

Child care and cot death

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Introduction

"And this woman's child died in the night; because she overlaid it." Kings 3:16-22

Overlaying was the historical explanation for sudden unexpected infant death. Implicit in this interpretation was the concept that the mother and infant were sharing the same bed. It is probable that some infants were dying in their own beds and therefore could not have been overlain. Status thymico-lymphaticus was one of the first alternative explanations for unexpected infant death. Suggested by Paultouf in 1889, it was hypothesised that an enlarged thymus gland, pressing on the trachea, was the cause of these deaths.¹ However a committee set up to investigate status thymico-lymphaticus concluded that there was no evidence that it was a pathological entity,² and it became accepted that a large thymus was not an explanation of death but merely an expression of good nutrition.³

Accidental mechanical suffocation or fulminating respiratory infection?

"despite their grief, the relief of parents is often very apparent when informed that the death was due to circumstances beyond their control" (1945)⁴

By the 1940s, in many western countries most babies no longer slept with their mothers and sudden deaths were increasingly labelled as accidental mechanical suffocation. The label appeared not to have come from a particular hypothesis, but from the death-scene findings i.e. babies were found face-down or head-covered. A 1944 issue of the *Journal of Paediatrics* published two opposing articles.^{5,6} The

lead article suggested that, "The problem of sudden death in infants previously thought to be well ("crib death") has not yet been completely solved. However, there is considerable evidence to indicate that pneumonia may be responsible for death in many such cases. . . . By it's (the prone position) habitual use, the hazard of "sudden death" or "crib death" of pneumonic origin would probably be eliminated." The second article by Dr. Abramson noted that accidental mechanical suffocation was responsible for more deaths than measles, scarlet fever and diphtheria combined. He advised that "Infants should not be placed prone unless under constant watch". These two articles characterised the debate, occurring at the time, that the label of Accidental Mechanical Suffocation had implications of parental negligence. It was suggested that this label should be avoided as there was no definite proof of suffocation.^{3,4,7,8} An anecdotal study involving six infants placed in various potentially obstructive situations,⁷ was subsequently interpreted as proof that,¹ "research this century has shown that bed-clothes are quite pervious to air in the quantities required for infant breathing and that a child always turns its head from a suffocating pillow". Parents were thus reassured that, even if the baby was found in a situation suggestive of obstruction (face-down or head-covered), this was not the cause of death.

If suffocation was not the cause of death, and if the baby was sleeping alone, then some alternative explanation was required. Investigators in the 1940s suggested that fulminating respiratory infection was this explanation. Microscopic evidence of acute respiratory disease was apparently found in 31 unselected cases of unexpected death.³ In retrospect it would appear that petechiae, so typical of SIDS, were being mis-interpreted to be evidence of infection. Although the anticipated infective agent was never isolated, unexpected deaths were increasingly labelled as fulminating respiratory infection rather than suffocation.

Sleep position revisited

"Some babies prefer to sleep on the abdomen. Many paediatricians recommend that this be encouraged on the grounds that it is safer for baby" (1977)⁹

Thus although sleep position and unexpected death had been the subject of debate 50 years ago, the association was largely dismissed. In 1978, Dr. Susan Beal from South Australia revived the debate,¹⁰ and 10 years later published summary data showing a strong association between sleep position

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and SIDS.¹¹ However only in the Netherlands was the data considered sufficiently conclusive to start an intervention campaign advising against the prone sleep position. This was in October 1987.¹²

During this same period, New Zealand was experiencing an epidemic of SIDS and three characteristic epidemiologic features had been identified: the SIDS rate was very high by international standards (>4.0/1000 live births); there was a threefold increase in the SIDS rate from the warm north to the cold south; the SIDS rate was very high in Maoris but very low in the Pacific people (ethnically and socioeconomically similar populations but Pacific people were recent immigrants to New Zealand). Ecological analysis highlighted the significant regional variation in both SIDS and total post-neonatal mortality rates within New Zealand, and showed that the SIDS rates correlated highly with climatic factors whereas non-SIDS mortality (post-neonatal mortality minus SIDS mortality) correlated better with social factors such as unemployment rates.¹³ A detailed review of 429 postneonatal deaths in southern New Zealand (1979–1984) concluded that there was no obvious under- or over-diagnosis of SIDS and that the southern New Zealand post-neonatal SIDS rate was 6.3/1000.¹⁴ This was the highest rate in the world at the time and contrasted with a reported Hong Kong SIDS rate of only 0.04/1000.¹⁵

Thermoregulation

"What could be more insidious and undetectable than an episode of hypothermia of uncertain duration which kills, and, having killed, leads to cooling and, therefore, to a built in alibi, with no specific indication of the cause of death." (1971)¹⁶

The consistent association of SIDS with winter and the marked climatic variation of SIDS rates within New Zealand, suggested that temperature had a potential aetiological role. Overheating was suggested as a mechanism whereby temperature might be important in SIDS,^{17,18} and to explore this hypothesis further a descriptive study of child care practices was undertaken in southern New Zealand during 1986.¹⁹ Similar data collected on 42 SIDS babies during

The Ballad of Moll Magee

*Come round me, little childer;
Ther, don't fling stones at me
Because I mutter as I go;
But pity Moll Magee.*

*My man was a poor fisher
With shore lines in the say;
My work was saltin' herrings
The whole of the long day.*

*And sometimes from the saltin' shed
I scarce could drag my feet,
Under the blessed moonlight,
Along the pebbly street.*

*I'd always been but weakly,
And my baby was just born;
A neighbour minded her by day,
I minded her till morn.*

*I lay upon my baby;
Ye little childer dear,
I look on my cold baby
When the morn grew frosty and clear.*

*A weary woman sleeps so hard!
My man grew red and pale,
And gave me money, and bade me go
To my own place, Kinsale.*

*He drove me out and shut the door,
And gave his curse to me;
I went away in silence,
No neighbour could I see.*

W.B. Yeats, Collected Poems 1906

1986–1987, showed that 30/42 (71%) of infants were reported as being found dead face-down or head-covered.²⁰ This unexpected finding prompted further investigation of the effect of sleep position on heat loss. A computer model of thermal balance explored the relationship between child care methods and thermoregulation, highlighted the importance of body surface area (BSA) in promoting heat loss.²¹ In the heavily dressed infant the head becomes the pre-eminent thermoregulatory organ. The model showed that BSA exposed for heat loss is reduced by the face-down or head-covered position. Sleep position becomes important in this context – a prone sleeping infant is much more likely to become face-down or head-covered than a supine infant. The model further clearly demonstrated that a soft under-surface would further impair heat loss.

Based on these epidemiological and theoretical data it was suggested that many SIDS are caused by hyperthermia precipitated by a combination of factors that either reduce heat loss and/or increase metabolic rate (Figure 1).²² In southern New Zealand there appeared to be a potentially adverse combination of child care practices (prone sleep position + soft underbedding + heavy dressing. Infant sheepskins came into common usage in southern New Zealand during the 1970s. During this time types of mattresses were also changing and more infants were sleeping prone. New Zealand child

care advice had previously strongly recommended the side position.²¹ These changes in underbedding consistency and sleep position were associated with a significant increase in the total 1 – 5 month mortality rate during the period 1970 – 1985.²¹

Intervention programmes

COT DEATH

You cannot predict it

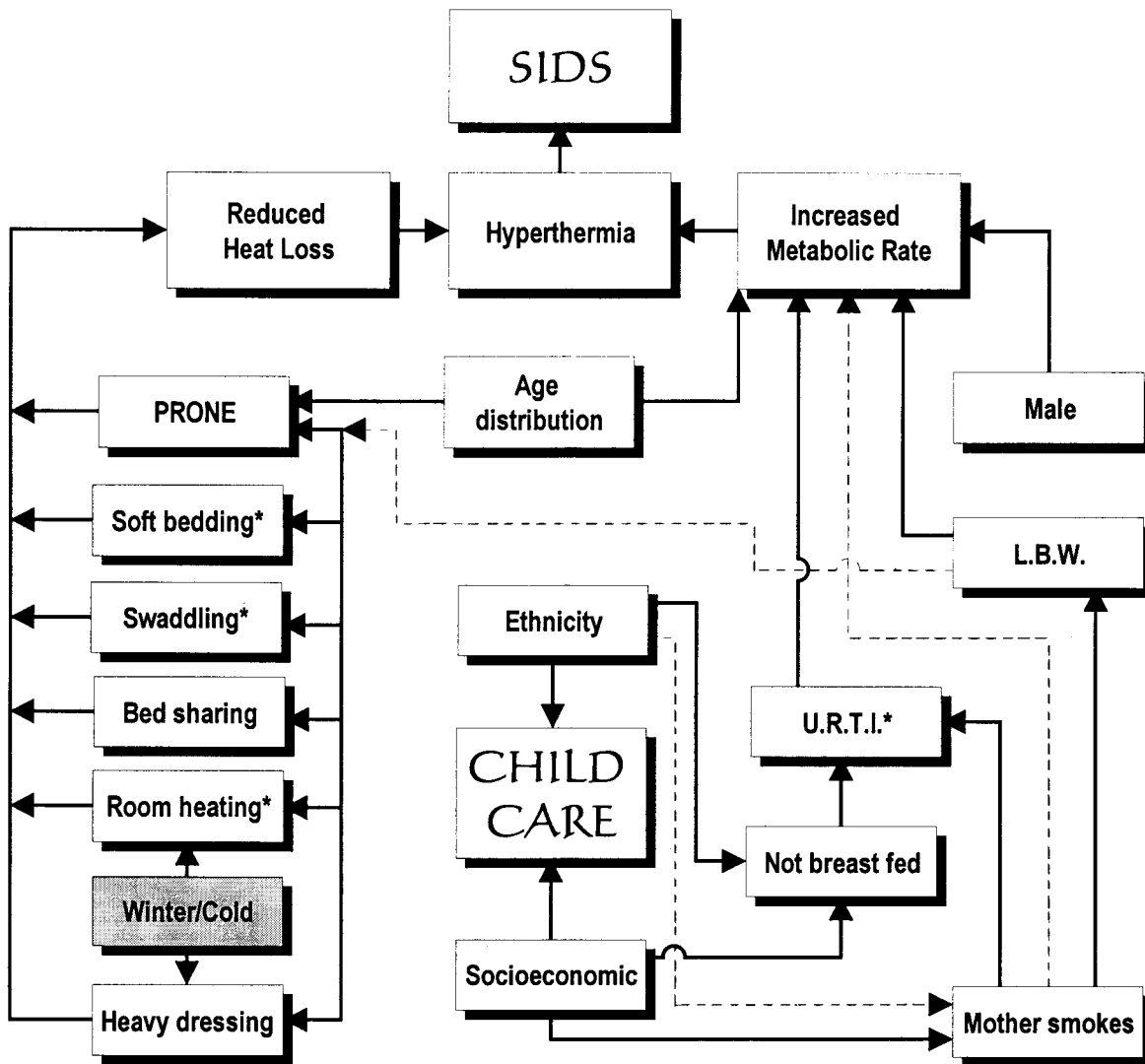
You cannot prevent it

YOU CAN REDUCE THE RISKS

Canterbury Cot Death Society Inc, New Zealand 1987

SIDS organisations have initiated and funded many of the early risk intervention campaigns. Parents, who have suffered

Figure 1. Epidemiological associations of sudden infant deaths syndrome (SIDS) which may reduce heat loss or increase metabolic rate



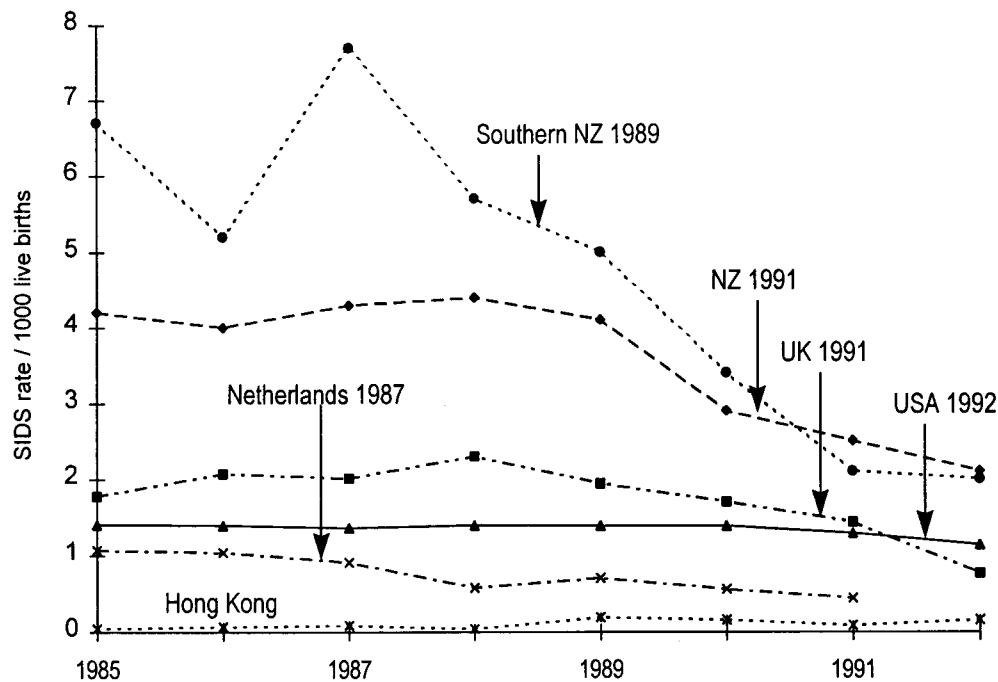
* Co-risk factors for SIDS when infant prone

the loss of a baby from SIDS, are the driving force behind these organisations. In Christchurch, New Zealand, the Canterbury Cot Death Society started to inform parents of SIDS risk-factors from 1987. In June 1989, a campaign in Dunedin, New Zealand advised parents to: sleep their infant on the side or back; to use firm underbedding; to use light dressing; and to keep the room evenly heated. In March 1991, Mitchell and colleagues published results of the New Zealand multicentre case-control cot death study which identified three modifiable SIDS risk factors: prone sleep position; lack of breast feeding; and maternal smoking.²³ Further analysis identified bedsharing with a smoker as a fourth modifiable risk factor.²⁴ These modifiable risk factors, formed the basis of the "Reduce the Risks Campaign" which was started throughout New Zealand in March 1991, in

Victoria, Australia in July 1990, and throughout Australia in July 1991.

In 1990 Fleming and colleagues in Avon, south-west England confirmed the theoretical suggestion that sleeping position, infant bedding and room heating may interact to increase the risk of SIDS.^{22,25} Further confirmatory evidence of this interactive effect came from Tasmania, Australia in 1993.²⁶ Anne Diamond, a television reporter, lost her baby from SIDS in early 1991. She travelled to New Zealand with her family to produce a documentary titled "Every Mother's Nightmare" (Thames Television for ITV, 1991). In October 1991, after this documentary was screened in the United Kingdom, the British government gave its support to the "Back to sleep Campaign" promoting supine sleeping. In June

Figure 2. Changes in sudden infant rates following campaigns advising against the prone sleep position given (Hong Kong SIDS rates shown for comparison).



1992 the American Academy of Paediatrics recommended that the side or back sleep position should be used for the well infant born at term with no medical complications.²⁷ National intervention campaigns have also started from 1990 in Norway, Denmark, Sweden, Austria, Germany, Belgium, France and other countries.

Figure 2 shows the dramatic results that some of these intervention campaigns have on SIDS mortality rates. Advice against prone sleep position was the common theme for all campaigns and a 50% fall in SIDS rates have followed most campaigns. Mitchell has argued that the criteria for causality in observational studies have been met,²⁸ and most SIDS researchers would probably now agree that the prone sleep position is causally associated with SIDS. However it is also very apparent that some countries had low rates of SIDS and high rates of prone sleeping (e.g. Netherlands in 1987 had a SIDS rate of 1 per 1000 and a prone sleeping rate of 60%) whereas in other countries the reverse was noted (e.g. southern New Zealand in 1986 had a SIDS rate of 6 per 1000 and a prone sleeping rate of 43%).^{12,19} To explain these discrepancies there must be other interacting factor(s). SIDS risk factors can be divided into those that are difficult to control (low birth weight, male sex, low socioeconomic status, upper respiratory tract infection), and those that can be modified (maternal smoking, bedsharing, lack of breast feeding). Other factors have now been identified which have an interactive effect when the baby sleeps prone (type of under-surface, heavy dressing, room heating and swaddling).^{25,26}

Although many studies have identified maternal smoking as an important SIDS risk factor, it is still uncertain whether this association is causal. It has proved easier to persuade mothers to sleep their babies on their backs, than to persuade mothers to stop smoking.

Mechanisms and future research

"Some time ago, in association with Dr Robert McCammon, we analysed the atmosphere breathed by infants covered in various manners by different types of bedding. We were able to demonstrate a reduction in oxygen or increase in carbon dioxide only after the addition of a rubber sheet, secured tightly at each border. The infants under ordinary bedding showed no discomfort until sufficient time had elapsed for heat and humidity to come into play." (1945)⁷

If we accept that prone sleep position is causally associated with SIDS, then the next step is to determine the mechanism of this association. The three main hypotheses are hyperthermia,²¹ obstruction,^{6,29} and re-breathing.^{30,31} All three hypotheses are compatible with an interactive effect occurring between prone sleep position and soft under-surface.^{21,32,33} Other theories include toxin production and allergy to the bedding surface.

If SIDS is to be totally prevented we need to establish the mechanism(s) of death. With falling SIDS rates, there are now increasing numbers of babies found dead on their sides or backs. Is the mechanism of death in these babies different to

that in the prone sleeping babies or is there a common theme? Conventional wisdom would suggest that SIDS is a multifactorial mixed bag of conditions caused by a wide variety of mechanisms. Dramatic falls in SIDS rates following changes in certain child care practices might indicate that this is in fact not the case. To discover mechanisms various approaches are possible:

Ecological Child Care Studies

Such studies are unlikely to identify mechanisms but they may provide useful clues for further research. One particular area of interest is bedsharing which has generated controversy recently.³⁴ Low rates of SIDS in Hong Kong are well documented and preliminary data from Hong Kong suggests that approximately one third of infants bedshare from 4 – 8 weeks of age.³⁵ This contrasts with only 2% of infants bedsharing in southern New Zealand in 1986 at the height of the SIDS epidemic there. However looking more carefully at this cross-cultural data, it becomes obvious that bedsharing means different things to different people. A baby, swaddled and placed supine on a firm bed at arms-length from the mother, is in a very different situation to a baby placed in direct skin-skin contact with the mother sleeping on a soft surface and covered with a thick duvet. Clarification and documentation of these different practices will be an important step in determining the relative merits or risks of bedsharing.

Lack of breast feeding has been another important risk factor for SIDS in New Zealand. Yet in 1986, 77% of southern New Zealand mothers breast fed,¹⁹ whereas in 1994 only 17% of a sample of Hong Kong mothers attempted breast feeding and only 9% were continuing at 4 weeks.³⁵ Ecological studies can help to highlight these apparent inconsistencies.

It should also be noted that many child care practices change both with increasing age of the child and secularly. In addition, subtle differences in child care may be difficult to document using structured questionnaires. For these reasons, it is likely that studies using anthropological methodology will be useful in highlighting various cultural differences in the child care related SIDS risk factors.³⁶

Death-scene investigations

Such investigations can provide information which might be otherwise overlooked^{37,38}. Systematic collection of death-scene data could also be used to test specific hypotheses e.g. hyperthermia, obstruction or re-breathing^{31,39}.

Physiological Studies

Definitive answers are most likely to come from physiological studies. Figure 1 speculates how the main epidemiological SIDS risk factors could interact to lead to SIDS by hyperthermia. Central to this hypothesis is that temperature (climate and season) has been one of the most consistent SIDS epidemiological risk factors. Although it is less easy to link temperature to a mechanism of death based in obstruction or re-breathing, it is possible that more than one mechanism may be at work e.g. hyperthermia + re-breathing. Based on death-scene data, it has been possible to demonstrate that re-breathing can be lethal to rabbits using a mannequin model.³¹ However it has also been shown that sudden hyperthermic death, without arousal, can occur in piglets covered with bedding.⁴⁰ In time, such studies should demonstrate the precise association of the various SIDS risk factors with actual mechanisms of death.

Conclusion

It is increasingly apparent that child care practices will be focal to an eventual understanding of mechanisms of death in SIDS. Ecological child care studies may be able to provide clues for further research but anthropological methodology will be required to better understand the interaction between such factors as sleep position, underbedding consistency and bedsharing. The interactive effects of maternal smoking, lack of breast feeding, upper respiratory tract infections, low birth weight and socioeconomic background need to be more fully explored in relation to other child care practices. Death scene investigations can provide hard data for hypothesis testing and physiological studies are expected to provide the definitive answers.

“ It is increasingly apparent that child care practices will be focal to an eventual understanding of mechanisms of death in SIDS. ”

References

1. Russell-Jones DL. Sudden infant death in history and literature. *Arch Dis Child* 1985;60:278-81.
2. Young M, Turnbull HM. An analysis of the data collected by the Status Lymphaticus Investigation Committee. *J Path Bacteriol* 1931;34:213-58.
3. Werne J, Garrow I. Sudden deaths in infant allegedly due to mechanical suffocation. *Am J Publ Health* 1947; 37:675-87.
4. Davison WH. Accidental infant suffocation. *Brit Med J* 1945;2:251-252.
5. Adams JM. A reevaluation of the pneumonias of infancy. *J Pediatr* 1944;25:369-85.
6. Abramson H. Accidental mechanical suffocation in infants. *J Pediatr* 1944;25:404-13.

7. Woolley PV. Mechanical suffocation during infancy. *J Pediatr* 1945;26:572-5.
8. Bowden K. Sudden death or alleged accidental suffocation in babies. *Med J Aust* 1950;1:65-72.
9. Illingworth R, Illingworth C. *Babies and Young Children*. London: Churchill Livingstone, 1977.
10. Beal SM, Blundell H. Sudden infant death syndrome related to position in the cot. *Med J Aust* 1978;2:217-8.
11. Beal S. Sleeping position and SIDS. *Lancet* 1988;ii:512.
12. de Jonge GA, Burgmeijer RJF, Engelberts AC, et al. Sleeping Position for infants and cot death in the Netherlands. *Arch Dis Child* 1993;69:660-3.
13. Nelson EAS, Taylor BJ. Climatic and social associations with postneonatal mortality rates within New Zealand. *NZ Med J* 1988;101:443-6.
14. Nelson EAS, Williams SM, Taylor BJ, et al. Postneonatal mortality in south New Zealand: necropsy data review. *Paediatr Perinat Epidemiol* 1989;3:375-85.
15. Davies DP. Cot death in Hong Kong: a rare problem? *Lancet* 1985;ii:1346-9.
16. Forrester RM. Sudden death in infancy. *Lancet* 1971;ii:757.
17. Bacon C, Scott D, Jones P. Heatstroke in well-wrapped infants. *Lancet* 1979;i:422-5.
18. Stanton AN, Scott DJ, Downham MAPS. Is overheating a factor in some unexpected infant deaths? *Lancet* 1980;ii:1054-7.
19. Nelson EAS, Taylor BJ. Infant clothing, bedding, room heating in an area of high postneonatal mortality. *Paediatr Perinat Epidemiol* 1989;3:151-61.
20. Nelson EAS, Taylor BJ, Mackay SC. Child care practices and the sudden infant death syndrome. *Aust Paediatr J* 1989;25:202-4.
21. Nelson EAS. Sudden infant death syndrome and child care practices. *M.D. Thesis*. Dunedin: University of Otago, 1989.
22. Nelson EAS, Taylor BJ, Weatherall IL. Sleeping position and infant bedding may predispose to hyperthermia and the sudden infant death syndrome. *Lancet* 1989;i:199-200.
23. Mitchell EA, Scragg R, Stewart AW, et al. Results of the first year of the New Zealand cot death study. *NZ Med J* 1991;104:71-6.
24. Scragg R, Mitchell EA, Taylor BJ, et al. Bedsharing, smoking, and alcohol in the sudden infant death syndrome. *Brit Med J* 1993;307:1312-8.
25. Fleming PJ, Gilbert R, Azaz Y, et al. Interaction between bedding and sleeping position in the sudden infant death syndrome: A population based case control study. *Brit Med J* 1990;301:85-9.
26. Ponsonby AL, Dwyer T, Gibbons LE, et al. Factors potentiating the risk of sudden infant death syndrome associated with the prone position. *N Engl J Med* 1993;329:377-82.
27. AAP Task Force on Infant Positioning and SIDS. Positioning and SIDS. *Pediatr* 1992;89:1120-6.
28. Mitchell EA, Ford RPK, Taylor BJ, et al. Further evidence supporting a causal relationship between sleeping position and SIDS. *J Paediatr Child Health* 1992;28 (suppl 1):S9-12.
29. Thach BT. Sudden infant death syndrome: old causes rediscovered? *N Engl J Med* 1986;315:126-8.
30. Bolton DPG, Taylor BJ, Campbell AJ, et al. Rebreathing expired gases from bedding: a cause of cot death? *Arch Dis Child* 1993;69:187-90.
31. Kemp JS, Kowalski RM, Burch PM, et al. Unintentional suffocation by rebreathing: a death scene and physiologic investigation of a possible cause of sudden infant death. *J Pediatr* 1993;122:874-80.
32. Emery JL, Thornton JA. Effects of obstruction to respiration in infants, with particular reference to mattresses, pillows and their coverings. *Brit Med J* 1968;3:209-213.
33. Kemp JS, Nelson VE, Thach BT. Physical properties of bedding that may increase risk of sudden infant death syndrome in prone-sleeping infants. *Pediatr Res* 1994;36:7-11.
34. Byard RW. Is co-sleeping in infancy a desirable or dangerous practice? *J Paediatr Child Health* 1994;30:198-199.
35. Nelson EAS, Chan PH. Child care practices and cot death in Hong Kong. *N Z Med J* 1996;109:144-146.
36. Gantley M, Davies DP, Murcott A. Sudden infant death syndrome: links with infant care practices. *Brit Med J* 1993;306:16-20.
37. Bass M, Kravath RE, Glass L. Death-Scene investigation in sudden infant death. *N Engl J Med* 1986;315:100-5.
38. Beal SM, Moore L, Collett M, et al. The danger of freely rocking cradles. *J Paediatr Child Health* 1995;31:38-40.
39. Bolton DPG, Nelson EAS, Taylor BJ, Weatherall IL. Thermal balance in infants. *J Appl Physiol* 1996;80(6):2234-2242.
40. Taylor BJ, Williams S. Babies found unexpectedly dead with their "head covered": characteristics and pathology (abstract). *The Fourth SIDS International Conference*, Washington, June 1996. □