

Forthcoming in *Human Nature* 2006

Parent-Infant Bed-sharing Behaviour: effects of feeding type, and presence of father.

Dr Helen L. Ball,
Parent-Infant Sleep Lab.,
Department of Anthropology,
University of Durham,
DH1 3HN
UK .

+44 191 334 0260

h.l.ball@dur.ac.uk

KEYWORDS: BED-SHARING, BREASTFEEDING, FORMULA-FEEDING, MOTHER-INFANT
BEHAVIOUR, INFANT SLEEP

ABSTRACT

An evolutionarily informed perspective on parent-infant sleep contact challenges recommendations regarding appropriate parent-infant sleep practices based on large epidemiological studies. In this study regularly bed-sharing parents and infants participated in an in-home video study of bed-sharing behaviour. Ten formula-feeding and ten breastfeeding families were filmed for 3 nights (adjustment, dyadic and triadic nights) for 8 hours per night. For breastfed infants, mother-infant orientation, sleep position, frequency of feeding, arousal and synchronous arousal were all consistent with previous sleep-lab studies of mother-infant bed-sharing behaviour, but significant differences were found between formula and breastfed infants. While breastfeeding mothers bed-shared with their infants in a characteristic manner that provided several safety benefits, formula-feeding mothers bed-shared in a more variable manner with consequences for infant safety. Paternal bed-sharing behaviour introduced further variability. Epidemiological case-control studies examining bed-sharing risks and benefits do not normally control for behavioural variables that an evolutionary viewpoint would deem crucial. This study demonstrates how parental behaviour affects the bed-sharing experience and indicates that cases and controls in epidemiological studies should be matched for behavioural, as well as socio-demographic, variables.

List of Figure Captions

Figure 1: Characteristic sleep position of breastfeeding mothers and infants

List of Tables

Table 1: Socio-demographic characteristics of families participating in study

Table 2: Comparison of breastfeeding mother-infant dyads bed-sharing in own homes (current study), hospital sleep lab in California (Richard, Mosko et al. 1996) and hospital sleep lab in Bristol UK (Young 1999).

Table 3: Comparison of breastfeeding mother-infant pairs in dyadic and triadic (with father) sleeping arrangements

Table 4: Infant head-covering on dyadic and triadic bed-sharing nights.

Table 5: Comparison of bed-sharing characteristics for breastfed and formula-fed infants.

BIOGRAPHICAL SKETCH

The author is a Senior Lecturer in Anthropology and Director of the Parent-Infant Sleep Lab at the University of Durham. Originally trained in primate ethology, she has been researching parent-infant behaviour, infant sleep safety, breastfeeding, and social sleep for 10 years.

ACKNOWLEDGEMENTS

Thanks are due to the parents and infants who allowed their bedrooms to be invaded by video cameras, Elaine Hooker who coded the video tapes, and Karen MacDonald who produced the illustration. Conversations with Jim McKenna, Jeanine Young, Sally Baddock and Martin Ward-Platt greatly improved this paper. The Nuffield Foundation and the Foundation for the Study of Infant Deaths (project 227) provided funding.

INTRODUCTION

An anthropological perspective on infant sleep biology, including the evolutionary underpinnings and developmental benefits of mother-infant co-sleeping, have been described in numerous publications by McKenna and colleagues (McKenna, Mosko et al. 1990; McKenna, Thoman et al. 1993); McKenna et al. 2001; Mosko et al. 1997) and those of several other biological anthropologists (Ball 2002, 2003; Ball et al. 1999, 2000; Hrdy 2000; Small 1992, 1998; Trevathan and McKenna 1994). The behavioural and polysomnographic studies reported by McKenna, Mosko, and colleagues throughout the nineties supported the logical conclusion derived from physiological, evolutionary, historical, psychological and cross-cultural data, that sleeping in close proximity to its mother ought to be in an infant's best interests.

A range of studies have demonstrated the benefits of prolonged intimate interaction (skin-to-skin contact, kangaroo care) between mother and infant in the immediate post-natal period, helping infants recover rapidly from birth-related fatigue (Ludington-Hoe, 1999), encouraging spontaneous breastfeeding (Gomez Papi, 1998), promoting continued breastfeeding (De Chateau 1977), helping newborns preserve energy and accelerating metabolic adaptation, and thus increasing the well being of the newborn infant (Christensson et al. 1992). Skin-to-skin contact is also associated with a significant increase in maternal oxytocin levels (Matthiesen, 2001; Nissen, 1995) with significance for uterine contraction, milk ejection, and mother-infant interaction; and with less maternal anxiety and more efficient participation of mothers in caring for their newborn infants (Vial-Courmont 2000). These studies demonstrate the physiological importance of mother-infant physical contact on infant development and mother-infant well-being and draw attention to the evolved interactive nature of the post-partum period. Mother-infant sleep contact over the first few months of life is a logical extension of post-partum skin-to-skin or kangaroo care with consequences for the development of infant sleep biology, and maternal feeding physiology (Ball 2003; McKenna and McDade 2005).

In Euro-American society, co-sleeping is often synonymous with bed-sharing -- i.e. parent(s) and infant sharing an adult bed for sleep -- although co-sleeping refers to a broader phenomenon of mother-infant sleep contact involving physical presence and sensory interchange -- but does not necessitate sleeping on a 'western' style bed, or even on the same sleep surface (McKenna and Mosko 2001). Bed-sharing as practiced in the UK and US is therefore one form of mother-infant co-sleeping -- and one that has attracted much controversy, being implicated in both accidental infant deaths and SIDS in various controlled and uncontrolled studies of sudden and unexpected infant deaths (Byard 1994; Carpenter, et al. 2004; Drago and Dannenberg 1999; Mitchell and Scragg 1993; Nakamura, Wind et al. 1999). So while close mother-infant contact at night appears to be evolutionarily and physiologically adaptive -- it has been argued that western bedding and sleeping arrangements may not be. Uncontrolled studies (such as those based on the data from the US Consumer Product Safety Commission, e.g. Drago and Dannenberg (1999); Nakamura, Wind et al. (1999)) tell us little about the relative risks and benefits of various sleeping arrangements for infants. Case-control studies (e.g. Blair et al 1999; Carpenter et al 2004; Tappin et al 2005) are expected to be more rigorous, however to date case-control studies examining SIDS and infant sleep safety have produced conflicting results regarding bed-sharing, and almost all such studies have failed to match cases and controls on the basis of behavioural variables such as feeding choice, parental alcohol and drug consumption , and frequency or type of bed-sharing and emphasise the matching of infants on socio-demographic variables and the location of their 'last' or 'reference' sleep.

We have previously reported on the effects of breast vs. formula feeding upon infant sleep characteristics and the propensity to bed-share (Ball 2003). In this paper we present the results of a study investigating how behavioural variables such as feeding choice and partner presence in the bed may affect mother-infant sleep behaviour and therefore infant sleep safety. Comparison is made with the detailed observations of mother-infant bed-sharing

behaviour from McKenna and Mosko's studies of breastfeeding Latina mothers and their babies (McKenna 1990; McKenna and Mosko 1994; McKenna, et al. 1997; Mosko et al. 1996; Mosko, et al. 1997a; Mosko et al. 1997b; Mosko et al. 1997c; Richard et al. 1997). These studies were conducted in a hospital sleep lab in California using polysomnographic monitoring and video observations of both mothers and infants sleeping together in a narrow hospital bed. Mother-infant dyads who normally bed-shared and breastfed were found to sleep in close proximity with a high degree of mutual orientation and arousal overlap. When bed-sharing, mothers placed infants in the supine position for sleep and infants breast-fed more, and cried less, than on nights when they slept apart from their mothers. Because of the confines of the narrow hospital bed in which mothers and infants slept, however, it was unclear whether the orientation, proximity, arousal, and breastfeeding frequencies reported were artefacts of sleeping in artificially cramped conditions – or an innate feature of normal bed-sharing for breastfeeding mothers and infants.

A study conducted in Bristol UK, addressed some of these issues. Young (Young 1999) examined mother-infant bed-sharing in a hospital sleep lab designed to resemble a domestic bedroom. Mothers and infants bed-shared in a full-size double bed, and were recorded via infra-red video, with infants being monitored polysomnographically. In terms of close proximity, mutual orientation, supine infant sleeping position, sleep state concordance, and breastfeeding frequency, these data supported the findings of McKenna and Mosko (Young 1999).

Both of the above-mentioned studies observed mothers and breastfed infants only, and did so in a hospital environment. The study reported here was designed to further explore 3 areas:

- a) to examine the bed-sharing behaviour of breastfeeding mother-infant pairs in their home environment (dyadic bed-sharing);
- b) to examine the effects of inclusion of fathers in the bed-sharing scenario (triadic

bed-sharing); and

c) to examine the bed-sharing behaviour of non-breastfeeding mother-infant pairs.

We report here on all 3 parts of this study. We hypothesised that because the home environment was more familiar to both mothers and infants they might sleep more deeply and exhibit fewer arousals at home than they had in the previous sleep lab studies. We also hypothesised that the presence of fathers bed-sharing with the mother-infant dyad might affect proximity and orientation of the infant. We further predicted that fathers' presence might affect the mothers' response-time to infant rooting or fussing behaviour, and possibly increase arousals in the mother-infant dyad due to the disturbance caused by an additional bed-partner. Finally, although the behaviour of non-breastfeeding bed-sharers had not been documented prior to this study, anecdotal evidence had led us to question whether mothers who do not breastfeed their infants bed-share differently from those who breastfeed. We hypothesised that the lack of a breast-baby axis of interaction¹ (i.e. among mothers who have never breastfed) would extrapolate to differences in bed-sharing compared with breastfeeding mothers.

METHODS

Ethics approval was obtained from both the University Ethics Committee, and the Local NHS Regional Ethics Committee.

Recruitment

Families with infants, who regularly bed-shared for whole or part nights, were recruited via posters in local health clinics and calls for volunteers in the local press, producing a self-

¹ We have observed that mothers who breastfeed carry, cuddle and interact with their infants held at breast-height, whereas mothers who do not breastfeed carry, cuddle and interact with their infants held at shoulder/face height. We named the primary focus of contact between the mother and the baby the 'axis of interaction'.

generated pool of volunteers from which we selected candidates who matched our inclusion criteria: non-smoking mother and father with infants under 6 months of age who were breastfed (for parts a and b of study) and formula fed (for part c of study). Families who met these criteria were visited at home by one of the research team who further explained the nature of the study, answered parents' questions, and subsequently obtained parents' signatures on an informed consent form.

Procedure

Prior to video-taping parents were asked to complete a series of sleep logs in order to assess the circumstances of bed-sharing and the degree to which it was practiced in the course of a normal week. Portable infra-red video equipment was then installed in the families' homes and parents were provided with verbal and written operating instructions. Parents were requested to begin recording when they went to bed, and to tape until they awoke for the morning, or for the 8-hour duration of the tape, whichever came sooner. Parents were provided with a remote control with which they could halt the recording at any time during the night. Families were videoed for an adjustment night (to eliminate 'first night effect' and to test the video set-up) and a member of the research team checked the video the following morning, adjusting the camera set-up if necessary. Families were then videoed for 2 test nights in randomly allocated dyadic and triadic bed-sharing configurations. On the dyadic night we filmed mothers and infants sleeping together (fathers slept elsewhere), and on triadic nights we filmed the infant sleeping with both parents. Following filming parents were offered the opportunity to review their tapes and to erase any portions they desired in accordance with Royal College of Physicians guidelines on use of videotaped material (one mother erased a 30 second portion). No physiological monitoring occurred. As a gratuity parents received a £10 gift voucher for a well-known baby store for each night of filming completed.

Analyses

A researcher trained in ethological observation techniques coded the videos in real-time. For each tape the frequency and duration of certain key behaviours (e.g. breastfeeding) were coded and expressed as a proportion of the total number of hours observed. For state and positional behaviours scan samples were coded every 3-minutes throughout the entire night, and scan frequencies were calculated as proportions of the total number of scans made, allowing within family and between family comparisons to be made.

RESULTS

Twenty families were videotaped bed-sharing at home with their infants: ten involving currently breastfeeding mothers and infants and ten involving mothers and infants who had never breastfed. No significant differences in night-time care-giving parameters were detected from the sleep logs of the breast and formula feeding families. All homes had central heating, and recordings of the two groups of families were evenly distributed across the year. The socio-demographic characteristics of the families in the two sub-samples are shown in Table 1. Parents of breastfed infants were older than those of formula-fed infants, had experienced slightly more years of education, and had greater household incomes (reflecting the current pattern of sociodemographic differences between breastfeeders and non-breastfeeders in the UK (Hamlyn 2002)), however the only difference that reached statistical significance between the two groups was household income.

Figure 1 Characteristic sleep position of breast-feeding mothers and infants.



Mother-infant bed-sharing at home

Data summarised from the video-tapes of the in-home bed-sharing nights for the 10 breastfeeding bed-sharing mother infant dyads are presented in Table 2 alongside data reported by Richard et al (Richard, Mosko et al. 1996) on 6 routinely bed-sharing breastfed infants and their mothers who were observed in the California sleep lab, and data reported by Young (Young 1999) on 5 routinely bed-sharing breastfed infants and their mothers who were observed in the Bristol sleep lab.

TABLE 2 HERE

A remarkably consistent picture emerges from these three studies. Breastfeeding bed-sharing mothers slept facing their infants for 71-76% of the night, infants slept facing their mothers for 87-97% of the night. Regardless of bed-size mothers and infants slept in close proximity to one another, often touching, but generally no more than 20cm (infant arm-length) apart. The frequencies of feeding bouts, and total length of feeding were greater in the California sleep lab study, than in both the Bristol sleep lab study, and the Durham in-home study, however the infants in the California study were of a younger (and more limited) age-range than the UK studies, which may account for the difference. Infants rarely slept in the prone position while bed-sharing in all 3 studies. The greatest difference between the Durham in-home study

and the Bristol and California Sleep Lab studies involves the proportion of the night infants spent in a lateral and supine sleep position. In the present study bed-sharing breastfeeding infants slept predominantly in a lateral position, whereas in the previous studies infants predominantly slept in a supine position. Our prediction that the home environment would be associated with fewer arousals and less mutual awareness than observed in sleep lab studies was not supported.

Inclusion of fathers

The effect of the father's presence in bed with the mother-infant dyad was explored by comparing infant sleep position, mother-infant proximity, orientation and breastfeeding data for the dyadic and triadic sleep nights:

TABLE 3 HERE

As shown in Table 3 a significant difference was observed regarding the location of the baby in the bed. On triadic nights babies were predominantly positioned in the centre of the bed, between both parents (although one mother exclusively slept her infant on the side of the bed on the triadic night), while on dyadic nights most mothers slept in the centre of the bed themselves, and moved the infant from side to side as needed for breastfeeding. Regarding sleep behaviour, mothers faced their infants (on average) for three-quarters of sleep time on both the dyadic and triadic bed-sharing nights, and the amount of time for which infants faced their mothers was no different on the two test nights. Furthermore infants and mothers spent over 70% of both nights in physical contact with one another, and breastfeeding activity was similar on both nights. Contrary to our prediction the father's presence did not, therefore, alter the characteristic picture of bed-sharing as practised by breastfeeding mothers and their infants.

Although breastfeeding mothers slept facing, and in close proximity to their infant, fathers

tended to sleep facing away from their infant, and were generally beyond their infant's reach (over 20cm away). There was one exception, a father who spent 83% of sleep-time touching his infant, who in turn spent 90% of sleep time facing his father. This father-infant dyad spent 53% of sleep time in a face-to-face orientation (compared to 5% between infant and mother), however the mother subsequently reported that she had mastitis on the triadic sleep night that made sleeping with pressure on the affected breast (facing the centre of the bed) uncomfortable. The behaviour observed in this family therefore was atypical of their normal night-time care-giving practices.

Mothers exhibited consistently synchronous arousal patterns with their infant: 9 of 10 mother-infant pairs arousing simultaneously on both dyadic and triadic nights, some pairs doing so up to nine times on a single night. Two fathers exhibited 100% synchronous arousals with their bed-partners on the triadic night, although the majority of fathers slept through half of their infants' arousals. Two fathers exhibited no synchrony with the mother-infant pair, never showing any signs of waking on the triadic night. Synchrony of fathers' sleep states during triadic bed-sharing therefore appears to be variable and idiosyncratic.

On both dyadic and triadic nights mothers spent large portions of sleep time in a distinctive sleeping posture (Figure 1), spontaneously exhibited by all breastfeeding mothers in this study. These mothers adopted a lateral sleeping position facing their infant, with the mother's knees drawn up under the infant's feet, and mother's upper arm positioned above the infant's head (either under or on top of the pillow). In contrast most fathers never slept in this position, or did so for only short periods of time. This position clearly facilitated breast-baby contact in these bed-sharing breastfeeding pairs. That this position also provides several benefits relating to bed-sharing safety is discussed below

FIGURE 1 HERE

Using interval sampling we coded the position of bedding and parents' limbs relative to the infant's body, head and face, and the direction and height of the infant in the bed on both dyadic and triadic bed-sharing nights. We observed no instances, on either dyadic or triadic sleep nights, of parents actually or potentially overlaying their infants. Despite the fact that there were pillows in the bed on all occasions no breastfed infants were observed with their face in the pillows, and pillows rarely touched the top of an infant's head -- due mainly to the characteristic position in which these breastfeeding mothers were observed to sleep. Cover position on babies was highly variable both from family to family, and between dyadic and triadic nights. Bed-covers were generally lower on an infant's body when sleeping with the mother only, or when sleeping on the outside of the mother on the triadic night, than when sleeping between both parents. However, there was no significant difference in the median proportion of scans in which babies had bed-covers over their heads on the dyadic and triadic nights (Table 4), or the median proportion of time babies spent with the covers above versus below their waists.

TABLE 4 HERE

Mothers predominantly kept the bed-covers at their own waist-height on the dyadic sleep night, and although covers were higher on the mother when the father was sharing the bed (due to fathers keeping the covers at chin height), there was no significant difference in cover height on the two nights. On the dyadic night there was a tendency for infants to rotate from a vertical towards a horizontal position in the bed, which was not observed on the triadic night, presumably due to the greater space available in the bed in the father's absence. That infants spent proportionally less of the dyadic night than the triadic night sleeping perpendicular to the headboard was significant.

Some families slept under duvets or comforters, while others used blankets, but all were sufficiently flexible that they did not cover the infant's head when they were pulled up under

the parents' chins. None of the infants videotaped wore more than a stretchy sleepsuit when bed-sharing, and none appeared unusually sweaty in the course of either dyadic or triadic bed-sharing nights, although without a temperature monitor attached to the infants our assessments here are based on limited evidence.

Behaviour of non-breastfeeding bed-sharing dyads

Videotapes of 10 families with infants who were not breastfed were analysed as above, and our hypothesis that the behaviour of bed-sharing non-breastfeeding mothers and infants would differ from that of breastfeeding dyads was supported. Table 5 compares the behavioural results for breastfeeding and non-breastfeeding bed-sharers. Significant differences were found between the two groups in relation to the proportion of the night mothers faced their infants and consequently the proportion of the night mothers and infants spent in face-to-face orientation; infant sleeping position (breastfed infants slept predominantly on their sides, formula-fed infants slept on their backs); height of infant in bed relative to mother (breastfed infants were at chest height, formula-fed infants were at face height); and feeding and waking frequency (breastfed infants woke and fed more frequently than formula-fed infants).

TABLE 5 HERE

DISCUSSION

Breastfeeding mother-infant dyads have now been observed displaying the same bed-sharing behaviour in 3 separate studies under different conditions suggesting that a robust picture of bed-sharing behaviour is emerging. The finding that a characteristic sleep position is consistently adopted by bed-sharing breastfeeding mothers suggests that adoption of this sleep position is an instinctive evolved behaviour. As female great apes are also documented to adopt this position when sharing sleeping nests with their small infants (Goodall 1968) it is possible that this behaviour evolved in the context of infant protection and

safety². Human mothers sleeping curled up around their infants in this manner effectively provide a barrier with their upper legs that prevents the baby moving down the bed under the covers. They also form a barrier with their upper arm above the baby's head, that prevents the baby from moving up the bed and into (or under) the mother's pillow(s). The baby sleeps flat on the mattress (not propped by pillows), either in a lateral or supine position³. The fact that the mother is curled around her infant means she cannot roll forwards onto it, and neither can any other bed-sharers lie on the baby without lying on the mother also. This position is identical to that described by Mosko et al (1997c); Richard et al (1996), and depicted by Young (1999).

We examined whether sleeping with both parents involved more hazardous situations for an infant than sleeping with the mother alone. Despite the fact that there were pillows in the bed on all occasions no infants were observed with their face in the pillows, and pillows rarely touched the top of an infant's head -- due to the characteristic position in which these breastfeeding dyads were to sleep. Potential infant overheating is sometimes cited as a risk factor in triadic bed-sharing due to possible thermal-coupling between two adult bodies (Tuffnell et al. 1996). The observation that most infants spent the vast majority of both nights in close proximity to the mother, with the father at some distance away, suggests that the presence of the father in the bed will have a negligible impact on the temperature of the infant -- although size of the bed and parental body size will both be factors affecting this relationship.

² Several pieces of artwork throughout 19th and 20th centuries have also depicted mothers and infants sleeping together in this position e.g. Elwell's 'The Firstborn' (Feren's Art Gallery, Hull, UK), and Mohderson's 'Mutter mit kind' (Berlin, Germany) .

³ It is possible that because the babies in the sleep lab studies were wired-up for polysomnographic monitoring the supine position may have been more comfortable, thus affecting sleep position. Alternatively we may have used different criteria to distinguish between lateral and supine positioning.

A picture emerges of some notable differences in sleeping arrangements between breastfeeding bed-sharing parents and infants and formula-feeding parents and infants. The most striking of these involve the infant's body position, and his/her position in the bed. Formula-fed infants predominantly slept supine, while all but one breastfed infant spent the majority of the night sleeping in a lateral position. This significant difference appears to reflect the ease of breastfeeding in the lateral position. The supine sleeping position is recommended for infants in all western countries due to the increased risk of cot death among infants sleeping prone (e.g. AAP 2000; Beal 2000; Dwyer 1996; Esmail et al. 1995; Fleming et al. 1990; Gibson et al. 2000; Markestad et al. 1995; Scragg, et al. 1996; Willinger et al. 2000). Although recommended in the US until recently, the lateral sleep position has been discouraged for UK infants for around a decade, as several case-control SIDS studies have indicated that sleeping on the side is associated with a greater risk of SIDS than supine sleep (Fleming et al. 2000; Scragg and Mitchell 1998; Skadberg et al. 1998; Wigfeld et al. 1992). It would seem, therefore, that when bed-sharing, formula-fed infants are more compliant with back-to-sleep guidelines than breastfed infants. The issue is complicated, however, in that epidemiological studies examining sleeping position have not done so in the context of bed-sharing. Several of the above-mentioned authors (e.g. Fleming et al. 2000; Skadberg et al. 1998; Wigfield, et al. 1992) have noted that infants sleeping alone who are positioned laterally may roll forwards into the prone position (thereby increasing their risk of SIDS), however an infant sleeping in a lateral position next to its mother's body is unable to roll forwards. It is currently unknown whether lateral sleeping in this context is also associated with an increased SIDS risk. The relationship between the sleeping position of babies who practice breastfeeding related bed-sharing and SIDS-risk is therefore a topic that requires further exploration in future epidemiological studies.

Infant 'height' in the bed (i.e. closeness to parental faces) also differed significantly between breastfed and formula-fed babies with parents of the latter exhibiting a tendency to place their infants high in the bed, with infants' faces level with parents' faces, and infants either

positioned between, or on top of, the parents' pillows. Breastfed infants were commonly positioned flat on the mattress, below pillow height, level with the mother's chest. The predominant location in the bed for all infants was the middle of the bed, between both parents, however breastfed infants also spent time sleeping on the outside of the mother, while formula-fed infants tended not to be moved around the bed. The changing location of the breastfed infants reflects the fact that some mothers moved their baby to their left or right to facilitate feeding from a particular breast. It was apparent, however that some mothers were able to feed from either breast while remaining in the same position.

As would be expected (see Ball 2003), feeding frequency and feeding duration differed significantly between breastfeeding and formula-feeding bed-sharers, the latter feeding on average once per night, while the former fed at least twice, some infants feeding four or more times during the night. Feeding frequency is related to arousal frequency and arousal synchrony between bed-sharing mothers and infants, with breastfeeding mothers and infants experiencing significantly greater arousal frequencies during the night than formula-feeding mothers and infants, together with more synchronous arousals.

Formula-feeding mothers did not have the same degree of orientation towards their infants during sleep as breastfeeding mothers, and spent significantly less time both facing their infant, and in mutual face-to-face orientation, than did breastfeeding mother-infant pairs. There was no significant difference found in the orientation of fathers to their breast or formula-fed infants.

Many of the bed-sharing safety issues discussed above regarding breastfed infants also apply to formula-fed infants. However, given the differences in bed-sharing parameters such as infant position and parental orientation between breast and formula-fed infants, it is useful for certain aspects of bed-sharing safety to be considered separately for each group.

Several of the formula-fed infants were placed with their heads (and shoulders) on their parents' pillows for the majority of the night. Breastfed infants, on the other hand, were never placed on or near the pillows. We suggest that mothers of formula-fed infants (particularly mothers who have never breastfed) sleep with their infants in the manner of sleeping with another adult (e.g. faces at same height, no consistent 'protective' sleeping position), while mothers of breastfed infants sleep with their babies in a more 'protective' manner – baby positioned at breast-level, with mother oriented towards baby in a characteristic position. The breastfeeding mothers in this study slept with their infants in a safer manner than the non-breastfeeding mothers.

Covering the face with bed-clothes was an infrequent occurrence for the majority of infants in both groups and neither breast nor formula fed babies were more likely to have their heads covered during bed-sharing, despite the fact that the breastfed babies in general slept lower in the bed than did the formula-fed babies.

These findings illustrate that bed-sharing is not a 'generic' behaviour for all mothers and infants. The sleep relationship observed (in this and other studies) between breastfeeding mothers and infants is qualitatively and quantitatively different from that observed between formula-feeding mothers and infants. The patterning of these differences is consistent with our understanding of the physiological mechanisms mediating maternal and infant behaviour, in that breastfeeding mothers experience a hormonal feedback cycle which promotes close contact with, heightened responsiveness towards, and bonding with infants in a way that is missing for mothers who do not breastfeed (Hrdy 1999, Small 1999). Furthermore, infants who are breastfed instinctively orient towards maternal breast odour (Varendi and Porter 2001), an instinct which would contribute to the maintenance of the characteristic sleeping position observed for breastfeeding mother-infant dyads.

These characteristic differences in sleep behaviour when bed-sharing may well affect the

outcomes of case-control studies regarding infant safety or SIDS-risk where cases and controls are not matched for infant feeding behaviour. The results presented here indicate that not only should cases and controls be matched for variables known to affect bed-sharing behaviour, but that detailed data should also be collected on the manner of bed-sharing by each family involved (e.g. infant position in the bed) regarding both their normal practice, and on the night in question.

CONCLUSION

This study confirms in the home environment the picture of bed-sharing among breastfed mother-infant dyads reported in sleep labs by two other research groups. For formula-fed infants we found that the bed-sharing picture is somewhat different due to the lack of a breast-baby orientation during sleep. Principal safety issues regarding bed-sharing relate to the characteristic differences of these two groups – the danger of accidental suffocation by an infant sleeping on or near the parental pillows is cause for concern regarding formula-fed infants, while the tendency of breastfed infant to assume a lateral rather than supine sleep position while bed-sharing might cause concerns regarding the possibly elevated risk of SIDS in non-supine sleeping infants. This issue could be addressed in a case-control study where the cases are matched for feeding behaviour. The father's presence in the bed did not appear to present any universal safety implications for bed-sharing infants, however the fact that there was great individual variation observed in paternal arousability in response to infants during the night would be worthy of further exploration. An important implication of this study is that epidemiological investigations of the risks of SIDS and accidental deaths in a bed-sharing context should include the matching of cases and controls by the feeding behaviour of the infants studied. The results of this study, and an evolutionary-informed viewpoint, predict that bed-sharing may be safer for breast-fed than never-breastfed infants.

BIBLIOGRAPHY

AAP (2000). "Task Force on Infant Sleep Position and Sudden Infant Death Syndrome:

- Changing concepts on sudden infant death syndrome: implications for infant sleeping environment and sleep position." Pediatrics 105(3): 650-656.
- Ball, H. L. (2002). "Reasons to bed-share: why parents sleep with their infants." Journal of Reproductive and Infant Psychology 20(4): 207-222.
- Ball, H. L. (2003). "Breastfeeding, bed-sharing and infant sleep." Birth 30(3): 181-188.
- Ball, H., E. Hooker, PJ Kelly. (2000). "Parent-Infant Cosleeping: fathers' roles and perspectives." Infant and Child Development 9: 67-74.
- Ball, H. L., E. Hooker, PJ Kelly. (1999). "Where will the baby sleep? attitudes and practices of new and experienced parents regarding cosleeping with their newborn infants." American Anthropologist 10 (1): 143-151.
- Beal, S. (2000). "Sudden Infant Death Syndrome in South Australia 1968-97. Part I: changes over time." Journal of Paediatrics and Child Health 36(6): 540-7.
- Byard, R. W. (1994). "Is co-sleeping in infancy a desirable or dangerous practice?" Journal of Paediatrics and Child Health 30: 198-199.
- Carpenter, R. G., L. M. Irgens, et al. (2004). "Sudden unexplained infant death in 20 regions in Europe: case control study." The Lancet 363: 185-191.
- Christensson, K., Siles, C, Moreno, L., Belaustequi, A., De La Fuente, P., Lagercrantz, H., Puyol, P., Winberg, J. (1992). "Temperature, metabolic adaptation and crying in healthy full-term newborns cared for skin-to-skin or in a cot." Acta Paediatrica 81(6-7): 488-93.
- De Chateau, P. and B. Wiberg (1977). "Long-term effect on mother-infant behaviours of extra contact during the first hour post partum. II. A follow up at three months." Acta Paediatrica Scandinavia 66(2): 145-151.
- Drago, D. A. and A. L. Dannenberg (1999). "Infant mechanical suffocation deaths in the united states, 1980-1997." Pediatrics 103 (5): 1-8.
- Dwyer, T. (1996). "Sudden infant death syndrome: after the "back to sleep" campaign." British Medical Journal 313: 180-181.
- Esmail, A., P. C. Lambert, et al. (1995). "Prevalence of risk factors for Sudden Infant Death Syndrome in South East England before the 1991 national 'back to sleep' health

- education campaign." Journal of Public Health Medicine 17 (3): 282-289.
- Fleming, P. J., P. Blair, et al. (2000). Sudden Infant Death Syndrome: Modifiable risk factors and the window of vulnerability. Sleep and Breathing in Children: A Developmental Approach. G. M. Loughlin, J. L. Carroll and C. L. Marcus, Marcel Dekker: 443-464.
- Fleming, P. J., R. Gilbert, et al. (1990). "Interaction between Bedding and Sleeping Position in the Sudden Infant Death Syndrome: A Population Based Case-Control Study." British Medical Journal 301: 85-89.
- Gibson, E., C. A. Dembofsky, et al. (2000). "Infant sleep position practices 2 years into the "Back to Sleep" Campaign." Clinical Pediatrics 39(5): 285-289.
- Gomez Papi, A. Baiges-Nogues., M. T.; Batiste Fernandez, M. T.; Marea Gutierrez, M. M.; Nieto Jurado, A.; Closa Monasterolo, R. (1998). "Kangaroo method in delivery room for full-term babies." Annals Espana Pediatrica. 48(6): 631-3.
- Hamlyn, B. (2002). Infant Feeding 2000: a survey conducted on behalf of the Department of Health, the Scottish Executive, the National Assembly for Wales and the Department of Health, Social Services and Public Safety in Northern Ireland. London, TSO.
- Hrdy, S. B. (1999). Mother Nature: A history of mothers, infants and natural selection. Pantheon, New York.
- Ludington-Hoe, S. M. A. G. C., Simpson, S., Hollingshead, A., Argote, L.A., Rey, H. (1999). "Birth-related fatigue in 34-36-week preterm neonates: rapid recovery with very early kangaroo (skin-to-skin) care." Journal of Obstetric, Gynecologic and Neonatal Nursing 28(1): 94-103.
- Markestad, T., B. Skadberg, et al. (1995). "Sleeping position and sudden infant death syndrome (SIDS): effect of an intervention programme to avoid prone sleeping." Acta Paediatrica 84: 375-378.
- Matthiesen, A., A. Ransjo-Arvidson, Nissen, E.; Uvnas-Moberg, K. (2001). "Postpartum maternal oxytocin release by newborns: effects of infant hand massage and sucking." Birth 28(1): 13-9.
- McKenna, J., M. Andolina, et al. (2001). "Bedsharing/breastfeeding mothers and infants:

- adaptation or pathology?" American Journal of Physical Anthropology 70th Annual Meeting Abstracts.
- McKenna, J. and S. Mosko (2001). Mother-infant cosleeping: toward a new scientific beginning. Sudden Infant Death Syndrome: problems, progress & possibilities. R. Byard and H. Krous. New York, Arnold: 258-272.
- McKenna, J. J. (1990). "Evolution and Sudden Infant Death Syndrome (SIDS): Part 1: Infant responsivity to parental contact." Human Nature 1(2): 145-177.
- McKenna, J. J. (2000). Cultural influences on infant and childhood sleep biology, and the science that studies it: toward a more inclusive paradigm. Sleep and Breathing in Children: A Developmental Approach. G. M. Loughlin, J. L. Carroll and C. L. Marcus, Marcel Dekker.
- McKenna, J. J. and N. J. Bernshaw (1995). Breastfeeding and infant-parent cosleeping as adaptive strategies: are they protective against SIDS. Biocultural Perspectives. P. Stuart-Macadam and K. Dettwyler (eds). New York, Aldine De Gruyter: 265-305.
- McKenna, J.J. and T. McDade (2005) "Why babies should never sleep alone: A review of the co-sleeping controversy in relation to SIDS, bed-sharing and breastfeeding." Paediatric Respiratory Reviews 6: 134-152.
- McKenna, J. J., S. Mosko, et al. (1990). "Sleep and arousal patterns of co-sleeping human mother/infant pairs: a preliminary physiological study with implications for the study of infant death syndrome (SIDS)." American Journal of Physical Anthropology 83: 331-347.
- McKenna, J. J. and S. S. Mosko (1994). "Sleep and arousal, synchrony and independence, among mothers and infants sleeping apart and together (same bed): an experiment in evolutionary medicine." Acta Paediatrica Supplement 397: 94-102.
- McKenna, J. J., S. S. Mosko, et al. (1997). "Bedsharing promotes breastfeeding." Pediatrics 100: 214-219.
- McKenna, J. J., E. B. Thoman, et al. (1993). "Infant-parent co-sleeping in an evolutionary perspective: implications for understanding infant sleep development and the Sudden Infant Death Syndrome." Sleep 16(3): 263-281.

- Mitchell, E. A. and R. Scragg (1993). "Are infants sharing a bed with another person at increased risk of Sudden Infant Death Syndrome?" Sleep 16(4): 387-389.
- Mosko, S., C. Richard, et al. (1997a). "Infant arousals during mother-infant bedsharing: implications for infant sleep and Sudden Infant Death Syndrome research." Pediatrics 100(5): 841-850.
- Mosko, S., C. Richard, et al. (1997b). "Maternal sleep and arousals during bedsharing with infants." Sleep 20(2): 142-150.
- Mosko, S., C. Richard, et al. (1997c). "Maternal proximity and infant CO2 environment during bedsharing and possible implications for SIDS research." American Journal of Physical Anthropology 103: 315-328.
- Nakamura, S., M. Wind, et al. (1999). "Review of hazards associated with children placed in adult beds." Archives of Pediatric and Adolescent Medicine 153: 1019-1023.
- Nissen, E. L., G., Widstrom, A.M., Uvnas-Moberg, K (1995). "Elevation of oxytocin levels early post partum in women." Acta Obstetrica et Gynecologica Scandinavica 74(7): 530-3.
- Richard, C., S. Mosko, et al. (1996). "Sleeping position, orientation, and proximity in bedsharing infants and mothers." Sleep 19(9): 685-690.
- Scragg, R. K. R. and E. A. Mitchell (1998). "Side sleeping position and bed sharing in the sudden infant death syndrome." Annals of Medicine 30: 345-349.
- Scragg, R. K. R., E. A. Mitchell, et al. (1996). "Infant room-sharing and prone sleep position in sudden infant death syndrome." Lancet 347: 7-12.
- Skadberg, B. T., I. Morild, et al. (1998). "Abandoning prone sleeping: effects on the risk of Sudden Infant Death Syndrome." The Journal of Pediatrics 132(2): 340-343.
- Small, M. (1992). "A Reasonable Sleep." Discover April: 83-88.
- Small, M. F. (1998). Our babies ourselves - how biology and culture shape the way we parent. New York, Doubleday Dell Publishing Group Inc.
- Tappin D, Ecob R, Brooke H. (2005) Bedsharing, roomsharing, and sudden infant death syndrome in Scotland: a case-control study. Journal of Pediatrics. 147(1):32-7

- Trevathan, W. R. and J. J. McKenna (1994). "Evolutionary environments of human birth and infancy: insights to apply to contemporary life." Children's Environments 11 (2): 88-104.
- Tuffnell, C. S., S. A. Petersen, et al. (1996). "Higher rectal temperatures in co-sleeping infants." Archives of Disease in Childhood 75: 249-250.
- Varendi, H., R.H. Porter (2001) "Breast odour as the only maternal stimulus elicits crawling towards the odour source." Acta Paediatrica 90 (4): 372-375.
- Vial-Courmont M. The "Kangaroo" ward Med Wieku Rozwoj. 2000;4(2 Suppl 3):105-17
- Wigfield, R. E., P. J. Fleming, et al. (1992). Can the Fall in Avon's Sudden Infant Death Rate be Explained by Changes in Sleeping Position? British Medical Journal. 304: 282-283.
- Willinger, M., C. W. Ko, et al. (2000). "Factors associated with caregivers' choice of infant sleep position, 1994-1998: the National Infant Sleep Position Study." Journal of the American Medical Association 283(16): 2135-42.
- Young, J. (1999). PhD thesis: Night-time behaviour and interactions between mothers and their infants of low risk for SIDS: a longitudinal study of room sharing and bedsharing. Institute of Infant and Child Health, University of Bristol.

Table 1: Socio-demographic characteristics of families participating in study

	Total sample	Breastfeeders	Non-breastfeeders	
Mother's age	28 years	30 years	25 years	ns
Father's age	31 years	34 years	27 years	ns
Infant's age	17 wks	18 wks	15 wks	ns
Mother's education	Up to age 18	Up to age 20	To age 17	ns
Father's education	Up to age 18	Up to age 19	To age 18	ns
Household income	£21,000	£29,000	£10,000	p=0.025
Parity	1.5	1.6	1.3	ns

Table 2: Comparison of breastfeeding mother-infant dyads bed-sharing in own homes (current study), hospital sleep lab in California (Richard, Mosko et al. 1996) and hospital sleep lab in Bristol UK (Young 1999).

	Current study (in home)	California study Hospital lab	Bristol study Hospital lab
Number of routinely bed-sharing (RBS) mother-infant pairs	10 pairs	6 pairs	5 pairs
Maternal age	28.8 (19-36) years	27 (18-37) years	35 (25-39) years
Infant age	2-6 months	2-4 months	1-5 months
Hours of RBS mother-infant bed-sharing observational data	80 hours	~48 hours	30 hours
Size of bed for bed-sharing	Double to King 4ft 6in to 6ft	Hospital bed , 3 ft	Double bed 4ft 6in
Proportion of sleep time for which:			
Mother faced infant	76% (median)	74%	71%
Infant faced mother	97% (median)	87%	89%
Face-to-face orientation	65% (median)	68%	56%
Infant supine	25% (median)	62%	72% (median)
Infant lateral	74% (median)	38%	13% (median)
Infant prone	0% (median)	0%	0% (median)
Proximity (head)	No data	<20cm	20-60cm
Proximity (body)	<20 cm (91%)	No data	<20cm (99%)
Bf frequency (whole night)	3.0 (median)	4.7 (mean)	3 (median)
Total feeding time during night	36 mins (median)	56 mins (mean)	34 mins (median)

Table 3: Comparison of breastfeeding mother-infant pairs in dyadic and triadic (with father) sleeping arrangements

	Dyadic night	Triadic night	
Hours of bed-sharing data (median)	8:06 hours	8:00 hours	
Orientation			
Mother facing infant	76%	73%	NS
Infant facing mother	97%	65%	NS
Face-to-face orientation	65%	47%	NS
Infant sleep position			
Infant supine	25%	40%	NS
Infant lateral	74%	54%	NS
Infant prone	0%	0%	NS
Infant bed position			
Infant in middle of bed (between parents on TN)	0%	65%	P=0.028
Infant on outside of bed next to mother	98%	35%	P=0.028
Mother-infant proximity			
Touching	71%	75%	NS
> 10cm apart	20%	9%	Ns
Breastfeeding			
Feed frequency / night	3 bouts	2.5 bouts	NS
Total feeding time	36 minutes	31 minutes	NS
Awakening frequency			
Number maternal arousals per night	6 (range=3-9)	4 (range=3-5)	P=0.037
Number of infant arousals per night	5 (range=2-9)	3 (range=2-5)	P=0.043
Number of mutual arousals per night	5 (range=2-9)	3 (range=1-4)	P=0.028

All averages are expressed as medians. All tests of significance for within-subject comparisons were conducted using Wilcoxon signed ranks test.

Table 4: Infant head-covering on dyadic and triadic bed-sharing nights.

	Dyadic	Triadic	Sig
Covers over baby's head (when parents asleep)	0% median (0-45%)	0% median (0-47%)	NS
Covers above baby's waist	96.1% median (27-100%)	72.1 (median) (28-100%)	NS
Covers at mother's chin level or above	15.0% median (0-91.5%)	31.6% median (0-81.7%)	NS
Baby rotated across bed (when parents asleep)	1.9% median (0-76.9%)	0% median (0-37.4%)	Z=-2.023 p=0.043
Infant face at mother's chest height (when all asleep)	83.3% median (38.9-100%)	100% median (36.9-100%)	NS

Table 5: Comparison of bed-sharing characteristics for breastfed and formula-fed infants.

	Formula-fed	Breastfed	Significance
Hours of bed-sharing data (median)	7.6 hours	8.0 hours	
Orientation to mother*			
Mother facing infant	59%	73%	$z=-1.96$, $p=0.05$
Infant facing mother	46%	65%	ns
Face-to-face orientation	32%	47%	$z=-2.277$, $p=0.02$
Orientation to father*			
Father facing infant	46%	26%	ns
Infant facing father	20%	9%	ns
Face-to-face orientation	8%	0%	ns
Infant sleep position			
Infant supine	83%	40%	$z=-2.328$, $p=0.02$
Infant lateral	6%	54%	$z=-2.414$, $p=0.02$
Infant prone	0%	0%	ns
Parent-infant proximity			
Touching mother	60%	75%	ns
Touching father	20%	6%	ns
Parent-Infant sleeping position			
Mother curled up round infant	25%	49%	ns
Father curled up round infant	0%	0%	ns
Height of infant in bed relative to mother			
Infant face level with mother's face or chin	71%	0%	$z=-2.472$, $p=0.01$
Infant face level with mother's chest	29%	100%	$z=-2.387$, $p=0.02$
Infant face below mother's chest height	0%	0%	ns
Direction of infant in bed			
Vertical position (perpendicular to headboard)	94%	86%	ns
Rotated between 30-60° to either side	5%	13%	ns
Feeding			
Feed frequency / night	1.0 bouts	2.5 bouts	$z=-2.599$, $p=0.009$
Total feeding time	9 minutes	31 minutes	$z=-2.699$, $p=0.007$
Awakening frequency			
Number maternal arousals per night	2 (range=0-4)	4 (range=3-5)	$z=-3.183$, $p=0.001$
Number of infant arousals per night	2 (range=0-3)	3 (range=2-5)	$z=-2.728$, $p=0.006$
Number of mutual arousals per night	1 (range=0-2)	3 (range=1-4)	$z=-2.988$, $p=0.003$

Figure 1: Characteristic sleep position of breastfeeding mothers and infants

