

Cigarette Smoking as a Risk Factor for Sudden Infant Death Syndrome: A Population-Based Study

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Abstract: Risk factors for sudden infant death syndrome (SIDS) were examined in a prospective study based on Swedish births between 1983 and 1985. All infants surviving the first week of life were included (279,938). The overall rate of SIDS was 0.7 per 1,000 first week survivors. Elevated relative risks were associated with low maternal age, multiparity, maternal smoking, and male infants.

Smoking doubled the risk and a clear dose-response relation by amount smoked was observed. Maternal smoking also seemed to influence the time of death, as infants of smokers died at an earlier age. In countries like Sweden, smoking may be the single most important preventable risk factor for sudden infant death syndrome. (*Am J Public Health* 1990; 80:29-32.)

Introduction

Although syndromes similar to sudden infant death syndrome (SIDS) have been known since biblical time, progress in solving the enigma of SIDS has been slow. The incidence of SIDS varies widely, being low in Scandinavia¹ and higher in other industrialized countries, e.g., in North America. In Sweden² and Finland,³ the incidence of SIDS has doubled since the 1970s, despite reductions in the infant mortality rate of almost 40 percent.²

SIDS and other causes of infant death share some risk factors, but the age at death distinguishes SIDS from the other causes of death.⁴ SIDS victims usually die within one to six months of age; for unknown reasons, there are two peaks of age at death: eight to nine weeks, and 13 to 15 weeks.^{2,5}

Low social class and maternal smoking have previously been associated with SIDS.^{1,3,4} Since smoking is more frequent in lower social classes,⁶ it is uncertain whether the increased risk for SIDS should be ascribed primarily to smoking or low social class.

In 1973, a medical birth registry was set up by the National Board of Health and Welfare in Sweden,⁷ and, since 1982, information has been collected prospectively for each pregnancy from the first antenatal visit. The registry provided an excellent opportunity to investigate the influence of maternal smoking and other risk factors on SIDS in an unselected, homogeneous low-risk population.

Methods

The Swedish National Board of Health and Welfare receives demographic data, previous reproductive history and pregnancy outcome on all hospital births. This is transmitted as copies of the standardized antenatal and obstetrical records, which are generally used in Sweden. In the first trimester, midwives at the antenatal care clinics record previous reproductive history, smoking habits, and family situation. Practically all Swedish women visit these clinics regularly during pregnancy.⁸ All births reported to the birth registry are validated every year against a population registry at Statistics Sweden, which receives information from the

parishes about all births and deaths. This cross-checking is done by using the mother's personal identification number. The Medical Birth Registry covers more than 99 percent of all births in Sweden.⁹

During the study period from 1983 to 1985, 280,256 infants survived the first week of life. The study was restricted to births of mothers between 15 and 44 years of age. The 318 births for which maternal age was either unknown or outside this interval were excluded, leaving a total of 279,938 infants for study. Ninety-five percent of these infants were born to Scandinavian women.

In Sweden, the death certificate includes information about when the death occurred, possible causes of death, and whether or not an autopsy was performed. In the present investigation, 698 infants were reported to have died between one and 51 weeks of age. SIDS was reported as the only cause of death in 190 infants (International Classification of Diseases, ICD 8, 1968, 795.99). Autopsies were performed on 98 percent of the cases (94 percent forensic and 4 percent clinical). Most deaths from other causes also had autopsies (58 percent clinical and 12 percent forensic).

Parity was defined as the number of live births plus stillbirths. Smoking habits were categorized as non-smoker (i.e., non-daily smoker), moderate smoker (smoking between one and nine cigarettes per day), or heavy smoker (10 cigarettes or more per day). Since it is common in Sweden for young couples to live together without being married, information about family situation was recorded as whether or not living with infant's father.

Multiple logistic regression analyses were performed in order to calculate associations of the independent variables on SIDS as estimated by the relative risk.¹⁰ The independent variables used in the analyses were maternal age, parity, family situation, smoking habits, type of birth (single or multiple), and sex of infant. The continuous variables were categorized in order to avoid assumptions about linearity. The statistical analyses were made using the SAS program package.^{11,12}

Results

Mortality from SIDS, 190 cases or 0.7 per 1,000 first week survivors during the three years, accounted for about 27 percent of the total infant mortality after the first week of life. Table 1 shows that maternal age was inversely associated with risk for SIDS. Other characteristics of the mothers associated with an excess number of SIDS were high parity, not cohabiting with infant's father and the number of cigarettes smoked per day. Higher risks for boys and for multiple births were also seen.

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TABLE 1—Number of Infants Surviving the first Week of Life and SIDS Death Rate by Characteristics of the Mother and Infant, Sweden, 1983–85

Characteristics	Infants No.	SIDS	
		No.	Death-rate per 1000
Maternal Age at Delivery (years)			
15–19	9,574	14	1.46
20–24	66,582	53	0.80
25–29	103,527	68	0.66
30–34	68,838	41	0.60
35–39	27,155	12	0.44
40–44	4,262	2	0.47
Parity			
1	112,994	52	0.46
2	101,323	75	0.74
3	47,333	38	0.80
≥4	18,288	25	1.37
Family Situation			
Living with father	253,588	164	0.65
Not living with father	14,436	17	1.18
Not available	11,914	9	0.76
Smoking Habits			
Non-smoker	181,218	88	0.49
Daily smoker			
1–9 cigarettes	48,465	45	0.93
≥10 cigarettes	31,225	46	1.47
Not available	19,030	11	0.58
Sex of Infant			
Boy	143,981	110	0.76
Girl	135,391	79	0.58
Not available	566	1	...
Type of Birth			
Single	274,526	184	0.67
Multiple	5,407	6	1.11
Not available	5	0	...
Total	279,938	190	0.68

Smoking habits varied with age and family situation: half of the teenage mothers smoked compared with 25 to 29 percent of mothers aged 25 or more. More than half of women who were not living with infant's father were daily smokers, compared to 29 percent of those living with infant's father.¹³ We therefore adjusted the estimates for the effects of other variables using a multiple logistic regression model (Table 2).

As seen in Table 2, high parity strongly increased the risk for SIDS, but high maternal age reduced the risk of SIDS. It is plausible that the effect of parity varies with age, but we detected no interaction between age and parity ($p = 0.6$). Infants not living with their father had 50 percent greater SIDS mortality than those living with their father (95% CI = 0.8, 2.5).

Maternal smoking was strongly related to SIDS even when controlling for other risk factors. Smoking up to nine cigarettes per day doubled the risk of SIDS and smoking 10 cigarettes or more per day nearly tripled the risk of SIDS, compared to non-smokers. We examined whether smoking increased the risk of SIDS mortality more for certain women than others, but no clear interactions were detected (smallest p -value = 0.11).

Age at Death of SIDS Infants

The age at death from SIDS ranged widely with a peak incidence at nine to 12 weeks. The age distribution reported from other studies—two peaks during the first six months of life^{2,5}—was not clearly observable in our study. Only when the age of death was grouped by three-week intervals was there a weak tendency toward an early and a late peak.

The SIDS victims were stratified into two groups of equal size. However, before this was done, the 10 percent with the longest survival time were excluded in order to obtain groups including only cases with typical ages at death. Early SIDS were defined as deaths occurring between seven and 67 days of age and late SIDS were those between 68 and 145 days of age. Although the magnitude of the risks differed between the two models, they were in general rather similar (Table 2). However, moderate maternal smoking almost tripled the risk for early SIDS, while no increase in the risk for late SIDS appeared. A similar but less marked pattern was true for infants not living with their father.

For further analyses of the difference between early and late SIDS, a logistic regression model based only on the SIDS cases was performed, to estimate the probability of dying before 68 days of age among the SIDS victims. The analysis showed that moderate maternal smoking was strongly associated with increased risk for early SIDS (RR 1.7, 95% CI = 1.2, 2.1). SIDS victims whose mothers were heavy smokers (RR 1.4, 95% CI = 0.9, 1.4), or not living with infants father (RR 1.8, 95% CI = 0.9, 2.3), also had an increased risk for short survival, while infants of mothers 35 years of older seemed to have higher probability for longer survival (RR 0.4, 95% CI = 0.1, 1.1).

The influence of maternal smoking on the time of dying from SIDS, is illustrated in Figure 1. Infants of non-smoking mothers had a symmetric age distribution with a mode value of nine to 12 weeks. Infants of smoking mothers however, had a right-skewed age distribution with a shorter modal time of survival, five to eight weeks.

Discussion

In the present study, the diagnosis of SIDS was based on cases where the death certificate stated SIDS as the only cause of death. As 98 percent of these cases underwent autopsy (and 94 percent forensic autopsy), the diagnostic accuracy in these cases must be considered as sufficient. The diagnostic difficulties of SIDS, when using death certificates, mainly concern underregistration,² so the incidence estimate (0.7 per 1000) may be an underestimate.

Maternal smoking has earlier been reported as a risk factor for SIDS.^{5,14,15} In the present study, a strong association between maternal smoking and SIDS was found. We have no direct measures of confounders associated with smoking that might adversely affect the infant. For instance, we have no information on whether there were other smokers in the household. However, adjustment for the effects of maternal age, parity, and family situation only marginally reduced the estimates. Such socio-demographic variables are also related to behavioral and lifestyle characteristics that could adversely affect the infant. It therefore seems unlikely that unmeasured confounders would appreciably influence the association. The present results were based on a prospective study, including about 280,000 infants. The population studied was a relatively homogeneous, low-risk population, which further suggests a limited influence of possible confounders.

The information on smoking habits was based on the mothers' reports to the midwives at their first visit to antenatal care. As practically all women in Sweden regularly visit these clinics during pregnancy, the influence of possible selection bias seems negligible.⁸ Since pregnant women today are exposed to anti-smoking information, this may have influenced the validity of self-reported smoking habits.

TABLE 2—Relative Risks* of Sudden Infant Death Syndrome Based on a Logistic Regression Model (257,361 Infants Surviving the first Week of Life in Sweden 1983–85)

	All SIDS (1–51 weeks) Relative risk (95% CI)	Early SIDS (7–67 days) Relative risk (95% CI)	Late SIDS (68–145 days) Relative risk (95% CI)
Maternal Age (years)			
15–19	2.0 (1.0, 4.0)	1.5 (0.5, 4.4)	2.6 (0.9, 7.6)
20–29 (ref. group)	1.0	1.0	1.0
30–34	0.7 (0.5, 1.0)	0.6 (0.3, 1.0)	0.8 (0.5, 1.5)
35–44	0.5 (0.2, 0.8)	0.3 (0.1, 0.8)	0.8 (0.4, 1.7)
Parity			
1 (ref. group)	1.0	1.0	1.0
2–3	2.2 (1.5, 3.3)	2.8 (1.6, 4.8)	2.2 (1.2, 3.9)
≥4	4.8 (2.7, 8.4)	5.0 (2.1, 11.9)	5.0 (2.2, 11.4)
Family Situation			
Living with father (ref. group)	1.0	1.0	1.0
Not living with father	1.5 (0.8, 2.5)	1.9 (0.9, 4.0)	0.7 (0.2, 2.2)
Smoking Habits			
Non-smoker (ref. group)	1.0	1.0	1.0
Daily smoker			
1–9 cigarettes	1.8 (1.2, 2.6)	2.8 (1.7, 4.8)	1.0 (0.5, 1.8)
≥10 cigarettes	2.7 (1.9, 3.9)	3.6 (2.1, 6.2)	2.0 (1.1, 3.5)
Sex of Infant			
Boy	1.4 (1.1, 1.9)	1.2 (0.8, 1.9)	1.7 (1.1, 2.7)
Girl (ref. group)	1.0	1.0	1.0
Type of Birth			
Single (ref. group)	1.0	1.0	1.0
Multiple	1.5 (0.7, 3.4)	2.1 (0.8, 5.8)	1.1 (0.3, 4.5)

*Estimates are adjusted for all other variables.

Moreover, women may also have stopped smoking during pregnancy. It has been reported elsewhere that 15 to 20 percent of pregnant smokers quit “on their own” during pregnancy.^{16,17} Thus, if a causal relationship between maternal smoking and SIDS exists, the true relative risk may be even greater than estimated herein.

Other studies have reported low birthweight to be associated with SIDS^{3,18} and smoking to be associated with low birthweight.¹⁷ Because the effect of maternal smoking on SIDS could be mediated by low birthweight, we also conducted an alternative analysis controlling for low birthweight

(<2500 grams). We found almost the same risk estimates for smoking (RR = 1.7 and RR = 2.5 for moderate and heavy smoking, respectively) indicating that smoking affects birthweight-specific as well as overall SIDS mortality.

The socioeconomic factor included in this study (cohabiting vs not cohabiting parents) has previously been associated with SIDS in Scandinavia,^{2,19} but information about maternal smoking was not included in those studies. In the present study, the crude relative risk of SIDS was 1.9 in non-cohabiting families, but daily smoking was more common among non-cohabiting women. Adjusted for the effects of differences in smoking habits, the relative risk was reduced to 1.5 (95% CI = 0.8, 2.5). These data suggest that smoking is a confounding factor, through which at least some of the effects of social class on SIDS rate are mediated, at least in the homogeneous populations of Sweden, where poverty and malnutrition are practically non-existent.

The previously reported bimodal age distribution of SIDS^{2,5} led us to stratify the SIDS cases into early and late SIDS. The most striking difference in risk factor pattern between early and late SIDS was the influence of maternal smoking, a finding in accordance with Golding, *et al.*⁵ Early SIDS was more strongly related to maternal smoking. We suggest that the reported bimodal age distribution may partly reflect differences in maternal smoking.

Today, smoking is probably the most important preventable risk factor for late fetal death.^{13,20} The present results suggest that this may also hold true for SIDS. Assuming that maternal smoking could be eliminated and infants delivered by mothers who gave up smoking faced the same mortality risk as their non-smoking peers (i.e., same maternal age, parity, sex, etc.), we estimated that SIDS death rate would be reduced by 27 percent. In terms of number of SIDS deaths, this means a reduction from 190 deaths to approximately 140 deaths during a three-year period in Sweden.

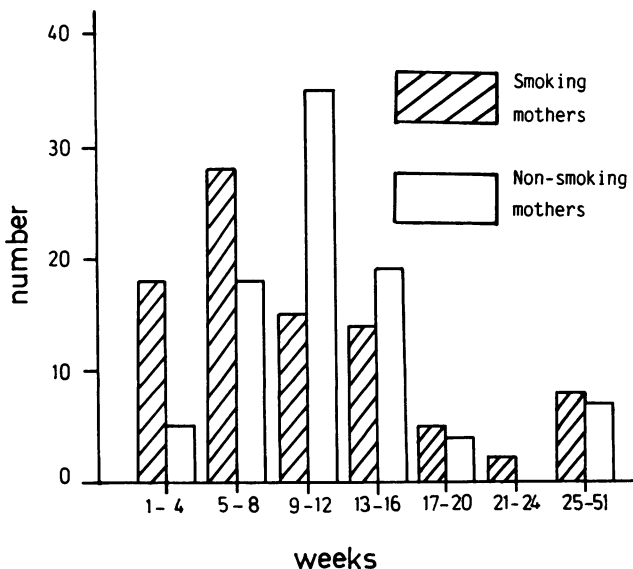


FIGURE 1—Age in Weeks of SIDS Infants in Sweden 1983–85 by Maternal Smoking Habits

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