Bed sharing is a risk for Sudden Infant Death Syndrome (SIDS) even when parents do not smoke and infants are breastfed.

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Bed sharing is a risk for Sudden Infant Death Syndrome (SIDS) even when parents do not smoke and infants are breastfed.

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Abstract

Objective: To resolve uncertainty as to the risk of Sudden Infant Death Syndrome (SIDS) associated with sleeping in bed with your baby if neither parent smokes and the baby is breastfed.

Design: Bed sharing was defined as sleeping with a baby in the parents' bed; room sharing as baby sleeping in the parents' room. Frequency of bed sharing during last sleep was compared between babies who died of SIDS and living control infants. Individual data from five large SIDS case-control data sets were combined. All missing data were imputed. Random effects logistic regression was used to control for potential confounding.

Setting: Home sleeping arrangements of parents and infants in 19 centres across UK, Europe, and Australasia.

Participants: There were 1,472 SIDS cases, and 4,679 controls.. Each study effectively included all cases, by standard criteria, occurring in a defined area and time period. Controls were randomly selected normal infants of the same age, time, and place.

Results: in the combined dataset. 22.3% of cases and 9.6% of controls were bed sharing, AOR for all ages 2.7; 95% Confidence Interval (CI) (1.4–5.3). Bed sharing risk decreased with infant age. When neither parent smoked, baby was less than 3 months of age, and breast fed and no other risk factors were present the AOR for bed sharing vs. room sharing was 5.1 (2.3–11.4). The absolute risk for room sharing infants in this group was very low (0.08 (0.05–0.14) per 1000 live births). This rate increased to 0.23 (0.11–0.43). per 1000 when bed sharing. Smoking and alcohol use greatly increased bed sharing risk

Conclusion: Bed sharing for sleep fulfils the criteria for a causal factor of SIDS. A substantial reduction of SIDS rates (up to 50%) could be achieved by discouraging bed sharing and encouraging room sharing.

Article Summary

Focus

- Is there a risk of SIDS due to bed sharing when baby is breast fed, the parents do not smoke, and the mother does not use alcohol or illegal drugs?
- At what age is it safe to bed share?
- How is risk associated with bed sharing affected by other factors?

Key Messages

- When the baby is breast fed and under 3 months, there is a fivefold increase in risk of SIDS when bed sharing with non-smoking parents, and mother has not taken alcohol or drugs.
- Smoking, alcohol and drugs greatly increase the risk associated with bed sharing.
- A 50% reduction is SIDS rates could be achieved by discouraging bed sharing.

Strength and limitations

- It is the largest ever analysis of individual records of 1472 SIDS cases and 4679 controls from five major case control studies.

- Questions on mother's alcohol use in the last 24 hours and illegal drug use were not asked in three of these studies.
- Imputation of missing data enabled a combined analysis of all the data. The analysis gives unbiased efficient models that describe the data accurately, especially in key areas.

Background

Despite the marked reduction in Sudden Infant Death Syndrome (SIDS)[1] following the advice to place babies to sleep on their back (supine),[2] SIDS remains the major cause of death in the post neonatal period (28 days through to the first birthday) in high income countries. For instance in the US SIDS remains the leading cause of postneonatal mortality where 2,353 babies died from SIDS in 2008, about 0.6 per 1000 live births.[3]

Some countries give advice to parents in their 'Reduce the Risks' literature not to bed share with their babies under any circumstances. For example, The Netherlands advise parents not to bed share for the first 3 months of life[4] based on their own research findings.[5] This is also the case for the US[6] where the American Academy of Pediatrics Task Force on SIDS cited European[7] and New Zealand[8] data (included in this paper) and made a clear statement advising against bed sharing for sleep. Other countries notably the UK and Australia advise only certain groups not to bed share for sleep.[9-12] Bed sharing and the risk of SIDS has become controversial, especially as some do not discourage or actively promote bed sharing.[13, 14]

There is general acceptance that sleeping with a baby is a risk factor for SIDS when sleeping on a sofa in any circumstances or in a bed if the mother smokes and/or has taken alcohol.[15, 16] However, authors differ as to whether, in the absence of these risk factors, bed sharing represents a risk.[17-22] Mitchell, in a recent review suggests that before embarking on further studies, much could be achieved by combining the information from current studies.[23]

However, these risks, specifically for non-smokers when breast feeding, cannot be quantified directly from published data by standard meta-analysis due to different ways risks are reported.[5, 17, 19, 24, 25] The limited assessment of interactions for instance between bed sharing and breast feeding due to lack of individual data to analyse was highlighted in the recent meta-analysis of case control studies of SIDS.[26] Therefore, the leading authors of five major recent case-control studies agreed to combine the *individual* data to estimate the risk associated with bed sharing in relation to breast feeding, smoking, mother's recent alcohol consumption, and illegal drug use, after controlling for the other most important risk predictors. These studies included all cases that some might now classify as "unascertained" or "asphyxia" because they were found bed sharing or sleeping face down.

Material and Methods

Study population

The data from the European case control studies 1992 – 1996, ECAS,[7] the Scottish 1996 –2000,[27] the New Zealand 1987–1990,[8] the Irish 1994–2003,[28] and the German GeSID 1998–2001[29] studies were combined. Cases and controls over one year of age were excluded. The combined data set comprised 1472 cases and 4679 normal controls of similar age. For details on how the controls were selected please see the original reports.

Notes on explanatory variables

The explanatory variables were defined as follows:

'*Bed sharing*' was defined as one or both parents slept with the baby in their bed so that they woke to find the baby dead in bed with them. Controls were bed sharing if the baby was in bed with them when they awoke on the day of interview, or equivalent questions.

'*Room sharing*' ~ sleeping in the parents' room but not in the parents' bed.

'*Breast fed*' ~ infant was being partiallycompletely breast fed at the time of death or interview.

'*Bottle fed*' ~ the infant was not breast fed at this time.

'Parents' ~ the mother and her current partner.

'*Age*' ~ the infant's age at death or at interview for controls.

'AOR' ~ multivariate adjusted odds ratio**.** AORs and rates are followed by the 95% Confidence Interval (CI) in parentheses.

All data sets enabled the identification of cases found sleeping in the parents' room or elsewhere and whether or not they were bed sharing, together with comparable control data. Cases and controls co-sleeping on a sofa or elsewhere were classed as not bed sharing and not sleeping in the parents' room. Whether or not the mother or partner smoked, together with the infant's age, sex, race, birth weight, mother's age, parity, whether single or with a partner, and position last placed to sleep, and how the baby was being fed at the time of death/interview were available for all data sets. In addition, data on mother's alcohol consumption in the last 24 hours and mother's illegal drug use after birth were available in two datasets. In total of sixteen variables, including the study* were used in the analyses.

Statistical analysis

All variables, other than case or control, age, and study, included some missing data. Missing data were imputed as described in the Statistical Appendix. Odds ratios were calculated by logit regression. Univariate analyses were adjusted for age and study because controls were on average 3 weeks older than cases, and the number of controls varied between studies. For multivariate AORs, a multilevel logit regression model was used with "bed sharing" random across studies. The fraction of bed sharing deaths ***attributable*** to bed sharing, that is the fraction of bed sharing deaths that would not have occurred had the babies not been bed sharing but placed supine in a cot in the parents' room, all other things being unchanged, was computed as described by Bruzzi et al.[30] Mortality rates were computed using the same multivariate model by omitting the trend of bed sharing with age. Rates are given for all children, computed by a weighted combination of the rates for boys and girls. The base rate for girls was the SIDS rate when none of the model risk factors were present. To obtain average AOR for infants <3 months and for infants aged 3 months or more, a logistic form if the rates model confined to records under 3 months and 3 months or more were fitted. The results are presented in Table 3.

Full details of the statistical methods are given in the Statistical Appendix.

Results

The age distribution of the 1472 cases is shown in Fig.1. The peak incidence rate is between 7 and 10 weeks.

* The ECAS data set comprises a set of 20 studies, five of which were excluded due to absence of data on feeding or unwillingness to participate.

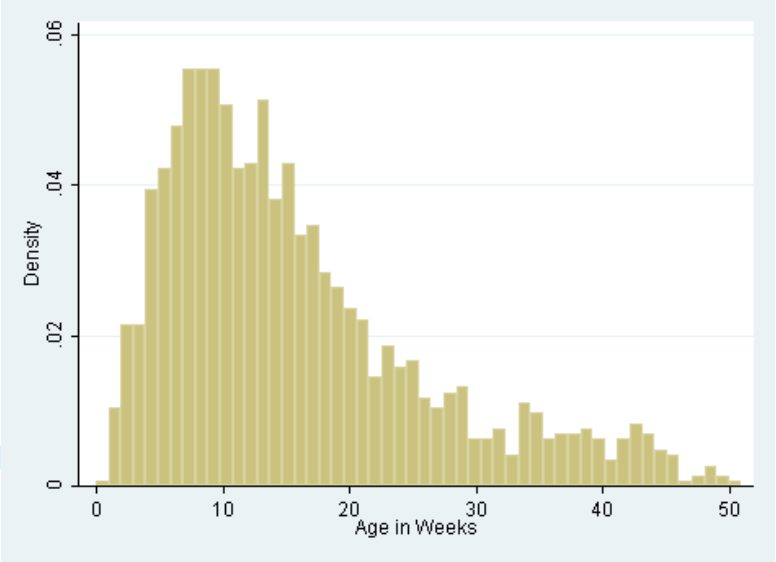

Fig. 1 The age distribution of the cases in the combined study.

Univariate and multivariate analyses

The data for each variable are tabulated for cases and controls in Table 1 together with percentage of missing data and the single factor ORs adjusted for age and study, together with the corresponding OR derived from analysis of the imputed data sets. Corresponding multivariate adjusted AORs from the overall model are also reported. For variables that interact with bed sharing, and consequently age, AORs reported in Table 1 are those for infants room sharing but not bed sharing.

Feeding

Table 1 shows that bottle feeding increases risk. When analysed as a single factor the OR for bottle feeding is 2.9 (2.5–3.3) however, the multivariate AOR is 1.5 (1.2–1.8).

Multivariate analyses for interactions between age, bed sharing and other variables

The baseline in the multivariate analysis is a breast fed baby placed on his/her back to sleep in a cot in the parents' room neither of whom smoke and having no other risk factors.

Bed Sharing

The log-linear downward trend in the OR for bed sharing in the first 6 months of life is shown in Fig 2, when neither parent smoked and when both smoked. These values are predicted by the overall model of the whole data set. Checks show that the predicted risks closely fit the data, especially when neither parent smoked and the mother had taken neither alcohol or drugs and the baby was breast fed and bed sharing, see appendix.

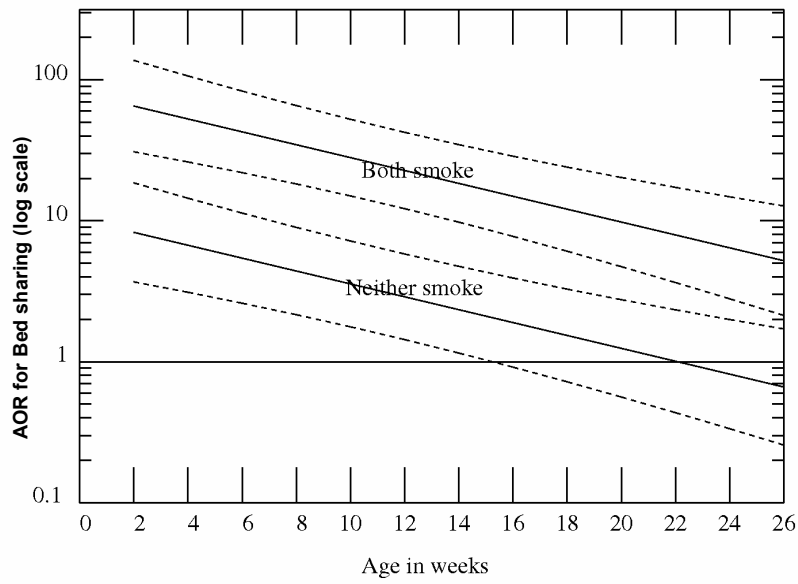

Fig. 2. Adjusted ORs (log scale) for SIDS by age for bed sharing breast fed infants, when neither parent smokes and both smoke. AORs are also adjusted for feeding, sleeping position when last left, room sharing, sex, race, and birth weight, mother's age, parity, marital status, alcohol and drug use.

The analysis showed that *only* position last left, parental smoking, maternal alcohol consumption in the last 24 hours, and illegal drug use, interact with bed sharing, and consequently the associated risks when bed sharing also decline with age. Table 2 summarises the adjusted AORs for each of these factors, first when room sharing and second when bed sharing at 2, 10 and 20 weeks of age. Three ages are used to illustrate the reduction in risks associated with bed sharing, as the baby gets older. Table 2 confirms that the OR for bed sharing is 8.3 (3.7–18.6) at 2 weeks and Fig 2 shows that bed sharing is a significant risk factor for the first 15 weeks of life in the absence of smoking, alcohol, drugs, and all other risk factors.

Position last left.

When sleeping in a cot there is a significant risk associated with placing the baby on its side and a substantial risk when placed prone. In contrast when bed sharing, being placed on the side is not associated with an increased risk and analysis shows that when placed prone there is little and no significant increase in risk for the first 3 months, Table 2.

Parental smoking

Table 2 also highlights the strength of the very significant interaction between smoking and bed sharing. Infants who bed share at 2 weeks of age whose parents both smoke are at 65-fold increased risk of SIDS compared with infants room sharing with parents who do not smoke. There is a 'dose response' effect, univariately, when room sharing, and when bed sharing at 2 weeks, 10 weeks and 20 weeks related to whether just the partner smokes, just mother smokes or both smoke. However, when the infant does not sleep with the parents, risks associated with parental smoking are comparatively small.

Alcohol and drugs

Table 2 shows the AORs associated with the mother having had 2 or more units of alcohol in the last 24 hours. If the baby does not bed share, two or more units increases the risk nearly 5-fold in contrast to a very substantial increase in risk when bed sharing, especially in the first weeks of life

(OR at 2 weeks of age = 89.6). The use of any illegal drugs by the mother, including cannabis , increases risk eleven-fold even when the baby is room sharing. The risks associated with a drug using mother bed sharing are unquantifiably large.

Average ORs for the first 3 months and after

In view of the trends in the AORs associated with bed sharing and age, Table 3 tabulates average under and over 3 months AORs for two key factors, smoking and alcohol when room sharing and bed sharing. These adjusted ORs apply when no other risk factors are present and the baseline groups is breast fed baby girls placed on their back for sleep by the bed of non-smoking parents and having no other risk factors. . Table 3 shows that if this group with baseline risk bed share, their average for the first 3 months, AOR, is 5.1 (2.3–11.4). After the infant is 3 months old the corresponding average AOR is 1.0 (0.3–3.0)

The multipliers shown in the last column shows the ratio of the AORs when bed sharing to the corresponding AOR when room sharing. In so far as these multipliers are >5.1 for the under 3 months, and > 1.0 after that age, they show how the interaction, first of smoking and then of parental smoking plus maternal alcohol with bed sharing, greatly enhances the risk associated with bed sharing. The data are too sparse to give meaningful AORs when mother is a drug user. It will also be noted that the second largest increase in risk associated with bed sharing occurs when baby is under 3 months and the mother smoked.

Calculation of AORs for other risk groups

Because, in the absence of interaction, AORs multiply, Tables 1, 2, and 3 enable approximate[†] AORs to be calculated for almost all other risk groups. Thus if the baby is not breast fed but bottle fed, Table 1 shows the AOR is multiplied by 1.5; if the baby's birth weight is between 2000g an 2499g the AOR is scaled up by 4.2, and so on. Thus the at 2 weeks the AOR for a bottle fed baby boy with birth weight 2140g who bed shares with a cohabiting 21 year old mother with one previous child and both parents smoke the

AOR = 65.1 (Table 2: both smoke)
× 1.5 (Table 1: bottle fed)
× 1.6 (Table 1: Male)
× 4.2 (Table 1: Birth weight)
× 3.0 (Table 1: mother's age)
× 2.3 (Table 1: 1 previous child)
= 4528

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If, using Table 2 we replace 65.1 by 2,1 we find that this alarming figure drops to 202 if the parents did not bed share. By changing the first AOR from 65.1 to 21.8 we find the average AOR for this child for the first 3 month to be approximately 1516, again reducing to an average of 202 if the baby did not bed share but is placed supine for sleep in a cot in the parents' room.

These alarming AORs show how the effect of multiple risk factors builds up, and indicates that infants with multiple risk factors are likely to be at far greater risk than in generally supposed.

The fraction of deaths while bed sharing attributable to bed sharing.

In this combined data set 22% (n=324) of the deaths occurred while bed sharing; 66% (n= 213) of these were under the age of 3 months. Overall 87.7% (86.3–89.2%) were attributable to bed

[†] The AORs obtained as described here will not be precise but will be well within the CI for the best estimates, see appendix

sharing, assuming that they would otherwise have been placed on their back in a cot in the parents' room. This rises to 89.5% (88.8–90.3%) for bed sharing deaths under 3 months of age.

Comparison of SIDS rates

To get an overview of the absolute risks and increases in risk associated with bed sharing, SIDS mortality rates for infants when room sharing or bed sharing are estimated and tabulated in Table 4 for six combinations of risk factors. In addition, Table 4 also shows the ratio of SIDS rates for bed sharing compared with room sharing. These SIDS rates have been calculated by assuming that the population SIDS rate is 0.5 per 1000 live births and apply to a typical cohabiting white mother age 26 – 30 having a second normal weight baby with birth weight between 2.5 and 3.5kg – the most common situation of a mother completing her family.

Table 4 shows that for room sharing breast fed babies placed supine whose parents do not smoke and with no other risk factors, the SIDS rate is predicted to be 0.08 (0.05–0.14) per 1000 live births. This rate is predicted to increase by 2.7 times, (1.4–5.3) to 0.23 (0.11–0.49) per 1000 when bed sharing. For all combinations of risk factors, the predicted increases in risk associated with bed sharing are statistically significant. These rates may be scaled up or down depending on the population SIDS rate, and other factors present, see appendix for details. For example from the Tables, 1 & 4 we find, that a 2.25kg bottle fed baby bed sharing with an 18 year old mother, who smokes and regularly takes 2+ units of alcohol and whose partner also smokes, has a predicted SIDS rate of 125 per 1000, i.e., 12.5%, see supplementary Table b) in appendix.

Discussion

Mitchell recently reviewed risks and benefits of bed sharing; he concluded that postulated benefits and guidelines for bed sharing safely are not evidence based.[21] He also found that there is only one small group with ***no*** increased risk of SIDS when bed sharing, namely breast fed infants over 3 months whose parents do not smoke, and whose mother does not take 2 or more units of alcohol or drugs and do not co-sleep on a sofa. Mitchell urged that parents had a right to know the risks they are exposing their infants to when bed sharing, but they were not quantified.

This study combines 5 major SIDS case-control studies. It includes 1472 cases and 4679 controls making it the largest study of SIDS risk factors with individual level data. By combining individual data this design allows the interaction of risk factors such as breast feeding, infant age and smoking to be examined in relation to bed sharing and SIDS. Accordingly it is able to examine the interplay of the risk factors relating to bed sharing in depth as never before. Our findings confirm Mitchell's conclusions and ***quantify*** the relative risks and predicted SIDS rates associated with bed sharing in a variety of circumstances.

It may be objected that the missing data in relation to alcohol and drug use in three of the five data sets make any attempt to exclude the contribution of these factors to the risks associated with bed sharing completely unreliable. However, for studies which did not include questions of mother's alcohol and drug use, we have gone back to the original records of breast fed bed sharing cases when both the mother and her partner were non-smokers, and established that neither alcohol nor drug use contributed in anyway to any of these deaths.

Also, it may be shown, see appendix, that because missing data are primarily determined by the study, by including 'study' when modelling the data the results will be unbiased. Further, the results from analysis of the completed data will primarily depend on the observed data, and only slightly on the imputed data. Consequently, this analysis is more efficient because it uses all the observed data, rather than depending solely on the complete records.

In particular, the combined data have enabled the demonstration of increased relative risk associated with bed sharing when the baby is breast fed and neither parent smokes (see Fig 2 & Table 2). The average risk is in the first 3 months and is 5.1 (2.3–11.4) times greater than if the baby is put down to sleep supine in a cot in the parents' room (Table 3). This increased risk is unlikely to be due to ***chance*** (p= 0.000059) ***Bias*** could occur because these estimates are based on models fitted to all the data or to all the data relating to infants under 3 months of age. Moreover, checks show that the models accurately describe the data, especially that relating to cases whose only risk factor is bed sharing, see appendix. Bias is also possible due to the selection of the studies. However, the present study incorporates far more data than were included in Vennemann et al's recent meta-analysis of the ORs for bed sharing in infants of non-smoking mothers.[25] The meta-analysis produced summary odds ratios very similar to those reported in this study. Furthermore, our findings are very unlikely to be due to ***confounding*** since the AORs are adjusted for all the major SIDS risk factors. Although the partner's consumption of alcohol is not included in the data set, it was found in the ECAS study that this factor was correlated with mother's alcohol consumption (r = 0.52) and, after taking account of the mother's alcohol, it did not add further to the prediction of risk.[7]

Mitchell's review of the mechanisms by which bed sharing might cause SIDS shows a causal pathway is not unreasonable.[21] Panel 1 reviews the evidence that the association of bed sharing with SIDS is causal by Bradford Hill's criteria.[31] Clearly, bed sharing can be a causal factor of SIDS. Recently there has been a tendency to record unexplained bed sharing infant deaths as due to 'suffocation-bed' (ICD code E913/W75)[32,33], or 'undetermined' rather than SIDS when the baby was bed sharing and may have suffocated.[34] This analysis includes all such cases. Certifying such deaths under other headings does nothing to minimise the tragedy[‡].

Other new findings

The risk of SIDS for an average family with no known modifiable risk factors - table 4 baseline (breast-fed, non-smoking, non-drinking parents who are room sharing and not bed sharing) was 0.08/1000 live births. This is the level of SIDS that might be achieved if all known modifiable risk factors were removed. Such a SIDS level may be deemed intrinsic (possibly genetic) and not directly amenable to behaviour modification. This is consistent with countries reporting low SIDS rates. National surveys in The Netherlands show that, following an active campaign to discourage bed sharing,[4] bed sharing rates have fallen from 13% in 1999, 10% in 2005 to 1.5% always bed sharing and 3.1% sometimes bed sharing in 2011.[38] The SIDS rate is 0.1 per 1000.[39] At the same time the percentage of infants being breastfed at 3 months of age has risen from 45% to 52%.[40]

A recent study commissioned by UNICEF[41] suggests that the promotion breast feeding and support of breast feeding mothers would reduce the burden of disease on the NHS and could thereby be cost effective. However, if bed sharing is promoted as a means of encouraging breast feeding, it is likely to increase the number of SIDS because the AOR for bed sharing, 2.7, is nearly double the AOR for bottle feeing, 1.5. Consequently, such an approach would be likely to *increase* the number of SIDS cases. If SIDS deaths are costed at more than £1.5 million each, as in the UNICEF report, the costs resulting from any increase in bed sharing would far outweigh any benefits from increased breast feeding rates, quite apart from the disastrous consequences for families associated with the loss of a child. To reap the benefit of increasing breast feeding duration and rates, the Dutch recommendations should be followed, namely: 'To achieve maximal security for the baby and optimal availability of breastfeeding, mothers are advised to take the baby of less than 4 months of age into their bed for feeding during the night, but afterwards to place the baby on its back into his own crib, placed adjacent to the parents' bed in the parents' bedroom'.[5]

[‡] Following an investigation into deaths certified as SIDS and unascertained, ONS found that many of their characteristics were very similar,[35] and now ONS reports these deaths together as unexplained deaths in infancy.[36] In 2004 Limerick and Bacon in a study of terminology used by pathologist in reporting SIDS found that when giving the cause of death of an infant found unexpectedly dead while bed sharing, only 1 in 70 said asphyxia.[37]

Thus, we do not suggest that babies should not be brought into the parent's bed for comfort and feeding. This has been investigated in previous studies and has not been found to be a risk factor provided the infant is returned to his or her own cot.[42,43] This study is concerned with risks associated with *sleeping* with a baby in bed. Table 3 and 4 of this report are designed to enable an informed choice to be made by parents as to whether the risks associated with bed sharing outweigh the postulated benefits. However, our models predict that 88% of the deaths that occurred while bed sharing would probably not have occurred had the baby been place on its back in a cot by the parents'bed. Even for the very low risk breast fed babies under 3 months of age, with no other risk factors other than that they slept in their parents' bed, the model predicts that 81% (78.9–82.0%) of the deaths could have been readily prevented in this way. One has to ask whether it is worth taking the risk, however small, of loosing a baby, when it can be so easily avoided.

Previous epidemiological studies showed that being placed on the front when put down for sleep was a risk factor for SIDS and fulfilled similar criteria as a causal risk for SIDS; in the 1970s OR 2.9 (1.2–7.5) and in 1986 from 5 pooled case control studies OR 3.0 (1.7–5.3).[2] A campaign to reduce prone sleeping effectively halved the number of SIDS cases worldwide between 1990 and 2000 saving thousands of babies in the developed world. Delay in implementing an effective 'back to sleep' campaign is estimated to have resulted in the deaths of 10,000 lives in the UK alone.[2]

Recent case studies indicate that now 50% or more of SIDS cases[18,44] occur while bed sharing. Our analysis shows that most of these SIDS deaths would not have occurred if bed sharing had not taken place.

If parents were made aware of the risks of sleeping with their baby, and room sharing were promoted, as 'Back to Sleep' was promoted 20 years ago, a substantial further reduction in SIDS rates could be achieved.

Word count 3968

Variable		Cases No.	Cases %	Controls No.	Controls %	% missing records	Complete records Single factor OR	Complete records Single factor 95% CI	Complete & imputed data Single factor OR*	Complete & imputed data Single factor 95% CI	Complete & imputed data Selected multivariate AOR	Complete & imputed data Selected multivariate 95% CI
Bed Sharing						0.9						
	No	1,131	77.7	4,192	90.4		1	-	1	-	1	-
	Yes	324	22.3	446	9.6		2.6	2.2–3.1	2.6	2.2–3.1	2.7‡	1.4–5.3
Feeding						0.8						
	Breast	504	34.9	2,491	53.5		1	-	1	-	1	-
	Bottle	940	65.1	2,168	46.5		2.9	2.5–3.3	2.9	2.5–3.3	1.5	1.2–1.8
Position last left						1.6						
	back all ages	377	26.5	1,972	42.6		1	-	1	-	1	-
	side	438	30.8	1,869	40.3		1.6	1.3–1.8	1.6	1.3–1.9	1.5†	1.2–2.1
	front	607	42.7	791	17.1		7.8	6.4–9.5	7.9	6.5–9.6	10.5†	7.5–14.6
Parental smoking						2.9						
	Neither	314	22.4	2,285	50.0		1	-	1	-	1	-
	Partner only	194	13.8	1,083	23.7		1.4	1.1–1.7	1.4	1.1–1.7	1.1*	0.8–1.4
	Mother only	194	13.8	427	9.4		3.7	3.0–4.6	3.8	3.1–4.7	1.5*	1.2–2.1
	Both	703	50.0	774	16.9		7.4	6.2–8.7	7.3	6.2–8.6	2.9*	2.3–3.6
Mother took 2 unit or more of alcohol in last 24 Hours						61.3						
	No	478	81.0	1,694	94.5		1	-	1	-	1	-
	Yes	112	19.0	99	5.5		5.1	3.7–7.0	6.5	4.6–9.3	4.8*	2.6–8.9
Mother used illegal drugs after birth						60.5						
	None	582	96.5	1,825	99.8		1	-	1	-	1	-
	Any	21	3.5	3	0.2		19.2	5.4–68.3	30.7	8.8–106.8	11.5*	2.2–59.5
Sex						0.3						
Unmatched studies:	Female	351	39.5	1,401	49.3		1	-	1	-	1	-
	Male	538	60.5	1,442	50.7		1.5	1.3–1.8	1.5	1.3–1.7	1.6	1.3–1.9
Matched studies:	Female	217	37.6	683	37.5		1	-	1	-	1	-
	Male	360	62.4	1,141	62.5		1.0	0.8´1.2	1.0	0.8–1.2	0.8	0.6–1.1
Race						0.3						
	White	1,181	81.1	4,242	90.7		1	-	1	-	1	-
	Non-white	276	18.9	434	9.3		3.0	2.5–3.6	3.0	2.5–3.6	1.5	1.1–1.9
Birth Weight group:						2.3						
	3500g or more	415	28.9	2,293	50.1		1	-	1	-	1	-
	2500 – 3499g	760	52.8	2,092	45.8		2.0	1.7–2.3	2.0	1.7–2.3	1.7	1.4–2.0
	2000 – 2499g	144	10.0	127	2.8		6.3	4.8–8.2	6.4	4.9–8.3	4.2	2.9–6.0
	under 2000g	120	8.3	59	1.3		13.5	9.6–18..9	13.8	9.8–19.4	9.6	6.2–14.7
Mother's age in years						0.6						
	over 30	326	22.4	1,921	41.2		1	-	1	-	1	-
	26 – 30	419	28.8	1,552	33.3		1.8	1.5–2.1	1.8	1.5–2.1	1.9	1.5–2.3
	21 – 25	434	29.9	910	19.5		3.3	2.8–3.9	3.3	2.8–3.9	3.0	2.4–3.8
	19 – 20	162	11.1	169	3.6		6.8	5.2–8.8	6.8	5.3–8.8	7.7	5.2–11.4
	18 & under	113	7.8	111	2.4		7.1	5.3–9.6	7.2	5.3–9.7	9.1	5.9–14.1
No. of live births including the present one:						0.8						
	1	407	28.1	1,836	39.4		1	-	1	-	1	-
	2	491	33.9	1,566	33.7		1.4	1.2–1.7	1.4	1.2–1.7	2.3	1.9–2.9
	3	280	19.3	748	16.1		1.8	1.5–2.2	1.9	1.5–2.2	3.8	2.9–4.9
	4	149	10.3	304	6.5		2.6	2.1–3.3	2.6	2.1–3.3	5.2	3.7–7.4
	5 or more	122	8.4	200	4.3		3.5	2.7–4.5	3.5	2.7–4.6	7.7	5.3–11.3
Mother's marital status:						0.2						
	Married or with partner	996	68.1	4,049	86.6		1	-	1	-	1	-
	Single	467	31.9	628	13.4		4.0	3.4–4.7	4.0	3.4–4.7	1.9	1.5–2.4
Where slept last						1.4						
	Parent's room	817	57.0	2,806	60.6		1	-	1	-	1	-
	Other room	616	43.0	1,823	39.4		1.3	1.1–1.5	1..3	1.2–1.5	2.4	2.0–2.9

‡ Multivatiate AOR for bed sharing pooled for all ages up to one year.
† Multivariate AOR when baby in a cot in parent's room & age is 3months.or less.
The corresponding AOR's when baby is over 3m are 1.4 (1.1–1.8) & 7.7 (5.9–10.2) respectively
* Multivariate AOR when baby in a cot on parent's room

Table 1 The number and percent of cases and controls for each factor, percent missing data, univariate ORs & CIs based on complete data. Also, univariate ORs & multivatiate AORs & CIs based on the imputed data sets.

Factor	Room sharing		Bed sharing					
			At 2 weeks		At 10 weeks `		At 20 weeks	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Position last left								
Back	**1.0**	—					**1.2**	0.6–2.8
Side	**1.8***	1.3–2.4	**8.3**	3.7–18.6	**3.6**	1.8–7.2	**0.8**	0.3–2.0
Front	**12.0***	8.6–16.8					**5.3**	1.8–16.0
Parental smoking								
None	**1.0**	—	**8.3**	3.7–18.6	**3.6**	1.8–7.2	**1.2**	0.6–2.8
Partner	**1.1**	0.8–1.4	**17.6**	8.1–38.4	**7.6**	3.8–15.1	**2.6**	1.2–6.0
Mother	**1.5**	1.2–2.1	**47.3**	18.9–118.4	**20.4**	8.8–46.9	**7.1**	2.8–18.0
Both	**2.9**	2.3–3.6	**65.1**	30.9–137.5	**28.1**	15.0–52.5	**9.8**	4.7–20.3
Mother's Alcohol 2+ vs. <2 units	**4.7**	2.6–8.7	**89.6**	25.3–317.3	**38.6**	12.6–117.7	**13.5**	4.6–39.4
Mother illegal drug user Yes vs. no	**11.4**	2.2–57.8	**Unquantifiably large**					

* After 3m, the AOR for put down on side is 1.4 (1.1–1.8) & front 7.7 (5.8–10.1) when room sharing
Note: For the first 3 months when bed sharing, risk is not affected by the position put down.

Table 2. The AORs for avoidable factors that interact with bed sharing, adjusted for all other factors. Therefore, they relate to the baseline corresponding to babies of non-smoking mothers who do not use drugs, and taking < 2 units of alcohol in the 24 hours, having a non-smoking partner, and no other risk factors.

Age group	Risk factors		Room sharing		Bed sharing		Multiplicative increase in AOR when bed sharing	
	Smokinig	Alcohol	AOR	95% CI	AOR	95% CI	Multiplier	95% CI
< 3month	no	no	1	-	**5.1**	2.3–11.4	**5.1**	2.3–11.4
	P	no	0.7	0.5–1.1	**7.8**	3.6–17.2	**11.2**	5.0–25.1
	M	no	1.3	0.8–2.2	**20.3**	7.4–56.2	**15.2**	5.3–43.3
	B	no	**2.9**	2.0–4.2	**21.8**	11.1–42.6	**7.5**	3.9–14.8
	B	**Y**	**13.7**	5.5–34.4	**151.0**	50.6–450.7	**11.0**	3.1–39.3
3 months & over	no	no	1	-	1.0	0.3–3.1	1.0	0.3–3.1
	P	no	1.2	0.9–1.7	**3.0**	1.2–7.5	**2.5**	1.0–6.3
	M	no	**1.7**	1.2–2.4	**6.1**	1.7–22.6	**3.6***	0.9–13.9
	B	no	**3.0**	2.3–4.0	**13.7**	6.1–31.0	**4.6**	2.0–10.3
	B	**Y**	**15.7**	8.1–30.4	**243.8**	76.1–781.4	**15.6**	4.2–57.4

The AORs in light type are not statistically significant.
*** This multiplier is significant at p = 0.062**

Table 3. Average AORs for smoking, smoking & maternal alcohol when room sharing and bed sharing with the multiplicative increase in risk due to bed sharing, for infants under 3 months and 3 months up to a year.

Group No.	Risk factors present			Room sharing		Bed sharing		Ratio of rates	
	Feeding	smoking	Alcohol	Rate/1000	95% CI	Rate/1000	95% CI	Ratio	95% CI
minimum risk	**Br**	no	no	**0.08**	0.05–0.14	**0.23**	0.11–0.49	**2.7**	1.4–5.3
1	**Bot**	no	no	**0.13**	0.08–0.21	**0.34**	0.16–0.73	**2.7**	1.4–5.3
2	Br	**P**	no	**0.09**	0.05–0.16	**0.52**	0.25–1.08	**5.6**	2.9–10.8
3	Br	**M**	no	**0.13**	0.08–0.23	**1.27**	0.54–3.00	**9.7**	4.4–21.7
4	Br	**B**	no	**0.24**	0.15–0.41	**1.88**	0.94–3.73	**7.7**	4.3–13.8
5	**Bot**	**B**	**Y**	**1.77**	0.87–3.48	**27.5**	10.4–68.4	**15.6**	5.7–41.5

*Predicted SIDS mortality rates for a cohabiting, white mother age 26 – 30, having a second normal weight baby with birth weight between 2.5 and 3.5kg.

Table 4. Predicted SIDS Mortality Rates for Normal Women*

Panel 1 Assessment of bed sharing as a causal risk for SIDS by Bradford Hill's criteria[31]

STRENGTH OF ASSOCIATION ✓
Adjusted Odds Ratio (AOR) for bed sharing = 2.7 (95% CI 1.4–5.3), p = 0.0027, for breast fed infants with no other risk factors. AOR for the first 3 months of life = 5.1 (2.3–11.4), p = 0.00006 . These AORs are moderately strong.

CONSISTENT ✓
All but two small published studies show increased risk of SIDS associated with bed sharing.

SPECIFIC ✓× not an essential criterion
Smoking, alcohol and drug use all have greatly increased risk when bed sharing ✓
Bed sharing is associated with other causes of death, e.g. Suffocation. ×
SIDS can occur in the absence of bed sharing. ×

TEMPORALLY CORRECT ✓
Bed sharing always precedes SIDS.

DOSE RESPONSE ✓
New Zealand study risk increased with duration of bed sharing.[45] Not otherwise investigated.

BIOLOGICALLY PLAUSIBLE ✓
Bed sharing risk is greatest to youngest infants who are most vulnerable.

COHERENCE ✓
The proposition that bed sharing is causally related to SIDS is coherent with theories that respiratory obstruction, re-breathing expired gases, and thermal stress (or overheating), which may also give rise to the release of lethal toxins.[46] All are mechanisms leading to SIDS. Infants placed prone are exposed to similar hazards.

DIRECT EXPERIMENTAL EVIDENCE ×
Not ethically possible.

ANALOGY ✓
Overlying is a serious cause of mortality in piglets. Sows are normally separated by a bar from piglets to prevent them being crushed when she turns over, but allowing her piglets to feed.

Panel 2

WHAT WAS ALREADY KNOWN ON THIS TOPIC

Babies who sleep in bed with their parents, who are smokers or have drunk alcohol in the last 24 hours, are at increased risk of Sudden Infant Death Syndrome (SIDS), however the risk from bed sharing if neither parent smokes and the baby is breastfed was uncertain.

WHAT THIS STUDY ADDS

This study combined 5 large data sets, making it the largest reported study of SIDS with individual level data.

Bed sharing for sleep satisfied recognised criteria as a *cause* of SIDS.

When neither parent smoked, baby was less than 3 months of age, and breast fed, bed sharing for sleep multiplied the risk of a baby dying from SIDS by 5, compared with room sharing.

Over 50% of SIDS deaths now occur while bed sharing. A substantial further reduction in SIDS rates, up to 50%, could be achieved if all infants slept on their back in a cot in the parental bedroom.

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Contributors

The first five authors played a major role in the design and analysis of their studies, and submitted data for this combined analysis. JRC and MS were responsible for imputing missing data. RGC combined and analysed the data and drafted the report. EAM advised on the analysis. All authors commented on drafts and have seen and approved the paper as submitted.

Conflict of interest

The first five authors are actively involved in SIDS and/or paediatric research. RGC is a member the Steering Committee of the Foundation for the Study of Infant Death's Care of Next Infant, CONI, project for which he receives travelling expenses. The last two authors are specialists in the imputation of missing data. We declare no conflict of interest.

Ethical approval

All studies were ethically approved. Only completely anonymised data were combined for this study.

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Appendix: Statistical methods

Missing data

Preliminary analysis, together with the study context, showed that missing values were most plausibly missing at random dependent on study. Therefore, since we include study indicators as covariates, a complete records analysis will give unbiased if somewhat inefficient inference[A1]. To include the information from studies in which alcohol and drug use data were not observed, we used multiple imputation (under the missing at random assumption) to impute missing data. We used the REALCOM-IMPUTE software[A2] with a single level imputation model because alcohol and drug data were too sparse among the studies in which they recorded to obtain convergence for a multilevel imputation model. Missing data were imputed for cases and controls separately. Ten imputed data sets were computed. Using STATA 12[A3] the substantive multilevel model was fitted to each in turn. Convergence was not achieved for one because the likelihood was flat in the region of the maximum; the results for the remaining 9 were combined for inference using Rubin's rules[A4].

Analysis showed that the between imputation variation across the 9 imputed data sets was small relative to the within imputation variance, so 9 imputations were sufficient.

Reliability of results based on observed and imputed data

First, remember that for cases of bed sharing infants <3 months whose parents did not smoke we have checked the original records to ensure that alcohol and drugs were not contributory factors in any.

Second, the prevalence of alcohol and drug use among mothers varies considerably across the studies where the information was collected. For controls, the prevalence of mother having more than 2 units of alcohol in the last twenty four hours (henceforth 'mother using alcohol') ranged from 0 to 9%, and the prevalence of mother using any illegal drug (henceforth 'mother using drugs') ranged from 0 to 0.6%. For cases the corresponding percentages range from 0 to 39% and 0 to 3% respectively. Consequently the ORs for mother using alcohol vary significantly across the centres. However, there is no evidence that the three-way interaction of mother using alcohol, bed sharing and centre is significant, $p = 0.429$. Therefore, the relationship between bed sharing and centre does not vary by mother using alcohol. In consequence the OR for bed sharing is not affected by varying prevalence of mother using alcohol across the centres. For mother using drugs the data are too sparse for the analogous three-way interaction to be tested. However, it seems unlikely it would be significant. In consequence the OR for bed sharing is not affected by varying prevalence of mother using drugs across the centres.

Third, because the alcohol and drug data are plausibly MAR dependent on study, which is included as an indicator variable in both the substantive model and the imputation model, theory suggests that the point estimates in the complete records analysis should be unbiased, and within sampling variation of those obtained after multiple imputation. The advantage of multiple imputation here is thus the recovery of information, primarily through the inclusion of the partially observed data from the three studies in which alcohol and drug use were not collected. The results are in line with this, as shown for example in Table 1, columns 8-11, and a comparison of the results of a complete records analysis with those presented here.

Calculation of univariate and multivariate odds ratios

Odds ratios were calculated by logit regression. Univariate analyses were adjusted for age and study because controls were on average 3 weeks older than cases, and the number of controls varied between studies. For multivariate AORs, multilevel logit regression model was fitted with 'bed sharing' random across studies; this was done to take account of a significant interaction of bed sharing with studies. Some other AORs showed significant interaction with studies; however, it was found that these were due to significant deviations in one or at most two studies. When parameters were added to the overall model, to account for these interactions, they had little effect on the main parameters, and only slightly *increased* the estimate of risk associated with bed sharing. The additional parameters were therefore dropped in the final model and these interaction ignored.

The trend in the ln(OR) for bed sharing with age was best represented by a linear downward trend on the logit scale, for the first six months followed by a constant term thereafter. In all four models were used for the analysis:

Model 1. A multilevel logit model of the whole data, including the interaction of age and bed sharing, modelled by the linear trend,

Model 2. To obtain rates applicable to all ages, the same model, excluding the age×bedsharing interaction was fitted, thereby obtaining average AOR for the year.

Models 3 & 4. To obtain average AORs for the first three months and later, a logistic forms of the rates model was fitted to records of infants under 3 months and 3 month or more. Logistic models were used because of convergence problems with multilevel models.

Goodness of fit of the models to the data

Goodness of fit tests are not available for multilevel logit models nor are they available after using Rubin's combination rules for the analysis of multiple imputed data sets. Therefore single level (i.e., standard) logistic models, using the same parameters as the overall model plus fixed effect parameters for study, were fitted to each of the 10 data sets completed with imputed data; both the log link and goodness of fit tests were applied to each. The link test confirmed that all the models were correctly specified: p(for regression on hat^2) averaged 0.44 and all were> 0.15, and p(for the constant) averaged 0.75 and all were >0.56. The average Hosmer-Lemeshow goodness of fit $\chi^2(48) = 40.3$ was less than expectation. and none had a p value < 0.13. It was, therefore, concluded that the model fit was excellent. Checks on the model, without the age trend, fitted to infants aged <3 months showed equally good fit.

To check the fit of the overall model to the data relating to the breast fed cases, age <3 months, whose parents did not smoke and whose mothers did not consume alcohol or use drugs but who were bed sharing, their deviance residuals were computed. The AOR for this groups is represented by the lower line in Fig 2. As above, the deviance residuals could only be computed after fitting a logistic model to each of the 10 completed data sets. Again, the results were pooled using Rubin's rules[A4]. It was found that the mean deviance for this group = - 0.098, s.e 0.1004. Also there was not evidence of any systematic deviation from the fitted line in that there was no evidence of a trend in the residual deviances with age; b = -0.0015, s.e. 0.005.

Similarly residual deviances were computed for this group after fitting model 3. The pooled average residual deviance was -0.147 with s.e. -0.096; p = 0.122. The trend in the residuals was 0.00012 with s.e. 0.005. Thus there is no suggestion that the model parameters do not represent these crucial data.

The Attributable Fraction

The attributable fraction (of deaths, computed as described by Brussi et al.[29]), was similarly computed for each of the 10 logistic models fitted to the imputed data sets. The results were combined using Rubin's combination rules.[A4]

Mortality rates

Rates were derived from the parameters of model 2. Rates are given for all children, computed by a weighted combination of the rates for boys and girls. The base rate for girls was the SIDS rate when none of the model risk factors were present. Then, logit(base rate) = model constant scaled by the addition of the logit of the population SIDS rate and the subtraction of the log(ratio of the number of cases to controls in the model). Combinations of AORs gave other rates from the base rate.

Estimating AORs and Rates for other groups

The AORs computed for other groups, as described on page 7 are approximate because the AORs for the factors which do not interact with age or bed sharing vary, but not significantly, across the 4 models used for the analyses. The AORs shown in the penultimate column of Table 1 are those given by model 2. These differ a little from the comparable AORs given by the Model 1, which includes the age×bed sharing interaction. Thus for the example on page 7, the AOR predicted by model 1 is 4,416 (1764–11,058) compared with 4528 shown.

When computing SIDS rates for other groups from those give in Table 4, the procedure is similar. However, the observed rate must first be divided by 7.43 to reduce the rate baseline – the rates reported in Table 4 relate the second infant with birth weight 2500 – 3499g of a cohabiting white women age 26 to 30. The appropriate baseline rate, i.e., for various smoking groups may then be scaled up according to the other risk factors present. However, if the computed rate is $r > 0.003$ per 1000, it should be reduced by $-r^2$, because the scaling is based on AORs and rates are probabilities. Conversely if the starting rate is >0.003 it has first to be scaled to an AOR by adding its square.

For example the estimated SIDS rate for a be sharing 18 year old cohabiting white mother, with her 1st baby, birth weight 2240g. bottle fed when both parents smoke and mother often has 2+units of alcohol is estimated to be

$$r = \{(0.0275 + 0.0275^2)/7.43\}\times 4.2\times 9.1 = 145.4$$

where:

0.0275 = rate from Table 4 when both smoke, mother uses alcohol and baby is bottle fed
0.0275^2 is added to obtain the corresponding AOR because the starting rate is >0.003
/7.43 to obtain the corresponding baseline AOR
×4.2 from Table 1 for babies 2000-2499
×9.1 from Table 1 for mothers aged 18

Thus, $r > 0.003$. Hence

$$\text{Pridicted rate per 1000} = 1000*(r-r^2) = 125 \text{ per } 1000,$$

which is exact because the AORs in Table 1 are derived from Model 2. Supplementary tables show predicted SIDS rates for two groups of women other than those in Table 4.

Rates may also be scaled up or down in direct relation to the population SIDS rate. Thus if the population SIDS rate is 0.4 per 1000 instead of 0.5 the the estimated rates will be reduced by 4/5 =0.8.

Supplementary tables of predicted rates for two other groups of women.

a) Cohabiting white women age 30+ with 1st baby birth weight >3500g

Group No.	Risk factors present			Room sharing	Bed sharing
	Feeding	smoking	Alcohol	Rate/1000	Rate/1000
Baseline	Br	no	no	**0.011**	**0.031**
1	**Bot**	no	no	**0.017**	**0.047**
2	Br	**P**	no	**0.013**	**0.070**
3	Br	**M**	no	**0.018**	**0.171**
4	Br	**B**	no	**0.033**	**0.254**
5	**Bot**	**B**	**Y**	**0.235**	**3.74**

b) Cohabiting white women age 18 - 19 with 1st baby with birth weight 2000 - 2499g

Group No.	Risk factors present			Room sharing	Bed sharing
	Feeding	smoking	Alcohol	Rate/1000	Rate
Baseline	Br	no	no	**0.4**	**1.2**
1	**Bot**	no	no	**0.6**	**1.8**
2	Br	**P**	no	**0.5**	**2.7**
3	Br	**M**	no	**0.7**	**6.5**
4	Br	**B**	no	**1.2**	**9.5**
5	**Bot**	**B**	**Y**	**8.8**	**124.6**

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A1 Carpenter JR, Goldstein H, Kenwood MG. (2012) Statistical modelling of partially observed data using multiple imputation: principles and practice. p20. In: Modern Methods for Epidemiology. Ed. Greenwood DC & Tu Y. Springer, London.2012.

A2 Carpenter JR, Goldstein H, Kenward MG. (2012). REALCOM-IMPUTE Software for Multilevel Multiple Imputation with Mixed Response Types. J Statistical Software. **45** :5: 1-14.

A3 StataCorp 2011. Stata Statistical Software: Release 12.1. College Station, TX: Stata Corporation.

A4 Rubin D. (1987) Multiple Imputation for Non-response in Surveys. Wiley, Chichester.

STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology*

Checklist for cohort, case-control, and cross-sectional studies (combined)

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	3	State specific objectives, including any pre-specified hypotheses	2 & 3
Methods			
Study design	4	Present key elements of study design early in the paper	3
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	3 & see original reports of the studies
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	All cases in defined areas & normal infants of similar age & sex in some studies.
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	4
Bias	9	Describe any efforts to address potential sources of bias	4
Study size	10	Explain how the study size was arrived at	3
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Table 1, as in previous studiy
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	2, 4 and appendix
		(*b*) Describe any methods used to examine subgroups and interactions	4,& appendix
		(*c*) Explain how missing data were addressed	4 & appendix
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed	—

		Case-control study—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	4 & appendix
		(*e*) Describe any sensitivity analyses	none
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Table 1
		(b) Give reasons for non-participation at each stage	Table 1
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Page 3 & original reports
		(b) Indicate number of participants with missing data for each variable of interest	Table 1
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	—
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	—
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	Table 1
		Cross-sectional study—Report numbers of outcome events or summary measures	
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Tables 1 - 4
		(*b*) Report category boundaries when continuous variables were categorized	Table 1
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	
Discussion			
Key results	18	Summarise key results with reference to study objectives	2
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	9
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	9 -10
Generalisability	21	Discuss the generalisability (external validity) of the study results	9-10
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	18

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

Bed sharing when parents do not smoke: Is there a risk of SIDS?
Findings of a combined analysis of five case-control data sets

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Bed sharing when parents do not smoke: Is there a risk of SIDS? Findings of a combined analysis of five case-control data sets.

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Abstract

Objective: To resolve uncertainty as to the risk of Sudden Infant Death Syndrome (SIDS) associated with sleeping in bed with your baby if neither parent smokes and the baby is breastfed.

Design: Bed sharing was defined as sleeping with a baby in the parents' bed; room sharing as baby sleeping in the parents' room. Frequency of bed sharing during last sleep was compared between babies who died of SIDS and living control infants. Individual data from five large SIDS case-control data sets were combined. All missing data were imputed. Random effects logistic regression was used to control for potential confounding factors.

Setting: Home sleeping arrangements of parents and infants in 19 studies across UK, Europe, and Australasia.

Participants: There were 1,472 SIDS cases, and 4,679 controls. Each study effectively included all cases, by standard criteria, occurring in a defined area and time period. Controls were randomly selected normal infants of the same age, time, and place.

Results: in the combined dataset, 22.3% of cases and 9.6% of controls were bed sharing, adjusted Odds Ratio, AOR for all ages 2.7; 95% Confidence Interval (CI) (1.4–5.3). Bed sharing risk decreased with increasing infant age. When neither parent smoked, baby was less than 3 months of age, and breast fed and no other risk factors were present the AOR for bed sharing vs. room sharing was 5.1 (2.3–11.4). The estimated absolute risk for room sharing infants in this group was very low (0.08 (0.05–0.14) per 1000 live births). This rate increased to 0.23 (0.11–0.43) per 1000 when bed sharing. Smoking and alcohol use greatly increased bed sharing risk, especially in the first weeks of life.

Conclusion: Bed sharing for sleep when the parents do not smoke or take alcohol or drugs increases the risk of SIDS. Risks associated with bed sharing are greatly increased when combined with parental smoking, maternal alcohol consumption and/or drug use. A substantial reduction of SIDS rates could be achieved if parents avoided bed sharing.

Article Summary

Focus

- Is there a risk of SIDS due to bed sharing when baby is breast fed, the parents do not smoke, and the mother does not use alcohol or illegal drugs?
- At what age is it safe to bed share?
- How is risk of SIDS associated with bed sharing affected by other factors?

Key Messages

- When the baby is breast fed and under 3 months, there is a fivefold increase in the risk of SIDS when bed sharing with non-smoking parents, and mother has not taken alcohol or drugs.
- Smoking, alcohol and drugs greatly increase the risk associated with bed sharing.
- A substantial reduction is SIDS rates could be achieved if parents avoided bed sharing.

Strength and limitations

- **This** is the largest ever analysis of individual records of 1472 SIDS cases and 4679 controls from five major case control studies.
- Questions on mother's alcohol use in the last 24 hours and illegal drug use were not asked in three of these studies.
- Imputation of missing data enabled a combined analysis of all the data. The analysis gives unbiased efficient models that describe the data accurately, especially in key areas.

Background

Despite the marked reduction in Sudden Infant Death Syndrome (SIDS)[1] following the advice to place babies to sleep on their back (supine),[2] SIDS remains the major cause of infant death in the post neonatal period (28 days through to the first birthday) in high income countries. For instance in the US SIDS remains the leading cause of postneonatal mortality where 2,353 babies died from SIDS in 2008, about 0.6 per 1000 live births.[3]

Some countries give advice to parents in their 'Reduce the Risks' literature not to bed share with their babies under any circumstances. For example, The Netherlands advise parents not to bed share for the first 3 months of life[4] based on their own research findings.[5] This is also the case for the US[6] where the American Academy of Pediatrics Task Force on SIDS cited European[7] and New Zealand[8] data (included in this paper) and made a clear statement advising against bed sharing for sleep. Other countries notably the UK and Australia advise only certain groups not to bed share for sleep.[9-12] Bed sharing and the risk of SIDS has become controversial, especially as some, while listing when it should be avoided, highlight the benefits of bed sharing.[13,14]

There is general acceptance that sleeping with a baby is a risk factor for SIDS when sleeping on a sofa in any circumstances or in a bed if the mother smokes and/or has taken alcohol.[15, 16] However, authors differ as to whether, in the absence of these risk factors, bed sharing represents a risk.[17-22] Mitchell, in a recent review suggests that before embarking on further studies, much could be achieved by combining the information from current studies.[23]

However, these risks, specifically for non-smokers when breast feeding, cannot be quantified directly from published data by standard meta-analysis due to the different ways risks are reported.[5, 17, 19, 24, 25] The limited assessment of interactions for instance between bed sharing and breast feeding due to lack of individual data to analyse was highlighted in the recent meta-analysis of case control studies of SIDS.[26] Therefore, the leading authors of five major recent case-control studies agreed to combine the *individual* data to estimate the risk associated with bed sharing in relation to breast feeding, smoking, mother's recent alcohol consumption, and illegal drug use, after controlling for the other most important risk predictors, namely whether the baby slept in the parents' room or elsewhere, position the baby is put down to sleep, mother single, mother's age and parity, and baby's birth weight These five datasets included all cases that some might now classify as "unascertained" or "asphyxia" because they were found bed sharing or sleeping face down.

Material and Methods

Study population

The data from the European case control studies 1992 – 1996, i.e., The European Concerted Action on SIDS, ECAS,[7] the Scottish 1996 –2000,[27] the New Zealand 1987–1990,[8] the Irish 1994–2003,[28] and the German GeSID 1998–2001[29] datasets were combined. Cases and controls over one year of age were excluded. The combined dataset comprised 1472 cases and 4679 normal controls of similar age. For details on how the controls were selected please see the original reports.

Notes on explanatory variables

The explanatory variables were defined as follows:

'*Bed sharing*' was defined as when one or both parents slept with the baby in their bed so that they woke to find the baby dead in bed with them. Controls were bed sharing if the baby was in bed with them when they awoke on the day of interview.

'*Room sharing*' ~ sleeping in the parents' room but not in the parents' bed.

'*Breast fed*' ~ infant was being partially or completely breast fed at the time of death or interview.

'*Bottle fed*' ~ the infant was not breast fed at this time.

'Parents' ~ the mother and her current partner.

'*Age*' ~ the infant's age at death or at interview for controls.
'AOR' ~ multivariate adjusted odds ratio**.** AORs and rates are followed by the 95% Confidence Interval (CI) in parentheses.

All datasets enabled the identification of cases found sleeping in the parents' room or elsewhere and whether or not they were bed sharing, together with comparable control data. Cases and controls co-sleeping on a sofa or elsewhere were included but grouped with those not bed sharing and not sleeping in the parents' room. Whether or not the mother or partner smoked, together with the infant's age, sex, race, birth weight, mother's age, parity, whether single or with a partner, and position the infant was last placed to sleep, and how the baby was being fed at the time of death/interview were available for all data sets. In addition, data on the mother's alcohol consumption in the last 24 hours and mother's illegal drug use after birth were available in two datasets. In total all the variables shown in Table, together with age at death or interview, and study* were used in the analyses.

Statistical analysis
All variables, other than case or control, age, and study, included some missing data. Missing data were imputed as described in the Statistical Appendix. Odds ratios were calculated by logit regression. Univariate analyses were adjusted for age and study because controls were on average 3 weeks older than cases, and the number of controls per case varied between studies. For multivariate AORs, a multilevel logit regression model was used with "bed sharing" random across studies. The fraction of bed sharing deaths ***attributable*** to bed sharing, that is the fraction of bed sharing deaths that would not have occurred had the babies not been bed sharing but placed supine in a cot in the parents' room, all other things being unchanged, was computed as described by Bruzzi et al.[30] Mortality rates were computed using the same multivariate model by omitting the trend of bed sharing with age. Rates are given for all infants computed by a weighted combination of the rates for boys and girls. The base rate for girls was the SIDS rate when none of the model risk factors were present. To obtain average AOR for infants <3 months and for infants aged 3 months or more, a logistic form if the rates model confined to records under 3 months and 3 months or more were fitted. .

Full details of the statistical methods are given in the Statistical Appendix.

Results

The age distribution of the 1472 cases is shown in Fig.1. The peak incidence rate is between 7 and 10 weeks.

(Fig.1 Here)

Fig. 1 The age distribution of the cases in the combined study.

Univariate and multivariate analyses

The data for each variable are tabulated for cases and controls in Table 1 together with percentage of missing data and the single factor ORs adjusted for age and study, together with the corresponding OR derived from analysis of the imputed data sets. Corresponding multivariate adjusted AORs from the overall model are also reported. For variables that interact with bed sharing, and consequently age, AORs reported in Table 1 are those for infants room sharing but not bed sharing.

* The ECAS data set comprises a set of 20 studies, five of which were excluded due to absence of data on feeding or unwillingness to participate.

Feeding
Table 1 shows that bottle feeding increases risk of SIDS. When analysed as a single factor the OR for bottle feeding is 2.9 (2.5–3.3) however, the multivariate AOR is 1.5 (1.2–1.8).

Multivariate analyses for interactions between age, bed sharing and other variables
The baseline in the multivariate analysis is a breast fed baby placed on his/her back to sleep in a cot in the parents' room neither of whom smoke and having no other risk factors.

Bed Sharing
The log-linear downward trend in the OR for bed sharing in the first 6 months of life is shown in Fig 2, when neither parent smoked and when both smoked. These values are predicted by the overall model of the whole data set. Checks show that the predicted risks closely fit the data, especially when neither parent smoked and the mother had taken neither alcohol or drugs and the baby was breast fed and bed sharing(see appendix).

(Fig. 2 here)

Fig. 2. Adjusted ORs (log scale) for SIDS by age for bed sharing breast fed infants, when neither parent smokes and both smoke vs. comparable infants sleeping supine in the parents' room. AORs are also adjusted for feeding, sleeping position when last left, where last slept, sex, race, and birth weight, mother's age, parity, marital status, alcohol and drug use.

The analysis showed that *only* position last left, parental smoking, maternal alcohol consumption in the last 24 hours, and illegal drug use, interact with bed sharing, and consequently the associated risks when bed sharing also decline with increasing age. Table 2 summarises the adjusted AORs for each of these factors, first when room sharing and second when bed sharing at 2, 10 and 20 weeks of age. Three ages are used to illustrate the reduction in risks associated with bed sharing, as the baby gets older. Table 2 confirms that the OR for bed sharing is 8.3 (3.7–18.6) at 2 weeks and Fig 2 shows that bed sharing is a significant risk factor for the first 15 weeks of life in the absence of smoking, alcohol, drugs, and all other risk factors.

Position last left.
When sleeping in a cot there is a significant risk associated with placing the baby on its side and a substantial risk when placed prone. In contrast when bed sharing, being placed on the side is not

associated with an increased risk and analysis shows that when placed prone there is little and no significant increase in risk for the first 3 months, Table 2.

Parental smoking

Table 2 also highlights the strength of the very significant interaction between smoking and bed sharing. Infants who bed share at 2 weeks of age whose parents both smoke are at 65-fold increased risk of SIDS compared with infants room sharing with parents who do not smoke. There is a 'dose response' effect, univariately, when room sharing, and when bed sharing at 2 weeks, 10 weeks and 20 weeks related to whether just the partner smokes, just mother smokes or both smoke. However, when the infant does not sleep with the parents, risks associated with parental smoking are comparatively small.

Alcohol and drugs

Table 2 also shows the AORs associated with the mother having had 2 or more units of alcohol in the last 24 hours. If the baby does not bed share, two or more units increases the risk nearly 5-fold in contrast to a very substantial increase in risk when bed sharing, especially in the first weeks of life (OR at 2 weeks of age = 89.6). The use of any illegal drugs by the mother, including cannabis, increases the risk eleven-fold even when the baby is room sharing. The risks associated with a drug using mother bed sharing are unquantifiably large.

Average ORs for the first 3 months and after

In view of the trends in the AORs associated with bed sharing and age, Table 3 tabulates average under and over 3 months AORs for two key factors, smoking and alcohol when room sharing and bed sharing. These adjusted ORs apply when no other risk factors are present and the baseline risk group group is breast fed baby girls placed on their back for sleep by the bed of non-smoking parents and having no other risk factors. Table 3 shows that if this group with baseline risk bed share, their average risk for the first 3 months, AOR is 5.1 (2.3–11.4). After the infant is 3 months old the corresponding average AOR is 1.0 (0.3–3.0)

The multipliers shown in the last column shows the ratio of the AORs when bed sharing to the corresponding AOR when room sharing. In so far as these multipliers are >5.1 for the under 3 months, and > 1.0 after that age, they show how the interaction, first of smoking and then of parental smoking plus maternal alcohol with bed sharing, greatly enhances the risk associated with bed sharing. The data are too sparse to give meaningful AORs when mother is a drug user. It will also be noted that the second largest increase in risk associated with bed sharing occurs when the baby is under 3 months and the mother smoked.

Calculation of AORs for other risk groups

Because, in the absence of interaction, AORs multiply, Tables 1, 2, and 3 enable approximate[†] AORs to be calculated for almost all other risk groups. Thus, at two weeks if the baby is not breast fed but bottle fed, Table 1 shows the AOR is multiplied by 1.5; if the baby's birth weight is between 2000g and 2499g the AOR is scaled up by 4.2, and so on. Thus at 2 weeks the AOR for a bottle fed baby boy with birth weight 2140g who bed shares with a cohabiting 21 year old mother with one previous child and both parents smoke the

AOR = 65.1 (Table 2: both smoke)
× 1.5 (Table 1: bottle fed)

[†] The AORs obtained as described here will not be precise but will be well within the CI for the best estimates, see appendix

× 1.6 (Table 1: Male)
× 4.2 (Table 1: Birth weight)
× 3.0 (Table 1: mother's age)
× 2.3 (Table 1: 1 previous child)
= 4528

.

If, using Table 2 we replace 65.1 with 2.9 we find that this alarming figure drops to 202 for parents who did not bed share. By changing the first AOR from 65.1 to 21.8 we find the average AOR for this child for the first 3 month to be approximately 1516, again reducing to an average of 202 if the baby did not bed share but is placed supine for sleep in a cot in the parents' room.

These alarming AORs show how the effect of multiple risk factors builds up, and indicates that infants with multiple risk factors are likely to be at far greater risk than is generally supposed.

The fraction of deaths while bed sharing attributable to bed sharing.
In this combined data set 22% (n=324) of the deaths occurred while bed sharing; 66% (n= 213) of these were under the age of 3 months. Overall 87.7% (86.3–89.2%) were attributable to bed sharing, assuming that they would otherwise have been placed on their back in a cot in the parents' room. This rises to 89.5% (88.8–90.3%) for bed sharing deaths under 3 months of age.

Comparison of SIDS rates
To get an overview of the absolute risks and increases in risk associated with bed sharing, SIDS mortality rates for infants (i.e., ages 0 up to 1 year) when room sharing or bed sharing are estimated and tabulated in Table 4 for six combinations of risk factors. In addition, Table 4 also shows the ratio of SIDS rates for bed sharing compared with room sharing. These SIDS rates have been calculated by assuming that the population SIDS rate is 0.5 per 1000 live births and apply to a typical cohabiting white mother aged 26 – 30 having a second normal weight baby with birth weight between 2.5 and 3.5kg – the most common situation of a mother completing her family.

Table 4 shows that for room sharing breast fed babies placed supine whose parents do not smoke and with no other risk factors, the SIDS rate is predicted to be 0.08 (0.05–0.14) per 1000 live births. This rate is predicted to increase by 2.7 times, (1.4–5.3) to 0.23 (0.11–0.49) per 1000 when bed sharing. For all combinations of risk factors, the predicted increases in risk associated with bed sharing are statistically significant. These rates may be scaled up or down depending on the population SIDS rate, and other factors present, see appendix for details. For example from the Tables, 1 & 4 we find, that a 2.25kg bottle fed baby bed sharing with an 18 year old mother, who smokes and regularly takes 2+ units of alcohol and whose partner also smokes, has a predicted SIDS rate of 125 per 1000, i.e., 12.5%, see supplementary Table b) in appendix.

Discussion

Mitchell recently reviewed risks and benefits of bed sharing; he concluded that postulated benefits and guidelines for bed sharing safely are not evidence based.[21] He also found that there is only one small group with ***no*** increased risk of SIDS when bed sharing, namely,+ breast fed infants over 3 months whose parents do not smoke, and whose mother does not take 2 or more units of alcohol or drugs and does not co-sleep on a sofa. Mitchell urged that parents had a right to know the risks they are exposing their infants to when bed sharing, but was unable to quantify these risks.

This study combines 5 major SIDS case-control studies. It includes 1472 cases and 4679 controls making it the largest study of SIDS risk factors with individual level data. By combining individual data this design allows the interaction of risk factors such as breast feeding, infant age and smoking to be examined in relation to bed sharing and SIDS. Accordingly it is able to examine the interplay

of the risk factors related to bed sharing in depth as never before. Our findings confirm Mitchell's conclusions and ***quantify*** the relative risks and predicted SIDS rates associated with bed sharing in a variety of circumstances.

It has been suggested that we should have taken into account the partner's alcohol consumption in the last 24 hours and his drug use. We did not include the former factor because in the analysis of the ECAS study it was found partner's consumption of alcohol was correlated with that of the mother did not add further to risk of SIDS.[7] To check on this possibility, we have gone back to the original records for the key sub group, namely babies < 3 months who were breast fed whose parents did not smoke and whose mother took less than 2 units of alcohol in the last 24 hours who either bed shared or room shared. We find that in both the bed sharing and room sharing groups the control partners had taken slightly *more* alcohol in the last 24 hours than the controls. Consequently, if we adjusted for this factor it would increase the OR for bed sharing, We also note that the subgroup OR based on the complete data is 5.6 (1.6 – 20.3), which is almost identical to the adjusted AOR for this group 5.1 (2.3 – 11.4), Table 3.

To respond to the criticism that the missing data in relation to alcohol and drug use in three of the five data sets make any attempt to exclude the contribution of these factors to the risks associated with bed sharing completely unreliable, we have gone back to the original records for bed sharing cases in the key subgroup. Most of these records include pertinent questions on alcohol use although not maternal use in the last 24 hours. This enabled us to establish that neither alcohol nor drug use contributed in any way to any of these deaths.

Also, as discussed in more detail in the appendix, because missing data are primarily determined by the study, by including 'study' when modelling the subset of complete data and modelling the imputed data, the results of both will be essentially unbiased. In this setting, multiple imputation is is expected primarily to recover to information by including the partially observed records in the analysis, This is what we find. Consequently, we can be confident of our estimate of the adjusted effect bed sharing from the imputed data.

Importantly, the combined data have enabled the demonstration of increased relative risk associated with bed sharing when the baby is breast fed and neither parent smokes (see Fig 2 & Table 2). The average risk is in the first 3 months and is 5.1 (2.3–11.4) times greater than if the baby is put down to sleep supine in a cot in the parents' room (Table 3). This increased risk is unlikely to be due to ***chance*** (p= 0.000059) ***Bias*** could occur because these estimates are based on models fitted to all the data or to all the data relating to infants under 3 months of age. Moreover, checks show that the models accurately describe the data, especially that relating to cases whose only risk factor is bed sharing, see appendix. Bias is also possible due to the selection of the studies. However, the present study incorporates far more data than were included in Vennemann et al's recent meta-analysis of the ORs for bed sharing in infants of non-smoking mothers.[25] The meta-analysis produced summary odds ratios very similar to those reported in this study. Furthermore, our findings are very unlikely to be due to ***confounding*** since the AORs are adjusted for all the major SIDS risk factors. Although the partner's consumption of alcohol is not included in the data set, it was found in the ECAS study that this factor was correlated with mother's alcohol consumption (r = 0.52) and, after taking account of the mother's alcohol consumption, it did not add further to the prediction of risk.[7]

Mitchell's review of the mechanisms by which bed sharing might cause SIDS shows a causal pathway is not unreasonable.[21] Panel 1 reviews the evidence that the association of bed sharing when mothers do not smoke with SIDS is causal by Bradford Hill's criteria.[31] Clearly, bed sharing in the white European context can be a causal factor of for SIDS. It has been argued that because the risk of bed sharing is greatly increased by parental smoking, alcohol and/or drugs, that it is the way we bed share rather than bed sharing itself that is important. Parental smoking greatly

enhances the risk of SIDS associated with bed sharing, but in what way their pattern of bed sharing differs for that of non-smokers is not obvious. Although breast feeding is lower among smokers than non-smokers, 46% cases of bed sharing smokers were breast feeding and 61% of controls. These figures are lower than for non-smokers, 62% and 73% respectively, but these differences do not demonstrate that parental smoking results in a different way of bed sharing. For non-smokers and smokers alike sleeping in a 'western style' bed with a baby carries a risk of SIDS. Why the risk is so greatly enhanced by parental smoking is not known.

Recently there has been a tendency to record unexplained bed sharing infant deaths as due to 'suffocation-bed' (ICD code E913/W75)[32,33], or 'undetermined' rather than SIDS when the baby was bed sharing and may have suffocated.[34] However, an investigation into deaths certified as SIDS and unascertained, the UK Office of National Statistics found that many of their characteristics were very similar,[35] and now ONS reports these deaths together as unexplained deaths in infancy.[36] In 2004 Limerick and Bacon in a study of terminology used by pathologist in reporting SIDS found that when giving the cause of death of an infant found unexpectedly dead while bed sharing, only 1 in 70 said asphyxia.[37] The selection of cases in our studies includes all such deaths . Certifying such deaths under headings other than SIDS does nothing to minimise the tragedy[‡].

Other new findings

The risk of SIDS for an average family with no known modifiable risk factors - Table 4 baseline (breast-fed, non-smoking, non-drinking parents who are room sharing and not bed sharing) was 0.08/1000 live births. This is the level of SIDS that might be achieved if all known modifiable risk factors were removed. Such a SIDS level may be deemed intrinsic (possibly genetic) and not directly amenable to behaviour modification. This rate is consistent with countries reporting low SIDS rates. National surveys in The Netherlands show that, following an active campaign to discourage bed sharing,[4] bed sharing rates have fallen from 13% in 1999, 10% in 2005 to 1.5% always bed sharing and 3.1% sometimes bed sharing in 2011.[38] During the same period as part of a general downward trend in SIDS mortality[39], SIDS rates have fallen 25% from 0.12 in 2000 to 0.09 per 1000 in 2010.[40,41] At the same time the percentage of infants being breastfed at 3 months of age has risen from 45% to 52%., and at 6 months from 24% to 32%[42], confirming that promotion of bed sharing is not necessary to achieve high rates of prolonged breast feeding.

A recent study commissioned by UNICEF[43] suggests that the promotion of breast feeding and support of breast feeding mothers in the UK would reduce the burden of disease on the National Health Service and could thereby be cost effective. However, if bed sharing is promoted as a means of encouraging breast feeding, it is likely to increase the number of SIDS because the AOR for bed sharing, 2.7, is nearly double the AOR for bottle feeing, 1.5. Consequently, such an approach would be likely to *increase* the number of SIDS cases. If SIDS deaths are costed at more than £1.5 million each, as in the UNICEF report, the costs resulting from any increase in bed sharing would far outweigh any benefits from increased breast feeding rates, quite apart from the disastrous consequences for families associated with the loss of a child. To reap the benefit of increasing breast feeding duration and rates, the Dutch recommendations should be followed, namely: 'To achieve maximal security for the baby and optimal availability of breastfeeding, mothers are advised to take the baby of less than 4 months of age into their bed for feeding during the night, but afterwards to place the baby on its back into his own crib, placed adjacent to the parents' bed in the parents' bedroom'.[5]

[‡] ~~Following an investigation into deaths certified as SIDS and unascertained, ONS found that many of their characteristics were very similar,[35] and now ONS reports these deaths together as unexplained deaths in infancy.[36] In 2004 Limerick and Bacon in a study of terminology used by pathologist in reporting SIDS found that when giving the cause of death of an infant found unexpectedly dead while bed sharing, only 1 in 70 said asphyxia.[37]~~

Thus, we do not suggest that babies should not be brought into the parent's bed for comfort and feeding. This has been investigated in previous studies and has not been found to be a risk factor provided the infant is returned to his or her own cot. [44,45] This study is concerned with risks associated with *sleeping* with a baby in bed. Table 3 and 4 of this report are designed to enable an informed choice to be made by parents as to whether the risks associated with bed sharing outweigh the postulated benefits. However, our models predict that 88% of the deaths that occurred while bed sharing would probably not have occurred had the baby been placed on its back in a cot by the parents'bed. Even for the very low risk breast fed babies under 3 months of age, with no other risk factors other than that they slept in their parents' bed, the model predicts that 81% (78.9–82.0%) of the deaths could have been readily prevented in this way. One has to ask whether it is worth taking the risk, however small, of losing a baby, when it can be so easily avoided.

Previous epidemiological studies showed that being placed on the front, prone, for sleep was a risk factor for SIDS and fulfilled similar criteria as a causal risk for SIDS; in the 1970s OR 2.9 (1.2–7.5) and in 1986 from 5 pooled case control studies OR 3.0 (1.7–5.3).[2] A campaign to reduce prone sleeping effectively halved the number of SIDS cases worldwide between 1990 and 2000 saving thousands of babies in the developed world. Delay in implementing an effective 'back to sleep' campaign is estimated to have resulted in the deaths of 10,000 lives in the UK alone.[2]

Recent case studies indicate that now 50% or more of SIDS cases[18,46] occur while bed sharing in contrast to 22% in this study, Table 1. In the UK, possibly due to the pro bed sharing lobby[14], in the 10 years between the two studies by Blair and his colleagues[45,18], the percentage of cases bed sharing (excluding sofa sharing) doubled and the percentage of controls bed sharing increased by 50% from 14.5% to 21.8%. Meanwhile, the crude unadjusted OR for bed sharing only changed from 2.0 to 2.2. (An adjusted OR for bed sharing is not reported for the latter study). Our analysis estimates that 88% of bed sharing deaths are attributable to bed sharing, i.e., would not have occurred had the baby not been bed sharing, The stability of the crude OR for bed sharing despite the increase in the prevalence of bed sharing suggests that our estimate of attributable risk may reasonably be applied currently. Consequently, our analysis suggests that about 90% of bed sharing SIDS deaths would not occur in the absence of bed sharing.

The current messages say that bed sharing is dangerous only if your or your partner are smokers, have been drinking alcohol, or drugs that make you drowsy, are very tired, or the baby is premature or low birth weight, are not effective because many of the bed sharing deaths involve these factors. Our findings suggest that professionals and the literature should take a more definite stand against bed sharing, especially for babies under 3 months. If parents were made aware of the risks of sleeping with their baby, and room sharing were promoted, as 'Back to Sleep' was promoted 20 years ago, a substantial further reduction in SIDS rates could be achieved. .

Variable		Cases No.	Cases %	Controls No.	Controls %	% missing records	Complete records Single factor OR	Complete records Single factor 95% CI	Complete & imputed data Single factor OR*	Complete & imputed data Single factor 95% CI	Complete & imputed data Selected multivariate AOR	Complete & imputed data Selected multivariate 95% CI
Bed Sharing						0.9						
	No	1,131	77.7	4,192	90.4		1	-	1	-	1	-
	Yes	324	22.3	446	9.6		2.6	2.2–3.1	2.6	2.2–3.1	2.7‡	1.4–5.3
Feeding						0.8						
	Breast	504	34.9	2,491	53.5		1	-	1	-	1	-
	Bottle	940	65.1	2,168	46.5		2.9	2.5–3.3	2.9	2.5–3.3	1.5	1.2–1.8
Position last left						1.6						
	back all ages	377	26.5	1,972	42.6		1	-	1	-	1	-
	side	438	30.8	1,869	40.3		1.6	1.3–1.8	1.6	1.3–1.9	1.5†	1.2–2.1
	front	607	42.7	791	17.1		7.8	6.4–9.5	7.9	6.5–9.6	10.5†	7.5–14.6
Parental smoking						2.9						
	Neither	314	22.4	2,285	50.0		1	-	1	-	1	-
	Partner only	194	13.8	1,083	23.7		1.4	1.1–1.7	1.4	1.1–1.7	1.1*	0.8–1.4
	Mother only	194	13.8	427	9.4		3.7	3.0–4.6	3.8	3.1–4.7	1.5*	1.2–2.1
	Both	703	50.0	774	16.9		7.4	6.2–8.7	7.3	6.2–8.6	2.9*	2.3–3.6
Mother took 2 unit or more of alcohol in last 24 Hours						61.3						
	No	478	81.0	1,694	94.5		1	-	1	-	1	-
	Yes	112	19.0	99	5.5		5.1	3.7–7.0	6.5	4.6–9.3	4.8*	2.6–8.9
Mother used illegal drugs after birth						60.5						
	None	582	96.5	1,825	99.8		1	-	1	-	1	-
	Any	21	3.5	3	0.2		19.2	5.4–68.3	30.7	8.8–106.8	11.5*	2.2–59.5
Sex						0.3						
Unmatched studies:	Female	351	39.5	1,401	49.3		1	-	1	-	1	-
	Male	538	60.5	1,442	50.7		1.5	1.3–1.8	1.5	1.3–1.7	1.6	1.3–1.9
Matched studies:	Female	217	37.6	683	37.5		1	-	1	-	1	-
	Male	360	62.4	1,141	62.5		1.0	0.8´1.2	1.0	0.8–1.2	0.8	0.6–1.1
Race						0.3						
	White	1,181	81.1	4,242	90.7		1	-	1	-	1	-
	Non-white	276	18.9	434	9.3		3.0	2.5–3.6	3.0	2.5–3.6	1.5	1.1–1.9
Birth Weight group:						2.3						
	3500g or more	415	28.9	2,293	50.1		1	-	1	-	1	-
	2500 – 3499g	760	52.8	2,092	45.8		2.0	1.7–2.3	2.0	1.7–2.3	1.7	1.4–2.0
	2000 – 2499g	144	10.0	127	2.8		6.3	4.8–8.2	6.4	4.9–8.3	4.2	2.9–6.0
	under 2000g	120	8.3	59	1.3		13.5	9.6–18..9	13.8	9.8–19.4	9.6	6.2–14.7
Mother's age in years						0.6						
	over 30	326	22.4	1,921	41.2		1	-	1	-	1	-
	26 – 30	419	28.8	1,552	33.3		1.8	1.5–2.1	1.8	1.5–2.1	1.9	1.5–2.3
	21 – 25	434	29.9	910	19.5		3.3	2.8–3.9	3.3	2.8–3.9	3.0	2.4–3.8
	19 – 20	162	11.1	169	3.6		6.8	5.2–8.8	6.8	5.3–8.8	7.7	5.2–11.4
	18 & under	113	7.8	111	2.4		7.1	5.3–9.6	7.2	5.3–9.7	9.1	5.9–14.1
No. of live births including the present one:						0.8						
	1	407	28.1	1,836	39.4		1	-	1	-	1	-
	2	491	33.9	1,566	33.7		1.4	1.2–1.7	1.4	1.2–1.7	2.3	1.9–2.9
	3	280	19.3	748	16.1		1.8	1.5–2.2	1.9	1.5–2.2	3.8	2.9–4.9
	4	149	10.3	304	6.5		2.6	2.1–3.3	2.6	2.1–3.3	5.2	3.7–7.4
	5 or more	122	8.4	200	4.3		3.5	2.7–4.5	3.5	2.7–4.6	7.7	5.3–11.3
Mother's marital status:						0.2						
	Married or with partner	996	68.1	4,049	86.6		1	-	1	-	1	-
	Single	467	31.9	628	13.4		4.0	3.4–4.7	4.0	3.4–4.7	1.9	1.5–2.4
Where slept last						1.4						
	Parents' room	817	57.0	2,806	60.6		1	-	1	-	1	-
	Elsewhere	616	43.0	1,823	39.4		1.3	1.1–1.5	1..3	1.2–1.5	2.4	2.0–2.9

‡ Multivatiate AOR for bed sharing pooled for all ages up to one year.
† Multivariate AOR when baby in a cot in parent's room & age is 3months.or less.
The corresponding AOR's when baby is over 3m are 1.4 (1.1–1.8) & 7.7 (5.9–10.2) respectively
* Multivariate AOR when baby in a cot in parents' room

Table 1 The number and percent of cases and controls for each factor, percent missing data, univariate ORs & CIs based on complete data. Also, univariate ORs & multivatiate AORs & CIs based on the imputed data sets.

Factor	Room sharing		Bed sharing					
			At 2 weeks		At 10 weeks `		At 20 weeks	
	AOR	95% CI	AOR	95% CI	AOR	95% CI	AOR	95% CI
Position last left								
Back	**1.0**	—					**1.2**	0.6–2.8
Side	**1.8***	1.3–2.4	**8.3**	3.7–18.6	**3.6**	1.8–7.2	**0.8**	0.3–2.0
Front	**12.0***	8.6–16.8					**5.3**	1.8–16.0
Parental smoking								
None	**1.0**	—	**8.3**	3.7–18.6	**3.6**	1.8–7.2	**1.2**	0.6–2.8
Partner	**1.1**	0.8–1.4	**17.6**	8.1–38.4	**7.6**	3.8–15.1	**2.6**	1.2–6.0
Mother	**1.5**	1.2–2.1	**47.3**	18.9–118.4	**20.4**	8.8–46.9	**7.1**	2.8–18.0
Both	**2.9**	2.3–3.6	**65.1**	30.9–137.5	**28.1**	15.0–52.5	**9.8**	4.7–20.3
Mother's Alcohol								
2+ vs <2 units vs None	**4.7**	2.6–8.7	**89.6**	25.3–317.3	**38.6**	12.6–117.7	**13.5**	4.6–39.4
Mother illegal drug user								
Yes vs. no	**11.4**	2.2–57.8	**Inestimably large**					

*** After 3m, the AOR for put down on side is 1.4 (1.1–1.8) & front 7.7 (5.8–10.1) when room sharing**
Note: For the first 3 months when bed sharing, risk is not affected by the position put down.
All AORs are adjusted for other factors in the table and bottle feeding, sex, whether matched or unmatched, race, birthweight group, mother's age proup, no. of live births(grouped), mother single, and where slept..

Table 2. The AORs for avoidable factors that interact with bed sharing, adjusted for all other factors. Therefore, they relate to the baseline corresponding to babies of non-smoking mothers who do not use drugs, and taking < 2 units of alcohol in the 24 hours, having a non-smoking partner, and no other risk factors.

Age group	Risk factors		Room sharing		Bed sharing		Multiplicative increase in AOR when bed sharing	
	Smokinig	Alcohol	AOR	95% CI	AOR	95% CI	Multiplier	95% CI
< 3month	no	no	1	-	**5.1**	2.3–11.4	**5.1**	2.3–11.4
	P	no	0.7	0.5–1.1	**7.8**	3.6–17.2	**11.2**	5.0–25.1
	M	no	1.3	0.8–2.2	**20.3**	7.4–56.2	**15.2**	5.3–43.3
	B	no	**2.9**	2.0–4.2	**21.8**	11.1–42.6	**7.5**	3.9–14.8
	B	**Y**	**13.7**	5.5–34.4	**151.0**	50.6–450.7	**11.0**	3.1–39.3
3 months & over	no	no	1	-	1.0	0.3–3.1	1.0	0.3–3.1
	P	no	1.2	0.9–1.7	**3.0**	1.2–7.5	**2.5**	1.0–6.3
	M	no	**1.7**	1.2–2.4	**6.1**	1.7–22.6	**3.6***	0.9–13.9
	B	no	**3.0**	2.3–4.0	**13.7**	6.1–31.0	**4.6**	2.0–10.3
	B	**Y**	**15.7**	8.1–30.4	**243.8**	76.1–781.4	**15.6**	4.2–57.4

The AORs in light type are not statistically significant.
*** This multiplier is significant at p = 0.062**

Age group	Risk factors		Room sharing		Bed sharing		Multiplicative increase in AOR when bed sharing	
	Smoking	Alcohol	AOR	95% CI	AOR	95% CI	Multiplier	95% CI
< 3month	No	no	1	-	**5.1**	2.3–11.4	**5.1**	2.3–11.4
	Partner	no	0.7	0.5–1.1	**7.8**	3.6–17.2	**11.2**	5.0–25.1
	Mother	no	1.3	0.8–2.2	**20.3**	7.4–56.2	**15.2**	5.3–43.3
	Both	no	**2.9**	2.0–4.2	**21.8**	11.1–42.6	**7.5**	3.9–14.8
	Both	**Y**	**13.7**	5.5–34.4	**151.0**	50.6–450.7	**11.0**	3.1–39.3
3 months & over	No	no	1	-	1.0	0.3–3.1	1.0	0.3–3.1
	Partner	no	1.2	0.9–1.7	**3.0**	1.2–7.5	**2.5**	1.0–6.3
	Mother	no	**1.7**	1.2–2.4	**6.1**	1.7–22.6	**3.6***	0.9–13.9
	Both	no	**3.0**	2.3–4.0	**13.7**	6.1–31.0	**4.6**	2.0–10.3
	Both	**Y**	**15.7**	8.1–30.4	**243.8**	76.1–781.4	**15.6**	4.2–57.4

The AORs in light type are not statistically significant.

*** This multiplier is significant at p = 0.062**

The AORs in both Tables are adjusted for all other factors in the table, any drug use by the mother since birth, bottle feeding, sex, whether matched or unmatched, race, birthweight group, mother's age proup, number of live births (grouped), mother single, and where slept.

Table 3. Average AORs for smoking, smoking & maternal alcohol when room sharing and bed sharing with the multiplicative increase in risk due to bed sharing, for infants under 3 months and 3 months up to a year.

Group No.	Risk factors present			Room sharing		Bed sharing		Ratio of rates	
	Feeding	smoking	Alcohol	Rate/1000	95% CI	Rate/1000	95% CI	Ratio	95% CI
minimum risk	**Br**	no	no	**0.08**	0.05–0.14	**0.23**	0.11–0.49	**2.7**	1.4–5.3
1	**Bot**	no	no	**0.13**	0.08–0.21	**0.34**	0.16–0.73	**2.7**	1.4–5.3
2	Br	**P**	no	**0.09**	0.05–0.16	**0.52**	0.25–1.08	**5.6**	2.9–10.8
3	Br	**M**	no	**0.13**	0.08–0.23	**1.27**	0.54–3.00	**9.7**	4.4–21.7
4	Br	**B**	no	**0.24**	0.15–0.41	**1.88**	0.94–3.73	**7.7**	4.3–13.8
5	**Bot**	**B**	**Y**	**1.77**	0.87–3.48	**27.5**	10.4–68.4	**15.6**	5.7–41.5

Group No.	Risk factors present			Room sharing		Bed sharing		Ratio of rates	
	Feeding	smoking	Alcohol	Rate/1000	95% CI	Rate/1000	95% CI	Ratio	95% CI
minimum risk	**Br**	no	no	**0.08**	0.05–0.14	**0.23**	0.11–0.49	**2.7**	1.4–5.3
1	**Bot**	no	no	**0.13**	0.08–0.21	**0.34**	0.16–0.73	**2.7**	1.4–5.3
2	Br	**Partner**	no	**0.09**	0.05–0.16	**0.52**	0.25–1.08	**5.6**	2.9–10.8
3	Br	**Mother**	no	**0.13**	0.08–0.23	**1.27**	0.54–3.00	**9.7**	4.4–21.7
4	Br	**Both**	no	**0.24**	0.15–0.41	**1.88**	0.94–3.73	**7.7**	4.3–13.8
5	**Bot**	**Both**	**Yes**	**1.77**	0.87–3.48	**27.5**	10.4–68.4	**15.6**	5.7–41.5

*Predicted SIDS mortality rates for a cohabiting, white mother age 26 – 30, having a second normal weight baby with birth weight between 2.5 and 3.5kg and having no other risk factors. I.e., mother is not a drug user, has a partner and room shares.

Table 4. Predicted SIDS Infant Mortality Rates for Normal Women*

Panel 1 Assessment of bed sharing, in the absence of parental smoking alcohol and maternal drug use, as a causal risk for SIDS by Bradford Hill's criteria[31]

STRENGTH OF ASSOCIATION ✓
Adjusted Odds Ratio (AOR) for bed sharing = 2.7 (95% CI 1.4–5.3), p = 0.0027, for breast fed infants with no other risk factors. AOR for the first 3 months of life = 5.1 (2.3–11.4), p = 0.00006 . These AORs are moderately strong.

CONSISTENT ✓
Of more than 12 published studies, all but two small ones show, after multivariate adjustment, increased risk of SIDS associated with bed sharing, some combined with sofa sharing.[26]

SPECIFIC ✓× (not an essential criterion)
Smoking, alcohol and drug use all have greatly increased risk when bed sharing ✓
Bed sharing is associated with other causes of death, e.g. Suffocation. ×
SIDS can occur in the absence of bed sharing. ×

TEMPORALLY CORRECT ✓
Bed sharing always precedes SIDS.

DOSE RESPONSE ✓
New Zealand study risk increased with duration of bed sharing.[47] Not otherwise investigated.

BIOLOGICALLY PLAUSIBLE ✓
Bed sharing risk is greatest to youngest infants who are most vulnerable.

COHERENCE ✓
The proposition that bed sharing is causally related to SIDS is coherent with theories that respiratory obstruction, re-breathing expired gases, and thermal stress (or overheating), which may also give rise to the release of lethal toxins,[48 48]are all mechanisms leading to SIDS, in the absence of smoking, alcohol aror drugs. . Infants placed prone are exposed to similar hazards.

DIRECT EXPERIMENTAL EVIDENCE ×
Not ethically possible.

ANALOGY ✓
Overlying is a serious cause of mortality in piglets. Sows are normally separated by a bar from piglets to prevent them being crushed when she turns over, but allowing her piglets to feed.

Panel 2

WHAT WAS ALREADY KNOWN ON THIS TOPIC

Babies who sleep in bed with their parents, who are smokers or have drunk alcohol in the last 24 hours, are at increased risk of Sudden Infant Death Syndrome (SIDS), however the risk from bed sharing if neither parent smokes and the baby is breastfed was uncertain.

WHAT THIS STUDY ADDS

This study combined 5 large data sets, making it the largest reported study of SIDS with individual level data.

When no other risk factors are present, bed sharing for sleep satisfies recognised criteria as a *cause* of SIDS

When neither parent smoked, baby was less than 3 months of age, and breast fed, bed sharing for sleep multiplied the risk of a baby dying from SIDS by 5, compared with room sharing.

Over 50% of SIDS deaths now occur while bed sharing. A substantial further reduction in SIDS rates, possibly over 40%, could be achieved if parents avoided bed sharing and all infants slept on their back in a cot in the parental bedroom.

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Contributors

The first five authors played a major role in the design and analysis of their studies, and submitted data for this combined analysis. JRC and MS were responsible for imputing missing data. RGC combined and analysed the data and drafted the report. EAM advised on the analysis. All authors commented on drafts and have seen and approved the paper as submitted.

Conflict of interest

The first five authors are actively involved in SIDS and/or paediatric research. RGC is a member the Steering Committee of the Foundation for the Study of Infant Death's Care of Next Infant, CONI, project for which he receives travelling expenses. The last two authors are specialists in the imputation of missing data. We declare no conflict of interest.

Ethical approval

All studies were ethically approved. Only completely anonymised data were combined for this study.

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~~Bed sharing is a risk for Sudden Infant Death Syndrome (SIDS) even when parents do not smoke and infants are breastfed.~~

Bed sharing when parents do not smoke: Is there a risk of SIDS? Findings of a combined analysis of five case–control data sets.

~~Bed sharing is a risk for Sudden Infant Death Syndrome (SIDS) even when parents do not smoke and infants are breastfed.~~

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Abstract

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Objective: To resolve uncertainty as to the risk of Sudden Infant Death Syndrome (SIDS) associated with sleeping in bed with your baby if neither parent smokes and the baby is breastfed.

Design: Bed sharing was defined as sleeping with a baby in the parents' bed; room sharing as baby sleeping in the parents' room. Frequency of bed sharing during last sleep was compared between babies who died of SIDS and living control infants. Individual data from five large SIDS case-control data sets were combined. All missing data were imputed. Random effects logistic regression was used to control for potential confounding factors.

Setting: Home sleeping arrangements of parents and infants in 19 ~~centres~~ studies across UK, Europe, and Australasia.

Participants: There were 1,472 SIDS cases, and 4,679 controls. Each study effectively included all cases, by standard criteria, occurring in a defined area and time period. Controls were randomly selected normal infants of the same age, time, and place.

Results: in the combined dataset, 22.3% of cases and 9.6% of controls were bed sharing, adjusted Odds Ratio, AOR for all ages 2.7; 95% Confidence Interval (CI) (1.4–5.3). Bed sharing risk decreased with increasing infant age. When neither parent smoked, baby was less than 3 months of age, and breast fed and no other risk factors were present the AOR for bed sharing vs. room sharing was 5.1 (2.3–11.4). The estimated absolute risk for room sharing infants in this group was very low (0.08 (0.05–0.14) per 1000 live births). This rate increased to 0.23 (0.11–0.43) per 1000 when bed sharing. Smoking and alcohol use greatly increased bed sharing risk, especially in the first weeks of life.

Conclusion: Bed sharing for sleep when the parents do not smoke or take alcohol or drugs increases the risk of SIDS. Risks associated with bed sharing are greatly increased when combined with parental smoking, maternal alcohol consumption and/or drug use. A substantial reduction of SIDS rates could be achieved if parents avoided bed sharing.

~~Bed sharing for sleepfulfils the criteria for a causal factor of SIDS. A substantial reduction of SIDS rates (up to 50%) could be achieved by discouraging bed sharing and encouraging room sharing.~~

Comment [EM1]: I think this might be a better statement. It gets away from causality and answers the question we initially are trying to answer.

Article Summary

Focus

- Is there a risk of SIDS due to bed sharing when baby is breast fed, the parents do not smoke, and the mother does not use alcohol or illegal drugs?
- At what age is it safe to bed share?
- How is risk of SIDS associated with bed sharing affected by other factors?

Key Messages

- When the baby is breast fed and under 3 months, there is a fivefold increase in the risk of SIDS when bed sharing with non-smoking parents, and mother has not taken alcohol or drugs.
- Smoking, alcohol and drugs greatly increase the risk associated with bed sharing.
- A ~~50%~~ substantial reduction is SIDS rates could be achieved ~~by discouraging~~ if parents avoided bed sharing.

Strength and limitations

- ~~It~~ **This** is the largest ever analysis of individual records of 1472 SIDS cases and 4679 controls from five major case control studies.
- Questions on mother's alcohol use in the last 24 hours and illegal drug use were not asked in three of these studies.
- Imputation of missing data enabled a combined analysis of all the data. The analysis gives unbiased efficient models that describe the data accurately, especially in key areas.

Background

Despite the marked reduction in Sudden Infant Death Syndrome (SIDS)[1] following the advice to place babies to sleep on their back (supine),[2] SIDS remains the major cause of infant death in the post neonatal period (28 days through to the first birthday) in high income countries. For instance in the US SIDS remains the leading cause of postneonatal mortality where 2,353 babies died from SIDS in 2008, about 0.6 per 1000 live births.[3]

Some countries give advice to parents in their 'Reduce the Risks' literature not to bed share with their babies under any circumstances. For example, The Netherlands advise parents not to bed share for the first 3 months of life[4] based on their own research findings.[5] This is also the case for the US[6] where the American Academy of Pediatrics Task Force on SIDS cited European[7] and New Zealand[8] data (included in this paper) and made a clear statement advising against bed sharing for sleep. Other countries notably the UK and Australia advise only certain groups not to bed share for sleep.[9-12] Bed sharing and the risk of SIDS has become controversial, especially as some, ~~do not discourage or actively promote bed sharing.~~[13, 14] while listing when it should be avoided, highlight the benefits of bed sharing.[13,14]

There is general acceptance that sleeping with a baby is a risk factor for SIDS when sleeping on a sofa in any circumstances or in a bed if the mother smokes and/or has taken alcohol.[15, 16] However, authors differ as to whether, in the absence of these risk factors, bed sharing represents a risk.[17-22] Mitchell, in a recent review suggests that before embarking on further studies, much could be achieved by combining the information from current studies.[23]

However, these risks, specifically for non-smokers when breast feeding, cannot be quantified directly from published data by standard meta-analysis due to the different ways risks are reported.[5, 17, 19, 24, 25] The limited assessment of interactions for instance between bed sharing and breast feeding due to lack of individual data to analyse was highlighted in the recent meta-analysis of case control studies of SIDS.[26] Therefore, the leading authors of five major recent case-control studies agreed to combine the *individual* data to estimate the risk associated with bed sharing in relation to breast feeding, smoking, mother's recent alcohol consumption, and illegal drug use, after controlling for the other most important risk predictors, namely whether the baby slept in the parents' room or elsewhere, position the baby is put down to sleep, mother single, mother's age and parity, and baby's birth weight. ~~—~~ These five ~~studies~~ datasets included all cases that some might now classify as "unascertained" or "asphyxia" because they were found bed sharing or sleeping face down.

Material and Methods

Study population

The data from the European case control studies 1992 – 1996, i.e., The European Concerted Action on SIDS, ECAS,[7] the Scottish 1996 –2000,[27] the New Zealand 1987–1990,[8] the Irish 1994–2003,[28] and the German GeSID 1998–2001[29] ~~studies~~ datasets were combined. Cases and controls over one year of age were excluded. The combined data-set comprised 1472 cases and 4679 normal controls of similar age. For details on how the controls were selected please see the original reports.

Notes on explanatory variables

The explanatory variables were defined as follows:

'*Bed sharing*' was defined as when one or both parents slept with the baby in their bed so that they woke to find the baby dead in bed with them. Controls were bed sharing if the baby was in bed with them when they awoke on the day of interview~~, or equivalent questions~~.

'*Room sharing*' ~ sleeping in the parents' room but not in the parents' bed.

'*Breast fed*' ~ infant was being partially or completely breast fed at the time of death or interview.

'*Bottle fed*' ~ the infant was not breast fed at this time.
'Parents' ~ the mother and her current partner.
'*Age*' ~ the infant's age at death or at interview for controls.
'AOR' ~ multivariate adjusted odds ratio**.** AORs and rates are followed by the 95% Confidence Interval (CI) in parentheses.

All data-sets enabled the identification of cases found sleeping in the parents' room or elsewhere and whether or not they were bed sharing, together with comparable control data. Cases and controls co-sleeping on a sofa or elsewhere were included but ~~classed~~grouped with those ~~as~~ not bed sharing and not sleeping in the parents' room. Whether or not the mother or partner smoked, together with the infant's age, sex, race, birth weight, mother's age, parity, whether single or with a partner, and position the infant was last placed to sleep, and how the baby was being fed at the time of death/interview were available for all data sets. In addition, data on the mother's alcohol consumption in the last 24 hours and mother's illegal drug use after birth were available in two datasets. In total ~~of sixteen~~all the variables shown in Table, together with age at death or interview, ~~including~~ and ~~the~~ study* were used in the analyses.

Comment [EM2]: See response to Blair point x

Statistical analysis
All variables, other than case or control, age, and study, included some missing data. Missing data were imputed as described in the Statistical Appendix. Odds ratios were calculated by logit regression. Univariate analyses were adjusted for age and study because controls were on average 3 weeks older than cases, and the number of controls per case varied between studies. For multivariate AORs, a multilevel logit regression model was used with "bed sharing" random across studies. The fraction of bed sharing deaths ***attributable*** to bed sharing, that is the fraction of bed sharing deaths that would not have occurred had the babies not been bed sharing but placed supine in a cot in the parents' room, all other things being unchanged, was computed as described by Bruzzi et al.[30] Mortality rates were computed using the same multivariate model by omitting the trend of bed sharing with age. Rates are given for all ~~children,~~ infants computed by a weighted combination of the rates for boys and girls. The base rate for girls was the SIDS rate when none of the model risk factors were present. To obtain average AOR for infants <3 months and for infants aged 3 months or more, a logistic form if the rates model confined to records under 3 months and 3 months or more were fitted. ~~The results are presented in Table 3~~.

Full details of the statistical methods are given in the Statistical Appendix.

Results

The age distribution of the 1472 cases is shown in Fig.1. The peak incidence rate is between 7 and 10 weeks.

* The ECAS data set comprises a set of 20 studies, five of which were excluded due to absence of data on feeding or unwillingness to participate.

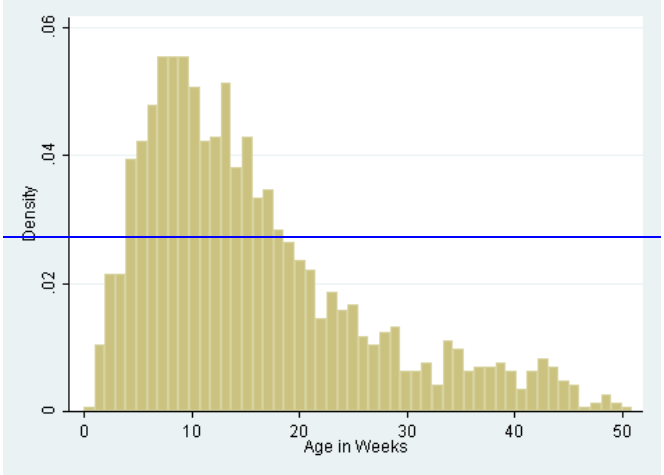

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Fig. 1 The age distribution of the cases in the combined study.

Univariate and multivariate analyses

The data for each variable are tabulated for cases and controls in Table 1 together with percentage of missing data and the single factor ORs adjusted for age and study, together with the corresponding OR derived from analysis of the imputed data sets. Corresponding multivariate adjusted AORs from the overall model are also reported. For variables that interact with bed sharing, and consequently age, AORs reported in Table 1 are those for infants room sharing but not bed sharing.

Feeding

Table 1 shows that bottle feeding increases risk of SIDS. When analysed as a single factor the OR for bottle feeding is 2.9 (2.5–3.3) however, the multivariate AOR is 1.5 (1.2–1.8).

Multivariate analyses for interactions between age, bed sharing and other variables

The baseline in the multivariate analysis is a breast fed baby placed on his/her back to sleep in a cot in the parents' room neither of whom smoke and having no other risk factors.

Bed Sharing

The log-linear downward trend in the OR for bed sharing in the first 6 months of life is shown in Fig 2, when neither parent smoked and when both smoked. These values are predicted by the overall model of the whole data set. Checks show that the predicted risks closely fit the data, especially when neither parent smoked and the mother had taken neither alcohol or drugs and the baby was breast fed and bed sharing, (see appendix).

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(Fig. 2 here)

Fig. 2. Adjusted ORs (log scale) for SIDS by age for bed sharing breast fed infants, when neither parent smokes and both smoke vs. comparable infants sleeping supine in the parents' room. AORs are also adjusted for feeding, sleeping position when last left, ~~room sharing~~where last slept, sex, race, and birth weight, mother's age, parity, marital status, alcohol and drug use.

The analysis showed that *only* position last left, parental smoking, maternal alcohol consumption in the last 24 hours, and illegal drug use, interact with bed sharing, and consequently the associated risks when bed sharing also decline with increasing age. Table 2 summarises the adjusted AORs for each of these factors, first when room sharing and second when bed sharing at 2, 10 and 20 weeks of age. Three ages are used to illustrate the reduction in risks associated with bed sharing, as the baby gets older. Table 2 confirms that the OR for bed sharing is 8.3 (3.7–18.6) at 2 weeks and Fig 2 shows that bed sharing is a significant risk factor for the first 15 weeks of life in the absence of smoking, alcohol, drugs, and all other risk factors.

Position last left.
When sleeping in a cot there is a significant risk associated with placing the baby on its side and a substantial risk when placed prone. In contrast when bed sharing, being placed on the side is not associated with an increased risk and analysis shows that when placed prone there is little and no significant increase in risk for the first 3 months, Table 2.

Parental smoking
Table 2 also highlights the strength of the very significant interaction between smoking and bed sharing. Infants who bed share at 2 weeks of age whose parents both smoke are at 65-fold increased risk of SIDS compared with infants room sharing with parents who do not smoke. There is a 'dose response' effect, univariately, when room sharing, and when bed sharing at 2 weeks, 10 weeks and 20 weeks related to whether just the partner smokes, just mother smokes or both smoke. However, when the infant does not sleep with the parents, risks associated with parental smoking are comparatively small.

Alcohol and drugs

Table 2 also shows the AORs associated with the mother having had 2 or more units of alcohol in the last 24 hours. If the baby does not bed share, two or more units increases the risk nearly 5-fold in contrast to a very substantial increase in risk when bed sharing, especially in the first weeks of life (OR at 2 weeks of age = 89.6). The use of any illegal drugs by the mother, including cannabis , increases the risk eleven-fold even when the baby is room sharing. The risks associated with a drug using mother bed sharing are unquantifiably large.

Average ORs for the first 3 months and after

In view of the trends in the AORs associated with bed sharing and age, Table 3 tabulates average under and over 3 months AORs for two key factors, smoking and alcohol when room sharing and bed sharing. These adjusted ORs apply when no other risk factors are present and the baseline risk groups~~s~~ group is breast fed baby girls placed on their back for sleep by the bed of non-smoking parents and having no other risk factors. ~~.~~ Table 3 shows that if this group with baseline risk bed share, their average risk for the first 3 months, AOR~~,~~ is 5.1 (2.3–11.4). After the infant is 3 months old the corresponding average AOR is 1.0 (0.3–3.0)

The multipliers shown in the last column shows the ratio of the AORs when bed sharing to the corresponding AOR when room sharing. In so far as these multipliers are >5.1 for the under 3 months, and > 1.0 after that age, they show how the interaction, first of smoking and then of parental smoking plus maternal alcohol with bed sharing, greatly enhances the risk associated with bed sharing. The data are too sparse to give meaningful AORs when mother is a drug user. It will also be noted that the second largest increase in risk associated with bed sharing occurs when the baby is under 3 months and the mother smoked.

Calculation of AORs for other risk groups

Because, in the absence of interaction, AORs multiply, Tables 1, 2, and 3 enable approximate[†] AORs to be calculated for almost all other risk groups. Thus, ~~the~~ at two weeks if the baby is not breast fed but bottle fed, Table 1 shows the AOR is multiplied by 1.5; if the baby's birth weight is between 2000g and 2499g the AOR is scaled up by 4.2, and so on. Thus ~~the~~ at 2 weeks the AOR for a bottle fed baby boy with birth weight 2140g who bed shares with a cohabiting 21 year old mother with one previous child and both parents smoke the

AOR = 65.1 (Table 2: both smoke)
× 1.5 (Table 1: bottle fed)
× 1.6 (Table 1: Male)
× 4.2 (Table 1: Birth weight)
× 3.0 (Table 1: mother's age)
× 2.3 (Table 1: 1 previous child)
= 4528

.

If, using Table 2 we replace 65.1 ~~by 2.1~~ with 2.9 we find that this alarming figure drops to 202 ~~if~~ for~~the~~ parents who did not bed share. By changing the first AOR from 65.1 to 21.8 we find the average AOR for this child for the first 3 month to be approximately 1516, again reducing to an average of 202 if the baby did not bed share but is placed supine for sleep in a cot in the parents' room.

These alarming AORs show how the effect of multiple risk factors builds up, and indicates that infants with multiple risk factors are likely to be at far greater risk than ~~in~~ is generally supposed.

[†] The AORs obtained as described here will not be precise but will be well within the CI for the best estimates, see appendix

The fraction of deaths while bed sharing attributable to bed sharing.
In this combined data set 22% (n=324) of the deaths occurred while bed sharing; 66% (n= 213) of these were under the age of 3 months. Overall 87.7% (86.3–89.2%) were attributable to bed sharing, assuming that they would otherwise have been placed on their back in a cot in the parents' room. This rises to 89.5% (88.8–90.3%) for bed sharing deaths under 3 months of age.

Comparison of SIDS rates
To get an overview of the absolute risks and increases in risk associated with bed sharing, SIDS mortality rates for infants (i.e., ages 0 up to 1 year) when room sharing or bed sharing are estimated and tabulated in Table 4 for six combinations of risk factors. In addition, Table 4 also shows the ratio of SIDS rates for bed sharing compared with room sharing. These SIDS rates have been calculated by assuming that the population SIDS rate is 0.5 per 1000 live births and apply to a typical cohabiting white mother aged 26 – 30 having a second normal weight baby with birth weight between 2.5 and 3.5kg – the most common situation of a mother completing her family.

Table 4 shows that for room sharing breast fed babies placed supine whose parents do not smoke and with no other risk factors, the SIDS rate is predicted to be 0.08 (0.05–0.14) per 1000 live births. This rate is predicted to increase by 2.7 times, (1.4–5.3) to 0.23 (0.11–0.49) per 1000 when bed sharing. For all combinations of risk factors, the predicted increases in risk associated with bed sharing are statistically significant. These rates may be scaled up or down depending on the population SIDS rate, and other factors present, see appendix for details. For example from the Tables, 1 & 4 we find, that a 2.25kg bottle fed baby bed sharing with an 18 year old mother, who smokes and regularly takes 2+ units of alcohol and whose partner also smokes, has a predicted SIDS rate of 125 per 1000, i.e., 12.5%, see supplementary Table b) in appendix.

Discussion

Mitchell recently reviewed risks and benefits of bed sharing; he concluded that postulated benefits and guidelines for bed sharing safely are not evidence based.[21] He also found that there is only one small group with ***no*** increased risk of SIDS when bed sharing, namely, + breast fed infants over 3 months whose parents do not smoke, and whose mother does not take 2 or more units of alcohol or drugs and does not co-sleep on a sofa. Mitchell urged that parents had a right to know the risks they are exposing their infants to when bed sharing, but ~~they were not quantified.~~ was unable to quantify these risks.

Comment [R.G.3]:
Comment [R.G.4]:

This study combines 5 major SIDS case-control studies. It includes 1472 cases and 4679 controls making it the largest study of SIDS risk factors with individual level data. By combining individual data this design allows the interaction of risk factors such as breast feeding, infant age and smoking to be examined in relation to bed sharing and SIDS. Accordingly it is able to examine the interplay of the risk factors ~~relating~~ related to bed sharing in depth as never before. Our findings confirm Mitchell's conclusions and ***quantify*** the relative risks and predicted SIDS rates associated with bed sharing in a variety of circumstances.

It has been suggested that we should have taken into account the partner's alcohol consumption in the last 24 hours and his drug use. We did not include the former factor because in the analysis of the ECAS study it was found partner's consumption of alcohol was correlated with that of the mother did not add further to risk of SIDS.[7] To check on this possibility, we have gone back to the original records for the key sub group, namely babies < 3 months who were breast fed whose parents did not smoke and whose mother took less than 2 units of alcohol in the last 24 hours who either bed shared or room shared. We find that in both the bed sharing and room sharing groups the control partners had taken slightly *more* alcohol in the last 24 hours than the controls. Consequently, if we adjusted for this factor it would increase the OR for bed sharing, We also note

that the subgroup OR based on the complete data is 5.6 (1.6 – 20.3), which is almost identical to the adjusted AOR for this group 5.1 (2.3 – 11.4), Table 3.

~~It may be objected~~To respond to the criticism ~~-~~that the missing data in relation to alcohol and drug use in three of the five data sets make any attempt to exclude the contribution of these factors to the risks associated with bed sharing completely unreliable,~~.~~ we have gone back to the original records for bed sharing cases in the key subgroup. Most of these records include pertinent questions on alcohol use although not maternal use in the last 24 hours. This enabled us to establish that neither alcohol nor drug use contributed in any way to any of these deaths.

~~However, for studies which did not include questions of mother's alcohol and drug use, we have gone back to the original records of breast fed bed sharing cases when both the mother and her partner were non-smokers, and established that neither alcohol nor drug use contributed in anyway to any of these deaths.~~

Also, ~~it may be shown, see~~as discussed in more detail in the appendix, ~~that~~ because missing data are primarily determined by the study, by including 'study' when modelling the subset of complete data and modelling the imputed data, the results ~~will~~ of both will be essentially unbiased. ~~Further~~In this setting, ~~the results from analysis of the completed~~ multiple imputation is~~data will~~ is expected primarily ~~depend on the observed data, and only slightly on the imputed data.~~to recover to information by including the partially observed records in the analysis, This is what we find. Consequently, we can be confident of our estimate of the adjusted effect bed sharing from the imputed data. ~~Consequently, this analysis is more efficient because it uses all the observed data, rather than depending solely on the complete records.~~

~~In particular~~Importantly, the combined data have enabled the demonstration of increased relative risk associated with bed sharing when the baby is breast fed and neither parent smokes (see Fig 2 & Table 2). The average risk is in the first 3 months and is 5.1 (2.3–11.4) times greater than if the baby is put down to sleep supine in a cot in the parents' room (Table 3). This increased risk is unlikely to be due to ***chance*** (p= 0.000059) ***Bias*** could occur because these estimates are based on models fitted to all the data or to all the data relating to infants under 3 months of age. Moreover, checks show that the models accurately describe the data, especially that relating to cases whose only risk factor is bed sharing, see appendix. Bias is also possible due to the selection of the studies. However, the present study incorporates far more data than were included in Vennemann et al's recent meta-analysis of the ORs for bed sharing in infants of non-smoking mothers.[25] The meta-analysis produced summary odds ratios very similar to those reported in this study. Furthermore, our findings are very unlikely to be due to ***confounding*** since the AORs are adjusted for all the major SIDS risk factors. Although the partner's consumption of alcohol is not included in the data set, it was found in the ECAS study that this factor was correlated with mother's alcohol consumption (r = 0.52) and, after taking account of the mother's alcohol consumption, it did not add further to the prediction of risk.[7]

Mitchell's review of the mechanisms by which bed sharing might cause SIDS shows a causal pathway is not unreasonable.[21] Panel 1 reviews the evidence that the association of bed sharing when mothers do not smoke with SIDS is causal by Bradford Hill's criteria.[31] Clearly, bed sharing in the white European context can be a causal factor of for SIDS. It has been argued that because the risk of bed sharing is greatly increased by parental smoking, alcohol and/or drugs, that it is the way we bed share rather than bed sharing itself that is important. Parental smoking greatly enhances the risk of SIDS associated with bed sharing, but in what way their pattern of bed sharing differs for that of non-smokers is not obvious. Although breast feeding is lower among smokers than non-smokers, 46% cases of bed sharing smokers were breast feeding and 61% of controls. These figures are lower than for non-smokers, 62% and 73% respectively, but these differences do

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not demonstrate that parental smoking results in a different way of bed sharing. For non-smokers and smokers alike sleeping in a 'western style' bed with a baby carries a risk of SIDS. Why the risk is so greatly enhanced by parental smoking is not known.

Recently there has been a tendency to record unexplained bed sharing infant deaths as due to 'suffocation-bed' (ICD code E913/W75)[32,33], or 'undetermined' rather than SIDS when the baby was bed sharing and may have suffocated.[34] However, an investigation into deaths certified as SIDS and unascertained, the UK Office of National Statistics found that many of their characteristics were very similar,[35] and now ONS reports these deaths together as unexplained deaths in infancy.[36] In 2004 Limerick and Bacon in a study of terminology used by pathologist in reporting SIDS found that when giving the cause of death of an infant found unexpectedly dead while bed sharing, only 1 in 70 said asphyxia.[37] The selection of cases in our studies includes all such deaths . Certifying such deaths under headings other than SIDS does nothing to minimise the tragedy‡.

Other new findings

The risk of SIDS for an average family with no known modifiable risk factors - ~~t~~Table 4 baseline (breast-fed, non-smoking, non-drinking parents who are room sharing and not bed sharing) was 0.08/1000 live births. This is the level of SIDS that might be achieved if all known modifiable risk factors were removed. Such a SIDS level may be deemed intrinsic (possibly genetic) and not directly amenable to behaviour modification. This rate is consistent with countries reporting low SIDS rates. National surveys in The Netherlands show that, following an active campaign to discourage bed sharing,[4] bed sharing rates have fallen from 13% in 1999, 10% in 2005 to 1.5% always bed sharing and 3.1% sometimes bed sharing in 2011.[38] During the same period as part of a general downward trend in SIDS mortality[39], ~~The~~ SIDS rates have fallen 25% from 0.12 in 2000 to 0.09 ~~is 0.1~~ per 1000 in 2010.[40,41]~~39~~ At the same time the percentage of infants being breastfed at 3 months of age has risen from 45% to 52%., and at 6 months from 24% to 32%[42]~~0~~, confirming that promotion of bed sharing is not necessary to achieve high rates of prolonged breast feeding.

A recent study commissioned by ~~UNICEF~~[41] UNICEF[43] suggests that the promotion of breast feeding and support of breast feeding mothers in the UK would reduce the burden of disease on the ~~NHS~~ National Health Service and could thereby be cost effective. However, if bed sharing is promoted as a means of encouraging breast feeding, it is likely to increase the number of SIDS because the AOR for bed sharing, 2.7, is nearly double the AOR for bottle feeing, 1.5. Consequently, such an approach would be likely to *increase* the number of SIDS cases. If SIDS deaths are costed at more than £1.5 million each, as in the UNICEF report, the costs resulting from any increase in bed sharing would far outweigh any benefits from increased breast feeding rates, quite apart from the disastrous consequences for families associated with the loss of a child. To reap the benefit of increasing breast feeding duration and rates, the Dutch recommendations should be followed, namely: 'To achieve maximal security for the baby and optimal availability of breastfeeding, mothers are advised to take the baby of less than 4 months of age into their bed for feeding during the night, but afterwards to place the baby on its back into his own crib, placed adjacent to the parents' bed in the parents' bedroom'.[5]

Thus, we do not suggest that babies should not be brought into the parent's bed for comfort and feeding. This has been investigated in previous studies and has not been found to be a risk factor provided the infant is returned to his or her own cot.[42,43,44,45] This study is concerned with risks associated with *sleeping* with a baby in bed. Table 3 and 4 of this report are designed to enable an informed choice to be made by parents as to whether the risks associated with bed sharing outweigh

~~‡ Following an investigation into deaths certified as SIDS and unascertained, ONS found that many of their characteristics were very similar,[35] and now ONS reports these deaths together as unexplained deaths in infancy.[36] In 2004 Limerick and Bacon in a study of terminology used by pathologist in reporting SIDS found that when giving the cause of death of an infant found unexpectedly dead while bed sharing, only 1 in 70 said asphyxia.[37]~~

the postulated benefits. However, our models predict that 88% of the deaths that occurred while bed sharing would probably not have occurred had the baby been placed on its back in a cot by the parents'bed. Even for the very low risk breast fed babies under 3 months of age, with no other risk factors other than that they slept in their parents' bed, the model predicts that 81% (78.9–82.0%) of the deaths could have been readily prevented in this way. One has to ask whether it is worth taking the risk, however small, of ~~loosing~~ losing a baby, when it can be so easily avoided.

Previous epidemiological studies showed that being placed on the front, prone, ~~when put down~~ for sleep was a risk factor for SIDS and fulfilled similar criteria as a causal risk for SIDS; in the 1970s OR 2.9 (1.2–7.5) and in 1986 from 5 pooled case control studies OR 3.0 (1.7–5.3).[2] A campaign to reduce prone sleeping effectively halved the number of SIDS cases worldwide between 1990 and 2000 saving thousands of babies in the developed world. Delay in implementing an effective 'back to sleep' campaign is estimated to have resulted in the deaths of 10,000 lives in the UK alone.[2]

Recent case studies indicate that now 50% or more of SIDS cases[18,~~44~~ 46] occur while bed sharing in contrast to 22% in this study, Table 1. In the UK, possibly due to the pro bed sharing lobby[14], in the 10 years between the two studies by Blair and his colleagues[45,18], the percentage of cases bed sharing (excluding sofa sharing) doubled and the percentage of controls bed sharing increased by 50% from 14.5% to 21.8%. Meanwhile, the crude unadjusted OR for bed sharing only changed from 2.0 to 2.2. (An adjusted OR for bed sharing is not reported for the latter study). Our analysis estimates that 88% of bed sharing deaths are attributable to bed sharing, i.e., would not have occurred had the baby not been bed sharing. The stability of the crude OR for bed sharing despite the increase in the prevalence of bed sharing suggests that our estimate of attributable risk may reasonably be applied currently. Consequently, ~~our~~ ~~Our~~ analysis ~~shows~~ suggests that ~~most of these~~ about 90% of bed sharing SIDS deaths would not ~~have occurred if bed sharing had not taken place.~~ occur in the absence of bed sharing.

The current messages say that bed sharing is dangerous only if your or your partner are smokers, have been drinking alcohol, or drugs that make you drowsy, are very tired, or the baby is premature or low birth weight, are not effective because many of the bed sharing deaths involve these factors. Our findings suggest that professionals and the literature should take a more definite stand against bed ~~If~~ sharing, especially for babies under 3 months. If parents were made aware of the risks of sleeping with their baby, and room sharing were promoted, as 'Back to Sleep' was promoted 20 years ago, a substantial further reduction in SIDS rates could be achieved.

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Comment [EM5]: This paragraph is excellent, and I would support replacing this with her paragraph.

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Variable		Cases No.	Cases %	Controls No.	Controls %	% missing records	Complete records Single factor OR	Complete records Single factor 95% CI	Complete & imputed data Single factor OR*	Complete & imputed data Single factor 95% CI	Complete & imputed data Selected multivariate AOR	Complete & imputed data Selected multivariate 95% CI
Bed Sharing						0.9						
	No	1,131	77.7	4,192	90.4		1	-	1	-	1	-
	Yes	324	22.3	446	9.6		2.6	2.2–3.1	2.6	2.2–3.1	2.7‡	1.4–5.3
Feeding						0.8						
	Breast	504	34.9	2,491	53.5		1	-	1	-	1	-
	Bottle	940	65.1	2,168	46.5		2.9	2.5–3.3	2.9	2.5–3.3	1.5	1.2–1.8
Position last left						1.6						
	back all ages	377	26.5	1,972	42.6		1	-	1	-	1	-
	side	438	30.8	1,869	40.3		1.6	1.3–1.8	1.6	1.3–1.9	1.5†	1.2–2.1
	front	607	42.7	791	17.1		7.8	6.4–9.5	7.9	6.5–9.6	10.5†	7.5–14.6
Parental smoking						2.9						
	Neither	314	22.4	2,285	50.0		1	-	1	-	1	-
	Partner only	194	13.8	1,083	23.7		1.4	1.1–1.7	1.4	1.1–1.7	1.1*	0.8–1.4
	Mother only	194	13.8	427	9.4		3.7	3.0–4.6	3.8	3.1–4.7	1.5*	1.2–2.1
	Both	703	50.0	774	16.9		7.4	6.2–8.7	7.3	6.2–8.6	2.9*	2.3–3.6
Mother took 2 unit or more of alcohol in last 24 Hours						61.3						
	No	478	81.0	1,694	94.5		1	-	1	-	1	-
	Yes	112	19.0	99	5.5		5.1	3.7–7.0	6.5	4.6–9.3	4.8*	2.6–8.9
Mother used illegal drugs after birth						60.5						
	None	582	96.5	1,825	99.8		1	-	1	-	1	-
	Any	21	3.5	3	0.2		19.2	5.4–68.3	30.7	8.8–106.8	11.5*	2.2–59.5
Sex						0.3						
Unmatched studies:	Female	351	39.5	1,401	49.3		1	-	1	-	1	-
	Male	538	60.5	1,442	50.7		1.5	1.3–1.8	1.5	1.3–1.7	1.6	1.3–1.9
Matched studies:	Female	217	37.6	683	37.5		1	-	1	-	1	-
	Male	360	62.4	1,141	62.5		1.0	0.8'1.2	1.0	0.8–1.2	0.8	0.6–1.1
Race						0.3						
	White	1,181	81.1	4,242	90.7		1	-	1	-	1	-
	Non-white	276	18.9	434	9.3		3.0	2.5–3.6	3.0	2.5–3.6	1.5	1.1–1.9
Birth Weight group:						2.3						
	3500g or more	415	28.9	2,293	50.1		1	-	1	-	1	-
	2500 – 3499g	760	52.8	2,092	45.8		2.0	1.7–2.3	2.0	1.7–2.3	1.7	1.4–2.0
	2000 – 2499g	144	10.0	127	2.8		6.3	4.8–8.2	6.4	4.9–8.3	4.2	2.9–6.0
	under 2000g	120	8.3	59	1.3		13.5	9.6–18..9	13.8	9.8–19.4	9.6	6.2–14.7
Mother's age in years						0.6						
	over 30	326	22.4	1,921	41.2		1	-	1	-	1	-
	26 – 30	419	28.8	1,552	33.3		1.8	1.5–2.1	1.8	1.5–2.1	1.9	1.5–2.3
	21 – 25	434	29.9	910	19.5		3.3	2.8–3.9	3.3	2.8–3.9	3.0	2.4–3.8
	19 – 20	162	11.1	169	3.6		6.8	5.2–8.8	6.8	5.3–8.8	7.7	5.2–11.4
	18 & under	113	7.8	111	2.4		7.1	5.3–9.6	7.2	5.3–9.7	9.1	5.9–14.1
No. of live births including the present one:						0.8						
	1	407	28.1	1,836	39.4		1	-	1	-	1	-
	2	491	33.9	1,566	33.7		1.4	1.2–1.7	1.4	1.2–1.7	2.3	1.9–2.9
	3	280	19.3	748	16.1		1.8	1.5–2.2	1.9	1.5–2.2	3.8	2.9–4.9
	4	149	10.3	304	6.5		2.6	2.1–3.3	2.6	2.1–3.3	5.2	3.7–7.4
	5 or more	122	8.4	200	4.3		3.5	2.7–4.5	3.5	2.7–4.6	7.7	5.3–11.3
Mother's marital status:						0.2						
	Married or with partner	996	68.1	4,049	86.6		1	-	1	-	1	-
	Single	467	31.9	628	13.4		4.0	3.4–4.7	4.0	3.4–4.7	1.9	1.5–2.4
Where slept last						1.4						
	Parents' room	817	57.0	2,806	60.6		1	-	1	-	1	-
	Elsewhere	616	43.0	1,823	39.4		1.3	1.1–1.5	1..3	1.2–1.5	2.4	2.0–2.9

‡ Multivatiate AOR for bed sharing pooled for all ages up to one year.
† Multivariate AOR when baby in a cot in parent's room & age is 3months.or less.
The corresponding AOR's when baby is over 3m are 1.4 (1.1–1.8) & 7.7 (5.9–10.2) respectively
* Multivariate AOR when baby in a cot in parents' room

Birth Weight group:					2.3							
3500g or more	415	28.9	2,293	50.1		1	-	1	-	1	-	
2500 – 3499g	760	52.8	2,092	45.8		2.0	1.7–2.3	2.0	1.7–2.3	1.7	1.4–2.0	
2000 – 2499g	144	10.0	127	2.8		6.3	4.8–8.2	6.4	4.9–8.3	4.2	2.9–6.0	
under 2000g	120	8.3	59	1.3		13.5	9.6–18..9	13.8	9.8–19.4	9.6	6.2–14.7	
Mother's age in years					0.6							
over 30	326	22.4	1,921	41.2		1	-	1	-	1	-	
26 – 30	419	28.8	1,552	33.3		1.8	1.5–2.1	1.8	1.5–2.1	1.9	1.5–2.3	
21 – 25	434	29.9	910	19.5		3.3	2.8–3.9	3.3	2.8–3.9	3.0	2.4–3.8	
19 – 20	162	11.1	169	3.6		6.8	5.2–8.8	6.8	5.3–8.8	7.7	5.2–11.4	
18 & under	113	7.8	111	2.4		7.1	5.3–9.6	7.2	5.3–9.7	9.1	5.9–14.1	
No. of live births including the present one:					0.8							
1	407	28.1	1,836	39.4		1	-	1	-	1	-	
2	491	33.9	1,566	33.7		1.4	1.2–1.7	1.4	1.2–1.7	2.3	1.9–2.9	
3	280	19.3	748	16.1		1.8	1.5–2.2	1.9	1.5–2.2	3.8	2.9–4.9	
4	149	10.3	304	6.5		2.6	2.1–3.3	2.6	2.1–3.3	5.2	3.7–7.4	
5 or more	122	8.4	200	4.3		3.5	2.7–4.5	3.5	2.7–4.6	7.7	5.3–11.3	
Mother's marital status:					0.2							
Married or with partner	996	68.1	4,049	86.6		1	-	1	-	1	-	
Single	467	31.9	628	13.4		4.0	3.4–4.7	4.0	3.4–4.7	1.9	1.5–2.4	
Where slept last					1.4							
Parents' room	817	57.0	2,806	60.6		1	-	1	-	1	-	
Elsewhere	616	43.0	1,823	39.4		1.3	1.1–1.5	1..3	1.2–1.5	2.4	2.0–2.9	

‡ Multivatiate AOR for bed sharing pooled for all ages up to one year.
† Multivariate AOR when baby in a cot in parent's room & age is 3months.or less.
The corresponding AOR's when baby is over 3m are 1.4 (1.1–1.8) & 7.7 (5.9–10.2) respectively
* Multivariate AOR when baby in a cot in parents' room

Table 1 The number and percent of cases and controls for each factor, percent missing data, univariate ORs & CIs based on complete data. Also, univariate ORs & multivatiate AORs & CIs based on the imputed data sets.

Factor	Room sharing		Bed sharing					
			At 2 weeks		At 10 weeks		At 20 weeks	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Position last left								
Back	1.0	—	8.3	3.7–18.6	3.6	1.8–7.2	1.2	0.6–2.8
Side	1.8*	1.3–2.4					0.8	0.3–2.0
Front	12.0*	8.6–16.8					5.3	1.8–16.0
Parental smoking								
None	1.0	—	8.3	3.7–18.6	3.6	1.8–7.2	1.2	0.6–2.8
Partner	1.1	0.8–1.4	17.6	8.1–38.4	7.6	3.8–15.1	2.6	1.2–6.0
Mother	1.5	1.2–2.1	47.3	18.9–118.4	20.4	8.8–46.9	7.1	2.8–18.0
Both	2.9	2.3–3.6	65.1	30.9–137.5	28.1	15.0–52.5	9.8	4.7–20.3
Mother's Alcohol								
2+ vs. <2 units	4.7	2.6–8.7	89.6	25.3–317.3	38.6	12.6–117.7	13.5	4.6–39.4
Mother illegal drug user								
Yes vs. no	11.4	2.2–57.8	Unquantifiably large					

* After 3m, the AOR for put down on side is 1.4 (1.1–1.8) & front 7.7 (5.8–10.1) when room sharing
Note: For the first 3 months when bed sharing, risk is not affected by the position put down.

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Factor	Room sharing		Bed sharing					
			At 2 weeks		At 10 weeks `		At 20 weeks	
	AOR	95% CI	AOR	95% CI	AOR	95% CI	AOR	95% CI
Position last left								
Back	**1.0**	—					**1.2**	0.6–2.8
Side	**1.8***	1.3–2.4	**8.3**	3.7–18.6	**3.6**	1.8–7.2	**0.8**	0.3–2.0
Front	**12.0***	8.6–16.8					**5.3**	1.8–16.0
Parental smoking								
None	**1.0**	—	**8.3**	3.7–18.6	**3.6**	1.8–7.2	**1.2**	0.6–2.8
Partner	**1.1**	0.8–1.4	**17.6**	8.1–38.4	**7.6**	3.8–15.1	**2.6**	1.2–6.0
Mother	**1.5**	1.2–2.1	**47.3**	18.9–118.4	**20.4**	8.8–46.9	**7.1**	2.8–18.0
Both	**2.9**	2.3–3.6	**65.1**	30.9–137.5	**28.1**	15.0–52.5	**9.8**	4.7–20.3
Mother's Alcohol								
2+ vs <2 units vs None	**4.7**	2.6–8.7	**89.6**	25.3–317.3	**38.6**	12.6–117.7	**13.5**	4.6–39.4
Mother illegal drug user								
Yes vs. no	**11.4**	2.2–57.8	**Inestimably large**					

*** After 3m, the AOR for put down on side is 1.4 (1.1–1.8) & front 7.7 (5.8–10.1) when room sharing**
Note: For the first 3 months when bed sharing, risk is not affected by the position put down.
All AORs are adjusted for other factors in the table and bottle feeding, sex, whether matched or unmatched, race, birthweight group, mother's age proup, no. of live births(grouped), mother single, and where slept..

Table 2. The AORs for avoidable factors that interact with bed sharing, adjusted for all other factors. Therefore, they relate to the baseline corresponding to babies of non-smoking mothers who do not use drugs, and taking < 2 units of alcohol in the 24 hours, having a non-smoking partner, and no other risk factors.

Age group	Risk factors		Room sharing		Bed sharing		Multiplicative increase in AOR when bed sharing	
	Smokinig	Alcohol	AOR	95% CI	AOR	95% CI	Multiplier	95% CI
< 3month	no	no	1	-	**5.1**	2.3–11.4	**5.1**	2.3–11.4
	P	no	0.7	0.5–1.1	**7.8**	3.6–17.2	**11.2**	5.0–25.1
	M	no	1.3	0.8–2.2	**20.3**	7.4–56.2	**15.2**	5.3–43.3
	B	no	**2.9**	2.0–4.2	**21.8**	11.1–42.6	**7.5**	3.9–14.8
	B	**Y**	**13.7**	5.5–34.4	**151.0**	50.6–450.7	**11.0**	3.1–39.3
3 months & over	no	no	1	-	1.0	0.3–3.1	1.0	0.3–3.1
	P	no	1.2	0.9–1.7	**3.0**	1.2–7.5	**2.5**	1.0–6.3
	M	no	**1.7**	1.2–2.4	**6.1**	1.7–22.6	**3.6***	0.9–13.9
	B	no	**3.0**	2.3–4.0	**13.7**	6.1–31.0	**4.6**	2.0–10.3
	B	**Y**	**15.7**	8.1–30.4	**243.8**	76.1–781.4	**15.6**	4.2–57.4

The AORs in light type are not statistically significant.
*** This multiplier is significant at p = 0.062**

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Age group	Risk factors		Room sharing		Bed sharing		Multiplicative increase in AOR when bed sharing	
	Smoking	Alcohol	AOR	95% CI	AOR	95% CI	Multiplier	95% CI
< 3month	No	no	1	-	**5.1**	2.3–11.4	**5.1**	2.3–11.4
	Partner	no	0.7	0.5–1.1	**7.8**	3.6–17.2	**11.2**	5.0–25.1
	Mother	no	1.3	0.8–2.2	**20.3**	7.4–56.2	**15.2**	5.3–43.3
	Both	no	**2.9**	2.0–4.2	**21.8**	11.1–42.6	**7.5**	3.9–14.8
	Both	**Y**	**13.7**	5.5–34.4	**151.0**	50.6–450.7	**11.0**	3.1–39.3
3 months & over	No	no	1	-	1.0	0.3–3.1	1.0	0.3–3.1
	Partner	no	1.2	0.9–1.7	**3.0**	1.2–7.5	**2.5**	1.0–6.3
	Mother	no	**1.7**	1.2–2.4	**6.1**	1.7–22.6	**3.6***	0.9–13.9
	Both	no	**3.0**	2.3–4.0	**13.7**	6.1–31.0	**4.6**	2.0–10.3
	Both	**Y**	**15.7**	8.1–30.4	**243.8**	76.1–781.4	**15.6**	4.2–57.4

The AORs in light type are not statistically significant.

*** This multiplier is significant at p = 0.062**

The AORs in both Tables are adjusted for all other factors in the table, any drug use by the mother since birth, bottle feeding, sex, whether matched or unmatched, race, birthweight group, mother's age proup, number of live births (grouped), mother single, and where slept.

Table 3. Average AORs for smoking, smoking & maternal alcohol when room sharing and bed sharing with the multiplicative increase in risk due to bed sharing, for infants under 3 months and 3 months up to a year.

Group No.	Risk factors present			Room sharing		Bed sharing		Ratio of rates	
	Feeding	smoking	Alcohol	Rate/1000	95% CI	Rate/1000	95% CI	Ratio	95% CI
minimum risk	**Br**	no	no	**0.08**	0.05–0.14	**0.23**	0.11–0.49	**2.7**	1.4–5.3
1	**Bot**	no	no	**0.13**	0.08–0.21	**0.34**	0.16–0.73	**2.7**	1.4–5.3
2	Br	**P**	no	**0.09**	0.05–0.16	**0.52**	0.25–1.08	**5.6**	2.9–10.8
3	Br	**M**	no	**0.13**	0.08–0.23	**1.27**	0.54–3.00	**9.7**	4.4–21.7
4	Br	**B**	no	**0.24**	0.15–0.41	**1.88**	0.94–3.73	**7.7**	4.3–13.8
5	**Bot**	**B**	**Y**	**1.77**	0.87–3.48	**27.5**	10.4–68.4	**15.6**	5.7–41.5

Group No.	Risk factors present			Room sharing		Bed sharing		Ratio of rates	
	Feeding	smoking	Alcohol	Rate/1000	95% CI	Rate/1000	95% CI	Ratio	95% CI
minimum risk	**Br**	no	no	**0.08**	0.05–0.14	**0.23**	0.11–0.49	**2.7**	1.4–5.3
1	**Bot**	no	no	**0.13**	0.08–0.21	**0.34**	0.16–0.73	**2.7**	1.4–5.3
2	Br	**Partner**	no	**0.09**	0.05–0.16	**0.52**	0.25–1.08	**5.6**	2.9–10.8
3	Br	**Mother**	no	**0.13**	0.08–0.23	**1.27**	0.54–3.00	**9.7**	4.4–21.7
4	Br	**Both**	no	**0.24**	0.15–0.41	**1.88**	0.94–3.73	**7.7**	4.3–13.8
5	**Bot**	**Both**	**Yes**	**1.77**	0.87–3.48	**27.5**	10.4–68.4	**15.6**	5.7–41.5

*Predicted SIDS mortality rates for a cohabiting, white mother age 26 – 30, having a second normal weight baby with birth weight between 2.5 and 3.5kg and having no other risk factors. I.e., mother is not a drug user, has a partner and room shares. -

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Table 4. Predicted SIDS Infant Mortality Rates for Normal Women*

Panel 1 Assessment of bed sharing, in the absence of parental smoking alcohol and maternal drug use, as a causal risk for SIDS by Bradford Hill's criteria[31]

STRENGTH OF ASSOCIATION ✓
Adjusted Odds Ratio (AOR) for bed sharing = 2.7 (95% CI 1.4–5.3), p = 0.0027, for breast fed infants with no other risk factors. AOR for the first 3 months of life = 5.1 (2.3–11.4), p = 0.00006 . These AORs are moderately strong.

CONSISTENT ✓
~~All but two small~~ Of more than 12 published studies, all but two small ones show, after multivariate adjustment, increased risk of SIDS associated with bed sharing~~.~~, some combined with sofa sharing.[26]

SPECIFIC ✓× (not an essential criterion)
Smoking, alcohol and drug use all have greatly increased risk when bed sharing ✓
Bed sharing is associated with other causes of death, e.g. Suffocation. ×
SIDS can occur in the absence of bed sharing. ×

TEMPORALLY CORRECT ✓
Bed sharing always precedes SIDS.

DOSE RESPONSE ✓
New Zealand study risk increased with duration of bed sharing.[4~~7~~5] Not otherwise investigated.

BIOLOGICALLY PLAUSIBLE ✓
Bed sharing risk is greatest to youngest infants who are most vulnerable.

COHERENCE ✓
The proposition that bed sharing is causally related to SIDS is coherent with theories that respiratory obstruction, re-breathing expired gases, and thermal stress (or overheating), which may also give rise to the release of lethal toxins,~~-~~[4~~86~~] ~~All~~[48] ~~-~~are all mechanisms leading to SIDS, in the absence of smoking, alcohol aror drugs. . Infants placed prone are exposed to similar hazards.

DIRECT EXPERIMENTAL EVIDENCE ×
Not ethically possible.

ANALOGY ✓
Overlying is a serious cause of mortality in piglets. Sows are normally separated by a bar from piglets to prevent them being crushed when she turns over, but allowing her piglets to feed.

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Panel 2

WHAT WAS ALREADY KNOWN ON THIS TOPIC

Babies who sleep in bed with their parents, who are smokers or have drunk alcohol in the last 24 hours, are at increased risk of Sudden Infant Death Syndrome (SIDS), however the risk from bed sharing if neither parent smokes and the baby is breastfed was uncertain.

WHAT THIS STUDY ADDS

This study combined 5 large data sets, making it the largest reported study of SIDS with individual level data.

When no other risk factors are present, ~~B~~bed sharing for sleep satisfies~~d~~ recognised criteria as a *cause* of SIDS~~.~~

When neither parent smoked, baby was less than 3 months of age, and breast fed, bed sharing for sleep multiplied the risk of a baby dying from SIDS by 5, compared with room sharing.

Over 50% of SIDS deaths now occur while bed sharing. A substantial further reduction in SIDS rates, ~~, up to 50%~~ possibly over 40%, ~~,~~ could be achieved if parents avoided bed sharing and all infants slept on their back in a cot in the parental bedroom.

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Contributors

The first five authors played a major role in the design and analysis of their studies, and submitted data for this combined analysis. JRC and MS were responsible for imputing missing data. RGC combined and analysed the data and drafted the report. EAM advised on the analysis. All authors commented on drafts and have seen and approved the paper as submitted.

Conflict of interest

The first five authors are actively involved in SIDS and/or paediatric research. RGC is a member the Steering Committee of the Foundation for the Study of Infant Death's Care of Next Infant, CONI, project for which he receives travelling expenses. The last two authors are specialists in the imputation of missing data. We declare no conflict of interest.

Ethical approval

All studies were ethically approved. Only completely anonymised data were combined for this study.

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STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology*
Checklist for cohort, case-control, and cross-sectional studies (combined)

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	3	State specific objectives, including any pre-specified hypotheses	2 & 3
Methods			
Study design	4	Present key elements of study design early in the paper	3
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	3 & see original reports of the studies
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	All cases in defined areas & normal infants of similar age & sex in some studies.
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	4
Bias	9	Describe any efforts to address potential sources of bias	4
Study size	10	Explain how the study size was arrived at	3
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Table 1, as in previous studiy
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	2, 4 and appendix
		(*b*) Describe any methods used to examine subgroups and interactions	4,& appendix
		(*c*) Explain how missing data were addressed	4 & appendix
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed	—

		Case-control study—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	4 & appendix
		(*e*) Describe any sensitivity analyses	none
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Table 1
		(b) Give reasons for non-participation at each stage	Table 1
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Page 3 & original reports
		(b) Indicate number of participants with missing data for each variable of interest	Table 1
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	—
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	—
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	Table 1
		Cross-sectional study—Report numbers of outcome events or summary measures	
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Tables 1 - 4
		(*b*) Report category boundaries when continuous variables were categorized	Table 1
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	
Discussion			
Key results	18	Summarise key results with reference to study objectives	2
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	9
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	9 -10
Generalisability	21	Discuss the generalisability (external validity) of the study results	9-10
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	18

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

Fig. 1

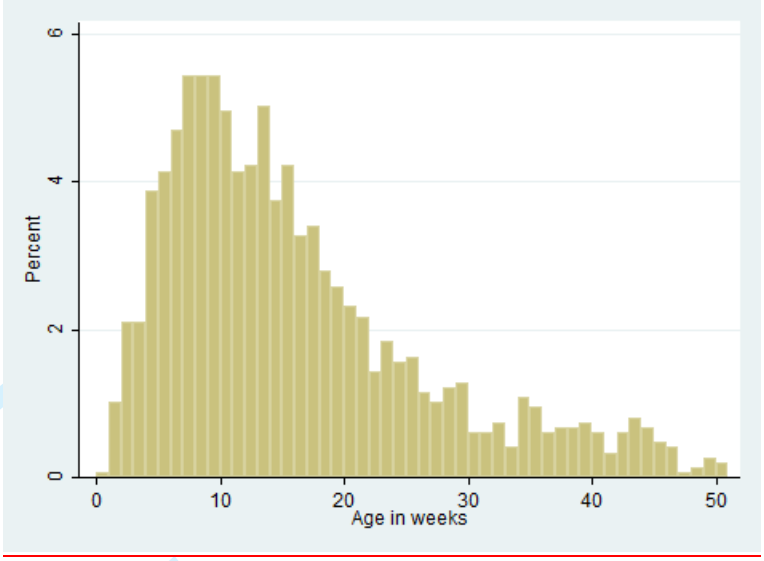
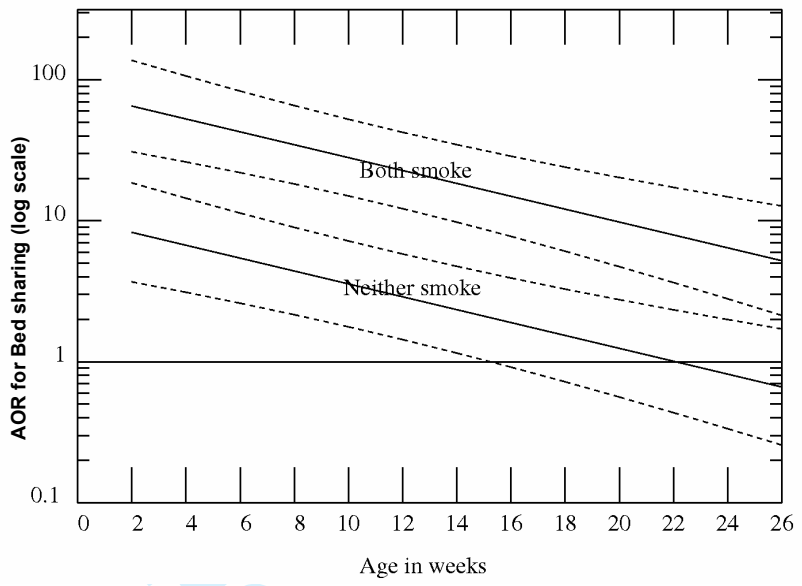


Fig 2



Appendix: Statistical methods

Missing data

Preliminary analysis, together with the study context, showed that missing values were most plausibly missing at random dependent on study. Therefore, since we include study indicators as covariates, a complete records analysis will give unbiased if somewhat inefficient inference[A1]. To include the information from studies in which alcohol and drug use data were not observed, we used multiple imputation (under the missing at random assumption) to impute missing data. We used the REALCOM-IMPUTE software[A2] with a single level imputation model because alcohol and drug data were too sparse among the studies in which they recorded to obtain convergence for a multilevel imputation model. Missing data were imputed for cases and controls separately. Ten imputed data sets were computed. Using STATA 12[A3] the substantive multilevel model was fitted to each in turn. Convergence was not achieved for one because the likelihood was flat in the region of the maximum; the results for the remaining 9 were combined for inference using Rubin's rules[A4].

Analysis showed that the between imputation variation across the 9 imputed data sets was small relative to the within imputation variance, so 9 imputations were sufficient.

Reliability of results based on observed and imputed data

Define the *key sub group* as babies < 3 months who were breast fed whose parents did not smoke and whose mother took less than 2 units of alcohol in the last 24 hours who either bed shared or room shared. ~~For this group~~ We have data on datasets, and for the key subgroup of cases and controls, we have extracted the paternal data from the original records. The unadjusted OR for bed sharing in this group is 5.6 (1.6– 20.3), p = 0.009. In both the bed sharing and room sharing groups the control partners had taken slightly *more* alcohol in the last 24 hours than the case~~s~~ partners. Consequently, after adjusting for partner's alcohol consumption in the last 24 hours, the OR is 7.7 (1.8 – 32.3), although the OR for partner's alcohol is not significant; OR = 0.73 (0.41 – 1.27), p =0.265.

~~First, remember that,~~ F~~f~~or , For cases, belonging to the key subgroup in the three studies for which maternal alcohol use in the last 24 hours was not available ~~of bed sharing infants <3 months whose parents did not smoke~~ we have checked the original records, most of which include pertinent questions about alcohol use, and ~~to~~ ensured that alcohol and drugs were not contributory factors in any.

Second, the prevalence of alcohol and drug use among mothers varies considerably across the studies where the information was collected. For controls, the prevalence of mother having more than 2 units of alcohol in the last twenty four hours (henceforth 'mother using alcohol') ranged from 0 to 9%, and the prevalence of mother using any illegal drug (henceforth 'mother using drugs') ranged from 0 to 0.6%. For cases the corresponding percentages range from 0 to 39% and 0 to 3% respectively. Consequently the ORs for mother using alcohol vary significantly across the ~~centres~~studies. However, there is no evidence that the three-way interaction of mother using alcohol, bed sharing and ~~centre~~ study is significant, p = 0.429. Therefore, the relationship between bed sharing and ~~centre~~ study does not vary by mother using alcohol. In consequence the OR for bed sharing is not affected by varying prevalence of mother using alcohol across the ~~centres~~studies. For mother using drugs the data are too sparse for the analogous three-way interaction to be tested. However, it seems unlikely it would be significant. In consequence the OR for bed sharing is not affected by varying prevalence of mother using drugs across the ~~centres~~studies.

Third, because the alcohol and drug data are plausibly missing at random, MAR, dependent on study, which is included as an indicator variable in both the substantive model and the imputation model, theory suggests that the point estimates in the complete records analysis should be

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unbiased[A5], and within sampling variation of those obtained after multiple imputation. The advantage of multiple imputation here is thus the recovery of information, primarily through the inclusion of the partially observed data from the three studies in which alcohol and drug use were not collected., c.f., Carpenter and Kenwood, p 220.[A5] The results are in line with this, as shown ~~for example~~ in Table 1, columns 8-11. ~~, and a comparison of the results of a complete records analysis with those presented here.~~ Also as reported above the OR for the key subgroup is 5.6 (1.6– 20.3). The number of observations in this subgroup are too small to attempt adjustment for other factors like maternal age parity and birth weight. Compare this subgroup OR with the fully adjusted AOR of 5.1 ((2.3 – 11.4) for breast fed babies < 3 month, whose parents do not smoke and whose mother did not take two units alcohol or more in the last 24 hours alcohol. This AOR is also adjusted for all the other factors in the model, see Table 3. The narrower CI results from the- –recovery of the partially observed data.

Calculation of univariate and multivariate odds ratios

Odds ratios were calculated by logit regression. Univariate analyses were adjusted for age and study because controls were on average 3 weeks older than cases, and the number of controls varied between studies. For multivariate AORs, multilevel logit regression model was fitted with 'bed sharing' random across studies; this was done to take account of a significant interaction of bed sharing with studies. Some other AORs showed significant interaction with studies; however, it was found that these were due to significant deviations in one or at most two studies. When parameters were added to the overall model, to account for these interactions, they had little effect on the main parameters, and only slightly *increased* the estimate of risk associated with bed sharing. The additional parameters were therefore dropped in the final model and these interaction ignored.

The trend in the ln(OR) for bed sharing with age was best represented by a linear downward trend on the logit scale, for the first six months followed by a constant term thereafter. In all four models were used for the analysis:

Model 1. A multilevel logit model of the whole data, including the interaction of age and bed sharing, modelled by the linear trend,

Model 2. To obtain rates applicable to all ages, the same model, excluding the age×bedsharing interaction was fitted, thereby obtaining average AOR for the year.

Models 3 & 4. To obtain average AORs for the first three months and later, a logistic forms of the rates model was fitted to records of infants under 3 months and 3 month or more. Logistic models were used because of convergence problems with multilevel models.

Goodness of fit of the models to the data

Goodness of fit tests are not available for multilevel logit models nor are they available after using Rubin's combination rules for the analysis of multiple imputed data sets. Therefore single level (i.e., standard) logistic models, using the same parameters as the overall model plus fixed effect parameters for study, were fitted to each of the 10 data sets completed with imputed data; both the log link and goodness of fit tests were applied to each. The link test confirmed that all the models were correctly specified: p(for regression on hat^2) averaged 0.44 and all were> 0.15, and p(for the constant) averaged 0.75 and all were >0.56. The average Hosmer-Lemeshow goodness of fit $\chi^2(48) = 40.3$ was less than expectation. and none had a p value < 0.13. It was, therefore, concluded that the model fit was excellent. Checks on the model, without the age trend, fitted to infants aged <3 months showed equally good fit.

To check the fit of the overall model to the data relating to the breast fed cases, age <3 months, whose parents did not smoke and whose mothers did not consume alcohol or use drugs but who were bed sharing, their deviance residuals were computed. The AOR for this groups is represented by the lower line in Fig 2. As above, the deviance residuals could only be computed after fitting a logistic model to each of the 10 completed data sets. Again, the results were pooled using Rubin's rules[A4]. It was found that the mean deviance for this group = - 0.098, s.e 0.1004. Also there was not evidence of any systematic deviation from the fitted line in that there was no evidence of a trend in the residual deviances with age; b = -0.0015, s.e. 0.005.

Similarly residual deviances were computed for this group after fitting model 3. The pooled average residual deviance was -0.147 with s.e. -0.096; p = 0.122. The trend in the residuals was 0.00012 with s.e. 0.005. Thus there is no suggestion that the model parameters do not represent these crucial data.

The Attributable Fraction

The attributable fraction (of deaths, computed as described by Brussi et al.[29]), was similarly computed for each of the 10 logistic models fitted to the imputed data sets. The results were combined using Rubin's combination rules.[A4]

Mortality rates

Rates were derived from the parameters of ~~model~~ Model 2. Rates are given for all ~~children~~infants, computed by a weighted combination of the rates for boys and girls. The base rate for girls was the SIDS rate when none of the model risk factors were present. Then, logit(base rate) = model constant scaled by the addition of the logit of the population SIDS rate and the subtraction of the log(ratio of the number of cases to controls in the model). Combinations of AORs gave other rates from the base rate.

Estimating AORs and Rates for other groups

The AORs computed for other groups, as described on page 7 are approximate because the AORs for the factors which do not interact with age or bed sharing vary, but not significantly, across the 4 models used for the analyses. The AORs shown in the penultimate column of Table 1 are those given by model 2. These differ a little from the comparable AORs given by the Model 1, which includes the age×bed sharing interaction. Thus for the example on page 7, the AOR predicted by model 1 is 4,416 (1764–11,058) compared with 4528 shown.

When computing SIDS rates for other groups from those give in Table 4, the procedure is similar. However, the observed rate must first be divided by 7.43 to reduce the rate baseline – the rates reported in Table 4 relate the second infant with birth weight 2500 – 3499g of a cohabiting white women age 26 to 30. The appropriate baseline rate, i.e., for various smoking groups may then be scaled up according to the other risk factors present. However, if the computed rate is r > 0.003 per 1000, it should be reduced by $-r^2$, because the scaling is based on AORs and rates are probabilities. Conversely if the starting rate is >0.003 it has first to be scaled to an AOR by adding its square.

For example the estimated SIDS rate for a bed sharing 18 year old cohabiting white mother, with her 1st baby, birth weight 2240g. bottle fed when both parents smoke and mother often has 2+units of alcohol is estimated to be

$$r = \{(0.0275 + 0.0275^2)/7.43\} \times 4.2 \times 9.1 = 145.4$$

where:

0.0275 = rate from Table 4 when both smoke, mother uses alcohol and baby is bottle fed

0.0275^2 is added to obtain the corresponding AOR because the starting rate is >0.003

/7.43 to obtain the corresponding baseline AOR

×4.2 from Table 1 for babies 2000-2499
×9.1 from Table 1 for mothers aged 18
Thus, r > 0.003. Hence

Predicted rate per 1000 = 1000*(r-r^2) = 125 per 1000,

which is exact because the AORs in Table 1 are derived from Model 2. Supplementary tables show predicted SIDS rates for two groups of women other than those in Table 4.

Rates may also be scaled up or down in direct relation to the population SIDS rate. Thus if the population SIDS rate is 0.4 per 1000 instead of 0.5 the the estimated rates will be reduced by 4/5 =0.8.

Supplementary tables of predicted rates for two other groups of women.

a) Cohabiting white women age 30+ with 1st baby birth weight >3500g

Group No.	Risk factors present			Room sharing	Bed sharing
	Feeding	smoking	Alcohol	Rate/1000	Rate/1000
Baseline	Br	no	no	**0.011**	**0.031**
1	**Bot**	no	no	**0.017**	**0.047**
2	Br	**P**	no	**0.013**	**0.070**
3	Br	**M**	no	**0.018**	**0.171**
4	Br	**B**	no	**0.033**	**0.254**
5	**Bot**	**B**	**Y**	**0.235**	**3.74**

b) Cohabiting white women age 18 - 19 with 1st baby with birth weight 2000 - 2499g

Group No.	Risk factors present			Room sharing	Bed sharing
	Feeding	smoking	Alcohol	Rate/1000	Rate
Baseline	Br	no	no	**0.4**	**1.2**
1	**Bot**	no	no	**0.6**	**1.8**
2	Br	**P**	no	**0.5**	**2.7**
3	Br	**M**	no	**0.7**	**6.5**
4	Br	**B**	no	**1.2**	**9.5**
5	**Bot**	**B**	**Y**	**8.8**	**124.6**

References

A1 Carpenter JR, Goldstein H, Kenwood MG. (2012) Statistical modelling of partially observed data using multiple imputation: principles and practice. p20. In: Modern Methods for Epidemiology. Ed. Greenwood DC & Tu Y. Springer, London.2012.

A2 Carpenter JR, Goldstein H, Kenward MG. (2012). REALCOM-IMPUTE Software for Multilevel Multiple Imputation with Mixed Response Types. J Statistical Software. **45** :5: 1-14.

A3 StataCorp 2011. Stata Statistical Software: Release 12.1. College Station, TX: Stata Corporation.

A4 Rubin D. (1987) Multiple Imputation for Non-response in Surveys. Wiley, Chichester.

A5 Carpenter JR, and Kenward MG. (2013) Multiple Imputation and its Application, Chichester: Wiley, pp 28, and 220.

Field Code Changed

Response to Dr. Alison Walker's and Referees' Comments

In this comment and response section the referees comments are in Tahoma italics script, and the responses are in Times New Roman.

From the managing editor, and Dr Alison Walker, associate editor:

Regarding the Horne, Moon and Gilbert reviews: please do respond to these reviewer comments. In particular the comment regarding the number needed to harm (NNTH) by bed sharing vs not as suggested by Ruth Gilbert (and mentioned in the abstract).

NNTH is a poor statistic and often incorrectly interpreted – see response to Professor Gilbert's comments. The estimated rates and rate ratios, together with their confidence limits present the results clearly and in a manner that can readily be understood.

Please also be much more cautious about the causality message; we suggest you remove this from the conclusion in the Abstract. The title also needs to state the study design and research question. We much prefer titles that frame a research question and study design as this is much more useful when researchers find articles via search engines and indexes. 'Headlines' could be to comment, editorials, news items, press releases, etc.

We have replaced the title, as requested. Now reads: "Bed sharing when parents do not smoke: Is there a risk of SIDS? Findings of a combined analysis of five case-control data sets."

The conclusions in the abstract have been amended as follows: "Bed sharing for sleep when the parents do not smoke or take alcohol or drugs increases the risk of SIDS. Risks associated with bed sharing are greatly increased when combined with parental smoking, maternal alcohol consumption and/or drug use. A substantial reduction of SIDS rates could be achieved if parents avoided bed sharing."

There is also a review from Dr Blair. We accept the potential for dispute here. However we would appreciate your response (some of which will duplicate your response to his review at the BMJ which was not provided to BMJ Open at the time of these reviews) wand specifically we would like you to respond to Blair's point vii and the arguments saying B-Hill's causality criteria are weak, in the manuscript.

In response to your request we have amended the panel to make clear that, in our view, it establishes bed sharing as a cause of SIDS in the absence of smoking, alcohol or drugs. We have also added a few sentences to the text.

We have responded to Dr. Blair in detail below. Dr. Blair refuses to accept that bed sharing in itself is carries a risk of SIDS, which includes suffocation because the two are generally indistinguishable. We believe that the data show that it is.

We appreciate the favourable comments by Professor Rosemary Horne and Professor Rachel Moon, and we have accepted their corrections to our text, which are most helpful. Some of Professor Ruth Gilbert's thoughtful minor comments require two additional short paragraphs at the end of the discussion.

Response to Dr. Ruth Gilbert's minor comments

1. Abstract: results: The fact that the absolute risk is not directly derived from the study but estimated would be clearer if described as 'estimated absolute risk'.

Accepted

2. It would assist assessment of the implications for individual women if the number needed to harm (NNTH) by bed sharing vs not could be derived from the estimated absolute risk difference for some illustrative examples (and mentioned in the abstract).

We do not think that it would be helpful to report NNTH. We note that like its companion statistic, NNT, it is seldom correctly understood, is biased, and reliable confidence intervals cannot be provided. (HuttonJL. Misleading Statistics. The problems Surrounding Number

Needed to Treat and Number needed to Harm. 2012 Pharm. Med. 24; 143-9). We report estimated Absolute Risk and Risk Ratios, together with their confidence limits for a number of representative groups, and in the appendix show how absolute risks may be calculated for other groups.

3. Abstract- conclusion: The wording should be changed to indicate that a substantial reduction could be achieved if parents avoided bed sharing. It is not at all clear how effective discouraging bed sharing might be (wording also relevant to key messages). Accepted

4. The conclusion could give more guidance about how the findings inform policy and individual decision making. The clear evidence of harm associated with bed sharing means that policy that advocates bed-sharing cannot be justified. The results support health promotion messages to all parents to avoid bed sharing. Given the low risk of SIDS however, some parents with strong preferences for bed sharing may choose to accept the very small increased risk of SIDS.

5. The conclusion includes the figure of 50% - which is worded as the population attributable fraction. It would be helpful if the authors could briefly mention how this was calculated in the discussion.

6. Background para2 last line: It would be clearer to write "some do not discourage bed sharing but actively promote it"

See revised text.

7. Discussion. The shift from 22% of SIDS bedsharing in the study to 50% now may represent a population shift towards more bedsharing or a change in the risk profile of SIDS. Could the authors comment on the explanation and whether this is likely to change their adjusted odds ratios? For instance, the risk of SIDS associated with front sleeping increased as health promotion messages to avoid front sleeping SIDS were adopted more by low risk than by high risk parents.

Two paragraphs have been included at the end of the discussion in response to points 4 to 7.

Response to Reviewer 3's comments

We welcome Dr. Peter Blair's comments because, despite the major contributions that he and his colleagues have made to SIDS research, he is a sceptic of the evidence that bed sharing under 3 months in itself carries a risk of SIDS. Dr. Blair was the first author of the most widely quoted paper on this topic 'Babies sleeping with their parents: case-control study of factors influencing the risk of sudden infant death syndrome' (Blair PS, Fleming PJ, Ward Platt M et al. 1999 BMJ 319: 1457-62.). In Table 3 of that paper the authors report that the multivariate OR for bed shares at the end of sleep is 9.78 (4.12 to 23.83). The base line for comparison is room sharers. This OR is adjusted for all 23 other significant factors, including parental smoking and smoke exposure. The analytical process for calculating a multivariate OR ensures that cases and controls are comparable in respect of *all* the other variables in the model, In particular this adjusted OR , by controlling for other risk factors leaving only bed sharing as a risk factor, is the estimated OR, all other actors being equal, and in particular, *when no other risk factors are present* . However, after reporting the fully adjusted OR for bed sharing, the authors then note that "Some factors in the multivariate model predominantly involved infants sleeping in a cot rather than the parental bed, such as infants put down in the prone sleeping position (20.8% deaths in a cot *v* 2.5% deaths in a shared bed), placed on a pillow (11.6% *v* 1.2% or infants being found with heads covered (19.0% *v* 6.9%)). Removal of these three variables halved the strength of the association with being found in a shared bed (multivariate odds ratio 4.62 (2.34 to 9.09))." The suggestion appears to be that these readily modifiable risk factors may largely be avoided by bed sharing. Of course the OR for bed sharing is reduced because the bed sharers with a comparatively low proportion of infants exposed to the risk factor are being compared with groups with a much larger proportion of infants of these risk factors, but the OR now no longer estimates the independent risk of bed sharing, all other things being equal. By further selective comparisons the authors conclude that "There is no evidence that bed sharing is

hazardous for infants of parents who do not smoke." This is in direct contradiction of the results of their analysis presented in their Table 3.

In the meta analysis of the risks associated with bed sharing [Bed Sharing and the Risk of Sudden Infant Death Syndrome: Can We Resolve the Debate? J. Pediatr. 2012 160(1) 44 – 8.e2] the multivariate OR for bed sharing in the CESDI study is correctly taken as 9.78. (A figure of 21.77 is quoted for Blair PS, 2009 includes sofa sharing). Nevertheless Dr Blair continues to raise every possible objection to our evidence that bed sharing in itself carries a risk of SIDS, and we welcome the opportunity to answer them.

Reviewer 3

More clarity is needed regarding how the differences in the data from the 5 studies were resolved, how missing data was checked and whether data can be imputed when whole studies did not ask certain questions. Interpretation of the findings also needs more clarity especially in terms of the reference groups used. the emphasis placed on teh findings is also questionable.

Responses to identical questions were provided from each of the five datasets, when available. Significant differences between the multivaiate adjusted ORs for bed sharing were resolved by the use of multi-level models in which bed sharing was taken as random across studiess, thereby giving an average AOR across studies with corresponding CI which includes the variation across studies, as stated in the Appendix: statistical methods, C*alculation of univariate and multivariate odds ratios*, paragraph 1.

Imputation was carried out separately for cases and controls. Because of the extreme sparseness of the alcohol and especially the drug use data, it was ot possible to impute using a multilevel model, nor was it possible to use a binary imputation model for drug use or alcohol, nor was it possible, after including in the imputation model all the main effects of variables in the substantive model, to adjust for study in the imputation model.

Thus drug use and alcohol, both coded 0/1, were imputed as continuous, and then rounded to the nearest of 0, 1. The reference imputation probability for alcohol and drug use, respectively, was therefore the reference baseline probability of alcohol and drug use over the studies with these observed.

After imputation, the average imputed rates of alcohol and drug use where checked in the cases and controls and found to be close to those in the observed data. Imputation for a variable missing in a study in this setting is valid provided the imputation model is appropriate. See, for example, the discussion in Carpenter and Kenward, (2013), p222. Also, iIn the current version the base line for any AOR is clearly specified.

I have reviewed this manuscript previously and still find the major points I raised have not been addressed by the authors. The primary focus of this paper, stated in the article summary, is to answer the question "Is there a risk of SIDS due to bed-sharing when baby is breast fed, the parents do not smoke and the mother does not use alcohol or illegal drugs?" This question cannot be addressed when only two of the five studies collected data on maternal alcohol consumption, none of them collected data on the use of illegal drugs prior to bed-sharing and the question is confined to one co-sleeping parent when there are often two .

Imputation provides a valid unbiased analysis of the data – see references in the statistical appendix. For the key group of cases bed sharing non-smokers our data sets either give details of alcohol and drug use of both the mother and her partner, or we have checked the original case records – see below.

The success of SIDS research in the last few decades has been an iterative process focussing closer and closer on the potential risks within the infant sleep environment prior to death. We have been able to utilise this cumulative knowledge in our latest UK case-control SIDS study in 2003-6 (BMJ 2009;339:b3666) and asked (what now seem obvious questions) who exactly was sleeping next to the baby for the last sleep and how much alcohol or drugs had they consumed. We found a significant interaction and nearly a third of the deaths occurred in these circumstances. The potential

role of parental alcohol and drugs in these bed-sharing deaths may also go some way in explaining the increased risk of bed-sharing amongst smokers in that this may act as a proxy if questions regarding alcohol and drugs were not asked.

The over-arching argument is thus whether bed-sharing in itself poses a risk to infants or whether the risk is within the hazardous circumstances in which we bed-share. These older studies (data collected between 1987 and 2003) do not have the data to resolve this argument.

The claim that the older studies did not collect data on the amount of alcohol consumed or on who was sleeping next to the baby is not correct. The amount of alcohol consumed by both parents was recorded in the ECAS and the Irish data set; the New Zealand study and the recent German study also asked potentially relevant but different questions on maternal alcohol consumption; also the position of those bed sharing was recorded in great detail in some of the data sets. While claiming the superior quality of their data, when calculating multivatiate ORs, they grouped bed sharing with sofa sharing, as noted By Professor Goerge B. Haycock in his comment on the Bradford study (http://pediatrics.aappublications.org/content/129/3/e673/reply#pediatrics_el_53902).

The authors of the study cited also claim in the text that the data are superior to other studies because the responses to the questionnaire were checked against the narrative report. However, checking the questionnaire responses against the narrative report is nothing new. RGC clearly recalls doing exactly this in the 1960s for the first case-control study. With regard to the latest revision of our report, for the crucial bed sharing cases where neither parent smoke and questions on alcohol or drug use were not included in the questionnaire, **we have, gone back to the narrative records and 'established that neither alcohol nor drug use contributed in any way to any of these deaths.' see paragraph 3 of the discussion and the Appendix.**

I'm sure it is a difficult task trying to combine data from different studies conducted in different countries at different time periods but there seems additional complexity in the way the data has been analysed in terms of the reference groups chosen and the interpretation placed upon them. I'm also a little perplexed that the authors seem to be advocating a ban on bed-sharing when their own findings seem to indicate a massive interaction with the hazardous circumstances in which these infants were found.

In our view, the analysis establishes beyond reasonable doubt that in the first three months bed sharing is a risk factor for SIDS in the absence of other risk factors. We present SIDS rates for room sharers and bed sharers for selected groups and show how rates for other groups may be calculated, thereby enabling informed choice. The increased risk of SIDS associated with bed sharing when combined with smoking, alcohol and other hazardous factors have been known for many years and have been included in SIDS prevention messages (E.g. FSID's Baby Zone leaflet). However, this messages does not appear to be getting through We note the rising proportion of SIDS occurring in bed often in hazardous circumstances, and the substantial proportion of the cases predicted by our data to be attributable to bed sharing. As scientists, that is as far is we can go. As parents we ask why take unnecessary risks.

Major Points

i) Different studies used different definitions for bed-sharing. The Scottish study for instance denoted an infant bed-shared even if they bed-shared some time during the last sleep but were then placed back and found in the cot. Also the New Zealand study had no reference sleep for the control infants and thus (from memory) defined a bed-sharing infant as one that usually bed-shared in the two weeks before the last sleep. How have these differences been reconciled? Stating in the material and methods section (Page 4, line 54) that 'equivalent questions' were used does not provide enough detail.

The Scottish study asks 'At what time did you last see your baby alive?', ' At what time did you find your baby dead?' and 'Did any one share the same bed, couch or chair with the baby during that sleep?'. Then 'Specify which' with 'bed' as the first option. If the baby was put back in the cot, this would be the last time the baby was seen alive, and so the baby would not be bed sharing during the terminal interval. Thus, the possibility that the baby had been put

back in a cot is excluded. With regard to the New Zealand data, Professor Mitchell writes 'This is incorrect. Although we did measure usual sleep location in the last two weeks we also used a nominated (or reference) sleep for the control infants. The specific question was: Did baby share a bed with another person during the nominated sleep (controls)/at the time of death (cases)?That is the data we used in the analyses.'
The questions are specific. *'equivalent questions'* deleted.

ii) The authors also state (page 9, lines 46 to 51) that for studies where questions on maternal alcohol use and drug use were not included they have "gone back to the original records of breast fed bed-sharing cases when both the mother and partner were non-smokers and established that neither alcohol nor drug use contributed in any way to any of these deaths." Firstly if this could be done it should be done for all cases and controls where possible not just a small subgroup and secondly what do the authors actually mean by this? If questions regarding parental alcohol and drug use were not asked in a detailed research investigation it is unlikely they would have been asked consistently or at all during the coronial investigation. Absence of these pertinent factors could mean that alcohol and drugs were not used but just as likely this could also mean these questions were not asked.
We do not have the resources to go back to all the case records, nor is this necessary. Furthermore there is no comparable narrative data for the controls. The question is, when neither parent smokes, can the cases of SIDS which occurred while bed sharing have been due to alcohol or drugs? This is unlikely especially at time before the bans on smoking in a public place. This is confirmed by our data. When neither parent smoked, of 125 cases only 2.4 % of mothers had taken alcohol and only 2.9% of 726 controls and none of the case or control mothers were drug users. It should also be noted that both the large New Zealand and German studies asked pertinent questions about alcohol use. We have therefore modified the text to read 'We have gone back to the original records, most of which included pertinent questions on maternal alcohol use, and established that neither alcohol nor drug use contributed in anyway to any of these deaths. If imputation had underestimated the use of alcohol or drugs among the corresponding controls this would have resulted in an underestimate of the risk associated with bed sharing in this group.

iii) None of the studies collected data on parental drug consumption prior to the last sleep of the SIDS infant or the reference sleep of the controls (usually within 24 hours of the interview). Using maternal use of illegal drugs after birth is a poor proxy of the circumstances surrounding the final event. We have shown in our previous larger SIDS study conducted in the 1990's that data on routine use for any factor is a poor marker for what actually happens in the last 24 hours. The authors need to acknowledge that they simply have not got the data to adjust for this important factor.
iv) None of the studies collected data on paternal alcohol consumption preceding the last sleep. The authors need to acknowledge that the risk to the infant could come from one or both parents and data on what each parent consumed and the exact sleeping arrangements needs to be collected to properly assess whether a co-sleeping environment is hazardous. Specifically any analysis needs to take into account which parent or parents were sleeping next to the infant.

These two points are taken together. The premise is incorrect. The ECAS studies used in in this analysis and the Irish study all collected data on the partner's alcohol consumption in the last 24 hours and partner's drug use after the baby was born. Further, when neither parent smoked, for 41% of the cases and their controls the original records also includes drug use in the last 24 hours. Analysis of the data show that when both partners were non-smokers none of the case or control mothers used drugs after birth or, when known, on the last night. However, in the 873 records of the corresponding partners, one partner of an 8 month old control baby did use illegal drugs, but not marihuana or hard drugs, both after birth and on the last night; he also had 4 alcoholic drinks; the baby was fully breast fed upt to the time of interview, slept in a cot in the parents' room but not in the parents' bed. This record does not affect our conclusions.

Also in the key sub group of babies < 3 months who were breast fed whose parents did not smoke and whose mother took less than 2 units of alcohol in the last 24 hours who either bed shared or room shared – we find that in both the bed sharing and room sharing groups the control partners had taken slightly *more* alcohol in the last 24 hours than the cases partners. For this key subgroup the OR for bed sharing, unadjusted for other factors is 5.6 (1.6 – 20.3), p = 0.009, After adjusting for partner's alcohol consumption in the last 24 hours, the OR is 7.7 (1.8 – 32.3), although the OR for partner's alcohol is not significant; OR = 0.73 (0.41 – 1.27), p =0.265.

We know of no study which takes account of the *exact sleeping arrangements* and *which parent or parents were sleeping next to the infant* in the analysis.Certainly not his own.

v) Maternal alcohol consumption prior to the last sleep was collected but only for 38.7% of the mothers in the study. Imputing values for parental and alcohol drug consumption on a particular night from a single study when more than 50% of the data is missing requires a fairly homogeneous population and good predictors of 'missingness'. Imputing values from a group of 5 studies, 3 of which did not even ask the question is surely making unreasonable equivalence assumptions across studies conducted in different countries with different cultures in different time periods. In fact one of the two studies where some of this data was collected was a multi-centre study of 20 regions across Europe; cultures with different drinking and drug habits. Just how one randomly selects a potential catastrophic event such as a parent drinking too much alcohol or taking drugs (cannabis, methadone, heroin, etc) before bed-sharing on the final night seems an impossible task.

We disagree. Define the key sub group as babies < 3 months who were breast fed whose parents did not smoke and whose mother took less than 2 units of alcohol in the last 24 hours who either bed shared or room shared. Then we note that for the key sub group the OR based on complete records is 5.6 (1.6 – 20.3). For further details see paragraph of the discussion and the second section of the appendix.

vi) In Table 3 and the abstract much is made of the risk associated with bed-sharing in the absence of other factors (AOR=5.1 (2.3-11.4)) but more clarity is needed to describe what this means? According to the Table the reference group seems to be infants < 3 months old who are room-sharing with parents who did not smoke or drink alcohol but the text also suggests these infants were also breastfed, female and placed supine (page 8, line 11 to 15). If so, then should the fivefold risk be attributed to bed-sharing on its own or is there a combined risk including bottle fed infants, male gender and those placed prone. If these factors (gender, mode of feeding and sleeping position) are adjusted for in this analysis (it is not made clear) then does not using such a low risk reference group inflate the risk of the other factors? For instance although there is a 5-fold risk for bed-sharing there is a 13-fold risk when the infants sleeps in the cot next to the bed of parents who smoke and have drank alcohol. I would have also thought more emphasis would have been put on the finding in the same table that when the parents smoked and bed-shared the risk increased to 21.8 (11.2-42.6) and when the parents also drank alcohol the risk increased to 151.0 (50.6-450.7)! In fact perhaps the most surprising finding in this table is that although the risk associated with bed-sharing in the absence of alcohol and smoking was unity amongst infants aged 3 months or older it was 243.8 (76.1-781.4) when smoking parents drank alcohol and bed-shared which should surely be the finding to emphasise in any abstract.

The titles makes clear that the ORs in Tables 2 & 3 are fully adjusted, in that no other risk factors are present. To avoid possible misunderstanding I have set this out for each table. Some other corrections have been made.

vii) The authors argue that in itself the act of an infant lying next to a sleeping adult is causal but this argument using the Bradford Hill criteria is fairly weak. The data cannot really be adjusted for recent alcohol and drug consumption so the contention that there is a strength of association in the absence of known factors does not really stand up. The consistency of findings amongst case-control studies is not comprehensive and there is certainly ecological data suggesting low SIDS rates amongst some populations that often bed-share (see point viii). The evidence of a dose response effect and an analogous example are weak at best but perhaps the argument for coherence is the most surprising. Given this study shows a 10 fold greater risk of bed-sharing amongst smokers (Fig 2), a 90 fold risk of bed-sharing when alcohol was involved (at 2 weeks) and an 'inestimably large' risk associated with stronger drugs than cannabis surely causality is more soundly argued on the

basis of potential overlaying for many of these bed-sharing deaths in hazardous circumstances rather than weakly asserting it is the bed-sharing itself and not the way we bed-share that puts infants at risk.

First, we have shown that the OR for the key group i.e., neither parent smoked mother did not use drugs and only one room sharing partner used drugs, and the baby was < 3 months and breast fed based on the observed data is significant and almost identical to the AOR for this group. The OR was not explained by the partner's alcohol consumption because control partners had taken more alcohol than the partners of cases Only one case partner had 4 units of alcohol in the last 24 hours.

Second, we are presenting the argument that bed sharing is causal for SIDS in the absence of smoking, alcohol or drugs. The Title of the panel has been changed to make this clear. The case for consistency makes sense in this context. Further, in a recent meta-analysis 3 studies have reported the ORs for bed sharing in infants of non-smoking mothers (reference number #26). The ORs were 0.98, 2.55 and 2.20.

Third, we do not deny that certain factors make bed sharing more hazardous. However the focus of this paper was to answer the question as to whether bed sharing is a risk when parents do not smoke or take alcohol or drugs. We have clearly shown that it is.

viii) The authors in the discussion (page10, lines 35 to 40) suggest bed-sharing in the Netherlands has fallen whilst the breastfeeding rates have slightly risen. What they don't say is whether the SIDS rate has changed in this period (I don't think it has) or whether there is any published evidence supporting a relationship between bed-sharing and breastfeeding in the other direction. Ecological data suggest there are several countries or cultures where bed-sharing and breastfeeding are quite prevalent and the SIDS rate fairly low (Sweden, Hong Kong, Japan, Brazil, Hispanic families in the US, Asian families in the UK). We have also shown an interdependent relationship between bed-sharing and breastfeeding (Blair PS, Heron J, Fleming PJ. Relationship between bed sharing and breastfeeding: longitudinal, population-based analysis. Pediatrics 2010;126(5):e1119-26) and any discussion of this relationship surely needs to be more balanced.

SIDS rates fell during this period, see revised text. We don't think further discussion of the well known relationship is necessary at this point.

ix) It is not clear but Figure 2 appears to be a subgroup analysis of bed-sharers across age involving only those who breastfeed and bed-share and only those families where either both parents smoke or neither. Further, both the legend and the text suggest the odds ratios have been adjusted for alcohol and drug use. Given the limitations of what has been collected I don't think this can be stated and given alcohol and drug use is probably more common amongst bottle feeding mothers it is important to include all the data split by any smoking/no smoking (rather than drop data where one parent smokes) and adjust for mode of feeding (rather than drop the data on bottle feeders completely).

This appears to be a misunderstanding from a previous review. Following the description of Fig 2, the text states explicitly that 'These values are predicted by the overall model of the whole data set.' The title of Fig.2 states that the AORs are adjusted for all other risk factors, as are the corresponding figures shown in Table 2. It is much more powerful to fit an overall model to the whole data, than to embark on subgroup analysis. We have checked both the overll fit of the model to the data and also the fit of the model in the area of special interest – see the appendix.

x) The lack of any analysis on sofa-sharing is disappointing, the New Zealand study did not ask about sofa-sharing but the other 4 studies did. The results suggest a much stronger risk with sofas than parental beds and a strong interaction with alcohol or drugs. The data on co-sleeping on a sofa should either be handled as a separate group or analysed together with bed-sharing to evaluate the risk of co-sleeping in general; combining this group with infants who slept in a cot (Table 1) or ignoring this group altogether (Tables 2,3 and 4)makes the interpretation of the risk associated with bed-sharing difficult.

The New Zealand study did examine sofa sharing, but it has not been reported as only 5 (1.3%) of the 393 deaths occurred on a sofa while bed sharing with another person. In the publications from the New Zealand Cot Death Study they have been included as bed sharing

deaths However, in the present study sofa sharing is not included with bed sharing. Sofa sharing was not categorised as bed sharing in the NZ dataset, because we only accepted a code of bed sharing when 'Room baby found' was 'parents' bedroom'; otherwise a code of 'bed sharing' was recoded as 'not bed sharing' and 'sleeping elsewhere'. In retrospect, we might have re-examined the risks of sofa sharing, but from the start the question was is bed sharing safe?

xi) In their conclusion the authors suggest the campaign used to reduce prone sleeping, which halved the SIDS rate, could be adopted to reduce bed-sharing claiming a potential further drop in SIDS rates of 88%. This is a poor analogy, prone sleeping was foisted onto parents in the 1950's and thus easier for them to relinquish as an infant care practice whilst bed-sharing has been practiced for thousands of years, is culture specific and potentially related to an increased duration of breastfeeding. I'm not sure how they derive an 88% reduction (half of SIDS infants are found co-sleeping up to a third of which are found on a sofa) but current campaigns do not support their contention. In the US the indication is that bed-sharing rates have increased, despite the American Academy of Pediatrics advising against bed-sharing for the last 6 years and State-specific aggressive campaigns depicting mothers as meat cleavers sleeping next to the child and parental bed- headboards as tombstones, yet the SIDS rate has remained static.

The analysis shows that in our data, 88% of the bed sharing deaths are attributable to bed sharing. The discussion now includes a brief discussion on prevention.

More Minor Points

i) In the background the authors suggest the UNICEF baby friendly website (reference 13) and NCT website (reference 14) actively promote bed-sharing. The UNICEF website page quoted no longer seems available. However the current UNICEF page related to this http://www.unicef.org.uk/BabyFriendly/Resources/Resources-for-parents/Caring-for-your-baby-at-night/) shows published evidence of a link between breastfeeding and bed-sharing and seems to acknowledge that bed-sharing is a recognised infant care practice but does not tell parents to bed-share. Again on Page 10 (lines 42-44) suggest UNICEF promotes bed-sharing which it doesn't. Similarly the NCT website acknowledges the SIDS evidence and that bed-sharing can occur (both intentionally and unintentionally) but does not actively promote bed-sharing. These references either need removing or rephrasing.

Rephrased – see the text and new reference. On Page 10 it does not say that UNICEF advocates bed sharing but that **if** bed sharing is promoted to improve breast feeding rates, then it is likely to be counter productive.

ii) The claim by the authors that "the results from analysis of the completed data will primarily depend on the observed data, and only slightly on the imputed data" (Page 9, lines 54-55) seems incongruous to the fact that over 60% of the maternal alcohol data was missing and was therefore imputed.

We are sorry if this was unclear.

Since study is the primary cause of missing alcohol and drug data, and study is adjusted for in the substantive model, we expect the complete records analysis to give essentially unbiased coefficients (Carpenter and Kenward, 2013, p28).

Further, it seems very plausible that alcohol and drug use are missing at random, given study, which is included both in the model of interest and in the imputation model.

Thus our multiple imputations, which is performed under the missing at random assumption, is expected mostly to recover information, rather than correct bais. The majority of this information comes from including in the analysis records whose alcohol and drug data are missing. In this respect, this example is similar to that discussed by Carpenter and Kenward (2013) p 220. As in that setting, most of the information will accrue to the estimates of parameters whose covariates form the observed part of the partially observed records (which are included after multiple imputation).

To put it another way, the imputation process generates random values conditional on the observed associations in the data. Ten data sets were imputed, in each of which the observed

data are the same and the imputed data may vary. The analysis combines the analysis of these 10 data using the same model and takes account of the variation between them due to the variation in the imputed values. Thus, the observed data receives much more weight than the imputed values.

Reference:
Carpenter JR and Kenward MG (2013) Multiple Impuation and its Application, Chichester: Wiley

Bed sharing when parents do not smoke: Is there a risk of SIDS?
An individual level analysis of five major cases-control studies.

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Bed sharing when parents do not smoke: Is there a risk of SIDS? An individual level analysis of five major cases-control studies.

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Abstract

Objective: To resolve uncertainty as to the risk of Sudden Infant Death Syndrome (SIDS) associated with sleeping in bed with your baby if neither parent smokes and the baby is breastfed.

Design: Bed sharing was defined as sleeping with a baby in the parents' bed; room sharing as baby sleeping in the parents' room. Frequency of bed sharing during last sleep was compared between babies who died of SIDS and living control infants. Five large SIDS case-control data sets were combined. Missing data were imputed. Random effects logistic regression controlled for confounding factors.

Setting: Home sleeping arrangements of infants in 19 studies across UK, Europe, and Australasia.

Participants: 1,472 SIDS cases, and 4,679 controls. Each study effectively included all cases, by standard criteria, Controls were randomly selected normal infants of similar age, time, and place.

Results: in the combined dataset, 22.2% of cases and 9.6% of controls were bed sharing, adjusted Odds Ratio, AOR for all ages 2.7; 95% CI (1.4–5.3). Bed sharing risk decreased with increasing infant age. When neither parent smoked, baby was less than 3 months, and breast fed and had no other risk factors the AOR for bed sharing vs. room sharing was 5.1 (2.3–11.4) and estimated absolute risk for these room sharing infants was very low (0.08 (0.05–0.14) per 1000 live births). This increased to 0.23 (0.11–0.43) per 1000 when bed sharing. Smoking and alcohol use greatly increased bed sharing risk.

Conclusion: Bed sharing for sleep when the parents do not smoke or take alcohol or drugs increases the risk of SIDS. Risks associated with bed sharing are greatly increased when combined with parental smoking, maternal alcohol consumption and/or drug use. A substantial reduction of SIDS rates could be achieved if parents avoided bed sharing.

Article Summary

Focus

- Is there a risk of SIDS due to bed sharing when baby is breast fed, the parents do not smoke, and the mother does not use alcohol or illegal drugs?
- At what age is it safe to bed share?
- How is risk of SIDS associated with bed sharing affected by other factors?

Key Messages

- When the baby is breast fed and under 3 months, there is a fivefold increase in the risk of SIDS when bed sharing with non-smoking parents, and mother has not taken alcohol or drugs.
- Smoking, alcohol and drugs greatly increase the risk associated with bed sharing.
- A substantial reduction is SIDS rates could be achieved if parents avoided bed sharing.

Strength and limitations

- **This** is the largest ever analysis of individual records of 1472 SIDS cases and 4679 controls from five major case control studies.
- Questions on mother's alcohol use in the last 24 hours and illegal drug use were not asked in three of these studies.
- Imputation of missing data enabled a combined analysis of all the data. The analysis gives unbiased efficient models that describe the data accurately, especially in key areas.

Background

Despite the marked reduction in Sudden Infant Death Syndrome (SIDS)[1] following the advice to place babies to sleep on their back (supine),[2] SIDS remains the major cause of infant death in the post neonatal period (28 days through to the first birthday) in high income countries. For instance in the US SIDS remains the leading cause of postneonatal mortality where 2,353 babies died from SIDS in 2008, about 0.6 per 1000 live births.[3]

Some countries give advice to parents in their 'Reduce the Risks' literature not to bed share with their babies under any circumstances. For example, The Netherlands advise parents not to bed share for the first 3 months of life[4] based on their own research findings.[5] This is also the case for the US[6] where the American Academy of Pediatrics Task Force on SIDS cited European[7] and New Zealand[8] data (included in this paper) and made a clear statement advising against bed sharing for sleep. Other countries notably the UK and Australia advise only certain groups not to bed share for sleep.[9-12] Bed sharing and the risk of SIDS has become controversial, especially as some, while listing when it should be avoided, highlight the benefits of bed sharing.[13,14]

There is general acceptance that sleeping with a baby is a risk factor for SIDS when sleeping on a sofa in any circumstances or in a bed if the mother smokes and/or has taken alcohol.[15, 16] However, authors differ as to whether, in the absence of these risk factors, bed sharing represents a risk.[17-22] Mitchell, in a recent review suggests that before embarking on further studies, much could be achieved by combining the information from current studies.[23]

However, these risks, specifically for non-smokers when breast feeding, cannot be quantified directly from published data by standard meta-analysis due to the different ways risks are reported.[5, 17, 19, 24, 25] The limited assessment of interactions for instance between bed sharing and breast feeding due to lack of individual data to analyse was highlighted in the recent meta-analysis of case control studies of SIDS.[26] Therefore, the leading authors of five major recent case-control studies agreed to combine the *individual* data to estimate the risk associated with bed sharing in relation to breast feeding, smoking, mother's recent alcohol consumption, and illegal drug use, after controlling for the other most important risk predictors, namely whether the baby slept in the parents' room or elsewhere, position the baby is put down to sleep, mother single, mother's age and parity, and baby's birth weight These five datasets included all cases that some might now classify as "unascertained" or "asphyxia" because they were found bed sharing or sleeping face down.

Material and Methods

Study population

The data from the European case control studies 1992 – 1996, i.e., The European Concerted Action on SIDS, ECAS,[7] the Scottish 1996 –2000,[27] the New Zealand 1987–1990,[8] the Irish 1994–2003,[28] and the German GeSID 1998–2001[29] datasets were combined. Cases and controls over one year of age were excluded. The combined dataset comprised 1472 cases and 4679 normal controls of similar age. For details on how the controls were selected, see the appendix.

Notes on explanatory variables

The explanatory variables were defined as follows:

'*Bed sharing*' was defined as when one or both parents slept with the baby in their bed so that they woke to find the baby dead in bed with them. Controls were bed sharing if the baby was in bed with them when they awoke on the day of interview.

'*Room sharing*' ~ sleeping in the parents' room but not in the parents' bed.

'*Breast fed*' ~ infant was being partially or completely breast fed at the time of death or interview.

'*Bottle fed*' ~ the infant was not breast fed at this time.

'Parents' ~ the mother and her current partner.
'*Age*' ~ the infant's age at death or at interview for controls.
'AOR' ~ multivariate adjusted odds ratio**.** AORs and rates are followed by the 95% Confidence Interval (CI) in parentheses.

All data sets enabled the identification of cases found sleeping in the parents' room or elsewhere and whether or not they were bed sharing, together with comparable control data. Cases and controls co-sleeping on a sofa or elsewhere were included but grouped with those not bed sharing and not sleeping in the parents' room. Whether or not the mother or partner smoked, together with the infant's age, sex, race, birth weight, mother's age, parity, whether single or with a partner, and position the infant was last placed to sleep, and how the baby was being fed at the time of death/interview were available for all data sets. In addition, data on the mother's alcohol consumption in the last 24 hours and mother's illegal drug use after birth were available in two datasets. In total all the variables shown in Table 1, together with age at death or interview, and study[‡] were used in the analyses.

Statistical analysis
All variables, other than case or control, age, and study, included some missing data. Missing data were imputed as described in the Appendix. Odds ratios were calculated by logit regression. Univariate analyses were adjusted for age and study because controls were on average 3 weeks older than cases, and the number of controls per case varied between studies. For multivariate AORs, a multilevel logit regression model was used with "bed sharing" random across studies. The fraction of bed sharing deaths ***attributable*** to bed sharing, that is the fraction of bed sharing deaths that would not have occurred had the babies not been bed sharing but placed supine in a cot in the parents' room, all other things being unchanged, was computed as described by Bruzzi et al.[30] Mortality rates were computed using the same multivariate model by omitting the trend of bed sharing with age. Rates are given for all infants computed by a weighted combination of the rates for boys and girls. The base rate for girls was the SIDS rate when none of the model risk factors were present. To obtain average AOR for infants <3 months and for infants aged 3 months or more, a logistic form if the rates model confined to records under 3 months and 3 months or more were fitted.

Full details of the statistical methods are given in the Appendix.

Results

The age distribution of the 1472 cases is shown in Fig.1. The peak incidence rate is between 7 and 10 weeks.

Fig. 1 here

Fig. 1 The age distribution of the cases in the combined study.

Univariate and multivariate analyses

The data for each variable are tabulated for cases and controls in Table 1 together with percentage of missing data and the single factor ORs adjusted for age and study, together with the corresponding OR derived from analysis of the imputed data sets. Corresponding multivariate

[‡] The ECAS data set comprises a set of 20 studies, five of which were excluded due to absence of data on feeding or unwillingness to participate.

adjusted AORs from the overall rates model are also reported. For variables that interact with bed sharing, and consequently age, AORs reported in Table 1 are those for infants room sharing but not bed sharing.

Feeding

Table 1 shows that bottle feeding increases risk of SIDS. When analysed as a single factor the OR for bottle feeding is 2.9 (2.5–3.3) however, the multivariate AOR is 1.5 (1.2–1.8).

Multivariate analyses for interactions between age, bed sharing and other variables

The baseline in the multivariate analysis is a breast fed baby placed on his/her back to sleep in a cot in the parents' room neither of whom smoke and having no other risk factors.

Bed Sharing

The log-linear downward trend in the OR for bed sharing in the first 6 months of life is shown in Fig 2, when neither parent smoked and when both smoked. These values are predicted by the overall model of the whole data set. Checks show that the predicted risks closely fit the data, especially when neither parent smoked and the mother had taken neither alcohol or drugs and the baby was breast fed and bed sharing(see appendix).

Fig.2 here

Fig. 2. Adjusted ORs (log scale) for SIDS by age for bed sharing breast fed infants, when neither parent smokes and both smoke vs. comparable infants sleeping supine in the parents' room. AORs are also adjusted for feeding, sleeping position when last left, where last slept, sex, race, and birth weight, mother's age, parity, marital status, alcohol and drug use.

The analysis showed that *only* position last left, parental smoking, maternal alcohol consumption in the last 24 hours, and illegal drug use, interact with bed sharing, and consequently the associated risks when bed sharing also decline with increasing age. Table 2 summarises the adjusted AORs for

each of these factors, first when room sharing and second when bed sharing at 2, 10 and 20 weeks of age. Three ages are used to illustrate the reduction in risks associated with bed sharing, as the baby gets older. Table 2 confirms that the OR for bed sharing is 8.3 (3.7–18.6) at 2 weeks and Fig 2 shows that bed sharing is a significant risk factor for the first 15 weeks of life in the absence of smoking, alcohol, drugs, and all other risk factors.

Position last left.

When sleeping in a cot there is a significant risk associated with placing the baby on its side and a substantial risk when placed prone. In contrast when bed sharing, being placed on the side is not associated with an increased risk and analysis shows that when placed prone there is little and no significant increase in risk for the first 3 months, Table 2.

Parental smoking

Table 2 also highlights the strength of the very significant interaction between smoking and bed sharing. Infants who bed share at 2 weeks of age whose parents both smoke are at 65-fold increased risk of SIDS compared with infants room sharing with parents who do not smoke. There is a 'dose response' effect, univariately, when room sharing, and when bed sharing at 2 weeks, 10 weeks and 20 weeks related to whether just the partner smokes, just mother smokes or both smoke. However, when the parents do not sleep with the infant, risks associated with parental smoking are comparatively small.

Alcohol and drugs

Table 2 also shows the AORs associated with the mother having had 2 or more units of alcohol in the last 24 hours. If the baby does not bed share, two or more units increases the risk nearly 5-fold in contrast to a very substantial increase in risk when bed sharing, especially in the first weeks of life (OR at 2 weeks of age = 89.6). The use of any illegal drugs by the mother, including cannabis, increases the risk eleven-fold even when the baby is room sharing. The risks associated with a drug using mother bed sharing are unquantifiably large.

Average ORs for the first 3 months and after

In view of the trends in the AORs associated with bed sharing and age, Table 3 tabulates average under and over 3 months AORs for two key factors, smoking and alcohol when room sharing and bed sharing. These adjusted ORs apply when no other risk factors are present and the baseline risk group is breast fed baby girls placed on their back for sleep by the bed of non-smoking parents and having no other risk factors. Table 3 shows that if this group with baseline risk bed share, their average risk for the first 3 months, AOR is 5.1 (2.3–11.4). After the infant is 3 months old the corresponding average AOR is 1.0 (0.3–3.0)

The multipliers shown in the last column shows the ratio of the AORs when bed sharing to the corresponding AOR when room sharing. In so far as these multipliers are >5.1 for the under 3 months, and > 1.0 after that age, they show the interaction, first of smoking and then of parental smoking plus maternal alcohol with bed sharing, greatly enhances the risk associated with bed sharing. The data are too sparse to give meaningful AORs when mother is a drug user. It will also be noted that the second largest increase in risk associated with bed sharing occurs when the baby is under 3 months and the mother smoked.

Calculation of AORs for other risk groups

Because, in the absence of interaction, AORs multiply, Tables 1, 2, and 3 enable approximate[§] AORs to be calculated for almost all other risk groups. Thus, at two weeks if the baby is not breast fed but bottle fed, Table 1 shows the AOR is multiplied by 1.5; if the baby's birth weight is between 2000g and 2499g the AOR is scaled up by 4.2, and so on. Thus at 2 weeks the AOR for a bottle fed baby boy with birth weight 2140g who bed shares with a cohabiting 21 year old mother with one previous child and both parents smoke the

AOR = 64.9 (Table 2: both smoke)
× 1.5 (Table 1: bottle fed)
× 1.6 (Table 1: Male)
× 4.2 (Table 1: Birth weight)
× 3.0 (Table 1: mother's age)
× 2.3 (Table 1: 1 previous child)
= 4,514

when compared with babies with no risk factors.
If, using Table 2 we replace 65.1 with 2.9 we find that this alarming figure drops to 202 for parents who did not bed share. By changing the first AOR from 65.1 to 21.8 we find the average AOR for this child for the first 3 months to be approximately 1516, again reducing to an average of 202 if the baby did not bed share but is placed supine for sleep in a cot in the parents' room.

These alarming AORs show how the effect of multiple risk factors builds up, and indicates that infants with multiple risk factors are likely to be at far greater risk than is generally supposed.

The fraction of deaths while bed sharing attributable to bed sharing.
In this combined data set 22% (n=323) of the deaths occurred while bed sharing; 66% (n= 212) of these were under the age of 3 months. Overall 87.7% (86.3–89.2%) were attributable to bed sharing, assuming that they would otherwise have been placed on their back in a cot in the parents' room. This rises to 89.5% (88.8–90.3%) for bed sharing deaths under 3 months of age.

Comparison of SIDS rates
To get an overview of the absolute risks and increases in risk associated with bed sharing, SIDS mortality rates for infants (i.e., ages 0 up to 1 year) when room sharing or bed sharing are estimated and tabulated in Table 4 for six combinations of risk factors. In addition, Table 4 also shows the ratio of SIDS rates for bed sharing compared with room sharing. These SIDS rates have been calculated by assuming that the population SIDS rate is 0.5 per 1000 live births and apply to a typical cohabiting white mother aged 26 – 30 having a second normal weight baby with birth weight between 2.5 and 3.5kg – the most common situation of a mother completing her family.

Table 4 shows that for room sharing breast fed babies placed supine whose parents do not smoke and with no other risk factors, the SIDS rate is predicted to be 0.08 (0.05–0.14) per 1000 live births. This rate is predicted to increase by 2.7 times, (1.4–5.3) to 0.23 (0.11–0.49) per 1000 when bed sharing. For all combinations of risk factors, the predicted increases in risk associated with bed sharing are statistically significant. These rates may be scaled up or down depending on the population SIDS rate, and other factors present, see appendix for details. For example from the Tables, 1 & 4 we find, that a 2.25kg bottle fed baby bed sharing with an 18 year old mother, who smokes and regularly takes 2+ units of alcohol and whose partner also smokes, has a predicted SIDS rate of 125 per 1000, i.e., 12.5%, see supplementary Table b) in appendix.

Discussion

[§] The AORs obtained as described here will not be precise but will be well within the CI for the best estimates, see appendix

Mitchell recently reviewed risks and benefits of bed sharing; he concluded that postulated benefits and guidelines for bed sharing safely are not evidence based.[21] He also found that there is only one small group with ***no*** increased risk of SIDS when bed sharing, namely, breast fed infants over 3 months whose parents do not smoke, and whose mother does not take 2 or more units of alcohol or drugs and does not co-sleep on a sofa. Mitchell urged that parents had a right to know the risks they are exposing their infants to when bed sharing, but was unable to quantify these risks.

This study combines 5 major SIDS case-control studies. It includes 1472 cases and 4679 controls making it the largest study of SIDS risk factors with individual level data. By combining individual data this design allows the interaction of risk factors such as breast feeding, infant age and smoking to be examined in relation to bed sharing and SIDS. Accordingly it is able to examine the interplay of the risk factors related to bed sharing in depth as never before. Our findings confirm Mitchell's conclusions and ***quantify*** the relative risks and predicted SIDS rates associated with bed sharing in a variety of circumstances.

It has been suggested that we should have taken into account the partner's alcohol consumption in the last 24 hours and his drug use. We did not include the former factor, because in the analysis of the ECAS study it was found partner's consumption of alcohol was correlated with that of the mother and did not add further to risk of SIDS.[7] To check on this possibility, we have gone back to the original records for the key sub group, namely babies < 3 months who were breast fed whose parents did not smoke and whose mother took less than 2 units of alcohol in the last 24 hours and did not use drugs, who either bed shared or room shared. We find that in both the bed sharing and room sharing groups the control partners had taken slightly *more* alcohol in the last 24 hours than the controls. Consequently, if we adjusted for this factor it would increase the OR for bed sharing, We also note that the subgroup OR based on the complete data is 5.6 (1.6 – 20.3), which is almost identical to the adjusted AOR for this group 5.1 (2.3 – 11.4), Table 3.
To respond to the criticism that the missing data in relation to alcohol and drug use in three of the five data sets make any attempt to exclude the contribution of these factors to the risks associated with bed sharing completely unreliable, we have gone back to the original records for bed sharing cases in the key subgroup. Most of these records include pertinent questions on alcohol use although not maternal use in the last 24 hours. This enabled us to establish that neither alcohol nor drug use contributed in any way to any of these deaths.

Also, as discussed in more detail in the appendix, because missing data are primarily determined by the study, by including 'study' when modelling the subset of complete data and modelling the imputed data, the results of both will be essentially unbiased. In this setting, multiple imputation is expected primarily to recover information by including the partially observed records in the analysis, This is what we find. Consequently, we can be confident of our estimate of the adjusted effect bed sharing from the imputed data.

Importantly, the combined data have enabled the demonstration of increased relative risk associated with bed sharing when the baby is breast fed and neither parent smokes and no other risk factors are present (see Fig 2 & Table 2). The average risk is in the first 3 months and is 5.1 (2.3–11.4) times greater than if the baby is put down to sleep supine in a cot in the parents' room (Table 3). This increased risk is unlikely to be due to ***chance*** (p= 0.000059) ***Bias*** could occur because these estimates are based on models fitted to all the data or to all the data relating to infants under 3 months of age. Moreover, checks show that the models accurately describe the data, especially that relating to cases whose only risk factor is bed sharing, see appendix. Bias is also possible due to the selection of the studies. However, the present study incorporates far more data than were included in Vennemann et al's recent meta-analysis of the ORs for bed sharing in infants of non-smoking mothers.[25] The meta-analysis produced summary odds ratios very similar to those reported in this study. Furthermore, our findings are very unlikely to be due to ***confounding*** since the AORs are adjusted for all the major SIDS risk factors. Although the partner's consumption of alcohol is

not included in the data set, it was found in the ECAS study that this factor was correlated with mother's alcohol consumption (r = 0.52) and, after taking account of the mother's alcohol consumption, it did not add further to the prediction of risk.[7]

Mitchell's review of the mechanisms by which bed sharing might cause SIDS shows a causal pathway is not unreasonable.[21] Panel 1 reviews the evidence that the association of bed sharing, when mothers do not smoke, have not taken alcohol or use drugs, with SIDS is causal by Bradford Hill's criteria.[31] Clearly, bed sharing in the white European context can be a causal factor for SIDS, especially in the first three months in the absence of other factors. It has been argued that because the risk of bed sharing is greatly increased by parental smoking, alcohol and/or drugs, that it is the way we bed share rather than bed sharing itself that is important. Parental smoking greatly enhances the risk of SIDS associated with bed sharing, but in what way their pattern of bed sharing differs for that of non-smokers is not obvious. Although breast feeding is lower among smokers than non-smokers, 46% cases of bed sharing smokers were breast feeding and 61% of controls. These figures are lower than for non-smokers, 62% and 73% respectively, but these differences do not demonstrate that parental smoking results in a different way of bed sharing. For non-smokers and smokers alike sleeping in a 'western style' bed with a baby carries a risk of SIDS. Why the risk is so greatly enhanced by parental smoking is not known.

Recently there has been a tendency to record unexplained bed sharing infant deaths as due to 'suffocation-bed' (ICD code E913/W75)[32,33], or 'undetermined', rather than SIDS when the baby was bed sharing and may have suffocated.[34] However, an investigation into deaths certified as SIDS and unascertained, the UK Office of National Statistics found that many of their characteristics were very similar,[35] and now ONS reports these deaths together as unexplained deaths in infancy.[36] In 2004 Limerick and Bacon in a study of terminology used by pathologist in reporting SIDS found that when giving the cause of death of an infant found unexpectedly dead while bed sharing, only 1 in 70 said asphyxia.[37] The selection of cases in our studies includes all such deaths . Certifying such deaths under headings other than SIDS does nothing to minimise the tragedy.

Other new findings

The risk of SIDS for an average family with no known modifiable risk factors - Table 4 baseline (breast-fed, non-smoking, non-drinking parents who are room sharing and not bed sharing) was 0.08/1000 live births. This is the level of SIDS that might be achieved if all known modifiable risk factors were removed. Such a SIDS level may be deemed intrinsic (possibly genetic) and not directly amenable to behaviour modification. This rate is consistent with countries reporting low SIDS rates. National surveys in The Netherlands show that, following an active campaign to discourage bed sharing,[4] bed sharing rates have fallen from 13% in 1999, 10% in 2005, to 1.5% always bed sharing and 3.1% sometimes bed sharing in 2011.[38] During the same period as part of a general downward trend in SIDS mortality,[39] SIDS rates have fallen 25% from 0.12 in 2000 to 0.09 per 1000 in 2010.[40,41] At the same time the percentage of infants being breastfed at 3 months of age has risen from 45% to 52%., and at 6 months from 24% to 32%[42], confirming that promotion of bed sharing is not necessary to achieve high rates of prolonged breast feeding.

A recent study commissioned by UNICEF[43] suggests that the promotion of breast feeding and support of breast feeding mothers in the UK would reduce the burden of disease on the National Health Service and could thereby be cost effective. However, if bed sharing is promoted as a means of encouraging breast feeding, it is likely to increase the number of SIDS because the AOR for bed sharing, 2.7, is nearly double the AOR for bottle feeding, 1.5. Consequently, such an approach would be likely to *increase* the number of SIDS cases. If SIDS deaths are costed at more than £1.5 million each, as in the UNICEF report, the costs resulting from any increase in bed sharing would far outweigh any benefits from increased breast feeding rates, quite apart from the disastrous consequences for families associated with the loss of a child. To reap the benefit of increasing breast feeding duration and rates, the Dutch recommendations should be followed, namely: 'To achieve maximal security for the baby and optimal availability of breastfeeding, mothers are advised to take the baby of less than 4 months of age into their bed for feeding during

the night, but afterwards to place the baby on its back into his own crib, placed adjacent to the parents' bed in the parents' bedroom'.[5]

Thus, we do not suggest that babies should not be brought into the parent's bed for comfort and feeding. This has been investigated in previous studies and has not been found to be a risk factor provided the infant is returned to his or her own cot. [44,45] This study is concerned with risks associated with *sleeping* with a baby in bed. Table 3 and 4 of this report are designed to enable an informed choice to be made by parents as to whether the risks associated with bed sharing outweigh the postulated benefits. However, our models predict that 88% of the deaths that occurred while bed sharing would probably not have occurred had the baby been placed on its back in a cot by the parents'bed. Even for the very low risk breast fed babies under 3 months of age, with no other risk factors other than that they slept in their parents' bed, the model predicts that 81% (78.9–82.0%) of the deaths could have been readily prevented in this way. One has to ask whether it is worth taking the risk, however small, of losing a baby, when it can be so easily avoided.

Previous epidemiological studies showed that being placed on the front, prone, for sleep was a risk factor for SIDS and fulfilled similar criteria as a causal risk for SIDS; in the 1970s OR 2.9 (1.2–7.5) and in 1986 from 5 pooled case control studies OR 3.0 (1.7–5.3).[2] A campaign to reduce prone sleeping effectively halved the number of SIDS cases worldwide between 1990 and 2000 saving thousands of babies in the developed world. Delay in implementing an effective 'back to sleep' campaign is estimated to have resulted in the deaths of 10,000 lives in the UK alone.[2]

Recent case studies indicate that now 50% or more of SIDS cases[18,46] occur while bed sharing in contrast to 22% in this study, Table 1. In the UK, possibly due to the pro bed sharing lobby[14], in the 10 years between the two studies by Blair and his colleagues[45,18], the percentage of cases bed sharing (excluding sofa sharing) doubled and the percentage of controls bed sharing increased by 50% from 14.5% to 21.8%. Meanwhile, the crude unadjusted OR for bed sharing only changed from 2.0 to 2.2. (An adjusted OR for bed sharing is not reported for the latter study). Our analysis estimates that 88% of bed sharing deaths are attributable to bed sharing, i.e., would not have occurred had the baby not been bed sharing, The stability of the crude OR for bed sharing despite the increase in the prevalence of bed sharing suggests that our estimate of attributable risk may reasonably be applied currently. Consequently, our analysis suggests that about 90% of bed sharing SIDS deaths would not occur in the absence of bed sharing.

The current messages say that bed sharing is dangerous only if your or your partner are smokers, have been drinking alcohol, or drugs that make you drowsy, are very tired, or the baby is premature or low birth weight, are not effective because many of the bed sharing deaths involve these factors. Our findings suggest that professionals and the literature should take a more definite stand against bed sharing, especially for babies under 3 months. If parents were made aware of the risks of sleeping with their baby, and room sharing were promoted, as 'Back to Sleep' was promoted 20 years ago, a substantial further reduction in SIDS rates could be achieved.

Variable		Cases No.	Cases %	Controls No.	Controls %	% missing records	Complete records Single factor OR	Complete records Single factor 95% CI	Complete & imputed data Single factor OR*	Complete & imputed data Single factor 95% CI	Complete & imputed data Selected multivariate AOR‡	Complete & imputed data Selected multivariate 95% CI
Bed Sharing						0.9						
	No	1,131	77.8	4,192	90.4		1	-	1	-	1	-
	Yes	323	22.2	446	9.6		2.6	2.2–3.1	2.6	2.2–3.1	2.7‡	1.4–5.3
Feeding						0.8						
	Breast	504	34.9	2,491	53.5		1	-	1	-	1	-
	Bottle	940	65.1	2,168	46.5		2.9	2.5–3.3	2.9	2.5–3.3	1.5	1.2–1.8
Position last left						1.6						
	back all ages	377	26.5	1,972	42.6		1	-	1	-	1	-
	side	438	30.8	1,869	40.3		1.6	1.3–1.8	1.6	1.3–1.9	1.5†	1.2–2.1
	front	607	42.7	791	17.1		7.8	6.4–9.5	7.9	6.5–9.6	10.5†	7.5–14.6
Parental smoking						2.9						
	Neither	314	22.4	2,285	50.0		1	-	1	-	1	-
	Partner only	194	13.8	1,083	23.7		1.4	1.1–1.7	1.4	1.1–1.7	1.1*	0.8–1.4
	Mother only	194	13.8	427	9.4		3.7	3.0–4.6	3.8	3.1–4.7	1.5*	1.2–2.1
	Both	703	50.0	774	16.9		7.4	6.2–8.7	7.3	6.2–8.6	2.9*	2.3–3.6
Mother took 2 unit or more of alcohol in last 24 Hours						61.3						
	No	478	81.0	1,694	94.5		1	-	1	-	1	-
	Yes	112	19.0	99	5.5		5.1	3.7–7.0	6.5	4.6–9.3	4.8*	2.6–8.9
Mother used illegal drugs after birth						60.5						
	None	582	96.5	1,825	99.8		1	-	1	-	1	-
	Any	21	3.5	3	0.2		19.2	5.4–68.3	30.7	8.8–106.8	11.5*	2.2–59.5
Sex						0.3						
Unmatched studies:	Female	351	39.5	1,401	49.3		1	-	1	-	1	-
	Male	538	60.5	1,442	50.7		1.5	1.3–1.8	1.5	1.3–1.7	1.6	1.3–1.9
Matched studies:	Female	217	37.6	683	37.5		1	-	1	-	1	-
	Male	360	62.4	1,141	62.5		1.0	0.8´1.2	1.0	0.8–1.2	0.8	0.6–1.1
Race						0.3						
	White	1,181	81.1	4,242	90.7		1	-	1	-	1	-
	Non-white	276	18.9	434	9.3		3.0	2.5–3.6	3.0	2.5–3.6	1.5	1.1–1.9
Birth Weight group:						2.3						
	3500g or more	415	28.9	2,293	50.1		1	-	1	-	1	-
	2500 – 3499g	760	52.8	2,092	45.8		2.0	1.7–2.3	2.0	1.7–2.3	1.7	1.4–2.0
	2000 – 2499g	144	10.0	127	2.8		6.3	4.8–8.2	6.4	4.9–8.3	4.2	2.9–6.0
	under 2000g	120	8.3	59	1.3		13.5	9.6–18..9	13.8	9.8–19.4	9.6	6.2–14.7
Mother's age in years						0.6						
	over 30	326	22.4	1,921	41.2		1	-	1	-	1	-
	26 – 30	419	28.8	1,552	33.3		1.8	1.5–2.1	1.8	1.5–2.1	1.9	1.5–2.3
	21 – 25	434	29.9	910	19.5		3.3	2.8–3.9	3.3	2.8–3.9	3.0	2.4–3.8
	19 – 20	162	11.1	169	3.6		6.8	5.2–8.8	6.8	5.3–8.8	7.7	5.2–11.4
	18 & under	113	7.8	111	2.4		7.1	5.3–9.6	7.2	5.3–9.7	9.1	5.9–14.1
No. of live births including the present one:						0.8						
	1	407	28.1	1,836	39.4		1	-	1	-	1	-
	2	491	33.9	1,566	33.7		1.4	1.2–1.7	1.4	1.2–1.7	2.3	1.9–2.9
	3	280	19.3	748	16.1		1.8	1.5–2.2	1.9	1.5–2.2	3.8	2.9–4.9
	4	149	10.3	304	6.5		2.6	2.1–3.3	2.6	2.1–3.3	5.2	3.7–7.4
	5 or more	122	8.4	200	4.3		3.5	2.7–4.5	3.5	2.7–4.6	7.7	5.3–11.3
Mother's marital status:						0.2						
	Married or with partner	996	68.1	4,049	86.6		1	-	1	-	1	-
	Single	467	31.9	628	13.4		4.0	3.4–4.7	4.0	3.4–4.7	1.9	1.5–2.4
Where slept last						1.4						
	Parents' room	817	56.9	2,806	60.6		1	-	1	-	1	-
	Elsewhere	617	43.1	1,823	39.4		1.3	1.1–1.5	1..3	1.2–1.5	2.4	2.0–2.9

‡ Multivatiate AORs including AOR for bed sharing pooled for all ages up to one year.
† Multivariate AOR when baby in a cot in parent's room & age is 3months.or less.
The corresponding AOR's when baby is over 3m are 1.4 (1.1–1.8) & 7.7 (5.9–10.2) respectively
* Multivariate AOR when baby in a cot in parents' room

Table 1 The number and percent of cases **and controls for each factor,** percent missing data, univariate ORs & CIs based on complete data. Also, univariate ORs & multivatiate AORs & CIs based on the imputed data sets.

Factor	Room sharing		Bed sharing					
			At 2 weeks		At 10 weeks `		At 20 weeks	
	AOR	95% CI	AOR	95% CI	AOR	95% CI	AOR	95% CI
Position last left								
Back	**1.0**	—					**1.2**	0.6–2.8
Side	**1.8***	1.3–2.4	**8.3**	3.7–18.6	**3.6**	1.8–7.2	**0.8**	0.3–2.0
Front	**12.0***	8.6–16.8					**5.3**	1.8–16.0
Parental smoking								
None	**1.0**	—	**8.3**	3.7–18.6	**3.6**	1.8–7.2	**1.2**	0.6–2.8
Partner	**1.1**	0.8–1.4	**17.6**	8.1–38.5	**7.6**	3.8–15.1	**2.6**	1.2–6.0
Mother	**1.5**	1.2–2.1	**47.5**	18.9–118.9	**20.4**	8.9–47.7	**7.1**	2.8–18.0
Both	**2.9**	2.3–3.6	**64.9**	30.8–136.9	**28.0**	15.0–52.3	**9.7**	4.7–20.2
Mother's Alcohol								
2+ vs <2 units vs None	**4.7**	2.6–8.7	**89.7**	25.3–317.7	**38.6**	12.6–117.8	**13.5**	4.6–39.4
Mother illegal drug user								
Yes vs. no	**11.4**	2.2–57.8	**Inestimably large**					

* After 3m, the AOR for put down on side is 1.4 (1.1–1.8) & front 7.7 (5.8–10.1) when room sharing
Note: For the first 3 months when bed sharing, risk is not affected by the position put down.
All AORs are adjusted for other factors in the table and bottle feeding, sex, whether matched or unmatched, race, birthweight group, mother's age proup, no. of live births(grouped), mother single, and where slept..

Table 2. The AORs for avoidable factors that interact with bed sharing, adjusted for all other factors. Therefore, they relate to the baseline corresponding to babies of non-smoking mothers who do not use drugs, and taking < 2 units of alcohol in the last 24 hours, having a non-smoking partner, and no other risk factors.

Age group	Risk factors		Room sharing		Bed sharing		Multiplicative increase in AOR when bed sharing	
	Smoking	Alcohol	AOR	95% CI	AOR	95% CI	Multiplier	95% CI
< 3month	No	no	1	-	**5.1**	2.3–11.4	**5.1**	2.3–11.4
	Partner	no	0.7	0.5–1.1	**7.8**	3.6–17.2	**11.2**	5.0–25.1
	Mother	no	1.3	0.8–2.2	**20.3**	7.4–56.4	**15.2**	5.3–43.4
	Both	no	**2.9**	2.0–4.2	**21.6**	11.1–42.3	**7.5**	3.9–14.6
	Both	**Y**	**13.7**	5.5–34.4	**151.0**	50.2–448.4	**10.8**	3.0–39.2
3 months & over	No	no	1	-	1.0	0.3–3.1	1.0	0.3–3.1
	Partner	no	1.2	0.9–1.7	**3.0**	1.2–7.5	**2.5**	1.0–6.3
	Mother	no	**1.7**	1.2–2.4	**6.1**	1.7–22.6	**3.6***	0.9–13.9
	Both	no	**3.0**	2.3–4.0	**13.7**	6.1–31.0	**4.6**	2.0–10.3
	Both	**Y**	**15.7**	8.1–30.4	**243.8**	76.1–781.4	**15.6**	4.2–57.4

The AORs in light type are not statistically significant.
*** This multiplier is significant at p = 0.062**
The AORs in both Tables are adjusted for all other factors in the table, any drug use by the mother since birth, bottle feeding, sex, whether matched or unmatched, race, birthweight group, mother's age proup, number of live births (grouped), mother single, and where slept.

Table 3. Average AORs for smoking, smoking & maternal alcohol when room sharing and bed sharing with the multiplicative increase in risk due to bed sharing, for infants aged under 3 months and 3 months up to a year.

Group No.	Risk factors present			Room sharing		Bed sharing		Ratio of rates	
	Feeding	smoking	Alcohol	Rate/1000	95% CI	Rate/1000	95% CI	Ratio	95% CI
minimum risk	**Br**	no	no	**0.08**	0.05–0.14	**0.23**	0.11–0.49	**2.7**	1.4–5.3
1	**Bot**	no	no	**0.13**	0.08–0.21	**0.34**	0.16–0.73	**2.7**	1.4–5.3
2	Br	**Partner**	no	**0.09**	0.05–0.16	**0.52**	0.25–1.08	**5.6**	2.9–10.8
3	Br	**Mother**	no	**0.13**	0.08–0.23	**1.27**	0.54–3.00	**9.7**	4.4–21.7
4	Br	**Both**	no	**0.24**	0.15–0.41	**1.88**	0.94–3.73	**7.7**	4.3–13.8
5	**Bot**	**Both**	**Yes**	**1.77**	0.87–3.48	**27.5**	10.4–68.4	**15.6**	5.7–41.5

*Predicted SIDS mortality rates for a cohabiting, white mother age 26 – 30, having a second normal weight baby with birth weight between 2.5 and 3.5kg and having no other risk factors. I.e., mother is not a drug user, has a partner and room shares.

Table 4. Predicted SIDS Infant Mortality Rates for Normal Women*

Panel 1 Assessment of bed sharing, in the absence of parental smoking alcohol and maternal drug use, as a causal risk for SIDS by Bradford Hill's criteria[31]

STRENGTH OF ASSOCIATION ✓
Adjusted Odds Ratio (AOR) for bed sharing = 2.7 (95% CI 1.4–5.3), p = 0.0027, for breast fed infants with no other risk factors. AOR for the first 3 months of life = 5.1 (2.3–11.4), p = 0.00006 . These AORs are moderately strong.

CONSISTENT ✓
Of more than 12 published studies, all but two small ones show, after multivariate adjustment, increased risk of SIDS associated with bed sharing, some combined with sofa sharing.[26]

SPECIFIC ✓× (not an essential criterion)
Smoking, alcohol and drug use all have greatly increased risk when bed sharing
Bed sharing is associated with other causes of death, e.g. Suffocation.
SIDS can occur in the absence of bed sharing.

TEMPORALLY CORRECT ✓
Bed sharing always precedes SIDS.

DOSE RESPONSE ✓
New Zealand study showed risk increased with duration of bed sharing.[47] Not otherwise investigated.

BIOLOGICALLY PLAUSIBLE ✓
Bed sharing risk is greatest to youngest infants who are most vulnerable.

COHERENCE ✓
The proposition that bed sharing is causally related to SIDS is coherent with theories that respiratory obstruction, re-breathing expired gases, and thermal stress (or overheating), which may also give rise to the release of lethal toxins,[48] are all mechanisms leading to SIDS, in the absence of smoking, alcohol or drugs. Infants placed prone are exposed to similar hazards.

DIRECT EXPERIMENTAL EVIDENCE ×
Not ethically possible.

ANALOGY ✓
Overlying is a serious cause of mortality in piglets. Sows are normally separated by a bar from piglets to prevent them being crushed when she turns over, but allowing her piglets to feed.

Panel 2

WHAT WAS ALREADY KNOWN ON THIS TOPIC

Babies who sleep in bed with their parents, who are smokers or have drunk alcohol in the last 24 hours, are at increased risk of Sudden Infant Death Syndrome (SIDS), however the risk from bed sharing if neither parent smokes and the baby is breastfed was uncertain.

WHAT THIS STUDY ADDS

This study combined 5 large data sets, making it the largest reported study of SIDS with individual level data.

When no other risk factors are present, bed sharing for sleep satisfies recognised criteria as a *cause* of SIDS

When neither parent smoked, baby was less than 3 months of age, and breast fed, bed sharing for sleep multiplied the risk of a baby dying from SIDS by 5, compared with room sharing.

Over 50% of SIDS deaths now occur while bed sharing. A substantial further reduction in SIDS rates, possibly over 40%, could be achieved if parents avoided bed sharing and all infants slept on their back in a cot in the parental bedroom.

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Contributors

The first five authors played a major role in the design and analysis of their studies, and submitted data for this combined analysis. JRC and MS were responsible for imputing missing data. RGC combined and analysed the data and drafted the report. EAM advised on the analysis. All authors commented on drafts and have seen and approved the paper as submitted.

Conflict of interest

The first five authors are actively involved in SIDS and/or paediatric research. RGC is a member the Steering Committee of the Foundation for the Study of Infant Death's Care of Next Infant, CONI, project for which he receives travelling expenses. The last two authors are specialists in the imputation of missing data. We declare no conflict of interest.

Ethical approval

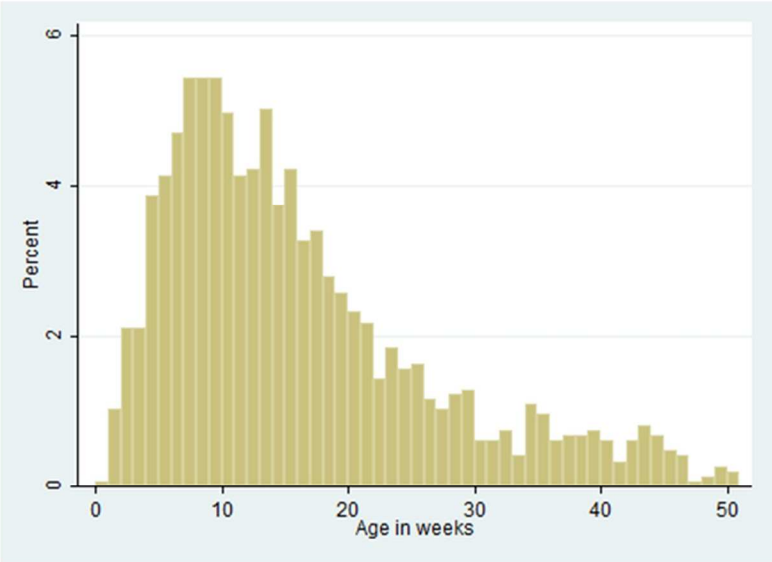
All studies were ethically approved. Only completely anonymised data were combined for this study.

Copyright

Data sharing

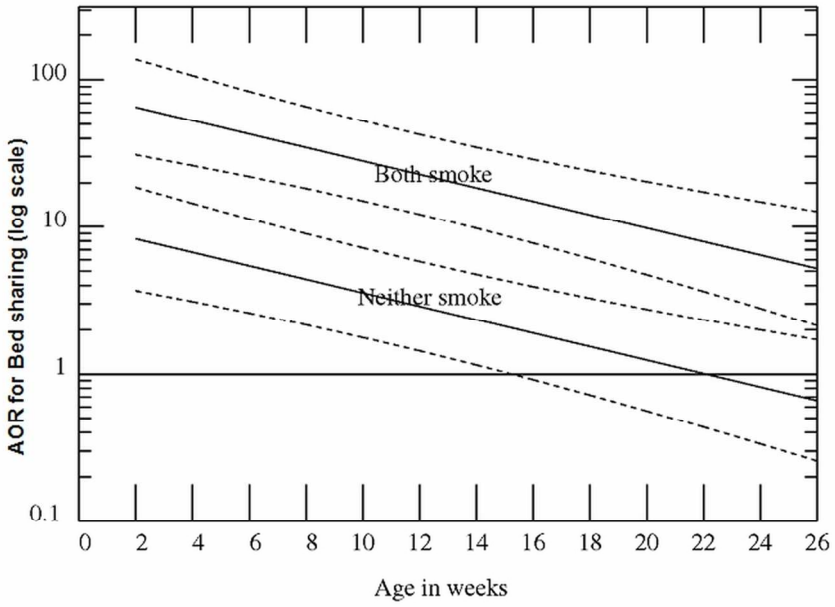
The original case-control data sets, and the imputed data, can only be made available to other research workers in this field, with the explicit permission of the person responsible for each data set.

Fig. 1.



138x90mm (300 x 300 DPI)

Fig 2



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Appendix: Selection of controls and Statistical methods

Selection of controls

ECAS dataset

For three studies, regional coordinators selected 6 live controls of the same gender and born at the same maternity ward 14 days subsequent to the index case. A delay period of 14 days was expected to assure that controls had an age similar to the SIDS baby when parents completed the questionnaire. Parents of the first four of these selected infants were invited to participate. If a family was unwilling to participate, another family among the two families of the remaining infants was invited.

For the other 12 studies included in this dataset it was intended that at least two live controls were obtained for each case. Almost all cases in these studies had 2 controls; all had one. These controls were selected from a list of births in the area and born within one week before or after the case. Controls were not matched for any other characteristic. Initially four controls were selected to be used as replacements if necessary.

GsSIDS dataset

For each case, 10 controls were selected that were matched for region, age, gender, and reference sleep. The control infants were recruited through the same or neighbouring local birth registration office where the case was registered. Control infants had been born 4–6 weeks after the case infant, so that by the time the interviews were done they had the same age as the index case (±2 weeks). From the control families who agreed, the three infants closest in age to the index case were selected. A total of 2702 controls were contacted; 58.7% agreed to participate.

Irish dataset

For every case notified to the SIDS register, four controls were selected randomly from the birth register and matched for date of birth and geographical location (same community care area as the index case). If an insufficient number of infants were born in the same community care area on a particular date, then a list of infants born on the two days either side of that date was also used. All families were invited by letter to participate in a standardized home interview. Where no response was obtained from controls families within one week, an additional four letters were sent, after which no further attempt at recruitment/replacement of controls was made. Information was collected on socio-demographics, pregnancy, the infant/child's medical history, the home environment, parenting practices and details of the last 48 hours, and last sleep period with a corresponding reference sleep period used for controls. An average of three controls per case were recruited; in the final dataset, the proportion of cases that had 4 completed control questionnaires was 33%, 3 control questionnaires = 22%, 2 controls = 20%, 1=11%, 6% had >4controls and 7% of cases had no corresponding control data.

New Zealand dataset

Controls were randomly selected from all births, except home births (less than 1%) in the participating regions. Controls had to be born and domiciled in the study region.

The following method was used to select controls:

(a) A date of interview (nominated date) was randomly selected.
(b) The control was then randomly allocated an age and date at interview.

(c) Births by day of the week vary considerably, probably because of induction of labour. The day of birth was adjusted to fit this distribution.
(d) An obstetric hospital was randomly chosen in proportion to the number of births over the previous year.
(e) In hospitals with more than one birth on the selected day random numbers were used to select a particular infant from among those born on the nominated day. For obstetric hospitals where there were no deliveries, a random direction indicator was used to indicate whether to go forwards or backwards in time to select the infant.

Thus, the controls were a representative sample of all live births in the study regions.

For questions on infant care practice that particularly related to the period of sleep prior to the death in the cases, parents of controls were given a nominated time of day which was randomly allocated to ensure that the distribution of this time among controls was similar to the estimated distribution of the time of death of the cases. If the infant was not asleep at the nominated time of day the direction indicator was used to select either the previous or subsequent sleep.

Scottish dataset

We identified babies born immediately before and after the index case in the same maternity unit to act as controls (2 controls for each index case). Controls were therefore matched for age, season, and maternity unit. If no contact could be made with the baby born immediately before the index case (or immediately after), then the baby born immediately before that first attempted control (or immediately after) was also attempted. If neither of the 2 babies born before or 2 babies born after could be contacted and a visit completed within 28 days of the index infant's death then no further attempts were made to contact other baby's parents to act as controls for the index case.

Statistical methods

Missing data

Preliminary analysis, together with the study context, showed that missing values were most plausibly missing at random dependent on study. Therefore, since we include study indicators as covariates, a complete records analysis will give unbiased if somewhat inefficient inference[A1]. To include the information from studies in which alcohol and drug use data were not observed, we used multiple imputation (under the missing at random assumption) to impute missing data. We used the REALCOM-IMPUTE software[A2] with a single level imputation model because alcohol and drug data were too sparse, among the studies in which they were recorded, to obtain convergence for a multilevel imputation model. Missing data were imputed for cases and controls separately. Ten imputed data sets were computed. Using STATA 12[A3] the substantive multilevel model was fitted to each in turn. Convergence was not achieved for one because the likelihood was flat in the region of the maximum; the results for the remaining 9 were combined for inference using Rubin's rules[A4].

Analysis showed that the between imputation variation across the 9 imputed data sets was small relative to the within imputation variance, so 9 imputations were sufficient.

Reliability of results based on observed and imputed data

First, define the *key sub group* as babies < 3 months who were breast fed whose parents did not smoke and whose mother took less than 2 units of alcohol in the last 24 hours and was not a drug user, who either bed shared or room shared. We have data on both maternal and paternal alcohol consumption in the last 24 hours and drug use after birth for two datasets, and for the key subgroup of cases and controls, we have extracted the paternal data from the original records. The unadjusted OR for bed sharing in this group is 5.6 (1.6– 20.3), p = 0.009. And for this group, in both the bed sharing and room sharing groups the control partners had taken slightly *more* alcohol in the last 24 hours than the cases' partners. Consequently, after adjusting for partner's alcohol consumption in the last 24 hours, the OR is 7.7 (1.8 – 32.3), although the OR for partner's alcohol is not significant; OR = 0.73 (0.41 – 1.27), p =0.265.

For cases, belonging to the key subgroup in the three studies for which maternal alcohol use in the last 24 hours was not available , we have checked the original records, most of which include pertinent questions about alcohol use, and ensured that alcohol and drugs were not contributory factors in any.

Second, the prevalence of alcohol and drug use among mothers varies considerably across the studies where the information was collected. For controls, the prevalence of mother having more than 2 units of alcohol in the last twenty four hours (henceforth 'mother using alcohol') ranged from 0 to 9%, and the prevalence of mother using any illegal drug (henceforth 'mother using drugs') ranged from 0 to 0.6%. For cases the corresponding percentages range from 0 to 39% and 0 to 3% respectively. Consequently the ORs for mother using alcohol vary significantly across the studies. However, there is no evidence that the three-way interaction of mother using alcohol, bed sharing and study is significant, p = 0.429. Therefore, the relationship between bed sharing and study does not vary by mother using alcohol. In consequence, the OR for bed sharing is not affected by varying prevalence of mother using alcohol across the studies. For mother using drugs the data are too sparse for the analogous three-way interaction to be tested. However, it seems unlikely it would be significant. In consequence, the OR for bed sharing is not affected by varying prevalence of mother using drugs across the studies.

Third, because the alcohol and drug data are plausibly missing at random, MAR, dependent on study, which is included as an indicator variable in both the substantive model and the imputation model, theory suggests that the point estimates in the complete records analysis should be unbiased,[A5] and within sampling variation of those obtained after multiple imputation. The advantage of multiple imputation here is thus the recovery of information, primarily through the inclusion of the partially observed data from the three studies in which alcohol and drug use were not collected, c.f., Carpenter and Kenwood, p 220.[A5] The results are in line with this, as shown in Table 1, columns 8-11. Also as reported above the OR for the key subgroup is 5.6 (1.6– 20.3). The number of observations in this subgroup are too small to attempt adjustment for other factors like maternal age parity and birth weight. Compare this subgroup OR with the fully adjusted AOR of 5.1 ((2.3 – 11.4) for breast fed babies < 3 month, whose parents do not smoke and whose mother did not take two units alcohol or more in the last 24 hours alcohol. or use drugs. This AOR is also adjusted for all the other factors in the model, see Table 3. The narrower CI results from the recovery of the partially observed data.

Calculation of univariate and multivariate odds ratios

Odds ratios were calculated by logit regression. Univariate analyses were adjusted for age and study because controls were on average 3 weeks older than cases, and the number of controls varied between studies. For multivariate AORs, multilevel logit regression model was fitted with 'bed sharing' random across studies; this was done to take account of a significant interaction of bed sharing with studies. Some other AORs showed significant interaction with studies; however, it was found that these were due to significant deviations in one or at most two studies. When parameters were added to the overall model, to account for these interactions, they had little effect on the main parameters, and only slightly *increased* the estimate of risk associated with bed sharing. The additional parameters were therefore dropped in the final model and these interactions ignored.

The trend in the ln(OR) for bed sharing with age was best represented by a linear downward trend on the logit scale, for the first six months followed by a constant term thereafter. In all four models were used for the analysis:

Model 1. A multilevel logit model of the whole data, including the interaction of age and bed sharing, modelled by the linear trend,

Model 2. To obtain rates applicable to all ages, the same model, excluding the age×bedsharing interaction was fitted, thereby obtaining average AOR for the year.

Models 3 & 4. To obtain average AORs for the first three months and later, a logistic forms of the rates model was fitted to records of infants under 3 months and 3 month or more. Logistic models were used because of convergence problems with multilevel models.

Goodness of fit of the models to the data

Goodness of fit tests are not available for multilevel logit models nor are they available after using Rubin's combination rules for the analysis of multiple imputed data sets. Therefore single level (i.e., standard) logistic models, using the same parameters as the overall model plus fixed effect parameters for study, were fitted to each of the 10 data sets completed with imputed data; both the log link and goodness of fit tests were applied to each. The link tests confirmed that all the models were correctly specified: p(for regression on hat^2) averaged 0.44 and all were> 0.15, and p(for the constant) averaged 0.75 and all were >0.56. The average Hosmer-Lemeshow goodness of fit $\chi^2(48) = 40.3$ was less than expectation. and none had a p value < 0.13. It was, therefore, concluded that the model fit was excellent. Checks on the model, without the age trend, fitted to infants aged <3 months showed equally good fit.

To check the fit of the overall model to the data relating to the breast fed cases, age <3 months, whose parents did not smoke and whose mothers did not consume alcohol or use drugs but who were bed sharing, their deviance residuals were computed. The AOR for this groups is represented by the lower line in Fig 2. As above, the deviance residuals could only be computed after fitting a logistic model to each of the 10 completed data sets. Again, the The results were pooled using Rubin's rules[A4]. It was found that the mean deviance for this group = - 0.098, s.e. 0.1004. Also there was not evidence of any systematic deviation from the fitted line in that there was no evidence of a trend in the residual deviances with age; b = -0.0015, s.e. 0.005.

Similarly residual deviances were computed for this group after fitting model 3. The pooled average residual deviance was -0.147 with s.e. 0.096; p = 0.122. The trend in the residuals was 0.00012 with s.e. 0.005. Thus, there is no suggestion that the model parameters do not represent these crucial data.

The Attributable Fraction

The attributable fraction (of deaths, computed as described by Brussi et al.[29]), was similarly computed for each of the 10 logistic models fitted to the imputed data sets. The results were combined using Rubin's combination rules.[A4]

Mortality rates

Rates were derived from the parameters of Model 2. Rates are given for all infants, computed by a weighted combination of the rates for boys and girls. The base rate for girls was the SIDS rate when none of the model risk factors were present. Then, logit(base rate) = model constant scaled by the addition of the logit of the population SIDS rate and the subtraction of the log(ratio of the number of cases to controls in the model). Combinations of AORs gave other rates from the base rate.

Estimating AORs and Rates for other groups

The AORs computed for other groups, as described on page 7 are approximate because the AORs for the factors which do not interact with age or bed sharing vary, but not significantly, across the 4 models used for the analyses. The AORs shown in the penultimate column of Table 1 are those given by model 2. These differ a little from the comparable AORs given by the Model 1, which includes the age×bed sharing interaction. Thus for the example on page 7, the AOR predicted by model 1 is 4,402 (1,758–11,022) compared with 4514 shown.

When computing SIDS rates for other groups from those give in Table 4, the procedure is similar. However, the observed rate must first be divided by 7.43 to reduce the rate baseline – the rates reported in Table 4 relate the second infant with birth weight 2500 – 3499g of a cohabiting white women age 26 to 30. The appropriate baseline rate, i.e., for various smoking groups may then be scaled up according to the other risk factors present. However, if the computed rate is r > 0.003 per 1000, it should be reduced by $-r^2$, because the scaling is based on AORs and rates are probabilities. Conversely if the starting rate is >0.003 it has first to be scaled to an AOR by adding its square.

For example the estimated SIDS rate for a bed sharing 18 year old cohabiting white mother, with her 1st baby, birth weight 2240g. bottle fed when both parents smoke and mother often has 2+units of alcohol is estimated to be

$$r = \{(0.0275 + 0.0275^2)/7.43\} \times 4.2 \times 9.1 = 145.4$$

where:

0.0275 = rate from Table 4 when both smoke, mother uses alcohol and baby is bottle fed

0.0275^2 is added to obtain the corresponding AOR because the starting rate is >0.003

/7.43 to obtain the corresponding baseline AOR

×4.2 from Table 1 for babies 2000-2499

×9.1 from Table 1 for mothers aged 18

Thus, r > 0.003. Hence

$$\text{Predicted rate per 1000} = 1000*(r-r^2) = 125 \text{ per } 1000,$$

which is exact because the AORs in Table 1 are derived from Model 2.

Supplementary tables show predicted SIDS rates for two groups of women other than those in Table 4.

Rates may also be scaled up or down in direct relation to the population SIDS rate. Thus if the population SIDS rate is 0.4 per 1000 instead of 0.5 the the estimated rates will be reduced by 4/5 =0.8.

Supplementary tables of predicted rates for two other groups of women.

a) Cohabiting white women age 30+ with 1st baby birth weight >3500g

Group No.	Risk factors present			Room sharing	Bed sharing	Ratio of rates	
	Feeding	smoking	Alcohol	Rate/1000	Rate/1000	Ratio	95% CI
Baseline	Br	no	no	**0.011**	**0.031**	**2.7**	1.4–5.3
1	**Bot**	no	no	**0.017**	**0.047**	**2.7**	1.4–5.3
2	Br	**P**	no	**0.013**	**0.070**	**5.6**	2.9–10.8
3	Br	**M**	no	**0.018**	**0.171**	**9.7**	4.4–21.7
4	Br	**B**	no	**0.033**	**0.254**	**7.7**	4.3–13.8
5	**Bot**	**B**	**Y**	**0.235**	**3.74**	**16.0**	5.8–44.2

OK 9/9/12

b) Cohabiting white women age 18 - 19 with 1st baby with birth weight 2000 - 2499g

Group No.	Risk factors present			Room sharing	Bed sharing	Ratio of rates	
	Feeding	smoking	Alcohol	Rate/1000	Rate/1000	Ratio	95% CI
Baseline	Br	no	no	**0.4**	**1.2**	**2.7**	1.4–5.3
1	**Bot**	no	no	**0.6**	**1.8**	**2.7**	1.4–5.3
2	Br	**P**	no	**0.5**	**2.7**	**5.6**	2.9–10.8
3	Br	**M**	no	**0.7**	**6.5**	**9.7**	4.4–21.7
4	Br	**B**	no	**1.2**	**9.5**	**7.6**	4.3–13.6
5	**Bot**	**B**	**Y**	**8.8**	**124.6**	**14.1**	5.7–39.0

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STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology*
Checklist for cohort, case-control, and cross-sectional studies (combined)

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	3	State specific objectives, including any pre-specified hypotheses	2 & 3
Methods			
Study design	4	Present key elements of study design early in the paper	3
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	3 & see original reports of the studies
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	All cases in defined areas & normal infants of similar age & sex in some studies.
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	4
Bias	9	Describe any efforts to address potential sources of bias	4
Study size	10	Explain how the study size was arrived at	3
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Table 1, as in previous studiy
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	2, 4 and appendix
		(*b*) Describe any methods used to examine subgroups and interactions	4,& appendix
		(*c*) Explain how missing data were addressed	4 & appendix
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed	—

		Case-control study—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	4 & appendix
		(*e*) Describe any sensitivity analyses	none
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Table 1
		(b) Give reasons for non-participation at each stage	Table 1
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Page 3 & original reports
		(b) Indicate number of participants with missing data for each variable of interest	Table 1
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	—
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	—
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	Table 1
		Cross-sectional study—Report numbers of outcome events or summary measures	
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Tables 1 - 4
		(*b*) Report category boundaries when continuous variables were categorized	Table 1
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	
Discussion			
Key results	18	Summarise key results with reference to study objectives	2
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	9
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	9 -10
Generalisability	21	Discuss the generalisability (external validity) of the study results	9-10
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	18

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.