

Adolescent smoking in pregnancy and birth outcomes

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Introduction: Cigarette smoking amongst pregnant adolescents is a preventable risk factor associated with low birthweight (<2500 g), preterm birth (<37 weeks) and infant mortality. The aim of this study was to compare birth outcomes of adolescents who smoke during pregnancy with those who do not and to construct their birthweight-for-gestational-age curves. **Methods:** A retrospective cohort analysis of 534 adolescents (≤ 19 years) and 8972 adults who delivered singleton births between 1998–2003 at the Liverpool Women's Hospital. **Results:** Adolescent pregnancy occurred in 5.6% of deliveries. Mean age of adolescents was 18.1 years (SD = 1.0) and 46.2% smoked during pregnancy including 83.5% light smokers (<10 cigarettes daily). Babies born to adolescent smokers were significantly lighter by -170 g ($P = 0.005$). The prevalence of low birthweight was almost double in adolescents who smoked (12.1% versus 6.8%, RR = 1.7; CI = 1.0–3.0), and their mean Apgar scores at 5 min were lower (<0.05). A higher prevalence of preterm birth ($P < 0.05$) and maternal anaemia ($P < 0.01$) occurred amongst adolescent smokers. Adolescents smoking >10 cigarettes daily had babies with larger birthweight reduction ($P = 0.001$). **Conclusion:** Almost half of all adolescents smoked during their pregnancy. Birthweight-for-gestational-age curves of smoking adolescents showed a marked fall-off in weight from 36 weeks of gestation, and at least 10% of adolescent smokers showed fetal growth restriction from before 32 weeks of gestation.

Keywords: adolescent, birth outcome, pregnancy, smoking

Introduction

Cigarette smoking during pregnancy amongst adolescents has been reported as a common risk factor for low birthweight (LBW), preterm birth, fetal growth restriction, infant mortality, and congenital abnormality.^{1–4}

The United Kingdom had the highest adolescent birth rate amongst European countries at 30.8 per 1000 births.⁵ In 2000 in England, nearly 39 000 under 18 year olds became pregnant. Although in 2001 the gestation rate in adolescents had decreased by 4%, the prevalence of cigarette smoking was unchanged or increased.⁶ A previous analysis of the effects of smoking on birthweight-for-gestational-age curves in teenage and adult primigravidae showed lower mean birthweight at all gestational ages in adolescents who smoked during pregnancy, although sample size for mothers <37 weeks of gestation was relatively small.⁷

This study aimed to describe pregnancy outcomes and birthweight-for-gestational-age growth patterns in relation to smoking practices for a large sample of adolescent pregnancies. The study describes for the first time adolescent smoking habits and their adverse effects in Liverpool, an area where adolescent pregnancy rates have doubled between 1998 and 2003.

Methods

This was a hospital-based retrospective study using data of delivery records available at the Liverpool Women's Hospital. The first 500 records from each month for the first 3 months of each year between 1998 and 2003 were obtained. This provided

a sample of 534 adolescent and 8972 adult delivery records. The sample included mothers who delivered live singleton births and whose delivery records had been entered on the hospital database. Mothers with disorders such as hypertension, eclampsia, pre-eclampsia, and those who delivered more than once during the study period and those with multiple pregnancy were excluded.

Data was available on maternal age, body weight, haemoglobin level, gestational age (by ultrasound), parity, gravidity, and ethnicity. Smoking status was determined from the self-reported smoking record in the hospital booking form. The number of cigarettes reported as smoked daily was also available.

A smoker was a mother who smoked at least one cigarette a day during pregnancy. Adolescence was defined as ≤ 19 years of age, gestational age as the number of completed weeks of gestation based on the estimated delivery date as determined by ultrasound examination, LBW as <2500 g, preterm birth as <37 weeks of gestation, and maternal anaemia as haemoglobin <11 g/dl. Apgar scores were recorded based on a 0–10 scale at the first and fifth minute after birth, and a low score was taken as <7.

Continuous variables were summarised using means and standard deviations (SDs). Chi-square, analysis of variance (ANOVA), and independent sample *t*-tests were performed to compare differences between categories. Probability values were two tailed and the significance level was 0.05. A stepwise logistic regression model was conducted to determine factors associated with LBW and preterm birth. The risk between different groups was compared for each outcome using the relative risk (RR) and 95% confidence interval (CI). ANOVA was used to compare differences in birth outcomes between smoking and non-smoking groups. The LMS program (version 1.16)⁸ and Excel statistical software were used for calculating and representing age-related reference centiles. The method assumes data can be normalised, which stretches one tail of the distribution and shrinks the other to remove skewness. This method normalises trends by a smooth (*L*) curve. Trends in the mean (*M*) and coefficient of variation (*S*) were similarly smoothed. Optimal smoothing values for the model were $\text{edf}(M) = 5$, $\text{edf}(S) = 2$, and $\text{edf}(L) = 0$, which corresponded to a normal conditional reference distribution for all gestational ages.

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The study was granted ethical approval by Ethical Committees at the Liverpool Women's Hospital, and the Liverpool School of Tropical Medicine.

Results

Of 9506 records screened from 1998 to 2003, 5.6% ($n = 534$) were adolescents. Of these adolescents, 46.2% smoked during pregnancy. The proportion with missing information on maternal smoking was 6.7%. All gestational ages and pregnancy outcome data on 99.1% of births were available. Annual adolescent pregnancy rates and the proportion of smokers are summarised in table 1. The adolescent pregnancy rate had significantly increased from 3.3% in 1998 to 8.2% in 2003 ($P < 0.0001$). Smoking prevalence fluctuated over the same period and was not uniform with an average of 46.2% (from 45.2% in 1998 to 46.3% in 2003).

Mean maternal age, weight at first antenatal visit, haemoglobin, and gestational age at delivery and their SDs in adolescents were 18.1 years (0.9), 63 kg (15.6), 11.6 g/dl (4.9),

Table 1 Annual percentage of adolescent pregnancies and their smoking prevalence

Year	Pregnancy % [n]	Smoking % (n)
1998	3.3 [1382]	45.2 (42)
1999	3.6 [1395]	47.7 (44)
2000	4.9 [1546]	40.6 (69)
2001	5.7 [1720]	51.1 (88)
2002	7.1 [1813]	45.5 (121)
2003	8.2 [1650]	46.3 (134)
All	5.6 [9506] ^a	46.2 (498) ^b

[n]: Sample size, all pregnancies; (n): Sample size, adolescent pregnancies

a: P -value for trend ($P < 0.0001$)

b: 6.7% of mothers omitted the question on smoking status

and 38.7 weeks (5.3), respectively. There were no significant differences between smoking and non-smoking groups for mean maternal weight and haemoglobin level at first attendance. The majority of adolescents were nulliparous (98.8%) and primigravidae (97.2%), and there were no significant differences between smoking and non-smoking adolescents for parity or gravidity. Ethnic groups included 87.6% for white Caucasians and 4.6% for blacks. There were no significant ethnic differences between smoking and non-smoking adolescents, or adults. The mean birthweight \pm SD of babies born to smokers was significantly lower than that for non-smokers (3146 ± 614 g, versus 3316 ± 659 g, $P = 0.005$). The prevalence of low Apgar scores (<7) was significantly increased amongst smoking than non-smoking adolescents (5.4% versus 3.0%, $P = 0.04$). The prevalence of LBW was 12.1 and 6.3% in smoking and non-smoking adolescents, respectively (RR = 1.7; 95% CI = 1.0–3.0).

Male babies born to adolescents had lower mean birthweight than females. This difference was not seen for babies of adults (table 2). The difference was largely due to shorter gestational age and increased preterm birth amongst male babies born to adolescent mothers. This gender-specific effect occurred for babies of both smokers and non-smokers, but was significant in univariate analysis only for non-smokers ($P < 0.01$). Regression analysis, which included maternal age, anaemia, smoking status, parity, and the child's sex, showed that adolescence ($P = 0.038$), smoking during pregnancy ($P < 0.001$), and parity ($P < 0.001$) were significantly associated with preterm birth. Whereas factors associated with LBW were smoking during pregnancy ($P < 0.001$) and parity ($P = 0.039$).

Adolescents who smoked >10 cigarettes daily had a shorter gestational age by 4 days compared with non-smokers (figure 1). The mean birthweight of adolescents who smoked >10 cigarettes daily was significantly reduced compared with non-smokers or those who smoked <10 cigarettes daily ($P < 0.001$) (figure 2).

Percentile curves of birthweight-for-gestational-age by smoking category were estimated (figure 3). The 10th centile for births of adolescent smokers was lower than for non-smokers at all gestational ages. Centile curves for the median birthweight (50th centile) before the 36th week of gestation were similar for the smoking and non-smoking adolescents. After 36 weeks

Table 2 Birth outcomes in smoking and non-smoking pregnant adolescents and adults

Child sex	Smokers				Non-smokers			
	Adolescents		Adults		Adolescents		Adults	
	Male	Female	Male	Female	Male	Female	Male	Female
LBW (%)	16.2 (111)	8.0 (112)	10.3 (1337) ^c	11.5 (1295)	9.9 (142)	3.3 (123) ^a	4.3 (2885) ^d	4.6 (2668)
Preterm birth (%)	14.4 (111)	9.8 (112)	10.6 (1336)	9.1 (1290)	12.7 (142)	4.1 (123) ^a	5.6 (2881) ^d	6.0 (2663)
Apgar score <7 at 1 min (%)	33.0 (109)	21.4 (112) ^a	18.2 (1338)	14.0 (1296) ^a	23.6 (140)	17.9 (123)	17.1 (2885)	14.0 (2668) ^a
Apgar score <7 at 5 min (%)	7.3 (109)	3.6 (112)	2.6 (1338)	2.2 (1296)	3.6 (140)	2.4 (123)	2.2 (2885)	1.9 (2668) ^a
Maternal anaemia (Hb < 11 g/dl)	39.4 (109)	43.5 (108)	25.3 (1295)	29.4 (1240) ^a	38.7 (137)	41.9 (117)	27.2 (2780)	28.8 (2568)
Mean gestational age \pm SD (days)	273 \pm 22	278 \pm 14 ^b	275 \pm 20	275 \pm 25	274 \pm 24	279 \pm 16 ^b	278 \pm 19	278 \pm 19
Mean birthweight \pm SD (g)	3136 \pm 731	3157 \pm 498	3198 \pm 600	3086 \pm 601 ^b	3299 \pm 755	3334 \pm 564	3509 \pm 610	3401 \pm 567 ^b

Brackets: Sample size

a: Differences between males and females $P < 0.03$ (chi-square test)

b: Differences between males and females $P < 0.001$ (independent sample, T -test)

c: Difference between smoking adolescent and adult babies $P = 0.06$ (chi-square test)

d: Difference between non-smoking adolescent and adult male babies, $P < 0.01$ (chi-square test)

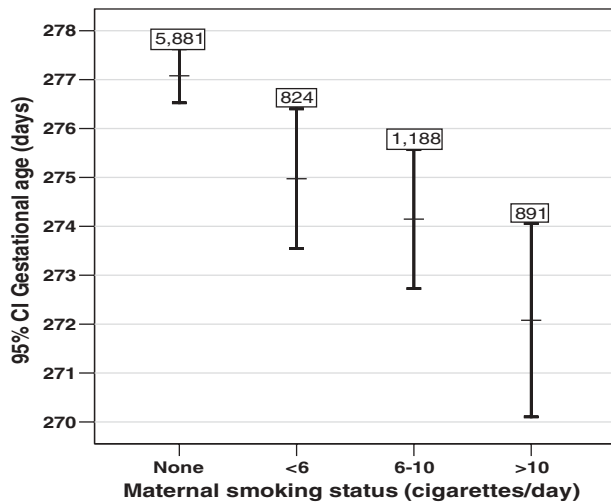


Figure 1 Mean gestational age (95% CI), and the number of cigarettes smoked daily by adolescents. Sample size above error bars

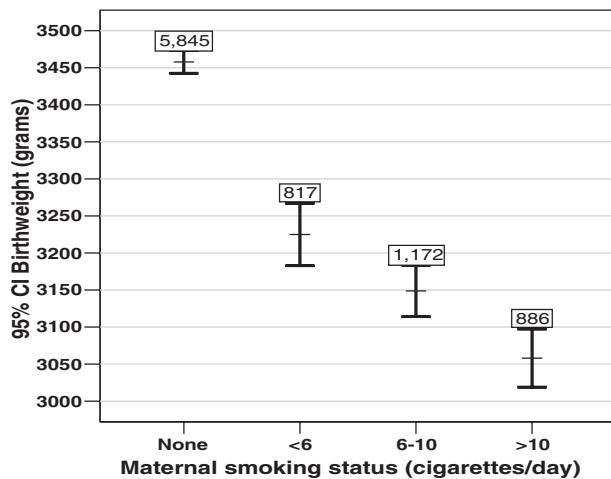


Figure 2 Mean birthweight (95% CI) and the number of cigarettes smoked daily by adolescents. Sample size above error bars

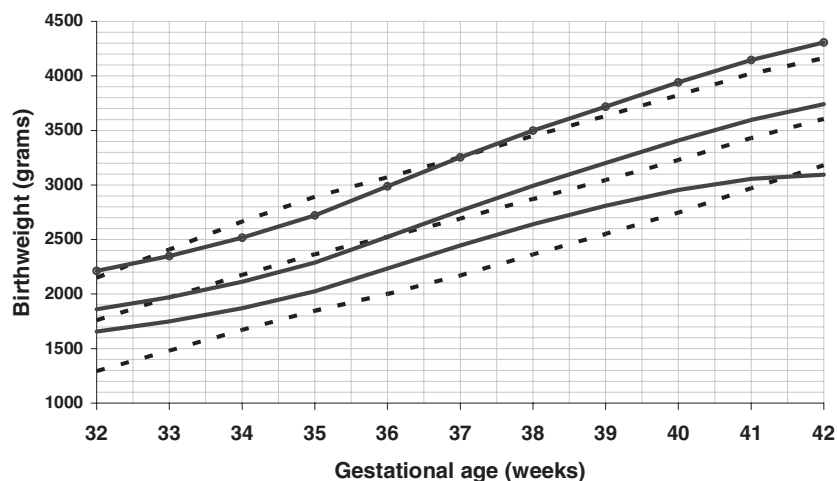


Figure 3 Birthweight-for-gestational-age curves (10th, 50th, and 90th centiles for babies born to smoking (dotted lines) and non-smoking (solid lines) adolescents

gestation the median centile for non-smokers increased above values for smokers.

Discussion

The Liverpool Women’s Hospital is the largest centre for deliveries in this region. The sample is likely to be representative as few deliveries occur at home and selection bias, which has been a concern with medical registries, should be minimal.⁹ Database records were available only from 1998 onwards. A total of 9506 records were obtained. Booking questionnaires given to pregnant women hospitalised for delivery included questions on demographic and smoking status variables and there was probably no emphasis on these behavioural questions in the antenatal care procedures. Smoking outcomes were not reported for 6.7%, which may have introduced some biases, although birthweights were available for 99.1%.

In this study, maternal self-reporting was used as an indicator of smoking during pregnancy. Epidemiologic studies of this type often rely solely on maternal self-reporting. Previous studies have shown a reasonable concordance between maternal self-reporting and metabolites of nicotine such as cotinine,¹⁰⁻¹³ and a previous study in the present population showed salivary cotinine was a sensitive indicator of maternal self-reported smoking as it related to their children’s cotinine level.¹⁴

The average adolescent pregnancy rate was 5.6%, which was an annual increase of 1% with a highly significant trend ($P < 0.0001$). In the USA, the proportion of infants delivered to this group of mothers was 13% in 1995,¹⁵ and in Sweden 3.6%.¹⁶ The sequentially increasing adolescent pregnancy rate in Liverpool is a major problem, and has occurred despite government action to introduce measures to reduce teenage pregnancy through local and national initiatives. It is unclear why this has occurred, and is compounded by the unchanged adolescent smoking prevalence during pregnancy. This increased slightly from 45.2% in 1998 to 46.3% in 2003 (not significant). In 2000, 33% of British women aged <19 years smoked, and just over one in three (35%) pregnant women smoked in the 12 months before their pregnancy.¹⁷ Of these, one in five smoked throughout pregnancy. Maternal smoking during pregnancy for all maternal ages has declined recently in the UK. The reduction amongst adolescents has been smaller and has increased in some instances.¹⁸ Others have reported that adolescents were more likely to smoke cigarettes during pregnancy than adults.^{19,20}

Adolescents who smoked during pregnancy delivered lighter babies (–170 g) with a higher prevalence of LBW. This is

comparable with previous findings from this population, for a smaller sample, covering the years 1997–1999.⁷ More than half of all adolescents (52%) in that study had smoked during pregnancy and the mean birthweight of babies born to smoking teenage mothers was 3112 g, which is below that in the present study (3146 g). The birthweight-for-gestational-age centile curves indicate that for those babies whose weights were above the 50th percentile, the weight reduction due to smoking exposure occurred after 36 weeks of gestation. In contrast, the 10th percentile curve for smoking adolescents remained consistently below the corresponding centile for non-smokers at all gestational ages, which suggests that some babies are at higher risk of growth restriction and from much earlier in pregnancy. This dichotomy could indicate that there are two forms of fetal growth restriction, which result from cigarette smoke exposure during pregnancy: a chronic form occurring from at least mid-pregnancy and a more acute form, which occurs towards term. The latter could relate to placental blood vessel constriction during the period of rapid weight gain from the 36th week of gestation, which would impair fetal nutrition.

A significant difference on frequency of low Apgar scores between babies of smokers and non-smokers was found. A Swedish study evaluating determinants of poor pregnancy outcomes amongst teenagers reported that 37.4% smoked during pregnancy, and that 2.2% were born to teenage mothers with an Apgar score <7 (5 min).²¹ Similar results are reported from Canada,¹ although in the present study the proportion with low Apgar scores (5 min) amongst smoking adolescents (5.4%) was higher. This may relate to the increased risk for low Apgar scores amongst LBW and preterm babies. A cross-sectional community-based survey in low socio-economic areas of Liverpool observed significantly higher numbers of preterm births in mothers who smoke during pregnancy and who were from socially deprived areas.²² Poor maternal education and poor understanding of smoking induced adverse birth outcomes could be related to these findings.

A positive association between young maternal age and smoking during pregnancy has been previously reported,^{16,19} although not in all studies.^{18,21} In the present analysis, adolescence was independently associated with preterm birth as well as smoking during pregnancy. This suggests that smoking patterns were established at younger ages and then maintained through adolescence. Mean gestational age was shortest in adolescents who smoked >10 cigarettes daily (figure 2).

Univariate analysis indicated a gender-specific effect on the male fetus of increased preterm birth and reduced birthweight (table 2). Usually male birthweights are on average higher than females. Gender-specific effects of *in utero* nicotine exposure have been described in experimental animals with males more adversely affected.²³ Related factors may be involved, as high caffeine consumption in the third trimester of pregnancy is also reported as restricting fetal growth to a greater extent in boys.²⁴

The prevalence of adolescent smoking during pregnancy in this study was higher than the average figure reported for British women,^{5,6,20} and no reduction in the proportion of adolescent smokers occurred over the 6 year period from 1998 to 2003. A major effort is required to influence smoking habits in this at risk group of young mothers.

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Key points

- Birth outcomes are compared amongst adolescents who smoke during pregnancy with those who do not.
- Birthweight-for-gestational-age curves of smoking adolescents showed marked fall-off in weight from 36 weeks of gestation with a male gender-specific effect.
- At least 10% of adolescent smokers showed fetal growth restriction from before 32 weeks of gestation.
- No reduction in the proportion of adolescent pregnant smokers occurred over the 6 year period from 1998 to 2003.
- Increased efforts are required to reduce adolescent smoking in pregnancy in this population.

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