was matched to each case infant on (in order of priority) maternal race/ethnicity (self-reported), age at death/interview, and birth weight (<2500 g, 2500–<4000 g, and ≥4000 g; ±250 g if in the middle category).[4] Potential control infants who met the matching criteria were identified through ongoing review of birth certificates at the Chicago Department of Public Health. They were randomly selected in groups of 20 for white infants and in groups of 40 for Hispanic and black infants, based on experience gained during the pilot phase of the study. The mothers of each group of infants were contacted simultaneously by mail and invited to participate. Mothers who responded to our invitation were interviewed on a "first come" basis, and once a control mother for a given case infant was interviewed, additional interested control responders for that infant were notified that they would not be needed.

The home interview consisted of nearly 500 questions taken from the death scene investigation and follow-up case interview, which were reworded to apply to a living infant. A reference sleep period was identified for the control infant to coincide with the time of day when the respective case infant was found unresponsive; all questions about "last sleep," including positioning, referred to this reference sleep.

The control response rate was 4.7% (260 enrolled + 231 interested but nonenrolled of 10 464). There were no differences between enrolled control mothers and those who were interested but not needed, including race/ethnicity, education, marital status, smoking or drinking during pregnancy, high-risk pregnancy, parity, abnormal birth outcome, Kessner index of prenatal care,[19] infant gender, and birth weight. Differences between enrolled responders and those who did not reply to our letter were found in maternal education (responders were more highly educated; $P = .001$), parity (responders had slightly lower parity; $P = .027$), and adequacy of prenatal care (65.2% of responders and 53.6% of nonresponders had adequate care; $P = .001$).

The study was approved by the institutional review board of the Loyola University Medical Center, Maywood, Illinois. A detailed description of the study methods has been reported elsewhere.[20]

Statistical Analysis

Analysis was conducted using data for the 260 SIDS infants and their 260 matched control infants. To determine differences in sociodemographic and sleep environment factors between cases and controls, we used the Cochran-Mantel-Haenszel statistic to estimate χ^2 in comparisons of binary and nominal-scaled variables and the independent sample t test to compare interval data. For both the univariate and multivariate analyses, conditional logistic regression was used to take the matching into account. Unadjusted and adjusted odds ratios (ORs) and corresponding 95% confidence intervals (CIs) were calculated. Bed sharing was defined conservatively as an infant sleeping with 1 or more people on the same sleep surface, such as a mattress or a sofa.

To determine the independent contribution of risk factors found to be significantly associated with SIDS on univariate analysis, we constructed a final multivariate model, using backward step-down variable selection. We also included maternal smoking during pregnancy in this model because it has been identified in previous research as a strong risk factor for SIDS[21] and as an effect modifier for some sleep-related risk factors.[22–24] The population attributable risk refers to the theoretical proportion of cases that might have been prevented if a certain risk factor were eliminated. It was calculated for each of the risk factors that remained in the final multivariate model separately and for all of the risk factors combined, using the method of Bruzzi et al.[25] Interactions were also tested between each of the sleep environment variables found significant on univariate analysis; as is often done for such analyses, the significance level for the interaction terms based on these comparisons was raised to .10.[26] All analyses were conducted using SAS/STAT, release 6.12. (SAS Institute, Inc, Cary, NC).

RESULTS

As per the study design, cases and controls were similar on the matched factors. The racial/ethnic composition of both groups was 75.0% black, 13.1% Hispanic white, and 11.9% non-Hispanic white (2 Hispanic black case infants were classified as black, and black control infants were matched to them). The mean age (89 days and 85 days, respectively) and birth weight (2813 g and 2915 g, respectively) were not significantly different between cases and controls ($P > .05$). There were differences between cases and controls on nonmatched demographic factors. Case mothers were slightly younger than the control mothers (23.2, standard deviation 5.4 vs 24.8, standard deviation 6.4 years; $P < .002$). They also had lower educational attainment, had less adequate prenatal care as measured by the Kessner index, and were more likely to be single and have higher parity (all significant at $P < .001$). There were no differences in employment status.

Because several sociodemographic factors were found to be associated with increased risk for SIDS, analyses were done to examine the potential confounding effects of these and other related variables on the association between the exposure variables, ie, infant sleep habits and maternal behaviors, and SIDS. Maternal age, marital status, education, and adequacy of prenatal care were found to represent closely all of the factors and were therefore used in subsequent analyses for adjustment purposes.[20]

There were small differences between case and control infants in their sleeping surface and the location (Table 1), but none of these differences was statistically significant. More than half of the infants in both groups were sleeping on an adult bed mattress for the last sleep, and fewer than one quarter were sleeping in cribs.

Several factors related to the sleep environment were associated with a higher risk of SIDS (Table 1). Being placed in the prone position at last sleep was associated with having more than twice the risk of SIDS (OR: 2.4; 95% CI: 1.7–3.4), compared with nonprone positions. A soft sleep surface (defined through self-report as the infant's head sinking 1 inch or more into the surface) was associated with having 5 times the risk of SIDS (OR: 5.1; 95% CI: 3.1–8.3), and pillow use was associated with almost 3 times the risk (OR: 2.5; 95% CI: 1.5–4.2). Covering of the head or face with bedding was associated with a similar risk level (OR: 2.5; 95% CI: 1.3–4.6), whereas other potential thermal factors, including swaddling during last sleep and the infant sweating in the past 2 days, were not.

SIDS infants were more likely than controls to have been ill with a runny nose or upper respiratory infection in the 2 days before death/interview (OR: 2.5; 95% CI: 1.7–3.8). Cases and controls did not differ in the frequency of cough, wheezing, diarrhea, or vomiting. Decreased risk of SIDS was found with

TABLE 1. The Chicago Infant Mortality Study, 1993-1996: Unadjusted and Adjusted Univariate ORs for Variables in the Sleep Environment*

Variable	SIDS Cases		Controls		Unadjusted OR† (95% CI)	Adjusted OR‡ (95% CI)
	N	%	*N*	%		
Surface						
Adult bed mattress	148	(56.9)	151	(58.1)	Reference	Reference
Crib	49	(18.9)	63	(24.2)	0.8 (0.5–1.2)	1.2 (0.7–2.2)
Sofa/chair	26	(10.0)	14	(5.4)	2.0 (0.96–4.1)	1.6 (0.7–3.7)
Other	37	(14.2)	32	(12.3)	1.1 (0.7–1.9)	1.3 (0.7–2.5)
Location						
Parent's bedroom	167	(64.2)	153	(58.8)	Reference	Reference
Infant's bedroom	20	(7.7)	33	(12.7)	0.6 (0.3–1.1)	0.8 (0.4–1.7)
Other room in infant's home	47	(18.1)	46	(17.7)	0.9 (0.6–1.5)	0.8 (0.5–1.5)
Other	26	(10.0)	28	(10.8)	0.8 (0.4–1.6)	0.9 (0.4–1.9)
Prone sleep position						
No	111	(42.7)	169	(65.0)	Reference	Reference
Yes	149	(57.3)	91	(35.0)	**2.4 (1.7–3.4)**	**2.3 (1.5–3.5)**
Soft sleep surface						
No	133	(51.2)	210	(80.8)	Reference	Reference
Yes	127	(48.8)	50	(19.2)	**5.1 (3.1–8.3)**	**5.1 (2.9–9.2)**
Pillow use						
No	192	(73.8)	224	(86.1)	Reference	Reference
Yes	68	(26.2)	36	(13.9)	**2.5 (1.5–4.2)**	**3.1 (1.6–5.8)**
Head and/or face covered						
No	224	(86.1)	245	(94.2)	Reference	Reference
Yes	36	(13.9)	15	(5.8)	**2.5 (1.3–4.6)**	**2.5 (1.2–5.2)**
Wrapped/swaddled						
No	231	(88.8)	234	(90.0)	Reference	Reference
Yes	29	(11.2)	26	(10.0)	1.1 (0.6–2.0)	1.0 (0.5–1.9)
Sweating in last 2 days						
No	247	(95.0)	243	(93.5)	Reference	Reference
Yes	13	(5.0)	17	(6.5)	0.8 (0.4–1.6)	0.7 (0.3–1.7)
Runny nose/upper respiratory infection in last 2 d						
No	143	(55.0)	197	(75.8)	Reference	Reference
Yes	117	(45.0)	63	(24.2)	**2.5 (1.7–3.8)**	**2.2 (1.3–3.5)**
Pacifier use						
No	221	(85.0)	177	(68.1)	Reference	Reference
Yes	39	(15.0)	83	(31.9)	**0.3 (0.2–0.5)**	**0.3 (0.2–0.5)**
Breastfeeding (ever)						
No	205	(78.8)	130	(50.0)	Reference	Reference
Yes	55	(21.2)	130	(50.0)	**0.2 (0.1–0.3)**	**0.4 (0.2–0.7)**
Breastfeeding (current)						
No	243	(93.5)	199	(76.5)	Reference	Reference
Yes	17	(6.5)	61	(23.5)	**0.2 (0.1–0.4)**	**0.3 (0.2–0.7)**
Shared bed (with anyone)						
No	129	(49.6)	181	(69.6)	Reference	Reference
Yes	131	(50.4)	79	(30.4)	**2.7 (1.8–4.2)**	**2.0 (1.2–3.3)**
Shared bed (with mother alone or with mother and father)						
No	129	(49.6)	181	(69.6)	Reference	Reference
Yes, mother or mother and father	70	(26.9)	59	(22.7)	**1.9 (1.2–3.1)**	1.3 (0.7–2.3)
Yes, with others	61	(23.5)	20	(7.7)	**5.4 (2.8–10.2)**	**4.1 (2.0–8.4)**
Shared room (with anyone)						
No	75	(28.8)	108	(41.5)	Reference	Reference
Yes	185	(71.2)	152	(58.5)	**1.8 (1.2–2.6)**	1.4 (0.9–2.3)
Shared room (with mother alone or with mother + father)						
No	75	(28.8)	108	(41.5)	Reference	Reference
Yes, mother or mother and father	94	(36.2)	89	(34.2)	**1.6 (1.1–2.4)**	1.2 (0.7–2.1)
Yes, with others	91	(35.0)	63	(24.2)	**2.2 (1.4–3.4)**	1.7 (0.9–2.9)

* $N = 260$ matched pairs. Sleep environment data refer to last sleep (cases) and reference sleep period (controls).
† Statistically significant ORs are indicated in **bold**.
‡ Adjusted for maternal age, marital status, education, and index of prenatal care.

pacifier use during last sleep (OR: 0.3; 95% CI: 0.2–0.5) and with breastfeeding for any length of time (ever; OR: 0.2; 95% CI: 0.1–0.3) or currently (OR: 0.2; 95% CI: 0.1–0.4).

Infant bed sharing with 1 or more people was associated with increased risk (OR: 2.7; 95% CI: 1.8–4.2). The OR associated with the mother alone ($n = 49$; 72% of the parental bed sharers) or with the mother and father together ($n = 19$; 28% of the parental bed sharers) was 1.9 (95% CI: 1.2–3.1). It was much higher for the other combinations of bed sharing, including other children alone or other children with 1 or both parents (OR: 5.4; 95% CI: 2.8–10.2). Fifteen SIDS infants shared a sofa during sleep, whereas no control infants did. After removal from analysis of these 15 SIDS cases and their matched controls, the ORs for bed sharing were similar. Sharing a room with anyone was associated with in-

creased risk of SIDS (OR: 1.8; 95% CI: 1.2–2.6), as was sharing a room with the mother or both parents (OR: 1.6; 95% CI: 1.1–2.4) or other combinations of people (OR: 2.2; 95% CI: 1.4–3.4) in the unadjusted model. After adjustment of the significant variables for the 4 potentially confounding variables (maternal education, marital status, age, and prenatal care), all of the significant factors in the unadjusted analyses remained significant except for parental bed sharing and room sharing (Table 1).

In the final multivariate model, factors that remained significant independent risk factors were not using a pacifier, soft sleep surface, maternal smoking in pregnancy, prone sleep position, pillow use, and bed sharing in combinations other than the parents alone (Table 2). When this analysis was limited to blacks only, results were similar. On the basis of the final full-sample multivariate model, the population attributable risks were not using a pacifier, 56%; soft sleep surface, 39%; maternal smoking in pregnancy, 37%; prone sleep position, 33%; pillow use, 17%; and bed sharing in combinations other than with the parent(s) alone 17% (Table 2). Usual sleep practices within the last 2 weeks before death for cases or the 2 weeks before the reference sleep period for controls, including sleep position, location, softness of the sleep surface, use of a pillow, room sharing, and bed sharing, were not associated with increased risk of SIDS after adjusting for maternal education, marital status, age, and prenatal care.

A significant positive interaction was found between prone sleep position and soft bedding surface ($P = .05$), ie, the combined presence of both factors had a greater effect than would be expected by simply multiplying the effects of each factor alone. The OR for prone sleep and soft surface, adjusted for the 4 confounding variables, was 21.0 (95% CI: 7.8–56.2). Similarly, an interaction was found for prone position and pillow use ($P = .04$), resulting in an OR of 11.8 (95% CI: 4.0–34.4). Softness of the sleep surface and pillow use were only weakly correlated. Other possible interactions were examined; there was none between bed sharing and surface softness or between bed sharing and maternal smoking either during pregnancy or postpartum.

CONCLUSIONS

Results from the Chicago Infant Mortality Study provide clues to explain the higher rate of SIDS among black infants compared with white infants. Placing infants on a soft surface for sleep, particularly in conjunction with prone positioning, may contribute to this disparity. The association of prone sleeping with SIDS has been well-established in countries outside the United States[2,27–29] but less so for the United States.[30–32] In this study, prone sleep position was confirmed as a risk factor for SIDS in univariate and multivariate analyses. The high rates of prone sleeping among both case and control infants in this predominantly black sample are consistent with reports that blacks were more likely to use the prone position even after the Back to Sleep campaign was under way.[4,33–38] This may explain, in part, the higher rate of SIDS in this population.[20]

We also found sleeping on a soft surface to be a strong independent risk factor for SIDS. Although the assessment of softness was subjective, participants were provided with guidelines and the questions were identical for case and control mothers. In addition, because little was known among the public about mattress softness and SIDS risk when this study was conducted, the responses here were not likely to be biased. The combination of soft sleeping surface and prone position was extremely hazardous, as found also in a Tasmanian case-control study of SIDS.[39]

As previously observed,[40,41] pillow use was associated with an increased risk of SIDS. Various mech-

TABLE 2. The Chicago Infant Mortality Study, 1993-1996: ORs and Population Attributable Risks for Risk Factors in the Sleep Environment*

Risk Factor	OR† (95% CI)	No. of Cases	PAR (%)
Pacifier use			
Yes	Reference	39	
No	2.9 (1.4–6.0)	221	56
Soft sleep surface			
No	Reference	133	
Yes	5.2 (2.6–10.2)	127	39
Maternal smoking in pregnancy			
No	Reference	135	
Yes	4.3 (2.1–8.9)	125	37
Prone sleep position			
No	Reference	111	
Yes	2.3 (1.3–4.3)	149	33
Pillow use			
No	Reference	192	
Yes	2.8 (1.3–6.2)	68	17
Bed sharing			
No	Reference	129	
Yes, with mother or mother and father	1.4 (0.7–2.8)	70	
Yes, in other combinations	3.6 (1.4–9.4)	61	17
All risk factors			93

PAR indicates population attributable risk.
* $N = 260$ matched pairs. Risk factors are for last sleep.
† Adjusted for maternal age, marital status, education, index of prenatal care, and other variables in the model.

anisms have been proposed to explain the association between soft sleep surfaces and SIDS. Asphyxia may occur when sleeping prone on soft surfaces as a result of rebreathing of expired air[42–46] or of blockage of external airways.[41] Another potential mechanism is hyperthermia, either directly or in conjunction with other thermoregulatory interactions.[47] Prone infants, especially those in contact with soft underbedding, may have reduced ability to lose heat, making them more susceptible to hyperthermia.[47]

The relationship between bed sharing and SIDS has sparked lively debate.[48–52] This study makes an important contribution by examining a population in which bed sharing is common.[53,54] An increased risk of SIDS was observed for bed sharing, but multivariate analysis indicated that the risk was primarily associated with bed sharing when the infant was sleeping with people other than the parents. Because there were few mother-father bed sharers, the findings for this category were driven primarily by the mother-infant dyad. These results are reassuring and consistent with laboratory studies demonstrating that more maternal inspections, more infant arousals, and less deep sleep among infants may occur when mothers and infants sleep together routinely.[55–57] Our results do not support a protective role for parent-infant bed sharing, however. Unlike studies in New Zealand and England, which have demonstrated that the risk of SIDS associated with bed sharing is primarily among smoking mothers,[23,24,29,58] in the Chicago Infant Mortality Study, the smoking status of the mother did not influence the risk of bed sharing.

Sleeping together on a sofa occurred with 15 SIDS but no control infants, indicating that this practice may be extremely hazardous. A similar finding has been reported from England.[23] Although it is possible that these infants died of asphyxiation or entrapment, infants who were found wedged or entrapped in other ways were not given a SIDS diagnosis. The SIDS diagnosis was reached after a thorough review, including a careful scene investigation. Regardless, sleeping with an infant on a sofa should be discouraged, as should bed sharing between an infant and family members other than the mother or parents.

Room sharing with parents was not associated with a reduced risk of SIDS, unlike the results of 2 other studies.[23,59] This was largely reflective of the strong correlation between room sharing and bed sharing and the high rate of bed sharing in this study, resulting in few families that shared a room without bed sharing. Also, usual sleep practices in the preceding 2 weeks were not significantly associated with SIDS. In light of our findings for last sleep, this result indicates that sleep-related risk reduction measures need to be followed at all times.

Pacifier use during last sleep was found to lower the risk of SIDS substantially in this sample, a finding consistent with that of several other studies.[29,60–62] It is not known whether this association is reflective of behavioral characteristics of the caregiver or of the infant or is the direct effect of the pacifier during sleep, either mechanical (eg, directly maintaining an open airway or keeping the infant in a face-to-side position) or longer term maturational effects influencing airway patency. Although using a pacifier to prevent SIDS has not been recommended in the United States,[3] it has been recommended in Germany for all infants[63] and in the Netherlands for bottle-fed infants.[60] Although some authors have argued that pacifiers should not be recommended until a physiologic mechanism that explains the association between pacifiers and the reduced risk of SIDS is identified,[64] this situation is similar to avoidance of the prone position, whose physiologic mechanism in SIDS causation is still unknown. Consideration should be given to including pacifiers as a new strategy that might reduce the risk of SIDS even further while continuing research to study possible adverse consequences, including breastfeeding duration,[65–70] dental malocclusion,[71–73] otitis media,[74–77] and other health problems.[78] In the meantime, parents who already use pacifiers for their infants and those who are not breastfeeding need not be discouraged from using them.

Breastfeeding was found to be protective against SIDS in the univariate analysis and after adjusting for sociodemographic factors, but it became nonsignificant in the multivariate model that included the other environmental factors. These results are consistent with most published reports and suggest that other factors associated with breastfeeding, rather than breastfeeding itself, are protective.[29,40,79,80]

As in any retrospective study, recall bias may occur if mothers of SIDS infants recall exposures more thoroughly than mothers of unaffected, healthy infants, thus yielding an apparent association when none exists. Prospectively collected data on sleep position, however, have confirmed results from other studies, indicating that recall bias has not been a major problem in case-control studies of SIDS.[81,82] The length of time lapsed between the exposure and the recall has been shown to have a greater influence on recall accuracy than case or control status.[83] In this study, parents of both SIDS victims and control infants were interviewed about their infant's sleep position shortly after the last sleep (or reference) period, minimizing recall bias.

The control selection process presented numerous challenges, particularly in light of the difficulty in recruiting people of color into research studies[84–90] and the criteria that controls be matched to case infants on race/ethnicity, birth weight, and age. Because the number of potential controls contacted was far larger than those actually enrolled, the possibility of nonresponse bias exists. Responders were more educated, had better prenatal care, and were of lower parity than nonresponders. Adjustments to outcomes of interest were made to help control for these differences.[20] However, there may have been other unmeasured differences between responders and nonresponders that could have confounded the relationships found in this study.

Parents are influenced strongly by physicians in choosing the sleep position for their infants.[4,20] Other infant care practices, such as bed sharing and use of soft bedding, may also be influenced by medical providers, particularly if reinforced by the media.[4]

To reduce the racial disparity in SIDS rates, all families must be counseled regularly about recommendations for reducing the risk of SIDS.[3,91] On the basis of the findings of this study, they should receive instruction that emphasizes supine sleeping, firm bedding, not using pillows, and not sharing a bed with other children or sleeping with another person on a sofa, while being sensitive to parental concerns and cultural traditions.

Although education about risk factors for SIDS is critical, it loses its effectiveness if financial constraints prevent families from following the recommendations. For example, parents may be unable to provide firm sleep surfaces for their infants if they cannot afford to purchase new, firmer mattresses. Similarly, bed sharing with other children may be unavoidable unless families have enough beds for their members or at least a crib for their infants. Thus, additional research is needed to determine the role that these factors may play in acceptance of the recommendations and to evaluate interventions, such as crib donation programs.

As a result of the Chicago Infant Mortality Study, a multiagency intervention was implemented in Chicago to reduce the risk of SIDS among black families, through brochures and posters, media messages, videotapes, direct parental education, and education of health providers. The greater decline in SIDS rates among blacks in Chicago than in previous years supports the effectiveness of this approach.[92] The national Back to Sleep campaign has expanded its outreach to target minority populations more effectively.[93] Risk factors particularly pertinent to black, as demonstrated in this study, must be addressed to reach the national goal of eliminating the racial disparity in SIDS.[94]

ACKNOWLEDGMENTS

This work was supported by the National Institute of Child Health and Human Development and the National Institute on Deafness and Other Communication Disorders under contract number NO1-HD-3-3188 and the Centers for Disease Control and Prevention and the Association of Teachers of Preventive Medicine under cooperative agreement number U50/CCU300860-06.

We sincerely thank the Office of the Medical Examiner of Cook County (Chicago, IL), the Chicago Department of Public Health, and the families that generously participated in this study. Finally, we acknowledge the significant contributions made by Dr Robert Kirschner to this study and to children's well-being in general; he will be deeply missed.

REFERENCES

1. Mathews TG, Menacker F, MacDorman MF. Infant mortality statistics from the 2000 period linked birth/infant death data set. *Natl Vital Stat Rep.* 2002;50:1–28
2. Kattwinkel J, Brooks J, Keenan ME, Malloy M. Infant sleep position and the sudden infant death syndrome (SIDS) in the United States: joint commentary from the American Academy of Pediatrics and selected agencies of the federal government. *Pediatrics.* 1994;93:820
3. American Academy of Pediatrics, Task Force on Infant Sleep Position and Sudden Infant Death Syndrome. Changing concepts of sudden infant death syndrome: implications for infant sleeping environment and sleep position. *Pediatrics.* 2000;105:650–656
4. Willinger M, Ko C-W, Hoffman HJ, Kessler RC, Corwin MJ. Factors associated with caregivers' choice of infant sleep position, 1994–1998: the National Infant Sleep Position Study. *JAMA.* 2000;283:2135–2142
5. DiMaio DJ, DiMaio VJM. Sudden infant death syndrome. In: DiMaio DJ, DiMaio VJM, eds. *Forensic Pathology.* New York, NY: Elsevier; 1989: 289–297
6. Hoffman HJ, Damus K, Hillman L, Krongrad E. Risk factors for SIDS: results of the National Institute of Child Health and Human Development SIDS Cooperative Epidemiological Study. *Ann N Y Acad Sci.* 1988;533:13–30
7. Jones AM, Weston JT. The examination of the sudden infant death syndrome infant: investigative and autopsy protocols. *J Forensic Sci.* 1976;21:833–841
8. State of California, Department of Health Services, Maternal and Child Health Branch. *Death Scene and Deputy Coroner Investigation Protocol for Sudden Unexpected Infant Deaths: Instruction Manual.* Sacramento, CA: State of California, Department of Health Services, Maternal and Child Health Branch; 1991
9. Office of the Medical Investigator, University of New Mexico School of Medicine. *Scene Investigator's Guidelines. SIDS/Childhood.* Albuquerque, NM: Office of the Medical Investigator, University of New Mexico School of Medicine; 1988
10. Task Force for the Study of Non-Accidental Injuries and Child Deaths. *Protocol for Determining if an Injury Is a Result of Child Abuse or Neglect.* Springfield, IL: Illinois Department of Children and Family Services; 1987
11. Task Force for the Study of Non-Accidental Injuries and Child Deaths. *Protocol for Child Death Autopsies.* Springfield, IL: Illinois Department of Children and Family Services; 1987
12. Stephens BG. Why the autopsy? In: Harper RM, Hoffman HJ, eds. *Sudden Infant Death Syndrome: Risk Factors and Basic Mechanisms.* New York, NY: PMA Publishing Corp; 1988:135–141
13. Anderson TL, Wells SJ. *Data Collection for Child Fatalities: Existing Efforts and Proposed Guidelines.* Chicago, IL: American Bar Association; 1991
14. Illinois Department of Public Health. *Sudden Infant Death Syndrome. Coroner/Medical Examiner's Manual.* Springfield, IL: Illinois Department of Public Health; 1988
15. Mitchell EA, Scragg R, Stewart AW, et al. Results from the first year of the New Zealand cot death study. *N Z Med J.* 1991;104:71–76
16. Smialek JE, Lambros Z. Investigation of sudden infant deaths. *Pediatrician.* 1988;15:191–197
17. State of California, Department of Health Services, Maternal and Child Health Branch. *Autopsy Protocol for Sudden Unexpected Infant Death.* Sacramento, CA: State of California, Department of Health Services, Maternal and Child Health Branch; 1991
18. Willinger M, James LS, Catz C. Defining sudden infant death syndrome (SIDS): deliberations of an expert panel convened by the National Institute of Child Health and Human Development. *Pediatr Pathol.* 1991;11:677–684
19. Kessner DM, Singer J, Kalk CE, Schlesinger ER. *Infant Death: An Analysis by Maternal Risk and Health Care.* Washington, DC: Institute of Medicine and National Academy of Sciences; 1973
20. Hauck FR, Moore CM, Herman SM, et al. The contribution of prone sleeping position to the racial disparity in Sudden Infant Death Syndrome: The Chicago Infant Mortality Study. *Pediatrics.* 2002;110: 772–780
21. Mitchell EA, Milerad J. Smoking and sudden infant death syndrome. In: *International Consultation on Environmental Tobacco Smoke (ETS) and Child Health.* Geneva, Switzerland: World Health Organization; 1999:105–129
22. Øyen N, Markestad T, Skjærven R, et al. Combined effects of sleeping position and prenatal risk factors in sudden infant death syndrome: the Nordic Epidemiological SIDS Study. *Pediatrics.* 1997;100:613–621
23. Blair PS, Fleming PJ, Smith IJ, et al. Babies sleeping with parents: case-control study of factors influencing the risk of the sudden infant death syndrome. *BMJ.* 1999;319:1457–1462
24. Scragg R, Mitchell EA, Taylor BJ, et al. New Zealand Cot Death Study Group. Bed sharing, smoking, and alcohol in the sudden infant death syndrome. *BMJ.* 1993;307:1312–1318
25. Bruzzi P, Green SB, Byar DP, Brinton LA, Schairer C. Estimating the population attributable risk for multiple risk factors using case-control data. *Am J Epidemiol.* 1985;122:904–914
26. Mickey RM, Greenland S. The impact of confounder selection criteria on effect estimation. *Am J Epidemiol.* 1989;129:125–137
27. Beal SM, Finch CF. An overview of retrospective case-control studies investigating the relationship between prone sleeping position and SIDS. *J Paediatr Child Health.* 1991;27:334–339
28. Mitchell EA. Sleeping position of infants and the sudden infant death syndrome. *Acta Paediatr.* 1993;82(suppl 389):26–30
29. Fleming PJ, Blair PS, Bacon C, et al. Environment of infants during sleep and risk of the sudden infant death syndrome: results of 1993–95 case-control study for confidential inquiry into stillbirths and deaths in infancy. *BMJ.* 1996;313:191–195
30. Hoffman HJ, Hillman LS. Epidemiology of the sudden infant death

syndrome: maternal, neonatal, and postneonatal risk factors. *Clin Perinatol.* 1992;19:717–737
31. Klonoff-Cohen HS, Edelstein SL. A case-control study of routine and death scene sleep position and sudden infant death syndrome in Southern California. *JAMA.* 1995;273:790–794
32. Taylor JA, Krieger JW, Reay DT, Davis RL, Harruff R, Cheny LK. Prone sleep position and the sudden infant death syndrome in King County, Washington: a case-control study. *J Pediatr.* 128(suppl):626–630, 1996
33. Brenner RA, Simons-Morton BG, Bhaskar B, et al. Prevalence and predictors of the prone sleep position among inner-city infants. *JAMA.* 1998;280:341–346
34. Johnson CM, Borkowski MM, Hunter KE, et al. Infant sleep position: a telephone survey of inner-city parents of color. *Pediatrics.* 1999; 104(suppl):1208–1211
35. Lesko SM, Corwin MJ, Vezina RM, et al. Changes in sleep position during infancy: a prospective longitudinal assessment. *JAMA.* 1998;280: 336–340
36. Saraiya M, Serbanescu F, Rochat R, Berg CJ, Iyasu S, Gargiullo PM. Trends and predictors of infant sleep positions in Georgia, 1990 to 1995. *Pediatrics.* 1998;102(3). Available at: www.pediatrics.org/cgi/content/full/102/3/e33
37. Pollack HA, Frohna JG. Infant sleep placement after the Back to Sleep campaign. *Pediatrics.* 2002;109:608–614
38. Gibson E, Dembofsky CA, Rubin S, Greenspan JS. Infant sleep position practices 2 years into the "Back to Sleep" campaign. *Clin Pediatr.* 2000; 39:285–289
39. Ponsonby A-L, Dwyer T, Gibbons LE, Cochrane JA, Wang Y-G. Factors potentiating the risk of sudden infant death syndrome associated with the prone sleep position. *N Engl J Med.* 1993;329:377–382
40. Brooke H, Gibson A, Tappin D, Brown H. Case-control study of sudden infant death syndrome in Scotland, 1992–5. *BMJ.* 1997;314:1516–1520
41. Scheers NJ, Dayton CM, Kemp JS. Sudden infant death with external airways covered: case-comparison study of 206 deaths in the United States. *Arch Pediatr Adolesc Med.* 1998;152:540–547
42. Kemp JS, Thach BT. Sudden death in infants sleeping on polystyrene-filled cushions. *N Engl J Med.* 1991;324:1858–1864
43. Kemp JS, Kowlaski RM, Burch PM, Graham MA, Thach BT. Unintentional suffocation by rebreathing: a death scene and physiologic investigation of a possible cause of sudden infant death. *J Pediatr.* 1993;122: 874–880
44. Kemp JS, Nelson VE, Thach BT. Physical properties of bedding that may increase risk of sudden infant death syndrome in prone-sleeping infants. *Pediatr Res.* 1994;36:7–11
45. Emery JL, Thornton JA. Effects of obstruction to respiration in infants, with particular reference to mattresses, pillows, and their coverings. *BMJ.* 1968;3:209–213
46. Skadberg BT, Oterhals A, Finborud K, Markestad T. CO_2 rebreathing: a possible contributory factor to some cases of sudden infant death? *Acta Paediatr.* 1995;84:988–995
47. Nelson EA, Taylor BJ, Weatherall IL. Sleeping position and infant bedding may predispose to hyperthermia and the sudden infant death syndrome. *Lancet.* 1989;1:199–201
48. Gessner BD, Ives GC, Perham-Hester KA. Association between sudden infant death syndrome and prone sleep position, bed sharing, and sleeping outside an infant crib in Alaska. *Pediatrics.* 2001;108:923–927
49. Grossman ER. Less than meets the eye: the Consumer Product Safety Commission's campaign against bed-sharing with babies. *Birth.* 2000; 27:277–280
50. Kemp JS, Unger B, Wilkins D, et al. 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. *Pediatrics.* 2000;106(3). Available at: www/pediatrics.org/cgi/content/full/106/3/e41
51. Mitchell EA, Scragg R. Are infants sharing a bed with another person at increased risk of sudden infant death syndrome? *Sleep.* 1993;16:387–389
52. McKenna JJ. Sudden infant death syndrome in cross-cultural perspective: is infant-parent cosleeping protective? *Annu Rev Anthropol.* 1996;25:201–216
53. Lozoff B, Wolf AW, Davis NS. Cosleeping in urban families with young children in the United States. *Pediatrics.* 1984;74:171–182
54. Klonoff-Cohen H, Edelstein SL. Bed sharing and the sudden infant death syndrome. *BMJ.* 1995;311:1269–1272
55. McKenna J, Mosko S, Richard C, et al. Experimental studies of infant-parent co-sleeping: mutual physiological and behavioral influences and their relevance to SIDS (sudden infant death syndrome). *Early Hum Dev.* 1994;38:187–201
56. Mosko S, Richard C, McKenna J, Drummond S. Infant sleep architecture during bedsharing and possible implications for SIDS. *Sleep.* 1996;19: 677–684
57. Mosko S, Richard C, McKenna J. Infant arousals during mother-infant bed sharing: implications for infant sleep and sudden infant death syndrome research. *Pediatrics.* 1997;100:841–849
58. Mitchell EA, Tuohy PG, Brunt JM, et al. Risk factors for sudden infant death syndrome following the prevention campaign in New Zealand: a prospective study. *Pediatrics.* 1997;100:835–840
59. Mitchell EA, Thompson JMD. Co-sleeping increases the risk of SIDS, but sleeping in the parents' bedroom lowers it. In: Rognum TO, ed. *Sudden Infant Death Syndrome, New Trends in the Nineties.* Oslo, Norway: Scandinavia University Press; 1995:266–269
60. L'Hoir MP, Engelberts AC, van Well GTJ, et al. Dummy use, thumb sucking, mouth breathing and cot death. *Eur J Pediatr.* 1999;158:896–901
61. Arnestad M, Andersen M, Rognum TO. Is the use of dummy or carry-cot of importance for sudden infant death? *Eur J Pediatr.* 1997;156: 968–970
62. Mitchell EA, Taylor BJ, Ford RPK, et al. Dummies and the sudden infant death syndrome. *Arch Dis Child.* 1993;68:501–504
63. Jorch H, Schleimer B. *The Optimal Sleep Environment for Your Child. A Guide for Parents and All Who Want To Become Parents* (translated from German). Bochum, Germany: Johanniter-Unfall-Hilfe; 1998
64. Fleming PJ, Blair PS, Pollard K, et al. Pacifier use and sudden infant death syndrome: results from the CESDI/SUDI case control study. *Arch Dis Child.* 1999;81:112–116
65. Aarts C, Hornell A, Kylberg E, Hofvander Y, Gecre-Medhin M. Breastfeeding patterns in relation to thumb sucking and pacifier use. *Pediatrics.* 1999;104(4). Available at: www.pediatrics.org/cgi/content/full/104/4/e50
66. Barros FC, Victora CG, Semer TC, Tonioli Filho S, Tomasi E, Weiderpass E. Use of pacifiers is associated with decreased breast-feeding duration. *Pediatrics.* 1995;95:497–499
67. Kloeblen-Tanver AS. Pacifier use is associated with shorter breastfeeding duration among low-income women. *Pediatrics.* 2001;108:526
68. Levy SM, Slager SL, Warren JJ, Levy BT, Nowak AJ. Associations of pacifier use, digit sucking, and child care attendance with cessation of breastfeeding. *J Fam Pract.* 2002;51:465
69. Nelson EAS, ICCPS Study Group. International Child Care Practices Study: breastfeeding and pacifier use. *J Pediatr Gastroenterol Nutr.* 2000; 31(suppl 2):S28
70. Victora CG, Behague DP, Barros FC, Olinto MT, Weiderpass E. Pacifier use and short breastfeeding duration: cause, consequence, or coincidence? *Pediatrics.* 1997;99:445–453
71. Adair SM, Milano M, Lorenzo I, Russell C. Effects of current and former pacifier use on the dentition of 24- to 59-month-old children. *Pediatr Dent.* 1995;17:437–444
72. Larsson E. The effect of dummy-sucking on the occlusion: a review. *Eur J Orthodont.* 1986;8:127–130
73. Svedmyr B. Dummy sucking. A study of its prevalence, duration and malocclusion consequences. *Swed Dent J.* 1979;3:205–210
74. Jackson JM, Mourino AP. Pacifier use and otitis media in infants twelve months of age or younger. *Pediatr Dent.* 1999;21:255–260
75. Niemela M, Uhari M, Hannuksela A. Pacifiers and dental structure as risk factors for otitis media. *Int J Pediatr Otorhinolaryngol.* 1994;29: 121–127
76. Uhari M, Mantysaari K, Niemela M. A meta-analytic review of the risk factors for acute otitis media. *Clin Infect Dis.* 1996;22:1079–1083
77. Warren JJ, Levy SM, Kirchner HL, Nowak AJ, Bergus GR. Pacifier use and the occurrence of otitis media in the first year of life. *Pediatr Dent.* 2001;23:103–107
78. North K, Fleming P, Golding J, ALSPAC Study Team. Pacifier use and morbidity in the first six months of life. *Pediatrics.* 1999;103(3). Available at: www.pediatrics.org/cgi/content/full/103/3/e34
79. Gilbert R. The changing epidemiology of SIDS. *Arch Dis Child.* 1994;70: 445–449
80. Kraus JF, Greenland S, Bulterys M. Risk factors for sudden infant death syndrome in the U.S. Collaborative Perinatal Project. *Int J Epidemiol.* 1989;18:113–120
81. Mitchell EA, Taylor BJ, Ford RPK, et al. Four modifiable and other major risk factors for cot death: the New Zealand study. *J Paediatr Child Health.* 1992;28(suppl 1):S3–S8
82. Gibbons LE, Ponsonby A-L, Dwyer T. A comparison of prospective and retrospective responses on sudden infant death syndrome by case and control mothers. *Am J Epidemiol.* 1993;137:654–659
83. Klemetti A, Saxen L. Prospective versus retrospective approach in the search for environmental causes of malformations. *Am J Public Health.* 1967;57:2071–2075

84. Paskett ED, DeGraffinreid C, Tatum CM, Margitic SE. The recruitment of African-Americans to cancer prevention and control studies. *Prev Med.* 1996;25:547–553
85. Swanson GM, Ward AJ. Recruiting minorities into clinical trials: toward a participant-friendly system. *J Natl Cancer Inst.* 1995;87:1747–1759
86. Thompson EE, Neighbors HW, Munday C. Recruitment and retention of African American patients for clinical research: an exploration of response rates in an urban psychiatric hospital. *J Consult Clin Psychol.* 1996;64:861–867
87. Coleman EA, Tyll L, LaCroix AZ, et al. Recruiting African-American older adults for a community-based health promotion intervention: which strategies are effective? *Am J Prev Med.* 1997;13:51–56
88. Bonner GJ, Miles TP. Participation of African Americans in clinical research. *Neuroepidemiology.* 1997;16:281–284
89. Corbie-Smith G, Thomas SB, Williams MV, Moody-Ayers S. Attitudes and beliefs of African Americans toward participation in medical research. *J Gen Intern Med.* 1999;14:537–546
90. Freimuth VS, Quinn SC, Thomas SB, Cole G, Zook E, Duncan T. African Americans' views on research and the Tuskegee Syphilis Study. *Soc Sci Med.* 2001;52:797–808
91. American Academy of Pediatrics, Task Force on Infant Positioning and SIDS. Does bed sharing affect the risk of SIDS? *Pediatrics.* 1997;100:272
92. Porter KS, Thomas SD. *Birth Outcomes and Infant Mortality, 1990–1999.* Chicago, IL: Chicago Department of Public Health Epidemiology Program; 2002
93. What's new with "Back to Sleep," SIDS "Back to Sleep" Campaign. Available at: www.nichd.nih.gov/sids/sids.cfm
94. US Department of Health and Human Services. *Healthy People 2010.* 2nd ed. With Understanding and Improving Health and Objectives for Improving Health. 2 vols. Washington, DC: US Government Printing Office; 2000

Sleep Environment and the Risk of Sudden Infant Death Syndrome in an Urban Population: The Chicago Infant Mortality Study

Fern R. Hauck, Stanislaw M. Herman, Mark Donovan, Solomon Iyasu, Cathryn Merrick Moore, Edmund Donoghue, Robert H. Kirschner and Marian Willinger

Pediatrics 2003;111;1207

PEDIATRICS®
OFFICIAL JOURNAL OF THE AMERICAN ACADEMY OF PEDIATRICS

Sleep Environment and the Risk of Sudden Infant Death Syndrome in an Urban Population: The Chicago Infant Mortality Study

Fern R. Hauck, Stanislaw M. Herman, Mark Donovan, Solomon Iyasu, Cathryn Merrick Moore, Edmund Donoghue, Robert H. Kirschner and Marian Willinger

Pediatrics 2003;111;1207