

Changes in snuff and smoking habits in Swedish pregnant women and risk for small for gestational age births

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Objective To examine associations between antenatal exposure to Swedish oral moist snuff (which includes essentially only nicotine) and to smoking and risks of small-for-gestational-age (SGA) births and to compare risks among women who stopped or continued using snuff or smoking during pregnancy.

Design Population-based cohort study.

Setting Sweden.

Population All live singleton births in Sweden 1999–2010.

Methods Odds ratios (OR) with 95% confidence intervals (CI) were calculated using multiple logistic regression analysis.

Main outcome measures SGA birth, also stratified into preterm (≤ 36 weeks of gestation) and term (≥ 37 weeks of gestation) SGA births.

Results Compared with non-tobacco users in early pregnancy, snuff users and above all smokers in early pregnancy had increased risks of

SGA births: adjusted ORs (95% CI) were 1.26 (1.09–1.46) and 2.55 (2.43–2.67), respectively). Snuff use had, if anything, a stronger association with preterm SGA than term SGA, whereas the opposite was true for smoking. Compared with non-tobacco users, women who stopped using snuff before their first visit to antenatal care had no increased risks of preterm or term SGA, and women who stopped using snuff later during pregnancy had no increased risk of term SGA. Smoking cessation early in pregnancy was associated with a larger reduction in risk than smoking cessation later in pregnancy.

Conclusions As both smoking and snuff use influence risk of SGA, both nicotine but above all tobacco combustion products are involved in the mechanisms by which maternal smoking increases the risk of SGA.

Keywords Infant, nicotine, small for gestational age, smoking cessation, tobacco use cessation.

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Introduction

Small-for-gestational-age (SGA) infants, especially preterm SGA infants, have increased morbidity and mortality as well as long-term adverse health and developmental outcomes.^{1–3} Smoking during pregnancy is the single most important preventable risk factor for SGA in high-income countries.⁴ A causal relationship between smoking and fetal growth restriction is established,^{5,6} and women who stop smoking before or early in pregnancy reduce their risks of having a preterm or a term SGA infant.^{7,8} However, the mechanisms by which smoking affects fetal growth are unknown.

Use of oral moist snuff (Swedish *snus*) has increased among women in Sweden and other parts of the world, including India, South Africa, Bangladesh, Malaysia and Nepal.⁹ Fetuses prenatally exposed to maternal smoking are exposed to both nicotine and tobacco combustion products, whereas fetuses prenatally exposed to maternal snuff use are essentially only exposed to nicotine. Like smoking, use of Swedish snuff during pregnancy is associated with increased risks of stillbirth¹⁰ and preterm birth.^{11,12} However, previous studies have failed to show an association between prenatal exposure to Swedish snuff and risk of SGA,^{10,13} possibly because of modest effects and limited statistical power. In

addition, no study has examined whether cessation of the use of snuff or any other form of smokeless tobacco before or during pregnancy influences the risk of an SGA birth.

The Swedish Medical Birth Register provided access to nationwide information about tobacco habits 3 months before pregnancy, in early pregnancy, and in late pregnancy for the years 1999–2010. We used this information to perform a large population-based study to compare the risks of SGA among snuff users and smokers, and among women who stop using snuff or stop smoking shortly before first visit to antenatal care or later during pregnancy.

Methods

Study population

We used information from the Swedish Medical Birth Register, which contains data on more than 98% of all births in Sweden. Starting at the first antenatal visit, information is prospectively recorded on standardised antenatal, obstetric and neonatal records. Copies of these records are forwarded to the Medical Birth Register after delivery, where the information is computerised.¹⁴

At the first visit to antenatal care, which takes place before 15 weeks of gestation for more than 95% of the pregnancies,¹⁵ information on snuff use and smoking habits at 3 months before pregnancy and present tobacco use has been recorded by midwives since 1999.

To increase the homogeneity of the study population, we only included women born in the Nordic countries (i.e. women born in Sweden, Denmark, Norway, Iceland and Finland) who delivered a live singleton infant in Sweden during the years 1999 to 2010 ($n = 945,371$). Of these women, 98% were born in Sweden. We excluded 4010 pregnancies with missing information on birthweight or gestational age at delivery. Of the remaining 941,361 women, information on both prepregnancy and early pregnancy tobacco habits was available for 852,645 women (91%). Among them, 663,649 (78%) were non-tobacco users both 3 months before pregnancy and in early pregnancy. Among 23,514 women reporting that they used snuff 3 months before pregnancy, 60% of them had stopped using snuff before the first visit to antenatal care. Similarly, among 161,702 prepregnancy smokers, 53% of them had stopped smoking at the first visit to antenatal care.

The definition of SGA is a birthweight more than two standard deviations below the mean weight for gestational age according to the sex-specific Swedish fetal growth curves. These growth curves are based on repeated ultrasound measurements of fetal dimensions from three Swedish centres and one Danish centre.¹⁶ In Sweden, gestational age is assessed by ultrasound scans in 97% of women, usually around 17 weeks of gestation.¹⁷ If ultrasound scan is not

available in early second trimester, the last menstrual period is used to calculate gestational age at delivery.

To estimate the effects of snuff and smoking exposure and risks of SGA, women were grouped as follows: (1) nonusers of tobacco (nonusers of snuff and cigarettes both before and in early pregnancy); (2) women who stopped using snuff (used snuff before but not in early pregnancy); (3) current snuff users (used snuff both before and in early pregnancy); (4) women who stopped smoking (smoked before but not in early pregnancy); and (5) current smokers (smoked both before and in early pregnancy). These groups included more than 99% ($n = 846,411$) of women with available information about tobacco habits ($n = 852,645$).

In gestational weeks 30–32, a second interview about current tobacco habit was obtained, using the same categorisation of tobacco habits as at the first antenatal visit. To be able to estimate whether changes in tobacco habits after early pregnancy affect the risk of term (≥ 37 completed weeks of gestation) SGA birth, we created a second study population, including women with term births (≥ 37 weeks of gestation). For 812,402 women with term births and information about tobacco habits in early pregnancy, information about tobacco habits in gestational weeks 30–32 was lacking for 32,919 women. Similar to our first study population, our second study population was divided into five groups: (1) non-tobacco users (nonusers of snuff and cigarettes, both in early and in late pregnancy); (2) women who stopped using snuff (used snuff in early but not in late pregnancy); (3) current snuff users (used snuff both in early and in late pregnancy); (4) women who stopped smoking (smoked in early but not in late pregnancy); and (5) current smokers (smoked both in early and in late pregnancy). Our second study population consisted of 767,375 women with term births.

Complications before pregnancy were classified according to the International Classification of Diseases, 10th version (ICD-10), as noted by the responsible doctor at discharge from hospital. Pregestational diabetes was identified at the first antenatal visit or by the ICD-10 codes O240 and O243 reported at discharge. Essential hypertension was identified at the first antenatal visit or by the ICD-10 codes O10 and O11 reported at discharge. Preterm birth was defined as a delivery before 37 completed weeks of gestation and term birth as a delivery at 37 weeks or later.

Information on body mass index (BMI) and height was collected at the first antenatal visit and information about maternal age and parity was collected at delivery. Information about mother's highest level of formal education was obtained through individual record linkage to the Education Register (31 December 2010), using the person-unique Swedish National Registration Number. The study was approved by one of the Regional Ethical Review Boards in Stockholm, Sweden.

Statistical analysis

Multivariable logistic regression analysis was used to estimate the association between tobacco habits and risk of SGA. Odds ratios (OR), presented with 95% confidence intervals (95% CI), were calculated before and after adjustments for potential confounders. Using women registered as non-tobacco users both before and in early pregnancy as the reference group, we estimated the risk of SGA among women who continued to use snuff, stopped using snuff, continued to smoke, or stopped smoking. Similarly, using women registered as non-tobacco users both in early and in late pregnancy as the reference group, we estimated the risk of term SGA among women who continued to use snuff, stopped using snuff, continued to smoke, or stopped smoking. Maternal age at delivery, parity, early pregnancy BMI, height, whether the woman was living with the father-to-be, education, pregestational diabetes and essential hypertension were considered as potential confounders, and observations with missing information on covariates were excluded from the multivariable analyses. All analyses were performed using the STATISTICAL ANALYSIS SOFTWARE (SAS) version 9.2 (SAS Institute, Inc., Cary, NC, USA). Because observations are not independent in women who delivered more than one singleton infant during the study period, we calculated estimates using clustered data in the generalised estimation equation method (PROC GENMOD).

Results

In total, 2.0% of births were SGA births, of which 0.4% were preterm SGA births (before 37 weeks) and 1.6% were term SGA births (Table 1). Compared with non-tobacco users, women who had stopped using snuff at registration to antenatal care had a slightly lower overall rate of SGA births. Women who had stopped smoking at registration for antenatal care had slightly higher rates of overall SGA births and term SGA births than non-tobacco users. Current snuff users in early pregnancy had higher rates of overall SGA, preterm SGA and term SGA births than both non-tobacco users and women who stopped using snuff. Current smokers in early pregnancy had substantially higher rates of overall SGA, preterm SGA and term SGA births than non-tobacco users and women who stopped smoking. High rates of SGA births were also found among the youngest mothers, primiparous women, underweight women ($\text{BMI} \leq 19.9$), short women (<165 cm), women not living with the father-to-be, women with low (≤ 12 years) education and women with essential hypertension.

Associations between tobacco exposure in early pregnancy and risk of SGA are presented in Tables 2 and 3. Compared with nonusers in early pregnancy, women who had stopped using snuff had a slightly reduced risk of SGA birth in the adjusted analyses (Table 2). Women who had stopped

smoking before their first visit to antenatal care had a risk of SGA birth similar to non-tobacco users. Women who continued to use snuff had a 30% increased risk of SGA, whereas the corresponding risk among women who continued to smoke was more than doubled.

Compared with non-tobacco users in early pregnancy, women who had stopped using snuff had slightly reduced risks of preterm and term SGA birth in the adjusted analyses (Table 3). Women who stopped smoking had a reduced risk of preterm SGA birth, but a slightly increased risk of a term SGA birth. Compared with non-tobacco users, women who continued to use snuff had increased risks of preterm and term SGA, and snuff use was, if anything, more associated with a risk of preterm SGA than term SGA. Compared with non-tobacco users, women who continued to smoke had substantially higher risks of preterm SGA and especially term SGA births.

Of 735,756 women with term pregnancies and information on tobacco habits, both from the first antenatal visit and from 30 to 32 weeks of gestation, 2.0% had SGA births (Table 4). Compared with non-tobacco users in early and late pregnancy, risk of term SGA birth was not increased in women who stopped using snuff from early to late pregnancy. In contrast, women who smoked in early pregnancy but stopped smoking in late pregnancy had an 80% higher risk of term SGA births than non-tobacco users. Women who continued to use snuff had a 30% increased risk of SGA, whereas the corresponding risk among women who continued to smoke was more than tripled.

Discussion and Conclusion

In this nationwide Swedish study, we found that use of oral moist snuff during pregnancy (including essentially only nicotine) increased the risk of an SGA birth, although antenatal exposure to maternal smoking (including exposure to both nicotine and tobacco combustion products) conferred a substantially higher risk of SGA birth. Compared with non-tobacco users, women who stopped using snuff in early pregnancy had a slightly reduced risk of an SGA birth, and women who stopped using snuff later during pregnancy had a risk of term SGA birth similar to non-tobacco users. Our study also confirms previous findings that smoking cessation during pregnancy decreases the risk of an SGA birth,^{7,8} especially if women stop smoking early in pregnancy.

Previous studies have failed to show a significantly increased risk of SGA associated with prenatal exposure to snuff,^{10,13} and other studies have reported modest but non-significant reductions in birthweight among snuff users.^{18,19} These findings probably stem from small sample sizes and lack of statistical power. However, one Indian study found that smokeless tobacco (mainly *mishri*) was associated with a significant reduction in birthweight and an increased risk of

Table 1. Numbers and rates of SGA by maternal characteristics. Women with live single births in Sweden, 1999–2010

Maternal characteristics	Total number <i>n</i>	Overall SGA		Preterm SGA		Term SGA	
		<i>n</i>	Rate (%)	<i>n</i>	Rate (%)	<i>n</i>	Rate (%)
Total	846,411	17,340	2.0	3607	0.4	13,733	1.6
Tobacco habits		0					
Nonuser	663,649	11,697	1.8	2592	0.4	9105	1.4
Stopped using snuff	14,093	237	1.7	47	0.3	190	1.3
Current snuff user	9129	207	2.3	53	0.6	154	1.7
Stopped smoking	85,181	1780	2.1	333	0.4	1447	1.7
Current smoker	74,359	3419	4.6	582	0.8	2837	3.8
Maternal age (years)							
≤ 19	13,297	466	3.5	85	0.6	381	2.9
20–24	98,448	2379	2.4	441	0.4	1938	2.0
25–29	259,170	5110	2.0	1014	0.4	4096	1.6
30–34	306,799	5686	1.9	1170	0.4	4516	1.5
≥ 35	168,696	3699	2.2	897	0.5	2802	1.7
Missing	1	0	0.0	0	0.0	0	0.0
Parity							
1	384,359	11,273	2.9	2240	0.6	9033	2.4
2	312,621	3880	1.2	860	0.3	3020	1.0
≥ 3	149,431	2187	1.5	507	0.3	1680	1.1
Body mass index							
≤ 19	74,009	2216	3.0	337	0.5	1879	2.5
20.0–24.9	428,436	8374	2.0	1618	0.4	6756	1.6
25.0–29.9	194,469	3522	1.8	808	0.4	2714	1.4
≥ 30	87,909	1926	2.2	579	0.7	1347	1.5
Missing	61,588	1302	2.1	265	0.4	1037	1.7
Height							
<165 cm	273,861	8050	2.9	1584	0.6	6466	2.4
165–174.9	463,045	7938	1.7	1703	0.4	6235	1.3
≥ 175	94,312	990	1.0	236	0.3	754	0.8
Missing	15,193	362	2.4	84	0.6	278	1.8
Living with the father-to-be							
Yes	796,544	15,703	2.0	3304	0.4	12,399	1.6
No	40,500	1396	3.4	263	0.6	1133	2.8
Missing	9367	241	2.6	40	0.4	201	2.1
Education (years)							
≤ 9	60,333	1818	3.0	345	0.6	1473	2.4
10–12	364,135	8041	2.2	1711	0.5	6330	1.7
13–14	116,627	2119	1.8	471	0.4	1648	1.4
≥ 15	302,929	5284	1.7	1068	0.4	4216	1.4
Missing	2387	78	3.3	12	0.5	66	2.8
Pregestational diabetes							
Yes	6398	102	1.6	36	0.6	66	1.0
No	840,013	17,238	2.1	3571	0.4	13,667	1.6
Essential hypertension							
Yes	5987	404	6.7	185	3.1	219	3.7
No	840,424	16,936	2.0	3422	0.4	13,514	1.6

low birthweight.²⁰ However, as there are differences in the ingredients of *mishri* and Swedish snuff, as well as major sociodemographic and cultural differences between the populations, it is uncertain how these results should be interpreted.

Snuff use and smoking generate similar plasma nicotine levels, but the peak generated by smoking has a longer duration.²¹ Smoking also entails a large number of combustion products.²² Smoking was associated with a 2.5-fold increased risk of SGA whereas snuff use was associated

with a 30% increase in risk, so the effect of tobacco combustion products on fetal growth is likely to be greater than that of nicotine.

Although it is generally agreed that there is a causal association between prenatal smoking exposure and fetal

growth restriction, the mechanisms and balance between nicotine and tobacco smoke combustion products remains unclear.⁶ Nicotine is likely to cause placental vasoconstriction²³ by changing the balance of vasoactive factors released by trophoblast cells and umbilical vein endothelial cells.²⁴ The majority of experimental animal studies also show that nicotine reduces fetal blood flow.²⁵ The carbon monoxide included in tobacco combustion products forms carboxyhaemoglobin, which inhibits the release of oxygen into fetal tissues.²⁵ We found that smoking was more associated with term than preterm SGA births, and that snuff use was, if anything, more associated with preterm than term SGA births. We can only speculate as to whether tobacco combustion products predominantly influence fetal growth late during pregnancy and whether nicotine, by influencing placentation, predominantly influences fetal growth in early pregnancy.

The snuff-related risks of SGA in our study indicate that nicotine is likely to play a role in the aetiology of intrauterine growth restriction. Like snuff, nicotine replacement therapy (NRT) mainly contains nicotine. Usually, NRT generates lower nicotine levels than smoking and probably also snuff, but nicotine level remains continuously high during use.²⁶ To provide NRT to smokers is discussed as one possibility for harm reduction during pregnancy. However, there is still insufficient evidence for the safety of NRT.^{27–29} The findings that antenatal exposure to snuff (including essentially only nicotine) increases the risks of preterm birth,^{11,12} stillbirth,¹⁰ and now in the present study also SGA birth, suggest that NRT should not be regarded as an alternative to smoking during pregnancy.

In this nationwide study, we included information on more than 800,000 women. Information on both snuff use and smoking before and in early pregnancy were recorded in early pregnancy, which precludes recall bias. We were also able to adjust for effects of possible confounders, such as maternal age, parity, BMI and social factors. However, information on

Table 2. Crude and adjusted odds ratios for SGA by change of tobacco habits in early pregnancy

	Crude odds ratio (95% CI)	Adjusted odds ratio (95% CI)*
Nonuser (reference group)	1.0	1.0
Snuff user/nonuser	0.97 (0.85–1.11)	0.86 (0.75–0.98)
Snuff user/snuff user	1.31 (1.13–1.51)	1.26 (1.09–1.46)
Smoker/nonuser	1.17 (1.11–1.24)	1.03 (0.98–1.09)
Smoker/smoker	2.69 (2.58–2.80)	2.55 (2.43–2.67)

*Odds ratios were adjusted for maternal age, parity, early pregnancy body mass index, maternal height, cohabitation, education, pregestational diabetes and essential hypertension.

Table 3. Crude and adjusted odds ratios for preterm and term SGA by change of tobacco habits in early pregnancy

	Preterm SGA (≤ 36 weeks) Odds ratio (95% CI)*	Term SGA (>37 weeks) Odds ratio (95% CI)*
Nonuser (reference group)	1.0	1.0
Snuff user/nonuser	0.80 (0.60–1.08)	0.87 (0.75–1.02)
Snuff user/snuff user	1.50 (1.13–1.98)	1.21 (1.02–1.43)
Smoker/nonuser	0.86 (0.76–0.98)	1.07 (1.01–1.14)
Smoker/smoker	1.85 (1.67–2.06)	2.76 (2.62–2.91)

*Odds ratios were adjusted for maternal age, parity, early pregnancy body mass index, maternal height, cohabitation, education, pregestational diabetes and essential hypertension.

Table 4. Rates of term SGA by change of tobacco habit from early to late pregnancy

Tobacco habits (early/late pregnancy)	Total term births (n = 735,756)	Term SGA (n = 14,897)		Crude OR (95% CI)	Adjusted OR (95% CI)*
		n	Rate (%)		
Nonuser (reference group)	699,831	10,197	1.46	1.0	1.0
Snuff user/nonuser	5420	86	1.59	1.10 (0.88–1.38)	1.08 (0.86–1.35)
Snuff user/snuff user	2396	46	1.92	1.31 (0.96–1.78)	1.38 (1.01–1.88)
Smoker/nonuser	17,536	499	2.85	2.01 (1.83–2.21)	1.82 (1.65–2.01)
Smoker/smoker	42,192	1900	4.50	3.18 (3.02–3.36)	3.21 (3.02–3.40)

*Odds ratios were adjusted for maternal age, parity, early pregnancy body mass index, maternal height, cohabitation, education, pregestational diabetes, and essential hypertension.

tobacco exposure 3 months before pregnancy was collected retrospectively by a midwife at the first visit to antenatal care. Information on smoking exposure in early and late pregnancy was prospectively collected, but we had no access to biological samples to validate this self-reported information. Women who stop smoking early in pregnancy may later resume smoking.³⁰ The validity of self-reported smoking during pregnancy is acceptable in Sweden,³⁰ but self-reported information about snuff use has not been validated. Gestational age was based on an early second-trimester ultrasound scan, and earlier ultrasound scanning may have improved our pregnancy dating.³¹ Hence, in pregnancies with early fetal growth restriction, we may have underestimated gestational age and, if anything, also smoking and snuff-related risks of SGA. Also, tobacco-related risk may have been influenced by unmeasured health-related factors with different distributions among tobacco users and non-tobacco users. For example, compared with non-tobacco users, snuff users and especially smokers are more likely to have low education level and be overweight or obese during pregnancy.¹⁰ These variables were accounted for in the adjusted analyses, but it raises the possibility of residual confounding, especially among smokers. Women who continue to use snuff during pregnancy may be more health conscious than smokers, but probably not more health conscious than non-tobacco users, which was our reference group.

In conclusion, both smoking, and to a lesser extent use of oral moist snuff, during pregnancy increase the risk of an SGA birth. These findings suggest that both nicotine and tobacco combustion products are involved in the mechanisms by which maternal tobacco use during pregnancy increases the risk of SGA birth, and that products containing nicotine should be avoided during pregnancy.

Disclosure of interests

None declared.

Contribution to authorship

SB analysed and interpreted the data, drafted the first draft of the manuscript, and provided statistical expertise. A-KW designed the study's analytic strategy and critically revised the manuscript. OS acquired the data and critically revised the manuscript. SC conceived and designed the study, interpreted the data, and critically revised the manuscript.

Details of ethics approval

The study was approved by one of the Regional Ethical Review Boards in Stockholm, Sweden: reference number: 2009/1726-32, date of approval 27 October 2009. The board did not require the women to provide informed consent.

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