ABSTRACT

Objectives: Children’s exposure to secondhand smoke (SHS) is causally linked to childhood morbidity and mortality. Over 38% of English children (aged 4–15) whose parents are smokers are exposed to SHS in the home. Little is known about the prevalence of SHS exposure in the homes of young infants (<3 months). This study aimed to estimate maternal self-reported prevalence of SHS exposure among infants of women who smoked just before or during pregnancy, and identify factors associated with exposure.

Setting: Primary Care, Nottingham, England.

Participants: Current and recent ex-smoking pregnant women (n=850) were recruited in Nottingham, England. Women completed questionnaires at 8–26 weeks gestation and 3 months after childbirth. Data on smoking in the home 3 months after childbirth was available for 471 households.

Primary and secondary outcome measures: Maternal-reported smoking in the home 3 months after childbirth.

Results: The prevalence of smoking in the home 3 months after childbirth was 16.3% (95% CI 13.2% to 19.8%) and after multiple imputation controlling for non-response 18.2% (95% CI 14.0% to 22.5%). 59% of mothers were current smokers; of these, 24% reported that smoking occurred in their home compared to 4.7% of non-smokers. In multivariable logistic regression, mothers smoking ≥11 cigarettes per day were 8.2 times (95% CI 3.4 to 19.6) more likely to report smoking in the home. Younger age, being of non-white ethnicity, increased deprivation and less negative attitudes towards SHS were also associated with smoking in the home.

Conclusions: This survey of smoking in the home 3 months after childbirth found a lower prevalence than previously reported in older children. Interventions to support smoking mothers to quit, or to help them restrict smoking in the home, should target attitudinal change and address inequality relating to social disadvantage, younger age and non-white ethnic groups.

BACKGROUND

Exposure to secondhand smoke (SHS) is the involuntary inhalation of other people’s cigarette smoke and globally, 40% of children are exposed. Children’s SHS exposure has been causally linked to respiratory tract infections, middle ear disease, sudden unexplained death in infancy and asthma. The WHO believes that SHS is a substantial threat to child health, and the US Surgeon General argues there is no safe exposure level.

In 2008, a study conducted in England reported 52% of children aged 4–15 whose parents were smokers were exposed to SHS in the home. This has reduced in recent years, with a reported 38.7% of children of smoking parents aged 4–15 years being exposed to SHS in the home in England in 2012, however it clearly remains a significant problem. Similar trends have been observed elsewhere, both in the UK and internationally (eg, USA; Ireland, France, Germany and the Netherlands). However, current UK prevalence estimates for
children’s SHS exposure in the home focus on children aged >4 years, and most studies include children aged 10–11 years. There is therefore little research examining SHS exposure in the home among young infants (≤3 months) and few prevalence estimates. We are aware of only one UK study estimating the prevalence of SHS among young infants. Among children of smokers, 82% of infants (average age 3 months) experienced SHS exposure in the home. Elsewhere, we are aware of just two studies, from the USA, in which 10.8–21.4% of infants of smoking mothers aged ≤9 months were exposed to SHS in the home and 24.5% were exposed to SHS for ≥1 h per day. Although these studies suggest SHS exposure may be a substantial issue, they were conducted prior to, or around the time that comprehensive smoke-free legislations were introduced. There are no contemporary estimates of prevalence in this age group. Additionally, of 41 studies investigating factors associated with children’s SHS exposure in the home identified by systematic review, only three included infants or children aged <2 years. This review found parental smoking, low socioeconomic status (SES) and being less educated were all consistently independently associated with children’s SHS exposure in the home. However, due to the small number of studies focusing on younger age groups, little is known about the influences on SHS exposure in the home experienced by young infants; consequently, this paper reports the prevalence of SHS exposure among young infants born to women from an English pregnancy cohort, and identifies factors associated with this exposure.

METHODS

This study presents secondary analysis on data collected as part of the longitudinal cohort, the Pregnancy Lifestyle Survey (PLS); methods and cohort characteristics have been described in detail previously. The study received a favourable opinion from Derbyshire Research Ethics Proportionate Review Sub-Committee (reference 11/EM/0078).

Participants

The baseline sample size for the PLS was 850, based on the cohort’s primary aim to estimate the proportion of smokers who initiate quit attempts in the second or third trimester of pregnancy. Women who were aged ≥16 years, between 8 and 26 weeks pregnant, and self-reported being current smokers or having smoked in the 3 months prior to pregnancy were eligible for participation.

Recruitment and data collection

Participants were recruited between August 2011 and August 2012 at two antenatal clinics within Nottingham University Hospitals NHS Trust, England. Participants completed a baseline questionnaire in the antenatal clinic when they were between 8 and 26 weeks gestation, and a follow-up questionnaire when their baby was 3 months old. At Follow-up, hospital administration staff obtained participants’ delivery dates from their antenatal records. Participants were sent a questionnaire 3 months after their delivery date by post or email; if not returned, completion by telephone was attempted.

The questionnaires have been described elsewhere. In summary, both the baseline and the follow-up questionnaires were similar in format and content, using yes/no, multiple choice and five-point Likert items. The baseline questionnaire was divided into six sections: screening questions, health and pregnancy, smoking beliefs, current smoking behaviour, interest in getting help to stop smoking and sociodemographic information. At the 3-month follow-up, the same topics were covered but edited to reflect women’s postnatal status. Additional questions about smoking in the home, and beliefs about harm caused to infants and children through SHS exposure were included.

Outcomes

The primary outcome measure was maternal-reported smoking by either themselves or someone else in their home 3 months after childbirth, using participants’ responses to the questions ‘how often do you smoke in your home nowadays?’ and ‘how often do other people smoke in your home nowadays?’. Responses used Likert items ranging from 1 (‘never’) to 5 (‘very often’). A binary outcome was created, where participants who responded ‘almost never’ to ‘very often’ (2–5 on scale) to either of these questions were considered to have smoking in the home 3 months after childbirth, and participants who responded ‘never’ to have a smoke-free home.

The maternal sociodemographic characteristics of age, ethnicity, highest qualification, age left full-time education and current employment status were taken from baseline questionnaires. Age left full-time education was categorised as ≤16 years (UK age of compulsory education), >16 years and still in full-time education. Ethnicity was categorised as a binary variable (white British vs other ethnicity) due to small numbers of participants in non-white British ethnic groups. A measure of socioeconomic status (SES) was created by mapping participants’ postcodes with corresponding 2007 Indices of Multiple Deprivation (IMD) scores, taken from routine UK Data Service data. The 2007 IMD measures a range of domains reflecting economic, social and housing issues, where higher scores reflect greater deprivation. Scores were divided into tertile groups.

Participant’s self-reported smoking behaviour was measured at both time points. Women were categorised as being a non-smoker, or smoking 0–5, 6–10, ≥11 cigarettes per day. Heaviness of smoking index (HSI) scores were calculated using the method described by
Borland et al. Partner smoking status at 3 months after childbirth was categorised as non-smoker, smoker or not applicable/no partner.

Attitudes to children’s SHS exposure were measured by asking participants the extent to which they agreed with four attitudinal statements using Likert items (figure 1). The items had high-internal consistency (Cronbach’s α=0.9),26 and so responses were combined into a single summed score (out of 20), whereby a higher score reflected a more negative attitude towards children’s SHS exposure. Attitude scores were highly negatively skewed, and so were categorised into a binary variable; a score of ≥15 represented ‘negative attitudes towards child SHS exposure’ and a score of <15 ‘less negative attitudes towards child SHS exposure’.

Data analysis
Statistical analyses were conducted using Stata V.13.27 Cohort characteristics and the characteristics of responders and non-responders at 3 months after childbirth are presented, and differences examined using χ² tests for categorical data and t tests for continuous data. The prevalence of smoking in the home was estimated using those with complete data; given that there was a high level (50%) of missing data at 3 months after childbirth and observed differences in the characteristics of responders and non-responders, multiple imputation methods28 were used to impute values for missing outcome data. Five imputed data sets were considered sufficient29 and were constructed using the mi command in Stata, based on the following baseline variables: smoking behaviour, HSI, age, ethnicity, qualifications, employment, IMD score and partner smoking status. These variables were selected based on characteristics associated with child SHS exposure in the home in a previous systematic review20 and variables associated with non-response.30 The imputed outcome variable was only used for estimates of smoking in the home; all other analyses were conducted using the original non-imputed outcome variable.

The variables smoking behaviour at baseline, smoking behaviour 3 months after childbirth and baseline HSI. Smoking behaviour at 3 months after childbirth was most strongly associated with the outcome measure, and was therefore included in the multivariable analyses and the other smoking variables omitted to avoid collinearity. Similarly, highest qualification and age left full-time education were considered in the multivariable analysis independently due to collinearity. Those variables reaching significance (p<0.05) were retained in the model, and non-significant variables re-entered into the model sequentially. Participants with missing data for exposure variables were excluded from multivariable analysis (n=6). ORs, 95% CI, and likelihood ratio test p values and Wald’s p values for trend for ordered categorical exposure variables are reported.

RESULTS
Cohort characteristics
The cohort consisted of 850 pregnant women, of which 56.6% were current smokers at baseline (table 1). The demographic profile of smokers within the cohort was similar to other UK pregnancy cohorts.23

Follow-up response rates
At follow-up, the response rate was 56% (n=476) after non-response and withdrawal (figure 2). Owing to missing data in some of the returned questionnaires, smoking in the home information was available for 471 participants. Table 1 shows the characteristics of women who did and did not respond to the follow-up questionnaire 3 months after childbirth.

1) If my baby regularly breathes in people’s tobacco smoke, it can seriously harm him/her
2) Smoking in the home can seriously harm babies (under 1 year old)
3) Smoking in the home can seriously harm children (over 1 year old)
4) Smoking in the home but not in the same room as a baby can seriously harm him/her

Rated using a 5-point Likert scale, 1 being ‘not at all’ and 5 being ‘extremely’
Smoking in the home 3 months after childbirth: prevalence and determinants

The ‘raw’ prevalence of smoking in the home 3 months after childbirth was 16.3% (95% CI 13.2% to 19.8%). At this time, 59% of mothers were current smokers; of these, 24% reported smoking in the home compared to 4.7% of non-smokers (table 2). After controlling for non-response bias using multiple imputation methods, prevalence of smoking in the home 3 months after childbirth was 18.2% (95% CI 14.0% to 22.5%).

Table 2 shows the results of univariate analysis for factors associated with smoking in the home 3 months after childbirth, using non-imputed data. The strongest observed associations were for maternal smoking at 3 months after childbirth; those mothers smoking \( \geq 11 \) cigarettes per day were 10.5 times more likely to report that smoking occurred in their home compared to non-smoking mothers at this time point. Maternal age, ethnicity, highest qualification, age left full-time education, IMD, partner smoking status and attitudes towards child

### Table 1 Cohort characteristics and comparison between responders and non-responders at 3 months postnatal

| Characteristic                                                                 | All cohort N=850 | Responders at 3 months postnatal N=476 | Non-responders and withdrawals at 3 months postnatal N=374 | p Value |
|--------------------------------------------------------------------------------|------------------|----------------------------------------|-------------------------------------------------------------|---------|
| Smoking behaviour baseline                                                     |                  |                                        |                                                             |         |
| Recent ex-smoker                                                              | 362 (43.4)       | 235 (50.1)                             | 127 (34.7)                                                  |         |
| \( \leq 5 \) cigarettes per day                                               | 191 (22.9)       | 105 (22.4)                             | 86 (23.5)                                                   |         |
| \( 6-10 \) cigarettes per day                                                 | 151 (18.08)      | 71 (15.1)                              | 80 (21.9)                                                   |         |
| \( \geq 11 \) cigarettes per day                                              | 131 (15.4)       | 58 (12.4)                              | 73 (20.0)                                                   | \(<0.0001\) |
| Age (years) Mean (SD)                                                         | 25.8 (5.5)       | 26.5 (5.6)                             | 24.8 (5.3)                                                  | \(<0.0001\) |
| Ethnicity                                                                     |                  |                                        |                                                             |         |
| White British                                                                 | 751 (89.0)       | 421 (89.0)                             | 330 (89.0)                                                  |         |
| Other ethnicities                                                              | 93 (11.0)        | 52 (11.0)                              | 41 (11.1)                                                   | 0.0007  |
| Highest qualification                                                         |                  |                                        |                                                             |         |
| No qualifications                                                             | 155 (18.2)       | 62 (13.0)                              | 94 (25.1)                                                   |         |
| GCSEs or equivalent                                                           | 355 (41.8)       | 184 (38.7)                             | 171 (45.7)                                                  |         |
| AS/A-Levels or equivalent                                                     | 174 (20.5)       | 118 (24.8)                             | 56 (15.0)                                                   |         |
| Degree or equivalent                                                          | 133 (15.7)       | 95 (20.0)                              | 38 (10.2)                                                   |         |
| Other qualification                                                           | 33 (2.9)         | 17 (3.6)                               | 16 (4.3)                                                    | \(<0.0001\) |
| Age left education                                                            |                  |                                        |                                                             |         |
| \( \leq 16 \) years of age                                                    | 469 (56.4)       | 232 (50.0)                             | 237 (64.6)                                                  |         |
| \( \geq 17 \) years of age                                                    | 334 (40.2)       | 211 (45.4)                             | 123 (33.5)                                                  | \(<0.0001\) |
| Still in full-time education                                                   | 28 (2.4)         | 21 (4.5)                               | 7 (1.9)                                                     | \(<0.0001\) |
| Employment                                                                    |                  |                                        |                                                             |         |
| Paid work, manual                                                             | 158 (18.7)       | 102 (21.5)                             | 56 (15.0)                                                   |         |
| Paid work, non-manual                                                         | 180 (21.3)       | 131 (27.6)                             | 49 (13.1)                                                   |         |
| Paid work, unclear whether manual/ non-manual                                  | 45 (5.3)         | 27 (5.7)                               | 18 (4.8)                                                    |         |
| Unemployed                                                                    | 201 (23.7)       | 92 (19.4)                              | 109 (29.2)                                                  |         |
| Full-time parent                                                              | 219 (25.9)       | 97 (20.5)                              | 122 (32.7)                                                  |         |
| Full-time student                                                             | 23 (2.7)         | 13 (2.7)                               | 10 (2.7)                                                    |         |
| Other                                                                        | 21 (2.5)         | 12 (2.5)                               | 9 (2.4)                                                     | \(<0.0001\) |
| Indices Multiple Deprivation score (IMD)*                                      |                  |                                        |                                                             |         |
| 1st tertile                                                                  | 284 (33.6)       | 178 (37.4)                             | 106 (28.8)                                                  |         |
| 2nd tertile                                                                  | 279 (33.1)       | 162 (34.0)                             | 117 (31.8)                                                  |         |
| 3rd tertile                                                                  | 281 (33.3)       | 136 (28.6)                             | 145 (39.4)                                                  | 0.002   |
| Baseline heaviness of smoking index (smokers only)                            |                  |                                        |                                                             |         |
| Low addiction                                                                 | 321 (67.6)       | 171 (72.8)                             | 150 (62.5)                                                  |         |
| Moderate addiction                                                            | 146 (30.7)       | 61 (26.0)                              | 85 (35.4)                                                   |         |
| High addiction                                                                | 8 (1.7)          | 3 (1.3)                                | 5 (2.1)                                                     | 0.06    |
| Partner smoking baseline                                                      |                  |                                        |                                                             |         |
| Partner does not smoke tobacco                                                | 499 (59.1)       | 172 (36.4)                             | 122 (32.9)                                                  |         |
| Partner smokes tobacco                                                        | 294 (34.8)       | 279 (58.9)                             | 220 (59.3)                                                  |         |
| No partner                                                                    | 51 (6.0)         | 22 (4.7)                               | 29 (7.8)                                                    | 0.12    |

*Higher score reflects greater deprivation.

GCSE, General Certificate of Secondary Education.
SHS exposure score were also significantly associated with smoking in the home in univariate analysis.

In exploratory multivariable logistic regression modelling, smoking behaviour at 3 months after childbirth, younger maternal age, being of non-white British ethnicity, being more deprived as measured by IMD and holding less negative attitudes towards child SHS exposure were significantly associated with smoking in the home 3 months after childbirth (table 2). The strongest observed association was for mothers who smoked ≥11 cigarettes per day, who were over eight times more likely to report smoking occurred in their home.

**DISCUSSION**

After multiple imputation to control for non-response, the prevalence of smoking in the home at 3 months following childbirth was 18.2%. Prevalence was higher in homes where mothers who smoked lived compared to those where mothers were non-smokers (24% and 4.7%, respectively). Mothers who were currently smoking ≥11 cigarettes per day, younger, of non-white ethnicity, more deprived and held less negative attitudes towards child SHS exposure were significantly more likely to report that smoking occurred in their home 3 months after childbirth.

As far as we are aware, this is the first survey to investigate smoking in the home immediately after childbirth since the introduction of UK smoke-free legislation. Our estimate of the prevalence of SHS in the home was similar to estimates among slightly older infants from the USA, where 10.8–24.5% of infants of smoking mothers were exposed. However, this was substantially lower than in the only previous UK survey in infants who were a similar age as those in our sample. In that study, 82% of infants aged on average 3 months old whose parents were smokers were exposed to SHS in the home. A number of factors are likely to have influenced our lower estimate of SHS exposure. Blackburn *et al*’s study was conducted in 2003; smoke-free legislation have since been implemented across the UK and this may have increased awareness of SHS and its implications. Additionally, UK smoking prevalence has reduced since the earlier survey, in particular among those of childbearing age; increasing numbers of UK households are reported as smoke-free and older children’s SHS exposure in the home has reduced. Together these factors suggest that rates of smoking in the home will have declined since Blackburn’s study.

The observed prevalence of young infant’s SHS exposure in the home is much lower than the most recent estimates of prevalence among older children in England, where 38.7% of children aged 4–15 years whose parents were smokers were exposed in the home in 2012. This finding is positive; young infants are particularly susceptible to the risks of SHS exposure as they have a higher respiration rate and underdeveloped lungs. This is exacerbated further as young infants experience increased SHS exposure due to the amount of time spent indoors in close proximity to smoking parents and surfaces such as carpets that have been contaminated with smoke, and having more hand to mouth contact compared to older children. However, SHS exposure is dangerous for children of all ages; it is not yet known at what age parents or carers start to consider their children to be less vulnerable to the effects of SHS exposure and relax their home smoking restrictions. The early postnatal period, where the prevalence of SHS exposure in the home appears greatly reduced, may be a significant time-point to prevent future SHS exposure, before smoking in the home becomes an established behaviour.

In a recent systematic review, children whose parents were smokers, of low SES, less educated or held less negative attitudes towards SHS were at an increased risk of SHS exposure in the home, with the largest risks observed for children living in households with smokers. With the exception of parental education, the factors associated with young infant’s SHS exposure in this study are similar to those among older children. The findings also show similarities to the current limited evidence base examining this in infants aged <2 years elsewhere; in the USA, having more children in the household, being of white ethnicity, low maternal education, low maternal age, being unmarried, lower income and markers of disadvantage during pregnancy were associated with infant SHS exposure.
| Characteristic                              | All sample (N=471) | Smoking occurs in the home (N=76) | Unadjusted OR (95% CI) | Adjusted OR (95% CI) |
|--------------------------------------------|--------------------|----------------------------------|------------------------|----------------------|
| Smoking status baseline                    |                    |                                  |                        |                      |
| Recent ex-smoker                           | 231 (49.0)         | 20 (8.7)                         | Reference*             |                      |
| Current smoker                             | 240 (51.0)         | 56 (23.3)                        | 3.21 (1.86 to 5.60)    |                      |
| Smoking behaviour baseline                 |                    |                                  |                        |                      |
| Recent ex-smoker                           | 231 (49.8)         | 20 (8.7)                         | Reference*             |                      |
| ≤5 cigarettes per day                      | 104 (22.4)         | 19 (18.3)                        | 2.36 (1.20 to 4.64)    |                      |
| 6–10 cigarettes per day                    | 71 (15.3)          | 14 (19.7)                        | 2.60 (1.23 to 5.45)    |                      |
| ≥11 cigarettes per day                     | 58 (12.5)          | 21 (36.2)                        | 5.99 (2.96 to 12.12)   |                      |
| Smoking status 3 months after childbirth   |                    |                                  |                        |                      |
| Ex-smoker                                  | 192 (40.8)         | 9 (4.7)                          | Reference*             |                      |
| Current smoker                             | 279 (59.2)         | 67 (24.0)                        | 6.43 (3.12 to 13.25)   |                      |
| Smoking behaviour 3 months after childbirth|                    |                                  |                        |                      |
| Ex-smoker                                  | 192 (40.8)         | 9 (4.7)                          | Reference*             |                      |
| ≤5 cigarettes per day                      | 105 (22.3)         | 25 (23.8)                        | 6.35 (2.84 to 14.23)   | 6.17 (2.63 to 14.46) |
| 6–10 cigarettes per day                    | 83 (17.6)          | 11 (13.3)                        | 3.11 (1.24 to 7.81)    | 2.09 (0.78 to 5.63)  |
| ≥11 cigarettes per day                     | 91 (19.3)          | 31 (34.1)                        | 10.51 (4.73 to 23.32)  | 8.17 (3.41 to 19.55) |
| Baseline heaviness of smoking index        |                    |                                  |                        |                      |
| Low addiction                              | 171 (36.3)         | 35 (20.5)                        | Reference*             |                      |
| Moderate addiction                         | 60 (12.7)          | 17 (28.3)                        | 1.54 (0.78 to 3.01)    |                      |
| High addiction                             | 3 (0.6)            | 2 (66.7)                         | 7.77 (0.68 to 88.19)   |                      |
| Not applicable/non-smoker                  | 237 (50.3)         | 22 (9.28)                        | 0.40 (0.22 to 0.71)    |                      |
| Maternal age (years)                       |                    |                                  |                        |                      |
| Mean (SD)                                  | 26.5 (5.6)         | 24.6 (4.6)                       | 0.93 (0.88 to 0.97)†   | 0.94 (0.89 to 1.00)† |
| Ethnicity                                  |                    |                                  |                        |                      |
| White British                              | 416 (88.9)         | 62 (14.9)                        | Reference†             |                      |
| Other ethnicity                            | 52 (11.1)          | 14 (26.9)                        | 2.10 (1.08 to 4.11)    | 2.69 (1.19 to 6.06)  |
| Highest qualification                      |                    |                                  |                        |                      |
| No qualifications                          | 61 (13.0)          | 20 (32.8)                        | Reference*             |                      |
| GCSEs or equivalent                        | 183 (38.9)         | 28 (15.3)                        | 0.37 (0.19 to 0.72)    |                      |
| AS/A-Levels or equivalent                  | 116 (24.6)         | 10 (8.6)                         | 0.19 (0.08 to 0.45)    |                      |
| Degree or equivalent                       | 94 (20.0)          | 11 (11.7)                        | 0.27 (0.12 to 0.62)    |                      |
| Other qualification                        | 17 (3.6)           | 7 (41.2)                         | 1.43 (0.48 to 4.33)    |                      |
| Age left full-time education               |                    |                                  |                        |                      |
| ≥17 years of age                           | 208 (45.3)         | 22 (10.6)                        | Reference†             |                      |
| ≤16 years of age                           | 230 (50.1)         | 48 (20.9)                        | 2.23 (1.29 to 3.84)    |                      |
| Still in full-time education               | 21 (4.6)           | 3 (14.3)                         | 1.41 (0.38 to 5.17)    |                      |
| Employment                                 |                    |                                  |                        |                      |
| Paid work, manual                          | 102 (21.8)         | 13 (12.8)                        | Reference              |                      |
| Paid work, non-manual                      | 129 (27.5)         | 13 (10.1)                        | 0.77 (0.34 to 1.74)    |                      |
| Paid work, unclear whether manual/         | 27 (5.8)           | 6 (22.2)                         | 1.96 (0.67 to 5.75)    |                      |
| non-manual                                 |                    |                                  |                        |                      |
| Unemployed                                 | 90 (19.2)          | 21 (23.3)                        | 2.08 (0.97 to 4.45)    |                      |
| Full-time parent                           | 97 (20.7)          | 18 (18.6)                        | 1.56 (0.72 to 3.39)    |                      |
| Full-time student                          | 13 (2.8)           | 2 (15.4)                         | 1.24 (0.25 to 6.26)    |                      |
| Other                                      | 11 (2.4)           | 3 (27.27)                        | 2.57 (0.60 to 10.93)   |                      |
| Indices Multiple Deprivation score (IMD)‡ |                    |                                  |                        |                      |
| 1st tertile                                | 157 (33.3)         | 16 (10.2)                        | Reference*             |                      |
| 2nd tertile                                | 157 (33.3)         | 17 (10.8)                        | 1.07 (0.52 to 2.20)    | 1.03 (0.47 to 2.25)  |
| 3rd tertile                                | 157 (33.3)         | 43 (27.4)                        | 3.32 (1.78 to 6.21)    | 2.30 (1.13 to 4.68)  |
| Partner smoking at 3 months after childbirth|                    |                                  |                        |                      |
| Partner does not smoke tobacco             | 201 (42.7)         | 17 (8.5)                         | Reference*             |                      |
| Partner smokes tobacco                     | 220 (46.7)         | 51 (23.2)                        | 3.27 (1.82 to 5.88)    |                      |
| No partner                                 | 50 (10.6)          | 8 (16.0)                         | 2.06 (0.83 to 5.09)    |                      |

Continued
A strength of this study was that during recruitment, 96% of women attending selected antenatal clinics within Nottingham University Hospital Trust were screened for eligibility, accounting for around one-third of all births within Nottingham, England, during this time. The demographic profile of smokers within this cohort is similar to the composition of other UK pregnancy cohorts, meaning that the sample is likely to be broadly representative. A potential limitation of this research was the lack of power within analysis due to small numbers of participants in some exposure variable groups. Furthermore, there were some differences between those who responded and those who did not respond at follow-up, which are described. These differences may have impacted on our prevalence estimates, however appropriate imputation methods were used to allow for this non-response bias. Non-response biases are less likely to have impacted on estimates of association with smoking in the home. A further potential limitation was reliance on reported smoking measures; parents may be inclined to give socially desirable responses resulting in under-estimates of children’s SHS exposure. However, maternal-reported SHS exposure has been found to correlate with urinary cotinine and home environmental nicotine (r range 0.3–0.6) in infants aged <2.5 years. As the cohort included only women who were current or recent ex-smokers during pregnancy, the prevalence estimate obtained does not reflect children’s SHS exposure in the home in the general population. However, as parental smoking, and in particular maternal smoking within the home, is the primary source of children and infant’s SHS exposure, this study gives a useful indication of the scale of young infant’s SHS exposure.

While the demographic characteristics associated with smoking in the home after childbirth are not easily modifiable, they may help to inform which infants, parents or families are best targeted in future interventions. The findings highlight that the best way to prevent or reduce smoking in the home immediately after childbirth is to help smoking mothers to quit and stay abstinent after childbirth. However, a recent systematic review did not find a significant effect of any behavioural intervention approach to prevent postpartum smoking relapse, and as such more research is needed to identify interventions which can support women at this important time. Where women are unable or unwilling to quit smoking, making their home smoke-free is the next most effective way to protect children. This study, consistent with research in older children, shows that less negative attitudes towards SHS exposure is associated with smoking in the home after childbirth. Interventions targeting attitudes towards SHS by supporting parents to recognise the benefits of protecting children from SHS may therefore be useful to promote smoke-free homes.

CONCLUSIONS
The prevalence of smoking in homes where young infants live is lower than has been reported in older children (>3 months), suggesting that the early postnatal period may be an ideal time to intervene to prevent SHS exposure in the home. The factors associated with smoking in the home immediately following childbirth were similar to those previously reported among older children. Interventions to support smoking mothers to quit, or to help them restrict smoking in the home, should target attitudinal change and address inequality relating to social disadvantage, younger age and non-white ethnic groups.

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Contributors SO performed the experiments. SO and SL analysed the data. SO, TC, LLJ, SC and SL conceived and designed the experiments. SO and SC performed the experiments. SO and SL analysed the data. SO, TC, LLJ, SC and SL wrote the paper. All authors read and approved the final manuscript.

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Table 2 Continued

| Characteristic | All sample (N=471) | Smoking occurs in the home (N=76) | Unadjusted OR OR (95% CI) | Adjusted OR OR (95% CI) |
|---------------|-------------------|---------------------------------|--------------------------|------------------------|
| Negative attitudes towards child SHS exposure (≥15 out of a possible 20) | 419 (89.5) | 51 (12.2) | Reference* | Reference* |
| Less negative attitudes towards child SHS exposure (≤14 out of a possible 20) | 49 (10.5) | 25 (61.0) | 7.52 (4.00 to 14.14) | 5.24 (2.57 to 10.68) |

*Significant at p<0.001.
†Significant at p<0.05.
‡Higher score reflects greater deprivation.

GCSE, General Certificate of Secondary Education; SHS, secondhand smoke.

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REFERENCES

1. Oberg M, Jaakkola MS, Woodward A, et al. Worldwide burden of disease from exposure to second-hand smoke: a retrospective analysis of data from 192 countries. Lancet 2011;377:139–46.

2. Royal College of Physicians. Passive smoking and children. A report of the Tobacco Advisory Group of the Royal College of Physicians. Secondary Passive smoking and children. A report of the Tobacco Advisory Group of the Royal College of Physicians, 2010. https://www.rcplondon.ac.uk/sites/default/files/documents/passive-smoking-and-children.pdf (accessed 12 Jan 2015).

3. World Health Organisation. International Consultation on Environmental Tobacco Smoke (ETS) and Child Health. Consultation Report. Secondary International Consultation on Environmental Tobacco Smoke (ETS) and Child Health, Consultation Report, 1999. http://www.who.int/tobacco/research/en/ets_report.pdf, (accessed 12 Jan 2015).

4. US Department of Health and Human Services. The Health Consequences of Smoking—50 Years of Progress: a Report of the Surgeon General. Secondary The Health Consequences of Smoking—50 Years of Progress: A Report of the Surgeon General, 2014. http://www.surgeongeneral.gov/library/reports/50-years-of-progress/full-report.pdf (accessed 08 Jan 2015).

5. Jarvis MJ, Sims M, Gilmore A, et al. Impact of smoke-free legislation on children’s exposure to secondhand smoke: cotinine data from the Health Survey for England. Tob Control 2011;21:18–23.

6. Jarvis MJ, Feyerabend C. Recent trends in children’s exposure to second-hand smoke in England: cotinine evidence from the Health Survey for England. Addiction 2015;110:1484–92.

7. Akhtar PC, Haw SJ, Currie DB, et al. Smoking restrictions in the home and secondhand smoke exposure among primary schoolchildren before and after introduction of the Scottish smoke-free legislation. Tob Control 2009;18:409–15.

8. Akhtar PC, Haw SJ, Levin KA, et al. Socioeconomic differences in second-hand smoke exposure among children in Scotland after introduction of the smoke-free legislation. J Epidemiol Community Health 2010;64:341–6.

9. Moore GF, Holliday JC, Moore LA. Socioeconomic patterning in second-hand smoke exposure indexed by cotinine in children from England from 1996 to 2006. Addiction 2010;105:543–53.

10. Whitrow MJ, Harding S, Maynard MJ. The influence of parental smoking and family type on saliva cotinine levels in UK saliva-collecting children: a cross sectional study. BMC Public Health 2010;10:262.

11. Blackburn C, Spencer N, Bonas S, et al. Effect of strategies to reduce exposure of infants to environmental tobacco smoke in the home: cross sectional survey. BMJ 2000;327:257.

12. Gibbons DE, Ornish GD, Brown SL, et al. The impact of lifestyle changes on cardiovascular disease risk factors and health outcomes in type 2 diabetes: a randomized trial. JAMA 2005;293:436–45.

13. United States Preventive Services Task Force. Review of the evidence for the clinical effectiveness of smoking cessation interventions. Am J Prev Med 2013;45:10S–11S.

14. Alwan N, Siddiqi K, Thomson H, et al. Children’s exposure to second-hand smoke in the home: a household survey in the North of England. Health Soc Care Community 2010;18:257–63.

15. Sims M, Tomkins S, Judge K, et al. Trends in and predictors of second-hand smoke exposure indexed by cotinine in children in England from 1996 to 2006. Addiction 2010;105:543–53.

16. Whitrow MJ, Harding S, Maynard MJ. The influence of parental smoking and family type on saliva cotinine levels in UK saliva-collecting children: a cross sectional study. BMC Public Health 2010;10:262.

17. Blackmore S, Spencer N, Bonas S, et al. Effect of strategies to reduce exposure of infants to environmental tobacco smoke in the home: cross sectional survey. BMJ 2000;327:257.

18. Gibbs DE, Ornish GD, Brown SL, et al. The impact of lifestyle changes on cardiovascular disease risk factors and health outcomes in type 2 diabetes: a randomized trial. JAMA 2005;293:436–45.

19. Hawkins SS, Berkman L. Identifying infants at high-risk for second-hand smoke exposure. Child Care Health Dev 2013;40:441–5.

20. Orton S, Jones LL, Cooper S, et al. Predictors of children’s secondhand smoke exposure at home: a systematic review and narrative synthesis of the evidence. PLoS ONE 2014;9:e112690.

21. Anuntaseree W, Mo-Suwan L, Ma A-Lee A, et al. Prevalence and associated factors of passive smoking in Thai infants. Prev Med 2008;47:443–6.

22. Bhuiya A, Kharaghani R, Mohsenifar A, et al. Factors associated with secondhand smoke exposure in infants. Tannah 2010;9:43–93.

23. Orton S, Bowker K, Cooper S, et al. Longitudinal cohort survey of women’s smoking behaviour and attitudes in pregnancy: study methods and baseline data. BMJ Open 2014;4:e004915.

24. UK Data Service. UK Data Service, Secondary UK Data Service, 2014. http://ukdataservice.ac.uk/ (accessed 14 Nov 2014).

25. Borland R, Yong HH, O’Connor RJ, et al. The reliability and predictive validity of the Heaviness of Smoking Index and its two components: findings from the International Tobacco Control Four Country study. Nicotine Tob Res 2010;12(Suppl):S45–50.

26. Cronbach LJ. Coefficient alpha and the internal structure of tests. Psychometrika 1951;16:297–334.

27. Stata Statistical Software: Release 13 [program]. College Station, TX: StataCorp LP., 2013.

28. Spratt M, Carpenter J, Sterne JA, et al. Strategies for multiple imputation in longitudinal studies. Am J Epidemiol 2010;172:478–87.

29. Schafer JL. Multiple imputation: a primer. Stat Methods Med Res 1999;8:5–16.

30. Arnold AM, Kornmal RA. Multiple imputation of baseline data in the cardiovascular health study. Am J Epidemiol 2003;157:74–84.

31. Office for National Statistics. Adult Smoking Habits in Great Britain, 2013. Secondary Adult Smoking Habits in Great Britain, 2013. 2014. http://www.ons.gov.uk/ons/dcp171778_386291.pdf (accessed 06 Jan 2015).

32. Fleming S, Thompson M, Stevens R, et al. Normal ranges of heart rate and respiratory rate in children from birth to 18 years of age: a systematic review of observational studies. Lancet 2011;377:1011–18.

33. Burri PH. Fetal and postnatal development of the lung. Annu Rev Physiol 1994;46:617–28.

34. Matt GE, Quintana PJ, Hovell MF, et al. Households contaminated by environmental tobacco smoke: sources of infant exposures. Tob Control 2004;13:29–37.

35. Matt GE, Wahlgren DR, Hovell MF, et al. Measuring environmental tobacco smoke exposure in infants and young children through urine cotinine and memory-based parental reports: empirical findings and discussion. Tob Control 1998;8:285–9.

36. Matt GE, Hovell MF, Zakarian JM, et al. Measuring secondhand smoke exposure in babies: the reliability and validity of mother reports in a sample of low-income families. Health Psychol 2000;19:232–38.

37. Hajek P, Stead LF, West R, et al. Relapse prevention interventions for smoking cessation. Cochrane Database Syst Rev 2013;8:CD003999.

38. Winkelstein ML, Tarzian A, Wood RA. Parental smoking behavior and passive smoke exposure in children with asthma. Ann Allergy Asthma Immunol 1997;78:419–23.

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