Chapter 5
Sudden Infant Death Syndrome

Charlotte K. Russell, Ph.D., Lane E. Volpe, Ph.D. and Prof. Helen L. Ball, Ph.D.

Lay summary Human infants have needs which are unique among primates. These are primarily a consequence of their comparatively poor neurological and muscular development at birth (compared to other primate infants who are able to cling and maintain proximity with their mother). This results in infants who would be very vulnerable in the absence of a caregiver and who rely on their mother to provide close contact for frequent feeds, safety and physiological regulation. Looking at human infants in this light allows us to think critically about the way parents in Western cultures care for their babies, and the possible consequences of these infant care practices for infant health, including the risk of sudden infant death syndrome (SIDS). In most traditional (non-Western) human societies, mothers keep their infants in close contact both during the day and the night. Infants in these societies wake frequently during periods of sleep, and breastfeed on demand. In contrast, in Western societies, infant care practices emphasise sleeping alone for extended periods of time, and early cessation of breastfeeding.

As both lone sleeping and use of infant formula are associated with increased incidence of SIDS, in human infants who have evolved to expect continuous physical contact with a caregiver, some researchers have suggested that SIDS (a syndrome characteristic of Western societies) may be a consequence of a mismatch between Western infant care practices, and the unique vulnerabilities of human infants. Where infants sleep has long been a focus of both parent-educators and campaigners trying to reduce the rate of SIDS.

C.K. Russell (✉) · L.E. Volpe · H.L. Ball
Parent-Infant Sleep Lab, Department of Anthropology, Durham University, Durham, UK
e-mail: c.k.russell@durham.ac.uk

H.L. Ball
e-mail: h.l.ball@durham.ac.uk

L.E. Volpe
The Implementation Group, Colorado, USA
e-mail: Lane@TheImplementationGroup.com

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Because some infants die of SIDS while sleeping in an adult bed, this sleep location has, for the past 20 years, been the focus of many anti-bed-sharing campaigns. However, because infant sleep location is also intimately related to infant feeding method (breast vs. formula), individual parenting ethos and cultural pressures, such campaigns have come to be regarded as being both ineffectual and unethical, and alternative approaches developed.

Alternate approaches focus on evidence-based education for parents, and culturally relevant interventions which facilitate close contact for infants and caregivers while providing safe sleeping spaces for infants who may be more vulnerable to SIDS. Such interventions, including the UNICEF UK Baby-Friendly Initiative, Infant Sleep Safety Tool (ISST) and Wahakura infant sleep basket, address infants' evolved needs while also acknowledging the trade-offs that parents consider in making decisions about infant care.

5.1 Introduction

5.1.1 Evolved Infant Biology and Infant Care

An evolutionary perspective on SIDS and night-time infant care considers the incongruity between an infant's evolved biological and behavioural needs, and culturally mediated twenty-first-century infant care practices. Understanding of human infants' evolved biological needs can be gained via the comparative perspective of human traits with those of other mammals and primates with whom we share a common ancestor.

As placental mammals, humans produce relatively well-developed live-born young who require maternal post-natal care and lactation. Developmental state at birth and gestational length vary among mammalian species, and infants can generally be categorised within two types. 'Altricial' species produce infants that are comparatively immature at birth; neuromuscular control is poor, infants are often blind and hairless and are 'cached', or sequestered in nests. They are fed infrequently with milk that is high in fat. Primates, along with many other mammals, produce 'precocial' infants—meaning they are well-developed at birth, able to see, hear and maintain proximity with their mothers via independent locomotion, or clinging. Mothers of precocial infants produce milk that provides energy, but little fat, that must be consumed frequently. Humans conform only partially to the typical 'precocial' primate pattern, with infants feeding frequently on milk that is relatively low in protein and fat, but high in sugar [1].

Unlike non-human primates, human infants also display secondarily altricial characteristics as a consequence of the limits placed either by the bipedally adapted

pelvis on foetal brain growth (see also Chap. 3 on the obstetric dilemma) or by the constraints of maternal basal metabolic rate (BMR) to sustain a foetus for longer than 9 months [2, 3]. Regardless of the limiting factor, the net result is that human infants are born in a state of neurological immaturity with particularly poor neuromuscular control at birth, creating an inability to independently locomote or cling, and relatively poor homeostatic control [4, 5]. The high sugar content of human milk supplies the energy needed for fast brain growth in infancy; however, human infants' lack of neuromuscular control means that mothers are responsible for providing close physical contact for safety, frequent feeds and physiological regulation.

Cross-cultural studies demonstrate that in most traditional human societies, infants are maintained in constant physical contact with a caregiver—usually their mother—both day and night, experience frequent arousals during periods of sleep and suckle on demand, throughout the first year of life [6]. Care is therefore congruent with infants' evolved needs, providing close contact and responding to frequent feeds. In contrast, social and cultural changes occurring in industrial and post-industrial societies have resulted in infant care practices that encourage solitary and prolonged sleep bouts from an early post-natal age, and which are now considered characteristic of Western cultures [7]. Feeding artificial infant formula (see also Chap. 4 on bottle feeding)—composed largely of another quite different species' milk—and encouraging, or even training, infants to sleep without parental presence both affect normal patterns of early sleep development [8, 9]. Decisions about infant sleep location are both influenced by, and impact on, infant feeding practices—notably breastfeeding initiation and duration [10]. A vast and lucrative market promotes sleep training programmes based on behavioural modification, while numerous infant care products (e.g. dummies, swaddling wraps, rocking, swinging or bouncing cradles, white noise apps and soft toys which vibrate to mimic mothers' heartbeat) exist with the principal aim of allowing infants to be 'put down', self-sooth, sleep longer or wake less.

5.1.2 Sudden Infant Death Syndrome (SIDS)

SIDS was defined in 1965 under code 795 of the international classification of diseases (ICD-8; now ICD-10, code R95). SIDS is not a 'cause' of death; it is a category of exclusion used to designate the death of an infant that, following a review of clinical history, post-mortem examination and investigation of the death scene, remains unexplained [11]. Although rare, SIDS is the primary designation of death for infants between one month and one year of age, affecting approximately 1 in 3000 babies in the UK and 1 in 2000 in the USA annually. Deaths typically occur during night-time or daytime sleep, and prevalence peaks at 2–3 months.

SIDS is grouped with other sudden explainable infant deaths under the category SUDI—sudden unexpected death in infancy. There are clinical similarities between SIDS and explained SUDI: both groups of infants have poorer overall health, along

with a history of apparent life-threatening events (ALTE) [12]. Differentiation of SIDS and explained SUDI can be problematic due to the lack of pathological markers distinguishing SIDS from soft suffocation. The evidence used to categorise such deaths, therefore, is often circumstantial. Coroners sometimes use the designation unexplained/unascertained, rather than SIDS or explained SUDI in response to contextual elements of the death scene, such as sleep-sharing at the time of death [13]. Local and national variation in designation can skew figures and distort comparisons between populations, particularly where population-level differences in the prevalence of certain risk factors—for example bed-sharing—exist [14].

Primarily, SIDS deaths are a phenomenon affecting Western post-industrial societies where prolonged and solitary infant sleeping has been promoted as a goal to be achieved early in infancy, and where parental behaviours (such as smoking or alcohol consumption) are incompatible with infant care. Alongside cultural variation in infant care practices, the incidence of SIDS varies dramatically, both on a global scale [15, 16], and within geographically local populations [17]. Typically, deaths occur during prolonged lone sleep bouts, or while sharing a sleep surface with an adult under dangerous circumstances. Studies in the UK found that 75 % of daytime SIDS occurred while infants were sleeping in a room alone [18]. Fifty-four per cent of SIDS infants died while sleep-sharing with an adult—however, only 6 % were sleep-sharing in the absence of cumulative risk factors including alcohol, illegal drugs, smoking and sofa-sharing [19]. Additionally, formula-feeding increases the risk of SIDS. A recent meta-analysis of 18 studies found that the risk of SIDS was lower for breastfed infants. This reduction was dose-responsive and may be explained in terms of decreased arousability from sleep, or immunological deficits associated with the absence of breastfeeding [20].

5.1.3 Cross-Cultural Perspectives

In the UK, studies of South Asian immigrants demonstrate an extremely low incidence of SIDS, with a death rate four times lower than their UK-born neighbours, despite residence in socio-economically disadvantaged areas typically associated with high SIDS rates. Studies comparing immigrant and Euro-born British families reveal substantially different infant care practices [17]. South Asian families employ ‘proximal care’ strategies, in which physical contact is maintained day and night between infants and one or more caregivers. Breastfeeding is typical, and frequent, and infant developmental trajectories are allowed to progress without interference [21]. Infant care therefore conforms to the pattern predicted by an evolutionary perspective based on comparative and cross-cultural patterns. In contrast, Euro-origin British families exhibit more ‘distal care’ strategies, encouraging self-soothing and sleeping alone from an early age, and earlier (within the first month) cessation of breastfeeding.

That an evolutionary mismatch exists between Western infant care practices and the unique vulnerabilities of human infants [22] may contribute to an explanation for

the high rates of SIDS in Western cultures. McKenna and colleagues have argued that close mother–infant contact compensates for infants' developmental immaturity, and that the absence of such contact during extended bouts of sleep—a consequence of infant care practices that aim to promote early infant independence—may therefore be failing to support infants during early critical developmental periods [23, 24]. This hypothesis builds upon a body of work which identifies multiple deleterious consequences of early physical separation of infants from mother or other carer, in both humans and non-humans, in terms of infants' physiological regulation and development [4, 5, 25–30].

5.2 Research Findings

5.2.1 SIDS Epidemiology

Since the 1960s, researchers have been searching for factors that explain or are associated with such deaths. Much of this work has employed the case–control study design (see Box 5.1). While case–control studies cannot provide proof of causation, repeated findings of an association between exposure to a 'factor' and incidence of SIDS suggest links between characteristics of infants or their care and an increased or decreased risk, and allow public health advisers to make recommendations for ways in which risk might be reduced and arguably how deaths might be prevented. Generally, such hypotheses regarding risk reduction interventions would be tested via randomised control trials, but with SIDS cases are too infrequent for this to be a realistic proposition.

Box 5.1: What Is a Case–Control Study?
Case–control studies are used widely in epidemiology, as their retrospective design enables researchers to study factors associated with diseases which, because of their rarity, would be difficult to study prospectively. In the case of SIDS, researchers compare two groups: the 'cases'—infants who have died and whose deaths have been designated SIDS, and the 'controls'—infants who did not die, but are individually matched on multiple variables, which may include physical and socio-economic characteristics, to 'case' infants. Using data obtained via family interviews, and examination of the death scene (or a predetermined sleep scene for controls), researchers conduct a retrospective analysis of factors to which infants were, or were not, exposed. Analysis of the incidence of exposure to one or more risk factors in both 'case' and 'control' groups results in an 'odds ratio' (OR) which, together with associated confidence intervals, describe the direction, magnitude and statistical significance of the effect of exposure to risk factor(s) on incidence of SIDS within the study population.

Case–control studies have identified a range of factors—both intrinsic and extrinsic to the infant—that are associated with SIDS deaths. These include lower socio-economic status, male infant, premature or low birthweight infant, pre- or post-natal smoke exposure and absence of breastfeeding [20, 31]. Additionally, numerous aspects of the sleep environment that produce some form of physiological challenge on an infant have also been associated with SIDS: prone- or side sleep position, overwrapping [32, 33], overheating, soft bedding or sleep surfaces [34, 35], co-sleeping in some circumstances [19, 36], not using a dummy [35, 37, 38], and infant sleeping in a separate room from their parents [18, 36].

Research into the key mechanisms underlying SIDS has identified a number of potentially causal factors that may increase individual infant vulnerability. Primarily, theories have focused on deficits in autonomic control, genetic factors and infection. As noted above, many extrinsic risk factors have been found that provide a physiological challenge to the infant, or may be associated with a failure to arouse normally from sleep, and form the focus of much current SIDS reduction guidance under the assumption that these are modifiable factors. The commonly accepted triple-risk hypothesis proposed by Filiano and Kinney [39] describes the confluence of a vulnerable infant, at a critical stage of development, exposed to an external stressor (Fig. 5.1).

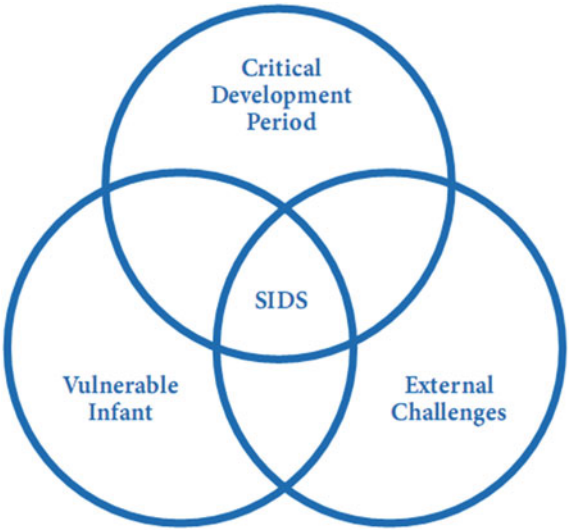

Fig. 5.1 The triple-risk model for SIDS

5.2.2 The Question of Sleep Location

The 'Back-to-Sleep' campaigns of previous decades were successful in modifying particular sleep behaviours (such as prone infant sleep position) and reducing SIDS rates in many countries across the Western world [40]. SIDS rates have now plateaued, and further reductions are proving difficult. The proportion of deaths occurring in a bed-sharing context and the absolute number of deaths occurring while an infant is sleep-sharing with an adult on a sofa have increased in recent years [19], prompting public health messages to focus on these issues as targets for further reduction. Such messages have so far had little impact on SIDS rates, however, suggesting that further change requires greater knowledge from parents and healthcare providers than can be achieved via a 'one-size-fits-all' infant care message [14]. It is now acknowledged in a variety of contexts that 'one-size-fits-all' messaging is ineffective and inappropriate, particularly for high-risk groups such as minority or low-income families [41].

Several reasons for the lack of further progress have been discussed. First, large-scale public health messages are inherently limited in their ability to effect widespread behaviour change, particularly when the targeted parenting behaviours relate to complex, multifaceted and culturally ingrained infant care practices. One-size-fits-all messages are not adequate to achieve the increased knowledge and commitment from parents and their healthcare providers, which are required for meaningful reductions in sleep-related mortality [14, 41]. Information is also directed to parents and providers without addressing their capacity to implement the recommended practices and is generally offered without contextual information about to whom the recommendations apply, under what circumstances and for how long [14]. Although studies have shown that most parents cannot eliminate all known risks to their infants for each sleep [42] and that there is a cost to parents in adhering to safe sleep advice [43], they are rarely assisted in prioritising risk factors or in developing strategies to ameliorate those costs.

Secondly, unlike infant sleep position, infant sleep location is embedded within a context of cultural and personal values and motivations. Where an infant sleeps is related to a deeply rooted belief system about the relationship of an infant and her caregiver, and about the very nature of infancy and parenting [44–48]. These beliefs may conflict with public health recommendations and policies, leading parents to reject paediatric advice in whole or in part.

Finally, infant sleep location is intricately related to other aspects of infant care, such as feeding method. Therefore, efforts to increase breastfeeding, which is also a protective factor for SIDS [20], represent a de facto intervention related to sleep location due to the nature and frequency of night-time feeding [49], yet the interplay of different safe sleep recommendations are rarely recognised or addressed in public health campaigns and parents are offered little guidance when various aspects of well-being and risk reduction agendas conflict [14]. Infant sleep location cannot be easily disarticulated from the larger behavioural context in which it exists.

5.3 Implications for Policy and Practice

5.3.1 Strategies to Reduce SIDS Based on an Evolutionary Perspective

Researchers who approach infant sleep behaviour and physiology using 'evolutionary thinking' consider the intersection between evolved infant biology and culturally determined patterns of night-time infant care described above. Using this, evolutionary framework [50] allows researchers to identify both proximate (immediate or mechanistic) and ultimate (evolutionary or adaptive) causes for individual parenting strategies [51, 52] including choice of infant sleep location. Existing studies have demonstrated the utility of evolutionary perspectives and methods for understanding the ways in which parents construct their infants' sleep environments [49, 53, 54]. These studies have documented how the complicated prospect of providing care to infants during the night causes parents to adopt strategies and behaviours that they had not planned [6], and to approach infant sleep location in a way that balances the constraints of infant physiology and development with parental goals and desires within a particular social and behavioural context [55, 56].

As part of the evolutionary approach to infant sleep environments, researchers and clinicians recognise that parent–offspring conflicts exist, producing a tension between the biological demands (maximising the reproductive success) of the infant and of the parent [52, 57, 58]. Individuals are repeatedly negotiating trade-offs between the benefit to infants derived from particular forms of care, and the costs to parents incurred by engaging in these forms of care [59, 60]. Parenting strategies are sensitive to individual circumstances [61] and calibrated to personal contexts and conditions, but are also adjusted over the lifetime of a single individual [62]. When applied to SIDS reduction and infant sleep location, this approach acknowledges the inherent trade-offs in providing night-time care to infants, and the costs to parents in following contemporary paediatric recommendations that lead them to pursue alternate strategies. Policy and practice interventions that take into account the biological needs of babies, and parent–infant trade-offs, can better understand the barriers to implementation of traditional SIDS reduction approaches and offer new innovations.

Although safe sleep guidelines and other public health messages suggest that risky infant sleep environments are potentially lethal to infants whenever they occur, in reality parents quickly learn that infants may be placed in a variety of sleep locations with no adverse outcomes. Therefore, parents may be willing to tolerate the risk of placing infants in a particular sleep location in exchange for other benefits; in so doing they weigh the costs and benefits of potentially risky sleep locations in ways that are complex and poorly understood [43]. Clinicians may use this awareness of trade-offs to engage in conversations with parents, such as by exploring the trade-offs that parents consider in selecting particular infant sleep locations or by examining the impact to the parents of attempting to implement sleep location

recommendations. If clinicians want us to select certain infant sleep locations over others, they must assist us in identifying the costs of those sleep arrangements that dissuade us from following guidance (e.g. the implications for maternal sleep disruption) and help us implement strategies to decrease these costs [43].

5.3.2 *Innovative Strategies for Practice*

Recent evidence-to-practice initiatives for public health education have focused on presenting an evolutionary understanding of infant sleep to parents and health practitioners, the development of interactive tools and materials that encourage discussion of parent and infant needs and trade-offs, and the provision of simple and culturally appropriate infant sleep spaces that offer alternate solutions in trade-off situations. To illustrate these approaches, we give an overview of three initiatives: (a) UNICEF UK Baby-Friendly Initiative's approach to supporting night-time infant care; (b) the Infant Safe Sleep Tool, a risk-assessment and communication tool for parents and health professionals; and (c) a New Zealand initiative for the provision of alternate infant sleep spaces.

UNICEF UK Baby-Friendly Initiative In the UK, public health policy initiatives to promote breastfeeding initiation and continuation reflect the relevance of an evolutionary perspective in emphasising the importance of prolonged physical contact between babies and their carers to both facilitate normal infant development and optimise maternal milk production, and the avoidance of night-time separation of mothers and infants [63, 64]. All UK breastfeeding support organisations now endorse and signpost both parents and health professionals to the Infant Sleep Information Source Website which presents evolutionary perspectives on infant sleep development, sleep needs and managing sleep safety (www.isisonline.org.uk). The existence of the latter, which is signposted to by numerous NHS Trusts and Local Councils, is helping providers and parents access consistent and research-based information on the underlying evolutionary biology of their infant's sleep needs, development and safety.

The Infant Sleep Safety Tool The Infant Sleep Safety Tool (ISST) was developed, trialled and evaluated by Durham University Parent-Infant Sleep Lab in partnership with Blackpool and North Lancashire NHS Trusts in a service delivery project that aimed to discuss infant sleep location trade-offs with parents. The tool comprises a colourful illustrated booklet 'Where might my baby sleep?' and training materials for healthcare providers and peer supporters. The booklet presents information about the risks and benefits of infant sleep locations, along with a double-page checklist highlighting the factors which combine with bed-sharing to increase infant risk of SIDS and accidental SUDI, informs parents, enables them to identify their individual risk profiles and facilitates communication between healthcare providers and parents on topics that can prove difficult to initiate or explore. Evaluation found that compared to mothers who had received routine care, those receiving the ISST had improved knowledge of several aspects of SIDS risk

and infant sleep safety, particularly relating to the roles of lone sleep, smoking, bed-sharing in hazardous circumstances and breastfeeding in affecting SIDS risk. Staff implementing the tool reported increased confidence in addressing issues relating to infant sleep safety with parents, and in discussing why parents implement hazardous night-time care strategies [65].

New Zealand Safe Sleep Spaces: **Wahakura** The disproportionately high SIDS rate among New Zealand's Maori population was found to be associated with parent–infant bed-sharing in the context of a high prevalence of maternal smoking in pregnancy and post-natally [66]. Due to the high degree of cultural value attached to bed-sharing in Maori culture, it was not considered a 'modifiable infant care practice' [14]. Tipene-Leach [67, 68] devised a safe sleep intervention involving infant sleep baskets woven from flax (via a traditional Maori technique) that he named Wahakura. These woven reed sleeping baskets are designed to support a modified form of bed-sharing—being placed on the parental bed—keeping the baby in close proximity while providing a safe sleep space. The provision of Wahakura produced by Maori weavers, and especially the process of teaching women to weave their own, provides an opportunity for discussion of safe infant sleep, and provision of information about SIDS risk reduction strategies [66]. The Wahakura programme is now in the process of evaluation, but since its inception the Maori SIDS rate has fallen substantially—while preserving parent–infant sleep proximity.

5.4 Conclusion

Humans are by nature adaptable, and critics of an evolutionary approach may point to humans' inherent capacity for both behavioural and biological plasticity, both of which have facilitated the cultural development of infant care practices including feeding of the milk of another species, and 'caching' of infants in specially designed cribs, cots and carriers. However, young infants have a limited ability to adapt, and the relative newness of cultural changes means that no evolutionary adaptations have occurred. By recognising that infant sleep locations are selected and modified as part of a larger behavioural repertoire, evolutionary perspectives on infant sleep location acknowledge that (a) infants biological needs are influenced by human evolutionary history; (b) human infants need close contact with a caregiver both day and night during early development; (c) when infant needs and parental (social and economic) needs conflict, parents will modify infant care practices in ways that trade off their own needs and those of their infants; (d) these trade-offs might increase or decrease infant exposure to SIDS risks, and sleep locations can be safer or unsafe according to the context in which they are implemented. By explicitly understanding these links, we can initiate more effective discussions with parents and develop new and innovative approaches to safe infant sleep that supersede one-size-fits-all recommendations that many parents are unable or unwilling to implement.

Glossary

Apparent life-threatening events (ALTE)	Incidents where babies cease breathing and become lifeless but are able to be resuscitated
Arousability	The ability to arouse from sleep easily. Poor or low arousability means an individual does not awaken upon application of normal stimuli
Back-to-Sleep campaign	A national population-based campaign of information and advertising to encourage parents to put infants in a supine position for sleep
Distal care strategies	Infant care behaviours that encourage separation of carer and baby: sleeping baby in room alone, use of bouncers and swings to sooth the baby, use of buggies to transport the baby
Proximal care strategies	Infant care behaviours that keep the baby close to a carer, e.g. carrying sling-use, sleeping within arm's reach
Risk factors	Characteristics found to be statistically associated with infant death outcomes in SIDS case–control studies
Sudden infant death syndrome (SIDS)	The death of an infant that following a review of clinical history, post-mortem examination and investigation of the death scene remains unexplained
Sudden unexpected death in Infancy (SUDI)	Sudden unexpected death in infancy includes SIDS and explained deaths occurring unexpectedly from illness accident, or deliberately
Triple-risk hypothesis	A model for explaining how SIDS occurs at the confluence of intrinsic, extrinsic and time-limited risk characteristics of an infant and his/her environment
UNICEF Baby-Friendly Initiative	A worldwide health promotion programme to encourage maternity practices that facilitate and support breastfeeding
Wahakura	A portable woven flax basket for use as an alternate strategy for bed-sharing in order to keep babies close but safe, when parents are smokers, was developed in NZ

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