Bed sharing, smoking, and alcohol in the sudden infant death syndrome

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Abstract

***Objectives*—To investigate why sharing the bed with an infant is a not consistent risk factor for the sudden infant death syndrome in ethnic subgroups in New Zealand and to see if the risk of sudden infant death associated with this practice is related to other factors, particularly maternal smoking and alcohol consumption.**

***Design*—Nationwide case-control study.**

***Setting*—Region of New Zealand with 78% of all births during 1987-90.**

***Subjects*—Home interviews were completed with parents of 393 (81·0% of total) infants who died from the sudden infant death syndrome in the postneonatal age group, and 1592 (88·4% of total) controls who were a representative sample of all hospital births in the study region.**

***Results*—Maternal smoking interacted with infant bed sharing on the risk of sudden infant death. Compared with infants not exposed to either risk factor, the relative risk for infants of mothers who smoked was 3·94 (95% confidence interval 2·47 to 6·27) for bed sharing in the last two weeks and 4·55 (2·63 to 7·88) for bed sharing in the last sleep, after other confounders were controlled for. The results for infants of non-smoking mothers were inconsistent with the relative risk being significantly increased for usual bed sharing in the last two weeks (1·73; 1·11 to 2·70) but not for bed sharing in the last sleep (0·98; 0·44 to 2·18). Neither maternal alcohol consumption nor the thermal resistance of the infant's clothing and bedding interacted with bed sharing to increase the risk of sudden infant death, and alcohol was not a risk factor by itself.**

***Conclusion*—Infant bed sharing is associated with a significantly raised risk of the sudden infant death syndrome, particularly among infants of mothers who smoke. The interaction between maternal smoking and bed sharing suggests that a mechanism involving passive smoking, rather than the previously proposed mechanisms of overlaying and hyperthermia, increases the risk of sudden infant death from bed sharing.**

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Introduction

Sharing the bed with young infants is common in many cultures, but this practice has been little studied and the limited available findings on its health consequences are conflicting. On the one hand, it has been proposed that infant bed sharing may reduce the risk of the sudden infant death syndrome by contributing to a consistently rich sensory environment and fostering the development of optimal sleeping patterns for the infant.[1,2] This idea is supported by the low sudden infant death rate in Hong Kong[3] and among Bangladeshis in Great Britain.[4] Both cultures have crowded living conditions and cultural preferences that are likely to be associated with a high prevalence of infant bed sharing.[5,6]

On the other hand, results from a small number of epidemiological studies suggest that infant bed sharing increases the risk of sudden infant death. Two case-control studies during the 1970s—one in England[7] and the other in the United States[8]—found that bed sharing was more common in cases than in controls. The authors of these reports speculated that the association between bed sharing and sudden infant death could be due either to the infant being taken to bed for comforting because of minor illness causing restlessness,[7] or to asphyxia from overlaying, possibly worsened by parental consumption of alcohol or drugs.[8] Two case series in the 1980s further supported a role for accidental asphyxia due to overlaying.[9,10] Death brought on by hyperthermia, arising from body heat generated by the parent, also has been proposed.[9]

We recently carried out a nationwide case-control study in New Zealand which found a twofold increase in the risk of sudden infant death associated with bed sharing after other risk factors were controlled.[11] However, in further analyses on data from the same sample we also found that bed sharing in the last sleep (before death in cases or interview in controls), by itself, was a risk factor only among Maori infants and not in infants of other ethnic groups who were predominantly of European descent or Pacific Island Polynesians resident in New Zealand.[12] This suggested an interaction between bed sharing and some other risk factor that occurred more commonly in Maori infants. Maternal cigarette smoking seemed most likely since this was the only other major modifiable risk factor for sudden death, besides bed sharing, that Maori infants were more likely to be exposed to than non-Maori infants.[12]

We report the first systematic analysis of bed sharing as a risk factor for the sudden infant death syndrome using data collected in a population based case-control study which covered a region with 78% of births in New Zealand. We examined how the risk of sudden infant death from bed sharing is related to other factors, particularly maternal smoking. We tested previous hypotheses—such as hyperthermia, recent infant illness, and overlaying—put forward to explain the possible association between bed sharing and sudden infant death. In particular, we examined whether maternal alcohol consumption, implicated in overlaying, is a risk factor by itself or whether it is confounded by other factors such as maternal smoking.

Methods

Methods have been described previously.[13] In brief, study subjects were selected from all live births during 1 November 1987 to 30 October 1990 in the health regions of Auckland, central North Island, southern North Island, Christchurch, and southern South Island. These regions had 78% of all births in New Zealand during 1988-90.

Cases were infants who died between the 28th day of life and the completion of their first year with a diagnosis of the sudden infant death syndrome with or without other abnormalities. Necropsies were carried out in 474 (97·8%) of cases. Controls were randomly

selected from all births, except home births (less than 1%), in the study regions—that is, they were not individually matched with cases. The methods for case identification, including the necropsy protocol, and for selection of controls have been described in detail.[13]

Parents (or guardians) of cases and controls were interviewed at home. Control infants were randomly allocated a nominated date (to ensure group matching with cases for infant age) and a nominated time of day so that the distribution of this time for controls was similar to the expected distribution of the time of death in cases. Interviews were completed in 393 (81·0%) of cases and 1592 (88·4%) of controls. Eighty one per cent of case interviews were completed within seven weeks of the infant's death, and 70% of controls within four days of the nominated date. Obstetric records were also examined in 465 (95·9%) cases and 1762 (97·9%) controls.

Most of the information in this report came from the interviews with parents. Parents were asked if baby usually shared a bed with another person for some period in the two weeks before death in cases or the nominated date in controls. Parents were not provided with any definition of bed sharing. Information was also collected on who usually shared the bed with the infant and the average number of hours spent bed sharing. Parents were also asked if the infant shared the bed with another person at the time of death for cases or during a nominated sleep (randomly allocated) before or after the nominated time for controls (subsequently called the last sleep). The minimum time for a sleep was 30 minutes at any time of day or night. Because there was a difference between cases and controls in the 24 hour distribution of the last sleep ($p=0·009$), the time for this was controlled in all case-control comparisons involving the last sleep.

The usual number of alcoholic drinks (beer, wine, sherry, port, spirits, and liqueur) consumed by the mother was recorded for the month before death or nominated date. The most alcohol drunk on any one occasion by the mother after pregnancy was also recorded and was used as an indicator of binge drinking, since we considered it unlikely that valid information could be collected about alcohol consumption at the time of death for cases.

Maternal and paternal smoking were defined as any cigarettes in the last two weeks. Infants were classified as breast fed if their main type of milk in the last two days was breast milk. The position the infant was put down to sleep at the last sleep (for cases) or nominated sleep (for controls) was classified as prone or not. Parents' ethnic origin was self assigned. Infants were classified as Maori if one or more parents were Maori, Pacific Islander if one or more parents were Pacific Islander but neither Maori, and other if neither parent was Maori or Pacific Islander. Maternal and paternal occupations were grouped according to the New Zealand based Elley-Irving classification of social class,[14] and the higher level of the two was assigned to the infant. The total thermal resistance (tog units) provided by the bedding and clothing of infants in the last sleep was calculated using data from the Shirley Institute, Manchester.[15] The severity of illness in the previous two days was graded using a weighted score based on the baby check system described by Morley *et al.*[16] Parents were also asked if the infant had been more than usually restless and irritable in the last two weeks.

The Cochran-Mantel-Haenszel statistic was used to estimate χ^2 statistics in comparisons of adjusted prevalences of bed sharing.[17] Relative risks were estimated from Mantel-Haenszel odds ratios and test based confidence intervals.[17] Logistic regression was used to calculate odds ratios adjusted for possible confounders. These were the age of mother at birth, age she left school, age of first pregnancy, and number of previous pregnancies; attendance at antenatal clinics and classes; the sex, gestational age, and weight at birth of the infant, and admission to a neonatal unit; mother's marital status, occupational status, and usual region of residence of the household; dummy use, breast feeding, and sleep position of the infant; the age of the infant, season and time of day at death (or nominated time for controls); and the room the infant usually slept in at night during the last two weeks or during the last sleep, as appropriate for the bed sharing variable.

The presence of interactive effects on the risk of sudden infant death between bed sharing and some other factor, such as maternal smoking, was assessed on an additive scale by creating indicator terms for each category of joint exposure[18] and determining statistical significance by the method of Breslow and Storer[19] and assessed on a multiplicative scale by using the logistic regression coefficient of the cross product term for those exposed to both risk factors to determine statistical significance.[18] The proportion of infant deaths attributable to joint exposure from maternal smoking and bed sharing was estimated by the method of Walker.[18] Dose-response was assessed by the method and criteria of Maclure and Greenland.[20]

Results

Initial analyses of bed sharing were restricted to controls to identify variables possibly related to the usual practice of bed sharing during the last two weeks among the general infant population. Bed sharing varied between ethnic groups—65·7% (197/300) in Maoris, 73·7% (101/137) in Pacific Islanders, and 35·5% (410/1154) in others ($\chi^2_2=139$). Because the relative risk of sudden infant death also varied between ethnic groups, being highest in Maoris, the confounding effects from ethnic groups were controlled for in all analyses.

TABLE I—*Proportion of controls who shared a bed in the last two weeks*

Variable	No	(%) (Adjusted for ethnic group)	p Value*
Socioeconomic group:			
1 And 2 (high (n=543))	227	48·2	0·36
3 And 4 (n=753)	321	42·4	0·46
⩾5 (Low) (n=294)	160	44·7	
Mother's marital status:			
Married (n=1179)	470	42·7	0·007
Not married (n=412)	238	51·9	
Age of mother at birth of child (years)			
<20 (n=119)	72	53·7	0·023
20-24 (n=356)	170	44·3	0·48
25-29 (n=563)	228	41·5	
⩾30 (n=542)	234	46·9	0·059
Age of infant (weeks):			
<13 (n=730)	339	46·2	0·049
13-19 (n=398)	172	42·5	0·35
20-25 (n=183)	65	37·1	
⩾26 (n=280)	132	46·6	0·073
Infant more restless and irritable in last 2 weeks:			
Yes (n=622)	302	47·4	0·058
No (n=965)	402	42·6	
Mother smoked in the last 2 weeks:			
Yes (n=510)	256	43·8	0·90
No (n=1081)	452	44·3	
Mother drank alcohol in the last month:			
Yes (n=938)	399	44·9	0·58
No (n=653)	309	43·7	
Position infant placed at nominated sleep:			
Prone (n=521)	202	40·3	0·020
Other (n=1063)	502	46·5	
Infant used dummy:			
Yes (n=165)	55	36·3	0·020
No (n=1420)	652	45·5	
Main type of milk drunk by infant in last 2 days:			
Breast (n=979)	500	52·1	<0·001
Other (n=602)	204	31·9	
Room infant slept in at night in last 2 weeks:			
Parents' bedroom (n=897)	504	53·2	
Own bedroom alone (n=531)	139	29·9	<0·001
With sibling (n=70)	28	41·8	0·058
Other room (n=93)	37	36·2	0·002

*Blanks indicate reference categories.

The prevalence of bed sharing was significantly ($p=0.007$) higher in infants with unmarried parents than married parents and in breast fed infants compared with bottle fed infants, but it was lower in infants who were placed in the prone sleeping position or used a dummy than in their comparison groups (table I). The prevalence of bed sharing was also related both to maternal age at the time of birth, being highest in mothers age <20 years and lowest in mothers aged 25-29 years, and to infant age, where it was highest in infants aged <13 weeks or >25 weeks and lowest in infants aged 20-25 weeks. There was no relation between the prevalence of bed sharing and parents' socioeconomic group, infant restlessness, maternal smoking, or alcohol intake (table I). Neither was the proportion standardised for ethnic origin for bed sharing in the last sleep related to illness in the previous two days, being 10·6% (134/1330) for infants with mild illness or no illness (illness score <8) and 8·8% (22/176) for infants with illness severe enough to need medical assessment (score ≥8; $p=0.52$).

In case-control comparisons that controlled for ethnic origin, bed sharing in the last two weeks and also the last sleep were associated with a significantly ($p<0.001$) higher risk of sudden infant death (table II). Infants who bed shared in the last two weeks but not in the last sleep had a significantly raised odds ratio (1·77; $p<0.001$), which suggests that the effect of bed sharing on the risk of sudden infant death may be cumulative and not necessarily acute. There was evidence of an increasing dose-response relation between relative risk of sudden infant death and the number of hours of bed sharing, with the risk being highest in infants who usually bed shared for more than five hours in each 24 hour period over the last two weeks, since the non-simultaneous 95% confidence intervals for comparisons between exposure levels did not contain unity.[20] However, the relative risk was not related to the number of parents who bed shared, since the relative risk for two parents sharing (1·52) was similar to that for one (1·74). Among infants who share the bed with both parents, the relative risk was significantly ($p<0.001$) raised only when either the mother or both parents smoked (table II).

The relative risk of sudden infant death associated with bed sharing was adjusted for ethnic origin and examined in subgroups to see if it varied with different levels of other variables, particularly smoking (table III). The risk was significantly raised in the infants of mothers who smoked cigarettes for all levels of smoking (relative risk for all smokers 2·03; 1·45 to 2·83), but not in the infants of non-smoking mothers (1·19); it did not vary with the number of cigarettes smoked. In contrast, the risk was significantly raised for infants of both non-smoking fathers (1·54) and smoking fathers (1·60). However, when infants where grouped by both maternal and paternal smoking categories, the risk from bed sharing among infants of smoking fathers was increased only if the mother smoked. Moreover, the relative risk was not related to the number of parents who smoked, being 2·01 (1·26 to 3·22) for infants with one smoking parent and only 1·63 (1·07 to 2·48) for infants with two smoking parents.

Infants of mothers who drank alcohol in the last month had significantly raised relative risk of sudden infant death associated with bed sharing (1·95; table III). Similarly, for maximum amount of alcohol drunk on one occasion by the mother after pregnancy, infants of mothers who drank one to seven glasses or eight or more glasses also had raised odds ratios, although the value was not significantly different from 1·0 in those who drank eight or more glasses of alcohol. However, as for paternal smoking, when infants were divided into further subgroups by maternal smoking the bed sharing risk of sudden infant death for subgroups of both alcohol variables was increased significantly ($p<0.05$) only among infants of smoking mothers (results not shown).

To calculate the separate effects of maternal smoking and alcohol consumption (in the last month) on the risk of sudden infant death from bed sharing, infants were divided into the eight mutually exclusive exposure subgroups for these three variables (table IV). Among infants who shared a bed, only those with smoking mothers had raised relative risks compared with the reference group, with the relative risk for infants exposed to both bed sharing and maternal

TABLE II—*Relative risk of sudden infant death associated with various measures of infant bed sharing, adjusted for ethnic origin*

Variable	No of cases	No of controls	Mantel-Haenszel odds ratio (95% confidence interval)
Usual bed sharing in last 2 weeks:			
No	145	883	1·00
Yes	248	708	1·64 (1·28 to 2·09)
Bed sharing in last sleep:			
No	297	1418	1·00
Yes	94	166	1·74 (1·24 to 2·44)*
Bed share in last 2 weeks/bed share in last sleep:			
No/no	133	870	1·00
Yes/no	164	548	1·77 (1·36 to 2·31)*
No/yes	11	9	5·74 (2·41 to 13·68)*
Yes/yes	83	157	2·19 (1·44 to 3·34)*
Usual number of hours bed sharing in last 2 weeks (per 24 hours):			
None	145	883	1·00
<2	88	351	1·37 (1·02 to 1·85)
2-5	62	176	1·65 (1·15 to 2·37)
>5	95	178	2·27 (1·59 to 3·25)
Number of parents bed sharing in last 2 weeks†:			
0	145	883	1·00
1	80	212	1·74 (1·24 to 2·44)
2	137	452	1·52 (1·15 to 2·00)
Number of smoking parents who shared beds in last 2 weeks‡:			
Neither	30	245	1·00
Father only	13	76	1·07 (0·49 to 2·32)
Mother only	26	39	3·82 (1·99 to 7·36)
Both	68	92	4·38 (2·58 to 7·42)

*Also controlling for time of last sleep.
†Excluding infants who shared bed with adults other than parent(s).
‡Restricted to infants sharing bed with both parents.

TABLE III—*Relative risk of sudden infant death associated with bed sharing in last two weeks among subgroups for smoking, alcohol, maternal and infant age, tog value, and infant restlessness, adjusted for ethnic origin*

Variable	Bed sharing: No of cases: Yes	Bed sharing: No of cases: No	Bed sharing: No of controls: Yes	Bed sharing: No of controls: No	Mantel-Haenszel odds ratio (95% confidence interval)
Mother smoked in last 2 weeks (cigarettes per day):					
0	64	67	452	629	1·19 (0·81 to 1·74)
1-9	58	22	102	88	1·99 (1·10 to 3·61)
10-19	63	31	92	105	2·04 (1·19 to 3·49)
≥20	63	25	62	61	2·04 (1·08 to 3·85)
Father smoked in last 2 weeks:					
No	98	78	429	624	1·54 (1·10 to 2·16)
Yes	143	66	268	251	1·60 (1·11 to 2·31)
Mother smoked/father smoked:					
No/no	47	56	336	504	1·18 (0·77 to 1·81)
No/yes	17	11	108	120	1·30 (0·56 to 3·00)
Yes/no	51	22	93	120	2·63 (1·47 to 4·72)
Yes/yes	126	55	160	131	1·63 (1·07 to 2·48)
Mother drank alcohol in last month:					
No	98	71	309	344	1·31 (0·91 to 1·88)
Yes	150	74	399	539	1·95 (1·40 to 2·71)
Most alcohol drinks by mother on one occasion after pregnancy (glasses):					
0	86	57	270	259	1·31 (0·88 to 1·95)
1-7	97	71	348	566	1·82 (1·29 to 2·59)
≥8	65	17	90	58	1·71 (0·86 to 3·41)
Age of mother at birth of child (years):					
<20	44	21	72	47	1·19 (0·61 to 2·32)
20-24	92	42	170	186	2·12 (1·37 to 3·29)
25-29	69	44	228	335	1·78 (1·15 to 2·76)
≥30	39	36	234	308	1·12 (0·65 to 1·92)
Age of infant (weeks):					
<13	128	74	339	391	1·49 (1·05 to 2·12)
13-19	72	36	172	226	2·15 (1·35 to 3·42)
20-25	19	13	65	118	2·19 (0·98 to 4·92)
≥26	29	22	132	148	1·07 (0·56 to 2·04)
Infant more restless and iritable in last 2 weeks:					
Yes	78	37	302	320	1·70 (1·09 to 2·66)
No	170	108	402	563	1·68 (1·25 to 2·25)
Tog value for bedding and clothing in last sleep:					
<10	147	79	464	597	1·73 (1·25 to 2·39)
≥10	93	61	230	274	1·51 (1·02 to 2·22)

smoking (3·75) being similar to that for infants also exposed to mateal alcohol (3·56). In contrast, the relative risk for bed sharing infants whose mothers drank alcohol but did not smoke (0·93) was similar to the reference group, as was the relative risk for bed sharing infants with mothers who neither smoked nor drank alcohol (0·92). Importantly, the relative risk for infants exposed to both alcohol and bed sharing was no higher than for those exposed to bed sharing only, within each smoking level. This suggests that maternal alcohol consumption was not interacting with bed sharing to increase the risk of sudden infant death.

With regard to maternal age at the infant's birth, the risk of sudden infant death from bed sharing was increased only in infants of mothers aged 20-24 and 25-29 years, but not of younger (<20 years) or older (≥30 years) mothers (table III). With regard to the age of the infant at death or nominated date, the relative risk was significantly increased only in those aged <26 weeks, although infants aged 13-19 and 20-25 weeks had higher risks than the youngest (<13 weeks). Importantly, the relative risk of sudden death from bed sharing was the same for infants who had been restless in the last two weeks as for those who had not. Neither did it vary with the total thermal resistance for bedding and clothing around infants in the last sleep, being 1·73 for infants exposed to <10 togs and 1·51 for those exposed to 10 or more togs (table III).

The relative risk sudden infant death from bed sharing adjusted for ethnic origin was not related to socioeconomic class, being 1·34 (0·78 to 2·28) for the highest category (groups 1 and 2), 1·77 (1·24 to 2·53) for groups 3 and 4, and 1·68 (1·07 to 2·62) for groups ≥5. Neither was it related to the main type of milk drunk by the infant in the last two days (relative risk for mainly breastfed infants 2·02 (1·39 to 2·94), for other infants 1·97 (1·40 to 2·79)) nor to the position the infant was placed in bed at the last sleep (prone group 1·74 (1·26 to 2·40), non-prone group 1·85 (1·22 to 2·80)).

The effect modification shown by maternal smoking on the sudden infant death risk from bed sharing in tables II-IV also existed within subgroups of all variables in the above two paragraphs, with significantly increased odds ratios for bed sharing occurring only for infants with smoking mothers (results not shown).

There was interaction on an additive scale between maternal smoking and infant bed sharing, since the increase in risk from joint exposure to these two variables was more than the sum of the increase in risk from each variable individually (table V). This additive interaction was statistically significant for both bed sharing in the last two weeks ($\chi^2=11·1$, $p=0·0009$) and also the last sleep ($\chi^2=21·0$, $p<0·0001$) in models controlling for ethnic origin (the multivariate models in table V could not be assessed because of the complexity of this calculation). Further, for bed sharing in the last sleep, there was also a significant multiplicative interaction since the p value for the regression coefficient of the interaction term between bed sharing and maternal smoking with logistic regression was <0·05 (table V). The additive interaction between maternal smoking and bed sharing was present separately in Maori, Pacific Island, and European infants (results not shown).

The main confounders of bed sharing, besides ethnic origin, were the room in which the baby slept, breast feeding, and prone sleeping position. Controlling for the effect of each variable increased the relative risk for bed sharing. Collectively, these three confounders explained most of the change in the risk of sudden infant death from bed sharing among infants of non-smoking mothers between the model controlling for ethnic origin and the full multivariate model in table V.

When bed sharing in the last two weeks was used as a measure of regular bed sharing practice, the proportion of disease events attributable to the joint effect of bed sharing and maternal smoking was calculated among those cases exposed to both risk factors (n=184 in table V). This was 41% (n=76) using odd ratios controlling for ethnic origin and 45% (n=84) using multivariate odds ratios (from table V). These case numbers each represent about 20% of the total 393 cases in the study.

There was a dose-response relation between hours of bed sharing each day when infants were classified by maternal smoking (table VI). The relative risk of sudden infant death increased sequentially as the daily hours of bed sharing increased, particularly among infants of smoking mothers, to a maximum risk among infants who shared for more than five hours (relative risk 6·58 after ethnic origin was controlled for).

Finally, we also examined the data to see if maternal alcohol consumption, by itself, was a risk factor for sudden infant death. Infants of mothers who drank alcohol once or more each day, over the last month, had a higher risk of sudden death when ethnic origin was controlled for (1·41, p=0·054), although the risk from this exposure was decreased when maternal smoking

TABLE IV—*Relative risk of sudden infant death, adjusted for ethnic origin, for infant subgroups classified by bed sharing and maternal smoking and alcohol use*

Mother smoked in last 2 weeks	Mother drank alcohol in last month	Infant shared bed in last 2 weeks	Cases (n=393)	Controls (n=1591)	Odds ratio (95% confidence interval)*
Yes	Yes	Yes	117	166	3·56 (2·29 to 5·52)
Yes	No	Yes	67	90	3·75 (2·29 to 6·16)
Yes	Yes	No	44	158	1·70 (1·05 to 2·76)
Yes	No	No	34	96	2·12 (1·25 to 3·60)
No	Yes	Yes	33	233	0·93 (0·56 to 1·53)
No	Yes	No	30	381	0·55 (0·33 to 0·91)
No	No	Yes	31	219	0·92 (0·55 to 1·56)
No	No	No	37	248	1·00

*Logistic regression analysis also adjusting for ethnic origin.

TABLE V—*Interaction between maternal smoking and infant bed sharing in effect on relative risk of sudden infant death*

Mother smoked in last 2 weeks	Bed sharing	Cases	Controls	Odds ratio (95% confidence interval) Adjusted for ethnic origin	Multivariate*
		Bed share in last 2 weeks			
Yes	Yes	184	256	4·77 (3·35 to 6·80)	3·94 (2·47 to 6·27)
Yes	No	78	254	2·61 (1·82 to 3·73)	1·42 (0·90 to 2·24)
No	Yes	64	452	1·19 (0·81 to 1·74)	1·73 (1·11 to 2·70)
No	No	67	629	1·00	1·00
p Value for multiplicative interaction				0·08	0·12
		Bed share in last sleep			
Yes	Yes	84	67	4·96 (3·06 to 8·05)†	4·55 (2·63 to 7·88)
Yes	No	176	440	2·63 (2·04 to 3·40)†	1·55 (1·08 to 2·22)
No	Yes	10	99	0·66 (0·30 to 1·45)†	0·98 (0·44 to 2·18)
No	No	121	978	1·00	1·00
p Value for multiplicative interaction				0·0031	0·0170

*See Methods for variables adjusted for.
†Also controlling for time of last sleep.

TABLE VI—*Relative risk of sudden infant death for infant subgroups classified by maternal smoking and usual number of bed sharing hours (per 24 hour period) in last two weeks*

Mother smoked in last 2 weeks	No of hours of bed sharing	No of cases	No of controls	Odds ratio (95% confidence interval) Adjusted for ethnic origin	Multivariate*
Yes	>5	76	67	6·58 (3·75 to 11·53)	5·73 (3·08 to 10·68)
Yes	2-5	47	78	4·06 (2·44 to 6·74)	3·99 (2·15 to 7·42)
Yes	<2	58	110	3·83 (2·48 to 5·94)	3·28 (1·89 to 5·68)
Yes	None	78	254	2·61 (1·82 to 3·73)	1·44 (0·91 to 2·27)
No	>5	19	111	1·33 (0·71 to 2·49)	2·50 (1·25 to 5·02)
No	2-5	15	98	1·21 (0·64 to 2·29)	1·42 (0·68 to 3·01)
No	<2	30	241	1·11 (0·70 to 1·77)	1·67 (0·98 to 2·83)
No	None	67	629	1·00	1·00

*See Methods for variables adjusted for.

TABLE VII—*Relative risk of sudden infant death associated with maternal alcohol intake*

Alcohol measurement	Cases	Controls	Mantel-Haenszel odds ratio (95% confidence interval)	
			Adjusted for ethnic origin	Adjusted for ethnic origin and maternal smoking
Usual alcohol intake in last month (glasses per day):				
0	169	653	1·00	1·00
<1	155	773	0·86 (0·67 to 1·11)	0·78 (0·60 to 1·01)
⩾1	69	166	1·41 (0·99 to 2·00)	1·16 (0·80 to 1·68)
Most alcohol drunk on one occasion after pregnancy (glasses):				
0	143	529	1·00	1·00
1-7	168	915	0·78 (0·60 to 1·004)	0·70 (0·54 to 0·91)
⩾8	82	148	1·43 (1·00 to 2·04)	0·97 (0·67 to 1·41)

was also controlled for (1·16, p=0·43; table VII). The maximum number of alcoholic drinks on one occasion was not related to the risk of sudden infant death after ethnic origin and maternal smoking were controlled for. These results complement those from table IV, which show that those infants with alcohol drinking mothers who were not exposed to bed sharing or maternal smoking had a significantly (p=0·03) lowered risk of sudden death (0·55) than infants not exposed to any of these three variables. Together, the results suggest that recent maternal alcohol consumption does not increase the risk of the sudden infant death syndrome.

Discussion

Our results do not support the idea that infant bed sharing protects against the sudden infant death syndrome.[1,2] Instead, they show that infant bed sharing is a risk factor for this syndrome, particularly among infants of mothers who smoke. For these infants, the risk of sudden death increased with increasing duration of bed sharing, although it did not vary with the number of cigarettes smoked by the mother.

There was an interaction between bed sharing and maternal smoking on the risk of sudden infant death for both measures of bed sharing (last two weeks and last sleep) on an additive scale, and for bed sharing in the last sleep on a multiplicative scale. Current epidemiological opinion prefers the additive definition of interaction because of its greater relevance to individuals and public health.[18] The first point at which concern arises about the excess risk from joint exposure to two variables is when it is more than the sum of the excess risk from each variable by itself—that is, it is more than additive; this would not necessarily show as interaction on a multiplicative scale. The interaction between maternal smoking and bed sharing explains why our earlier report found bed sharing, by itself, to be a risk factor only among Maoris since they have a higher maternal smoking prevalence than non-Maoris (65% *v* 24% in controls).[12]

In contrast, we found that neither maternal alcohol consumption nor the thermal resistance of the infant's clothing and bedding interacted with bed sharing to increase the risk of sudden infant death; neither was alcohol a risk factor by itself. The latter result is consistent with an earlier study in the United States which found that maternal alcohol use in pregnancy was not related to sudden infant death.[21]

Our results are unlikely to be due to selection bias because of the high response rates in both cases (81%) and controls (89%). Recall bias is also unlikely to be present because bed sharing was not commonly known to be a possible risk factor within New Zealand at the time we interviewed parents. Further, for maternal smoking we have shown good agreement between information collected from obstetric records at the time of delivery and home interviews for both cases and controls.[22] However, we acknowledge the limitations of our measure of maternal alcohol ingestion, in terms of excluding a possible interaction with bed sharing, where the ideal would have been to record alcohol consumed just before the infant death or nominated sleep.

These results have implications as to the likely mechanism(s) by which bed sharing increases the risk of sudden infant death. They do not support a role for overlaying or hyperthermia, for the following reasons. Firstly, if either of these mechanisms was involved the increase in risk of sudden death from bed sharing should have been similar for all infants, regardless of whether the mother smoked. It seems unlikely that maternal smoking would interact with either of these mechanisms to cause an increased risk due to bed sharing only in infants with mothers who smoke. Secondly, infants sharing the bed with two parents should have have a higher risk of sudden death than those sharing with one (table II) since two parents would either take up more bed space, and hence increase the likelihood of overlaying, or generate more body heat to increase the likelihood of infant hyperthermia. Thirdly, infants surrounded by 10 or more togs of clothing and bedding, and therefore more likely to be hyperthermic, should have had a higher sudden death risk from bed sharing than infants with less than 10 togs. Fourthly, infants who shared beds in the last two weeks, but not in the last sleep, should not have had an increased risk of sudden death (table II) since the effects of overlaying and hyperthermia are acute. Fifthly, the lack of an interaction between maternal alcohol and bed sharing on the sudden infant death risk, which would most likely involve overlaying, also argues agaisnt this mechanism. However, because of reports that have identified cases with parents who had consumed large amounts of alcohol before the death (for example, coroners' reports) or who were suspected of substance misuse,[9] overlaying may cause sudden infant death in some circumstances.

SMOKING AND BED SHARING

Unless there is a third unknown common factor, the interaction between maternal smoking and bed sharing suggests these are components of a sufficient cause that involves a passive smoking mechanism.[18] Some mothers may be smoking in bed with their infants, although this may not occur commonly because of increasing parental concern in recent years about the effects of passive smoking on children. If few mothers are smoking in bed with their infants, then an alternative explanation for our findings is that rebreathing of expired air from the mother by the infant could lead to hypoxia, as has been postulated to occur in infants dying suddenly who might rebreath their own expired air when placed prone.[23] Infants who share beds have been observed to position themselves within a few inches of their mothers' faces, and mother and infant are usually faced towards each other.[2] Rebreathing may occur, to varying degrees, in all infants who share beds but be most hazardous for infants of smoking mothers.

Unabsorbed tobacco components from the mother may flow continuously over, and be inhaled by, the baby during sleep, ultimately causing hypoxia and increasing the risk of sudden death. A cumulative exposure by this mechanism would be consistent with the finding of an increased relative risk for infants who usually shared beds in the last two weeks but not in the last sleep (table II).

If bed sharing is a marker for passive smoking among infants of smoking mothers then our results are consistent with previous epidemiological studies which show that maternal smoking is a risk factor for sudden infant death.[22] Infants can be exposed to the components of maternal cigarette smoke through inhalation,[24,25] and passive smoking has been associated with

raised blood concentrations of 2,3-diphosphoglycerate, a marker for hypoxia in children.[26]

We are not aware of any studies that have examined the association between the daily number of cigarettes smoked and the concentration of unabsorbed tobacco components in expired air. An absence of an association between these two variables could explain the lack of a dose-response effect from the number of cigarettes smoked by the mother on the risk of sudden infant death from bed sharing (table III), which was surprising and requires further investigation.

The observation that paternal smoking did not modify the relative risk from bed sharing was also unexpected. Perhaps infants are placed on the outside of the bed next to the mother, but away from the father, thus limiting their paternal smoking exposure. Because maternal smoking during pregnancy is highly correlated with smoking after pregnancy, another possible explanation for the lack of a paternal effect (and also for no dose-response effect with the number of maternal cigarettes smoked) is that infant's exposure to smoking either from the mother or the father, does not adversely affect the risk of sudden infant death as much as exposure during pregnancy, which is primarily from the mother. The dependence of paternal smoking, as a risk factor by itself, on the presence of maternal smoking exposure has been reported previously.[22] Further studies of parental smoking and bed sharing may help to explain why we have observed no effect with fathers and no dose response effect with mothers.

IMPLICATIONS FOR PUBLIC HEALTH STRATEGIES

If bed sharing and maternal smoking are causally related to sudden infant death then our results have implications for public health strategies to reduce deaths from this condition. The attributable risk for cases exposed to both risk factors calculated from our data for bed sharing in the last two weeks suggests that about 20% of all sudden infant deaths in New Zealand can be explained by the joint effect of these two factors. Thus, removal of either risk factor from those exposed to both, which would theoretically prevent all deaths from their joint action, could prevent about a fifth of all sudden infant deaths in New Zealand. Given the difficulty that many people have in stopping smoking, recommendations that parents who smoke should not share beds with their infants may be more effective in lowering the rate of sudden infant deaths than advising them to stop smoking.

Our results also have public health implications for countries and cultures where bed sharing is common. Much of the increased rate of sudden infant deaths in New Zealand Maoris is explained by their higher prevalences of bed sharing and maternal smoking compared with non-Maoris.[12] Similarly, part of the increased sudden death rate among black infants in the United States[21] may be due to their increased exposure to both bed sharing[27] and maternal smoking[28] compared with whites. In contrast, sudden infant death rates are currently low in populations, such as in Hong Kong[3] and among Bangladeshis in Great Britain,[4] where bed sharing is common but the prevalence of maternal smoking is also low.[5,6] However, our findings suggest that such populations could experience a substantial increase in the sudden infant death rate if the prevalence of maternal smoking increases in the future, not only from the main effect for infant exposure to smoking but also from the interactive effect for the joint exposure to maternal smoking and bed sharing.

Finally, our findings for infants of non-smoking mothers are conflicting, with our measure of bed sharing in the last two weeks being associated with a significant increase in the risk of sudden infant death, in contrast to the measure of bed sharing in the last sleep which had no increase in risk (table V). Overall, our results suggest there could be an increased risk for these infants, particularly if they share beds for more than five hours a day (table VI). However, any increase in the risk of sudden death from bed sharing in this group needs to be balanced against the possible benefits from bed sharing. These include longer continuation of breast feeding after birth (R Ford, personal communication), which itself is associated with a lowered risk of sudden infant death,[29] and anecdotal evidence of improved bonding with the child and better sleeping patterns for the mother. Because this paper is the first to report bed sharing data for infants of non-smoking mothers, our results need confirmation by other studies.

Public health implications

- This study found that bed sharing is a risk factor for sudden infant death, particularly among infants of mothers who smoke
- Neither maternal alcohol consumption nor the thermal resistance of the infants' clothing and bedding interacted with bed sharing to increase the risk of sudden infant death, nor was alcohol a risk factor in itself
- These results do not support a role in sudden infant death for overlaying or hyperthermia
- Removal of either the risk factor of bed sharing or maternal smoking would theoretically prevent a fifth of sudden infant deaths
- Countries and cultures where bed sharing is common and the prevalence of maternal smoking is low could experience increases in sudden infant death if maternal smoking prevalence increases in the future

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Non-fasting serum triglyceride concentration and mortality from coronary heart disease and any cause in middle aged Norwegian women

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Abstract

***Objective*—To study the association between non-fasting serum triglyceride concentrations and mortality in women from coronary and cardiovascular disease and all causes.**

***Design*—Follow up by ambulatory teams of men and women who underwent cardiovascular screening for a mean of 14·6 years.**

***Setting*—National health screening service in Norway.**

***Subjects*—25 058 men and 24 535 women aged 35-49 years.**

***Main outcome measure*—Predictive value of non-fasting serum triglyceride concentrations.**

***Results*—At initial screening total serum cholesterol concentration, serum triglyceride concentration, blood pressure, height, and weight were measured, and self reported information about smoking habits, physical activity, and time since last meal were recorded. During subsequent follow up 108 women died from coronary heart disease, 238 from cardiovascular diseases, and 931 from all causes. In women mortality increased steadily with increasing triglyceride concentration for all three causes of death. With the proportional hazards model and adjustment for age, systolic blood pressure, total cholesterol concentration, time since last meal, and number of cigarettes a day the relative risk between triglyceride concentration $\geq 3{\cdot}5$ mmol/l and $< 1{\cdot}5$ mmol/l was 4·7 (95% confidence interval 2·5 to 8·9) for deaths from coronary heart disease, 3·0 (1·9 to 4·8) for deaths from cardiovascular disease, 2·3 (1·8 to 2·9) for total deaths in all women.**

***Conclusions*—A raised non-fasting concentration of triglycerides is an independent risk factor for mortality from coronary heart disease, cardiovascular disease, and any cause mortality among middle aged Norwegian women in contrast to what is seen in men.**

Introduction

The role of triglycerides in the development of cardiovascular disease is as yet unestablished. Many epidemiological studies have found a relation between serum triglyceride concentration and the incidence of and mortality from coronary heart disease.[1,2] The relation is weakened and often disappears, however, when other risk factors are considered.[3] Most studies have been done in men, but among the few studies in women triglyceride concentrations has come out as an independent risk factor.[4,5] Austin reviewed the importance of raised plasma triglyceride concentrations from perspectives other than the epidemiological and concluded that it is premature to dismiss triglyceride concentration as a potentially important risk factor.[2]

In various counties in Norway the National Health Screening Service has organised large scale screening examinations for risk factors for the development of cardiovascular disease for the past 20 years. From these studies we have previously reported non-fasting triglyceride concentration to be a weak predictor of death from coronary heart disease in men; the strength of association depending heavily on whether total cholesterol concentration was accounted for.[6] The period of follow up is now sufficient (12 to 16 years) to give fairly precise estimates of the relation between triglyceride concentration and mortality from coronary disease in women.

Subjects and methods

During 1974-8 all men and women aged 35-49 years in three Norwegian countries were invited to attend a cardiovascular study. The attendance rate was high: 93% in women and 89% in men (24 535 women and 25 058 men). The previous study on men also included the Oslo study (1972-3) and the Tromsø study (1974), in which only men were studied.[6]

A detailed description of the study procedures has been given by Bjartveit *et al.*[7] All people participating answered a questionnaire at home about history of cardiovascular disease, diabetes, treatment for hypertension, symptoms of angina pectoris, physical activity during leisure, smoking habits, and stress factors in social life. In this study the healthy group consists of those who gave negative answers to questions about myocardial infarction, angina pectoris, other heart disease, atherosclerosis of legs, cerebral stroke, diabetes, treatment for hypertension, use of nitroglycerine, and symptoms suggesting angina pectoris or atherosclerosis obliterans, or both.

Height and weight were measured to the nearest centimetre and half a kilogram. After a minimum of two minutes' rest systolic and diastolic blood pressures were measured twice to the nearest 2 mm with a

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