

Sudden Infant Death Syndrome: An Anthropological Hypothesis

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Considerable research effort has been focused on the Sudden Infant Death Syndrome (SIDS), a problematic diagnosis that is now the most frequently identified "cause" of death in infancy in the United States (Kelley & Shannon, 1982; Merritt & Valdes-Dapena, 1984) and England (Murphy, Newcombe, & Sibert, 1982). The incidence is about 2/1000 live births, or about 10,000/year (Bergman, Ray, Pomeroy, Wohl, & Beckwith, 1972; Guntheroth, 1977; Zebal & Friedman, 1984). Cases of suffocation and other obvious differential diagnoses are not included in the category of SIDS or are subtracted from calculations of incidence (Bergman, *et al.*, 1972). Factors proposed to be causally related to at least some of these unexplained deaths vary widely. They include:

Chronic hypoxia (Baker & McGinty, 1977; Cornwell, 1979; Jeffery, Rahilly, & Read, 1983; Naeye, 1974, 1976, 1977; Naeye, Ladis, & Drage, 1976; Shannon, Kelly, & O'Connell, 1977);

Acute hypoxia resulting from sleep apnea or specifically "upper airway apnea" (Guilleminault, Peraïta, Souquet, & Dement, 1975; Guilleminault, Ariagno, & Korobkin, 1979; Guilleminault, Ariagno, Souquet, & Dement, 1976; Steinschneider, 1972);

Cardiac conduction disorders (Guilleminault *et al.*, 1976);

Botulism (Marx, 1978; Pottgen & Hillegass, 1977);

Hypoglycemia resulting from pancreatic islet cell hyperplasia (Polak & Wigglesworth, 1976; Cox, Guelpa, & Terrapon, 1976) or impaired gluconeogenesis (Cornwell, 1979);

Undetected respiratory viral infections, especially during the growth of active immunity (Carpenter, Gardner, Pursall, McWeeny, & Emery, 1979; Guntheroth, 1977);

Overheating (Stanton, Scott, & Downham, 1980);

Maternal prenatal drug addiction (Chavez *et al.*, 1979);

Allergy, including hypersensitivity to cow's milk (Guntheroth, 1977);

Gastroesophageal reflux (Jeffery, Raphilly, & Read, 1983; MacFadyen, Hendry, & Simpson, 1983);

Hyperextension of the atlanto-occipital joint leading to acute damage of brain stem respiratory centers (Gilles, Bina, & Sotrel, 1979);

Autonomic instability (Guilleminault *et al.*, 1976);

Overactive endogenous opioid system (Kuich & Zimmerman, 1981);

Intrinsic chronic hypotonia (Korobkin & Guilleminault, 1979);

Delay in the normal disappearance of fetal brown fat cells (Gadson & Emery, 1976; Naeye, 1974);

Damage to or abnormality of the central nervous system (Anderson-Huntington & Rosenblith, 1976; Naeye, Ladis, & Drage, 1976; Quattrochi, Baba, Liss, & Adrion, 1980);

Characteristics of infant temperament such as low activity and responsiveness (Naeye, Messmer, Specht, & Merritt, 1976);

Inadequate adaptive response to airway obstruction (Purcell, 1976);

Structural features or changes of the respiratory tract (Sasaki, Levine, Laitman, Phil, & Crelin, 1977; Tonkin, 1975); and

Infanticide (Guntheroth, 1977).

Epidemiological studies have identified male sex, low socioeconomic status, feeding techniques other than breast feeding, blood type B, winter or cold climate, ethnicity, maternal age, and passive smoking as possible predisposing factors (Babson & Clarke, 1983; Bergman *et al.*, 1972; Bergman & Wiesner, 1976; Cunningham, 1976; Fleshman & Peterson, 1977; Naeye, Ladis & Drage, 1976; Peterson & Chinn, 1977; Tonkin, 1975). Infants less than 1 month of age are rarely victims; the syndrome is most common between 1 and 5 months of age, with a peak incidence at 2–3 months and a declining incidence thereafter (Bergman *et al.*, 1972). Indeed, the specific and narrow age distribution of SIDS is nearly unique among causes of infant death and suggests a window of developmental vulnerability, although its basis remains a mystery.

It is likely that there are several final common pathways for SIDS and a large number of predisposing factors, both intrinsic and environmental. The multiplicity of possibilities and a complex literature of incomplete replications have led some writers to question the status of SIDS as a "syndrome" (Avery & Frantz, 1983). Nevertheless, the possibility of interactions of spe-

cific aspects of infant care with predispositions to SIDS has not received adequate consideration, and that is the concern we raise here. Our thesis does not question the potential validity of previously proposed explanations. It calls attention, rather, to a separate cluster of independent variables that has largely eluded the public notice of investigators; specifically, the proximity of infants to primary caretakers during sleep and waking and the associated frequency of feeding and other stimulation. This cluster is salient to the anthropologist because of its extremely distinctive features in 20th-century urban Western cultures.

Comparative Studies of Infant Sleeping Arrangements

Although useful estimates of SIDS are not available from other cultural settings, the unique features of infant care in the United States and other Western industrial societies bear a provocative relationship to some factors relevant to SIDS. Most striking is the high proportion of infants who sleep in a room separate from their parents. A world-wide, cross-cultural study of 90 nonindustrial societies, chosen for mutual independence as cultural units and representative of the world range, found the mother and infant typically sharing the same bed in 41 groups, in different beds in the same room in 19, and in the same room with the bed unspecified by the original ethnographer in 30 societies (Barry & Paxson, 1971). In no society were infants kept in a separate room during the first year, the time of greatest risk for SIDS.

To place the basic human picture in a phyletic context, direct, continuous mother-infant contact during infant sleep is characteristic of all nonhuman higher primates. Experimental disruption of this pattern can be instructive, despite uncertainties in cross-species generalization. In one study using Rhesus monkeys, for example, a mechanical mother surrogate was cooled during the night, leading the infant to withdraw and sleep alone. This proved to have unexpectedly serious consequences, in view of previous experience with such animal models: one infant died during the night, and a second nearly died before reinstitution of the approachable nightly surrogate. Gross and microscopic necropsy revealed no pathological changes other than dehydration (Harlow, Plubell, & Baysinger, 1973).

Possible Consequences of Sleep Arrangements

The consequences for human infants of sleeping in the same room with a caretaker are many. They may include more frequent night feeding and more responsive vigilance on the part of the adult. The more frequent wak-

ing to feed may alter aspects of the sleep cycle, and it is known that SIDS-related phenomena are differentially associated with stages of sleep and their transitions (Steinschneider, 1972; Watanabe, Inokuma, & Negoro, 1983). Sleeping in the same bed with an adult can be expected, in addition, to alter an infant's microenvironment, for example, to increase auditory stimulation (particularly entraining rhythms from adult breathing), increase somesthetic and perhaps vestibular stimulation, promote heat exchange and mutual temperature regulation, and increase the concentration of water vapor and carbon dioxide in the air breathed by the infant. Taken together, the effects of cosleeping are relevant to at least three phenomena related to SIDS: sleep apnea, hypoglycemia, and hyperthermia.

Sleep apneas (temporary breathing halts) have been implicated in the etiology and onset of SIDS, and "spontaneous, pathologically protracted central apnea" is currently "the most favored hypothesis for crib death" (Merritt & Valdes-Dapena, 1984; p. 199). Apnea is also implicated in many "near-miss" cases (Guilleminault *et al.*, 1976, 1979; Steinschneider, 1972), though others show no respiratory irregularity and there may in fact be several developmental patterns of respiratory instability (Thoman, Miano, & Freese, 1975). Based on a variety of theories, investigators have used warm, mildly oscillating waterbeds or other gentle rocking devices to reduce apnea and promote regular respiration (Korner, Kraemer, Haffner, & Cosper, 1975; Korner, 1979; Peterson & Chinn, 1977). They have even been used to treat asphyxia in neonates at risk (Blurton Jones, Ferreira, Brown, & MacDonald, 1978). Some of the studies used the estimated rhythm of maternal breathing as the rhythm of oscillation (Korner, 1979). McKenna (1984, 1987) has paid particular attention to the role of respiratory rhythms in his analysis of the literature, and his recent laboratory data appear to support their importance in stimulating regular infant breathing (J. J. McKenna, personal communication, 1985). The possibility of increased carbon dioxide concentration in the infant's microenvironment is of note because CO_2 concentration in the blood stream is a primary mechanism for stimulating breathing, and recent evidence suggests that chemoreceptors in the upper respiratory tract may allow an infant to detect carbon dioxide in the air with similar stimulating effect (Sullivan & Yu, 1983).

Hypoglycemia resulting from impaired gluconeogenesis (Cornwell, 1979; Lardy, 1975) or pancreatic islet cell hyperplasia (Polak & Wigglesworth, 1976; Cox *et al.*, 1976) may be a factor in some cases of SIDS. The reduced feeding frequency associated with separate sleeping arrangements may be relevant to this risk factor. Observations pointing to possible role for compromised blood glucose level include: (1) the greater likelihood of SIDS in cold weather and cold climates, where greater body heat production is required (Bergman *et al.*, 1972); (2) the greater likelihood of SIDS in poorer and presumably less well-nourished families (Bergman *et al.*, 1972); (3) the

fact that incidence peaks at the age when infants begin to sleep through the night, thus skipping a feeding (Bergman *et al.*, 1972); and (4) evidence that in some instances the victim had refused or vomited the last feeding before sleep (Lardy, 1975; see also Silverstein *et al.*, 1983). These circumstances led to a blind study of levels of three liver gluconeogenic enzymes in SIDS victims and controls (Lardy, 1975). Two of the enzymes did not differ between the groups, but phosphoenolpyruvate carboxykinase (PEPCK) levels were found to be substantially lower in SIDS victims than in victims of other diseases or of accidents. Lardy (1975) argues that under conditions of serious challenge to blood glucose regulatory dynamics, low PEPCK activity might compromise an appropriate adaptive response, resulting in death. If blood glucose dynamics figure in the syndrome, then attention should be given to the possibility that sleeping through the night may increase risk through reduction in feeding frequency and that the maintenance of night feeding during the age of high incidence may thus reduce risk.

The identification of heatstroke as a cause of death in some heavily wrapped infants (Bacon, Scott, & Jones, 1979) led Stanton, Scott, and Downham (1980) to examine 33 consecutive cases of unexplained infant death in two English cities. Fifteen of the cases were excessively clothed or covered at the time of death, and 8 showed histological changes in the small intestine similar to those found in heatstroke. The authors point out that while infants will cry to lowered temperatures, they remain passive to raised ambient temperature (Rutter & Hull, 1979). Others have demonstrated that higher environmental temperature is associated with increased apneic episodes in premature babies (Daily, Klaus, & Meyer, 1969; Steinschneider & Weinstein, 1983). These observations are consistent with the epidemiological findings of higher rates of SIDS in winter or cold months, when infants are more likely to be overdressed and covered; Stanton *et al.*, (1980) cite as one case an 18-week-old boy who was wearing, at death, "a vest and nightgown, covered by two flannelette sheets each folded into eight, with a blanket wrapped round the sheets and the baby, and two more blankets on top" (p. 1055). The findings, in some victims of SIDS, of delayed disappearance of fetal brown fat cells (Gadson & Emery, 1976; Naeye, 1974), which are thought to be involved in the generation of body heat (Hull, 1966), is also relevant. Even though some of the cases presented by Stanton *et al.*, (1980) were attended by their parents just prior to death, it seems possible that physical separation at night decreases the likelihood of parental detection of infant hyperthermia and intervention to restore normal temperature.

The Management of Infant Sleep

The present speculations aside, we know little about the effects of nightly separation and isolation on infants. Since it has not often been conceptu-

alized as a variable by behavioral scientists, it has not been well studied. However, two problems well known to most American parents, bedtime protest and night waking, may be relevant. One widely read child care manual (Spock, 1976) solves the first problem by letting the infant "cry itself to sleep," even if the enragement results in vomiting. Night waking is identified as a problem by 20–30% of English and American mothers of infants (Bergman & Wiesner, 1976; Bernal, 1973; Jenkins, Owen, Bax, & Hart, 1984; Lozoff, Wolf, & Davis, 1985). Since infants sleep separately, they presumably must cry vigorously to be heard. It seems reasonable to raise the possibility that prolonged or exhausting crying at bedtime or during night waking could compromise respiration in infants already at risk, even though SIDS victims do not seem to die during crying spells. It is also perhaps worth noting in this connection that endogenous endorphin release has been shown to be a consequence of physical stress (at least in adults: Carr *et al.*, 1981; Chung & Dickenson, 1980) and a cause of sleep apnea in infants (Chernick, 1981). The respiratory depressant effects of exogenous opiates may thus have a stress-induced natural counterpart (Kuich & Zimmerman, 1981). In addition, in infants whose glucose reserves are marginal, long crying could conceivably deplete them to dangerously low levels. Finally, if prolonged crying were habitual, chronic hypoxia would be more likely, and pathological changes indicative of hypoxia (e.g., fat-laden cells in the corpus callosum) are seen in SIDS victims (Naeye, 1974). The importance of these observations is magnified by recent findings that night waking is (1) more associated with pre- and perinatal factors than with parental behavior (Blorton Jones *et al.*, 1978), and (2) often associated with family illness and other indices of stress (Lozoff, *et al.*, 1985), thus raising the possibility of heightened (1) physiological and (2) environmental risk for night wakers as well.

Infant Sleep Management in Two Nonindustrial Cultures

Data from two nonindustrial societies illustrate their typical minimization of these behavioral problems. The !Kung San of Botswana (like the Siriono, the Copper Eskimo, and other hunting and gathering groups) employ what may be a fundamental human pattern of infant care (Konner, 1980). Almost all infant sleep during the mother's waking hours occurs in a "sling" at the mother's side, in direct contact with her body. The remainder, and all sleep while the mother is asleep, occurs within a foot of her body, if not touching it. Infant sleep and waking follow the infant's rhythm but cause little inconvenience due to the close proximity. Infants suckle about four times per hour during the day. At night they wake repeatedly and are fed and consoled before crying vigorously. Some ad lib night feedings occur without the

mother waking, all without her rising from her bed. Questions from visiting anthropologists about rolling over on the infant meet with amused declaration that this does not happen. Mothers' descriptions of the pattern of mutual postural adjustments during the night are reminiscent of those of a conjugal couple in our culture. Fathers may sleep on the same mats (Konner, 1977; Konner & Worthman, 1980).

Currently, of course, hunting and gathering is rare and disappearing among human life styles. The critical aspects of infant care as described for the !Kung can also be found, however, in some relatively traditional agricultural peoples, who do represent a major current adaptive niche. The worldwide study cited earlier indicates the continued closeness of sleeping arrangements in most nonindustrial societies. More detailed data are available from the Kipsigis of Kenya, a Highland Nilotic group in the Western Highlands of Kenya.

Although Kipsigis mothers do not use a sling, they and their child care assistants (usually an older daughter) often carry the baby on the hip, held secure by one hand, or on the back, tied in with a cloth. In addition, young babies frequently sit or rest in the caretaker's lap while she carries out food preparation or other chores. When awake, therefore, the infants are found to be touching the caretakers (through two layers of cloth) over 80% of the time during the first 5 months (Super, 1980). When asleep during the day, this figure drops to about 30%, but the caretaker usually remains within eyesight. At night, the baby sleeps with the mother on a skin or mat on the mud floor, covered with a blanket. Other young children sleep in another bed in the same room, while the father typically sleeps in a separate hut.

The sleep-wake pattern is altered by this proximity of the mother and the associated ease of feeding, as in the !Kung case. Twenty-four-hour sleep records on 10 infants indicate several similarities between the development of sleep patterns in Kipsigis and middle class American infants (Super & Harkness, 1982), but they indicate a divergence in one important aspect: while American babies increase their longest sleep episode from 4 to about 8 h during the first 4 months (satisfying their parents' desire to sleep through the night themselves), the Kipsigis babies do not show this change. Their longest sleep episode increases very little for at least the first 8 months.

During both day and night, nursing is ad lib for the Kipsigis infant, although the mother may be away briefly, in the garden or collecting wild vegetables, as the child grows beyond 3 months of age. In any case, the average number of feeds/24 h remains about 20 during the first 8 months.

In addition to the frequency of feeding and the proximity of caretakers, especially during the night, it is worth mentioning a further aspect of infant care in these and other nonindustrial societies: vastly greater levels of somesthetic and vestibular stimulation that result from body contact. Among

both the Kipsigis and the !Kung, infants in the first year are touching their caretaker 2–3 times as often as same-aged Americans, while both awake and asleep (Super, 1980, Fig. 8–1; Konner, 1976, Fig. 10.2). The consequences of high levels of somesthetic and vestibular stimulation are substantial. Experimental studies (Clark, Kreutzberg, & Chee, 1977; Porter, 1972) demonstrate that moderate physical stimulation beyond typical American levels can effect a significant advance in reflexive and gross motor behavior. One study increased the gains in reflex and motor skills, during a 1-month intervention, at a rate four times that found in a matched control group. However, the intervention (80 min of rotation at moderate speed in the lap of the experimenter in an office swivel chair, distributed over the course of a month) appears substantially less than the stimulation resulting from being carried on the hip or back for most of every day while the caretaker forages for food, winnows grain, herds cows to the river, and so on. It is conceivable that the typically subdued American pattern of early vestibular stimulation is inadequate for optimal CNS maturation in some infants, putting them at increased risk or extending the period of risk, for centrally mediated disorders such as sleep apnea and some portion of SIDS.

Intervention

The evidence cited thus far is circumstantial. One intervention study, however, suggests SIDS rates may be open to substantial environmental manipulation, specifically, in this case, through promotion of breast feeding. An association of SIDS rate with bottle feeding (as opposed to breast feeding) has been found in some studies (e.g., Cunningham, 1976), although others, from different countries, have failed to replicate this finding (e.g., Biering-Sorensen, Jorgensen, & Hilden, 1978). Indirect mechanisms such as a varying association with sleep patterns could lead to a variety of relationships in different populations. For example, Elias *et al.* (1986) have found a substantially higher frequency of night waking in American La Leche League infants whose mothers practice intensive breast feeding, including night feeding, with close mother–infant sleeping proximity. Studies like these call into question the assumption that sleeping through the night in the first six months of life is normal.

In any event, the Sheffield Intervention Programme (Carpenter *et al.*, 1983) reports a reduction of “possibly preventable” infant deaths from 5.2 to 1.9/1000, where 79% of the “possibly preventable” preintervention cases were SIDS (that is, not attributable to any specific cause; the remainder included death from infectious disease, accidents, and violence). Twelve percent of the decline was attributed to demographic changes during the

period of surveillance, 9% to a reduction in precipitate deliveries, and 36% to such factors as increased case conferences, home assessments, and general vigilance promoted by the program. Two specific interventions accounted for the remainder of the decline: 18% by a home visiting program for infants identified as being at high risk, the initial and primary effort; and 24% by the promotion of breast feeding, an intervention prompted by the observation of frequent use of overly concentrated formula. Thus, the increase in breast feeding was the most powerful single identifiable factor in reducing infant deaths from SIDS (and other "preventable" causes) by nearly two-thirds. A number of statistical assumptions are employed to arrive at this estimate, and the authors are appropriately cautious about the attributions of cause. Nevertheless, the results are striking not only for their demonstration of a reduction in SIDS but also for the fact that this reduction was effected through a relatively simple change in infant care strategy, one well within the range of normal societal variation, that somehow altered the environmental risk for, presumably, some portion of biologically vulnerable infants.

It is not possible to know in the absence of other information why breast feeding reduced mortality in the Sheffield study. One possibility is that it altered the pattern of night feeding and thus night sleeping. The inconsistent epidemiological reports suggesting some factor closely but not invariably associated with breast feeding are compatible with this interpretation. It has been noted that regional and national estimates of SIDS incidence range widely (see Valdez-Dapena, 1980). The Sheffield results raise the possibility that differences in infant care may contribute significantly to this variation, although no appropriate cross-national analysis has been carried out, and differential reporting is likely to be the major determinant of the variation.

New Research Questions and a Caution

Our purpose in drawing attention to child care variables in relation to SIDS is not to lessen the importance of other factors such as prematurity, dysmaturity, or upper respiratory infection nor is it to add to the potential burden of undeserved guilt SIDS parents often bear, nor necessarily to suggest a major change in American infant care. It is to point to a new paradigm for research on infants at risk, namely, to examine disorders such as SIDS in light of preurban, preindustrial techniques of rearing, particularly those that are likely to have existed as our general species characteristics were established. The contrast between current practices and those more typical of our species can be especially illuminating.

Evolutionary or anthropological studies, however, can only raise questions; they cannot point to solutions. If observations suggest we have de-

parted in some sense from a "natural" infant care adaptation, the solution may also be novel, such as apnea monitors, oscillating waterbeds, and other mechanical devices for infants found to be at risk. Further, in view of a tendency in some quarters to identify "natural" modes of child care with exclusively maternal ones, we note that fathers too have warm, mildly oscillating bodies and are capable of stimulating infants during apnea episodes, consoling them before whimpering becomes crying, and feeding them often enough to prevent declines in blood glucose.

The modern, urban, middle-class method of infant care is clearly superior in several respects to that of hunter-gatherers and subsistence farmers, for instance, in the prevention of infection and nutritional deficit. In addition, adoption of nonindustrial patterns may have different consequences for urban middle-class families than they have in other cultural contexts. The chance of suffocation during cosleeping, for example, however small it is, may be greater on a soft mattress with many blankets than on a skin mat on the ground. More generally, patterns of infant care are intimately related to many aspects of family life, mothers' chores and responsibilities, and the child's later development, in ways which the social and behavioral sciences are only now beginning to investigate (Super, 1980), and it is a universal observation of anthropologists that artificial introduction of culture change has many unforeseen effects, sometimes unfortunate ones.

Nevertheless, carefully monitored behavioral interventions, such as the Sheffield Intervention Programme, have been shown profoundly to affect environmentally related, "possibly preventable" deaths. In addition, if one carefully considers the known risks of cosleeping in urban Western cultures, the problem of fatality from suffocation or "overlaying," rarely reported in the medical literature, must be weighed against fatalities from alternatives such as unsafe cribs (Smialek, Smialek, & Spitz, 1977; Bass, Kravath, & Glass, 1986).

While the circumstantial evidence presented here does not recommend any single course of prevention or treatment, it does indicate possible infant care variables worth investigating concerning infants found to be at risk. Infant care practices long accepted by our culture, and endorsed by parents as well as professionals, may provide a background of risk for the incidence of SIDS or for related deaths not included in the SIDS category such as those associated with suffocation. For some portion of cases of the syndrome perhaps we should return to the earlier diagnosis of "crib death," if the crib, by isolating the infant, in fact plays a role in the etiology.

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