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Reliability of self reported smoking status by pregnant women for estimating smoking prevalence: a retrospective, cross sectional study

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ABSTRACT

Objective To determine what impact reliance on self reported smoking status during pregnancy has on both the accuracy of smoking prevalence figures and access to smoking cessation services for pregnant women in Scotland.

Design Retrospective, cross sectional study of cotinine measurements in stored blood samples.

Participants Random sample (n=3475) of the 21029 pregnant women in the West of Scotland who opted for second trimester prenatal screening over a one year period.

Main outcome measure Smoking status validated with cotinine measurement by maternal area deprivation category (Scottish Index of Multiple Deprivation).

Results Reliance on self reported smoking status underestimated true smoking by 25% (1046/3475 (30%) from cotinine measurement v 839/3475 (24%) from self reporting, z score 8.27, P<0.001). Projected figures suggest that in Scotland more than 2400 pregnant smokers go undetected each year. A greater proportion of smokers in the least deprived areas (deprivation categories 1+2) did not report their smoking (39%) compared with women in the most deprived areas (22% in deprivation categories 4+5), but, because smoking was far more common in the most deprived areas (706 (40%) in deprived areas compared with 142 (14%) in affluent areas), projected figures for Scotland suggest that twice as many women in the most deprived areas are undetected (n=1196) than in the least deprived areas (n=642).

Conclusion Reliance on self reporting to identify pregnant smokers significantly underestimates the number of pregnant smokers in Scotland and results in a failure to detect over 2400 smokers each year who are therefore not offered smoking cessation services.

INTRODUCTION

Although the risks of smoking during pregnancy for both mother and child are well established,[1] smoking during pregnancy is still common, with smoking rates varying from 24% in Scotland[2] to 17% in England.[3]

Smoking prevalence generally increases with deprivation, and this is certainly true of Scotland, where 41% of women in the most deprived areas report smoking compared with only 14% in the least deprived areas.[4] Alarmingly, the gap in smoking prevalence between deprivation areas is larger in the pregnant population, where smoking is reduced to 8% in the least deprived areas but to only 38% in the most deprived area (data from the Scottish Morbidity Record (SMR02) for 2005, provided by NHS Information Services Division, www.isdscotland.org).

Self reported smoking is commonly used in antenatal clinics to determine the smoking status of pregnant women. However, this is an inaccurate method of identifying smokers,[5] with studies suggesting up to a quarter of pregnant smokers are missed when self reporting is relied on.[6-8] The accuracy of self report varies by the setting in which the questions are asked. Routinely collected data, such as in antenatal care, is often less accurate than data collected in settings perceived as more neutral, such as in research interviews.[9] With mounting social and medical pressure on women to quit smoking during pregnancy, there is greater likelihood that pregnant women will not report their smoking. Such inaccuracy can affect the reliability of smoking prevalence figures and access to smoking cessation services.

National targets to improve the nation's health generally include targets to reduce smoking during pregnancy,[10 11] often with the explicit aim of reducing inequalities related to deprivation. The Scottish government uses self reported smoking at maternity booking to construct targets and to measure the success of services in reaching such targets. These measures need to be robust in order to assess if services are achieving their aim and if money is being well spent in trying to achieve these targets.

Smoking cessation interventions have been shown to be moderately effective in reducing continued smoking into late pregnancy, with a risk of smoking for the intervention group relative to the control group of 0.94.[12] Perhaps more importantly intervention is effective at reducing the proportion of babies

of low birth weight (relative risk 0.81 (95% CI 0.70 to 0.94)) and of preterm births (0.84 (0.72 to 0.98)), and at increasing birth weight (33 g (11 g to 55 g) increase in weight).[12] These findings have helped promote the development of smoking cessation programmes directed at pregnant women.[13] Entry to such specialist cessation services in Scotland, however, usually depends on self reporting of smoking at the maternity booking visit.[14] Therefore, unless a woman admits to being a current smoker at maternity booking she will not be referred to specialist smoking cessation services and will not receive appropriate support, putting her own health and the health of her unborn child at risk. This study aimed to assess the robustness of self reporting at maternity booking as a method to set targets and to identify pregnant smokers.

Few studies have looked at the variation in accuracy of self reported smoking by deprivation, although the education level of pregnant women has been linked to the accuracy of self reporting.[15] We hypothesised that self reporting is less effective at identifying smokers in the most deprived areas compared with identifying those in more affluent areas, and that this further compounds existing health disparities during pregnancy.[16]

We compared the routinely collected self reported smoking status of pregnant women with their smoking status validated by means of serum cotinine measurement in order to: use the validated smoking prevalence in the study population to estimate the true smoking prevalence in pregnant women in Scotland; to identify the number of pregnant women in the study population who smoked but had no access to smoking cessation services in order to estimate the number of such women in Scotland; and to identify any variation in the level of under-reporting of smoking by area deprivation and determine what impact this will have on existing health inequalities in pregnancy.

METHODS

Sample

The records of all women in the West of Scotland who opted for prenatal screening in the second trimester for Down's syndrome and neural tube defects between May 2003 and July 2004 (that is, likely to result in a 2004 birth) were matched with their obstetric records from the Scottish Morbidity Records (SMR02) (data for 2004, provided by NHS Information Services Division, www.isdscotland.org). The prenatal screening process involves measuring maternal serum α fetoprotein and human chorionic gonadotrophin. Excess serum is stored at −20°C. At the time of linking, 2004 was the most recent complete year in the SMR02 dataset. The SMR02 data contain self reported smoking information collected by the midwife at the maternity booking appointment, usually carried out at 8-12 weeks of gestation, for all women delivering in an NHS facility. Women were asked for their smoking status and were recorded as current, former, or never smokers (or unknown if the response was not recorded). Information on the baby's date of birth, mother's date of birth, maternal area deprivation

(Scottish Index of Multiple Deprivation, which is based on postcode of residence reflecting material deprivation)[17] and date of booking was also available in the SMR02 data. Second trimester prenatal screening was usually carried out at 15-16 weeks of gestation. The records were matched using the mother's surname, forename, date of birth, and hospital number using probability matching techniques.[18] After data linkage, the database was returned with all patient-identifiable information removed and samples selected for cotinine measurement.

A simple random sample of linked records was selected for cotinine analysis from the births in the 2004 calendar year.

Sample size

A sample size of 3200 records allowed a 3% difference in the proportion of cotinine validated smoking and self reported smoking to be detected in the sample as a whole and a difference of 3% to be detected when comparing the combined deprivation categories 1 and 2 with the combined categories 4 and 5. We made the a priori decision to collapse the two highest and two lowest deprivation categories to give a greater power with the chosen sample size. To allow for technical difficulties (such as insufficient serum, etc), 3550 women were randomly selected from the linked dataset for cotinine analysis.

Cotinine analysis

As cotinine is derived only from nicotine metabolism, its measurement in serum is a good indicator of recent nicotine exposure. Cotinine testing was carried out on thawed serum samples at the West of Scotland Regional Genetics Service laboratories using commercially available kits (Cozart STD Micro-Plate Cotinine EIA), and those performing the tests were blind to the women's reported smoking status. Samples were assayed in singletons only. Samples with cotinine concentrations between 10 and 30 ng/ml (close to the cut-off value) were re-assayed and the mean of the two values taken as the final cotinine concentration. Cotinine concentrations ≥13.7 ng/ml were taken to indicate current smoking.[19]

Statistical analysis

The prevalences of cotinine validated current smoking and self reported current smoking were determined for the whole sample, and by area deprivation categories, and statistically compared (one-sample test of equality of proportions) using STATA (version 8).

The number of cotinine validated smokers not captured by self reporting (referred to as undetected smokers) was determined by identifying women with never, former, or unknown smoking status who had cotinine values ≥13.7 ng/ml, for the whole sample and by deprivation category.

The degree to which the study sample represents the population from which the sample was drawn and the population of pregnant women in Scotland was

Table 1 | Basic characteristics of 3475 pregnant women in the West of Scotland and their subsequent babies. (Values are numbers (percentages) unless stated otherwise)

Characteristic	Value
Self reported smoking status in pregnancy:	
Current smoker	839 (24.1)
Former smoker	367 (10.6)
Never smoker	1971 (56.7)
Unknown	298 (8.6)
Mean (SD) maternal age (years)*	29.4 (6.0)
Mean (SD) gestation at delivery (weeks)	39.2 (2.0)
Mean (SD) birth weight of baby (g)	3390.8 (600.0)
Deprivation category†:	
1 (least deprived)	440 (12.7)
2	545 (15.7)
3	733 (21.1)
4	730 (21.0)
5 (most deprived)	1023 (29.5)

*Data missing for one record.
†Based on Scottish Index of Multiple Deprivation. Data missing for four records.

determined by comparing the distribution of maternal age, deprivation category, and self reported smoking status in the study sample with the population of pregnant women in the West of Scotland who opted to be screened, the total pregnant population in the West of Scotland (including those who did not opt for screening), and the population of pregnant women in Scotland. Cotinine validated smoking prevalence in the study sample was used to estimate the true smoking prevalence in the population of pregnant women in Scotland, accounting for differences in the distribution of deprivation, maternal age, and self reported smoking status using standardisation techniques. For example, the estimated number of cotinine validated pregnant smokers in Scotland aged <20 in deprivation categories 1 and 2 who reported never smoking would be calculated by multiplying the proportion of such women in the study sample by the number of pregnant women aged <20 in deprivation categories 1 and 2 reporting never smoking in the Scottish pregnant population. Scottish Morbidity Records (SMR02) data were used to project figures for Scotland.

The number of undetected smokers was estimated by subtracting the number of smokers identified by self reporting from the estimated number of true smokers. Fifty women with no data on deprivation category or age were excluded, leaving 52591 pregnant women in Scotland with a 2004 birth. In generating the projected estimates for Scotland, we collapsed the maternal age categories (to <24, 25-29, 30-34 and ≥35 years) and the highest and lowest deprivation categories (1+2 and 4+5) because of small numbers in the sample population.

Statistical significance of differences between categorical variables was determined with Pearson's χ^2 test. All analyses were performed with SPSS (version 15) or STATA (version 8). To explore the sensitivity of the findings to the cotinine concentration we used in this

study to denote a current smoker, we repeated the analyses using alternative cotinine levels found in the literature.

Ethical approval and data protection
We contacted the Central Office for Research Ethics Committees (corec.org.uk), which advised that ethical approval was not needed for the study. Data protection issues were discussed with the data protection officer at the University of Glasgow and a confidentiality statement for use of NHS patient data was completed. The Privacy Advisory Committee of the Information Services Division (ISD) of NHS National Services approved the study for linkage with routinely collected data held by ISD.

RESULTS
Of the 29975 women in the West of Scotland who gave birth in 2004, 21029 (70%) opted for second trimester screening. Of these, 97% could be linked to their obstetric SMR02 data and 3550 were randomly selected for cotinine analysis; 98% of samples were located and assayed (fig 1). Seventy one serum samples with cotinine concentration of 10-30 ng/ml (close to the cut-off value) were re-analysed.

Over half of the 3475 women in the sample reported never smoking, and just less than a quarter reported being current smokers. The self reported smoking status was unknown for 9% of the study population (table 1). The profile of maternal age, baby's birth weight, and gestation at delivery were all typical of that seen in Scotland.[20] Women in deprived areas were over-represented in this sample, as in the West of Scotland.[17]

Under-reporting of smoking in the sample population
According to the figures for self reported smoking status, 839 (24.1%) of the pregnant women were current smokers. This value is significantly lower than the cotinine validated estimate of 1046 (30.1%) who were current smokers (table 2). As expected, the prevalence of smoking in the most deprived categories was greater than in the least deprived categories, with both the self reported and cotinine validated estimates. However, the difference between the cotinine validated and self reported smoking estimates is greater in the
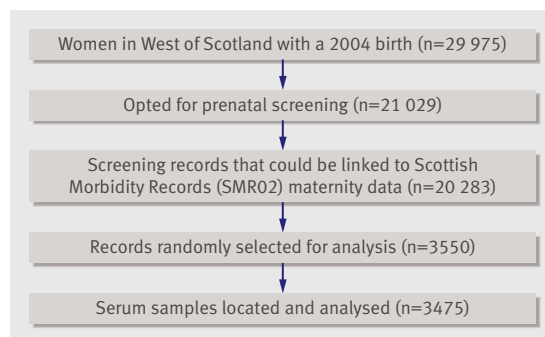

Fig 1 | Selection of study sample for cotinine analysis

Women in West of Scotland with a 2004 birth (n=29 975)
↓
Opted for prenatal screening (n=21 029)
↓
Screening records that could be linked to Scottish Morbidity Records (SMR02) maternity data (n=20 283)
↓
Records randomly selected for analysis (n=3550)
↓
Serum samples located and analysed (n=3475)

Table 2 | Prevalence of current smoking among 3475 pregnant women in the West of Scotland according to self reported smoking and cotinine validated smoking

	Self reported smoking*		Cotinine validated smoking†		Difference		
	No of women	Percentage (95% CI)	No of women	Percentage (95% CI)	Percentage points	z score	P value
Total sample (n=3475)	839	24.1 (22.7 to 25.6)	1046	30.1 (28.6 to 31.6)	6.0	8.27	‹0.001
Deprivation category‡:							
1+2 (n=985)	101	10.3 (8.5 to 12.3)	142	14.4 (12.3 to 16.7)	4.1	4.23	‹0.001
4+5 (n=1753)	587	33.5 (31.3 to 35.7)	706	40.3 (38.0 to 42.6)	6.8	6.03	‹0.001

*Measured at booking appointment (8-12 weeks of gestation).
†Measured at about 15 weeks of gestation. Cotinine concentrations ≥13.7 ng/ml were taken to indicate current smoking.
‡Based on Scottish Index of Multiple Deprivation (categories 1+2 are least deprived, 4+5 are most deprived).

most deprived groups than in the least deprived groups (table 2).

Sixty one (7%) of the self reported smokers had cotinine concentrations below the cut-off value for current smoking, and were therefore classified as non-smokers (table 3). These women could have quit between their booking and screening appointments, have been light smokers, or be recording errors.

The proportion of cotinine validated current smokers who were correctly identified by self reporting was 74.4%. This means that 25.6% (n=268) of cotinine validated smokers were not detected by self reporting and were therefore not offered smoking cessation services (table 4). The number of such undetected smokers was about three times greater in the most deprived areas than in the least deprived areas. However, this represented a smaller proportion of the total number of cotinine validated smokers in the deprived areas than in the affluent areas; it seems that a greater proportion of women in affluent areas failed to report their smoking compared with women in deprived areas.

Although not the focus of this study, the proportion of cotinine validated smokers in the "unknown" category for self reported smoking broadly represented the distribution across the whole study population.

Projected smoking figures for Scotland

We determined the degree to which our sample was representative of the screened population, the West of Scotland population (from which the sample was drawn), and the Scottish population of pregnant women (table 5). We found no differences between the sample population and the screened population in any of the characteristics examined. Comparing the sampled population with the West of Scotland population, there were no significant differences in the distribution of self reported smoking or maternal age, but there were small but significant differences by area deprivation. The distribution of maternal age within deprivation categories was also compared across populations and no differences were seen between the sampled and West of Scotland populations. Comparing the sampled population with the Scottish population, there was a significant difference in area deprivation and self reported smoking but not maternal age. These data showed the need to adjust at least for differences in self reported smoking and area

deprivation when generating projected figures for Scotland. Although no differences in the maternal age distribution were detected, projected figures were also adjusted for maternal age to account for any residual confounding that might arise between age categories.

After adjustment for the distribution of area deprivation, self reported smoking, and maternal age, we estimated the number of pregnant smokers in Scotland to be 14521 (that is, a smoking prevalence of 27.6%), and 2400 of these would be undetected by self report, representing 4.6% of the total population of pregnant women in Scotland. The number of undetected smokers in the most deprived areas (deprivation categories 4+5, n=1196) is nearly twice that in the least deprived areas (categories 1+2, n=642). Using the projected figures for Scotland, the prevalence of smoking in the most deprived areas is 39% compared with 14% in the least deprived areas.

The distribution of cotinine values produced two quite distinct populations (see figure in the extra material on bmj.com), suggesting that the findings were robust to the chosen cotinine cut-off value of 13.7 ng/ml. Using an alternative cut-off of 24 ng/ml[21] produced a prevalence of cotinine validated smoking for the study population of 29.3% (n=1018), very similar to the 30.1% produced using the original cut-off (see extra material on bmj.com for all other data using the alterative cut-off value).

DISCUSSION

Using cotinine validation to identify smokers, we estimate that 1046 of the 3475 women in the study population smoked during pregnancy, which is 25% higher than figures based on self reported smoking (839/

Table 3 | Proportion of pregnant women with serum cotinine concentration above and below the cut-off value for current smoking by their self reported smoking status. (Values are numbers (percentages))

	Serum cotinine concentration	
Self reported smoking status	‹13.7 ng/ml	≥13.7 ng/ml
Current (n=839)	61 (7)	778 (93)
Former (n=367)	273 (74)	94 (26)
Never (n=1971)	1875 (95)	96 (5)
Unknown (n=298)	220 (74)	78 (26)

Table 4 | Cotinine validated current smoking among pregnant women that was undetected (not captured by self reported smoking status)

	No of cotinine validated smokers	No (%) of cotinine validated smokers not captured by self reporting	Undetected smokers as % of all pregnant women
Total sample (n=3475)	1046	268 (25.6)	7.7
Deprivation category*:			
1+2 (n=985)	142	56 (39.4)	5.7†
4+5 (n=1753)	706	155 (22.0)	8.8

*Based on Scottish Index of Multiple Deprivation (categories 1+2 are least deprived, 4+5 are most deprived).
†z=0.293, P=0.003 for difference in distribution of undetected smokers across deprivation categories 1+2 and 4+5.

3475). The projected true smoking prevalence for pregnant women in Scotland (after adjusting for area deprivation, maternal age, and self reported smoking) is 28%, notably higher than the 23% based on self reporting.[2] Projected figures suggest that in Scotland each year more than 17% of pregnant smokers (n=2400) are not identified as such and are therefore not offered smoking cessation services.

There was a striking difference in smoking prevalence in pregnant women between area deprivation categories, reflecting that seen elsewhere.[22] Nearly 40% of smokers in the least deprived areas (deprivation categories 1+2) did not report their smoking status compared with only 22% of smokers in the most deprived areas (categories 4+5). This possibly reflects a greater expectation in more affluent areas that women will quit smoking during pregnancy. However, because of the larger number of smokers in deprived areas, in absolute terms, there were three times as many undetected smokers in the most deprived areas compared with the least deprived areas in the sample population.

In our sample, about a quarter of validated smokers went undetected. This proportion is similar to that seen in other studies of pregnant women in the UK[19] and elsewhere.[6-8 23] Higher proportions of undetected smokers have been seen: in one US study more than 50% of cotinine validated smokers were undetected by self reporting.[24] High proportions of undetected smokers (the proportion of smokers who do not report their smoking) are commonly seen in pregnant populations involved in cessation programmes,[25 26] as might be expected. Other studies have reported lower proportions of undetected smokers;[22 27] some as low as 1%.[28] The variation in proportion of undetected smokers can be largely explained by different populations and settings in which smoking status was reported. The study that reported only 1% undetected smokers was based on a Swedish population in which only 8% of the pregnant population were smokers,[28] whereas the study reporting over 50% undetected smokers examined a population in a deprived area with a smoking prevalence of 35%.

There is general agreement that serum cotinine is ideal for measuring smoking status because of its long half life (9 hours in pregnant women)[29] and the procedure's optimised sensitivity (94%) and specificity (81%).[4 19] There is little variation in the cotinine cut-off level used to define a pregnant smoker, with some studies using the lower value of 10 ng/ml[7 27] and others using values up to 24 ng/ml.[8 21] The results of our study were robust to the chosen cut-off value. Cotinine is specific for nicotine, but not necessarily for smoking; both nicotine replacement therapy and exposure to environmental tobacco smoke have been shown to elevate serum cotinine levels. The median cotinine level recorded in studies measuring the impact of exposure to environmental tobacco smoke is well below our chosen cut-off value of 13.7 ng/ml—a median cotinine concentration of 4 ng/ml has been reported for office staff[30] and 8 ng/ml for bar staff.[31] Therefore, women exposed to environmental tobacco smoke were unlikely to be miscoded as smokers in our study. The women in this study were pregnant in 2003-4, and nicotine replacement therapy was not routinely recommended in the West of Scotland until two specialist smoking cessation programmes began offering it in 2002 (CATCH)[32] and 2004 (BREATHE).[33] The only service offering nicotine replacement therapy during the time the study women were pregnant was CATCH, which offered it to 65 women. Even if all these 65 women used nicotine replacement products the small number of women involved would be unlikely to bias our findings greatly. In addition, a smoking cessation study based in Glasgow during 2001-3 showed that only 0.8% (6/718) of women reported taking nicotine replacement therapy,[34] again suggesting that any effects of nicotine replacement therapy in the study population would be minimal.

The recording of self reported smoking status at the antenatal clinic booking visit usually took place about three weeks before the collection of blood used for cotinine analysis. It was possible, therefore, for women to have quit smoking and correctly report being a former smoker at the booking appointment but to resume smoking before the blood was collected. Therefore, it should be acknowledged that some of the unreported smokers may have been former smokers who relapsed after reporting their smoking status and not smokers deliberately denying their smoking status. This distinction may not be so important for the objective of this study—determining the true prevalence of smoking among pregnant women. It may be that, within reason, the later in pregnancy that smoking is measured the more accurate it will be in terms of recording the true number of pregnant smokers—in that it will capture more of those that relapse.[23] As a result, these data will slightly overestimate the number of current

Table 5 | Distribution of maternal age, area deprivation, and self reported smoking status among pregnant women in the study sample, the screened sample, the West of Scotland, and Scotland. (Values are numbers (percentages) unless stated otherwise)

	Pregnant women (2004 birth)*			
All	Study sample (n=3475)	Screened population (n=20283†)	West of Scotland‡ (n=29 975)	Scotland (n=52862)
Self reported smoking status§				
Current	839 (24)	4896 (24)	7303 (25)	12 366 (24)
Former	367 (11)	2072 (10)	2770 (9)	4712 (9)
Never	1971 (57)	11 353 (56)	16 980 (57)	30 680 (59)
Unknown	298 (9)	1962 (10)	2614 (9)	4074 (8)
Difference from study sample	—	χ^2=4.4, P=0.2	χ^2=5.5, P=0.1	χ^2=13.3, P=0.004
Deprivation category (Scottish Index of Multiple Deprivation)				
1+2	985 (28)	5683 (28)	8738 (29)	19621 (37)
3	733 (21)	4028 (20)	5601 (19)	9825 (19)
4+5	1753 (51)	10 531 (52)	15 636 (52)	23 145 (44)
Difference from study sample¶	—	χ^2=4.5, P=0.3	χ^2=17.4, P<0.002	χ^2=130, P<0.001
Maternal age (years) by deprivation category				
Categories 1+2:				
<20	21 (2)	140 (3)	235 (3)	528 (3)
20-24	74 (8)	505 (9)	770 (9)	1753 (9)
25-29	220 (22)	1243 (22)	1836 (21)	4360 (22)
30-34	390 (40)	2246 (40)	3455 (40)	7744 (40)
35-39	244 (25)	1354 (24)	2085 (24)	4395 (22)
≥40	36 (4)	193 (3)	357 (4)	764 (4)
Difference from study sample	—	χ^2=2.8, P=0.7	χ^2=4.2, P=0.5	χ^2=5.7, P=0.3
Category 3:				
<20	38 (5)	188 (5)	303 (5)	586 (6)
20-24	117 (16)	642 (16)	882 (16)	1629 (17)
25-29	188 (26)	1084 (27)	1452 (26)	2568 (27)
30-34	230 (31)	1270 (32)	1835 (33)	3068 (32)
35-39	138 (19)	741 (18)	959 (17)	1529 (16)
≥40	22 (3)	101 (3)	170 (3)	306 (3)
Difference from study sample	—	χ^2=1.4, P=0.9	χ^2=1.6, P=0.9	χ^2=5.4, P=0.4
Categories 4+5:				
<20	215 (12)	1205 (12)	1907 (12)	3026 (13)
20-24	430 (25)	2672 (25)	4052 (26)	6318 (27)
25-29	464 (27)	2774 (26)	4018 (26)	5922 (25)
30-34	411 (24)	2434 (23)	3575 (23)	5211 (22)
35-39	197 (11)	1258 (12)	1763 (11)	2444 (10)
≥40	35 (2)	177 (2)	321 (2)	450 (2)
Difference from study sample	—	χ^2=2.9, P=0.7	χ^2=1.8, P=0.9	χ^2=7.2, P=0.2
All categories combined:				
Difference from study sample	—	χ^2=3.1, P=0.7	χ^2=4.4, P=0.5	χ^2=3.6, P=0.6

*Excluding home births and births at non-NHS hospitals.
†Refers to those screening records that could be linked with their obstetric records from the Scottish Morbidity Records (SMR02).
‡Made up of Argyll and Clyde, Ayrshire and Arran, Dumfries and Galloway, Forth Valley, Greater Glasgow, Highland, Lanarkshire, and Western Isles health boards.
§Smoking figures for West of Scotland are for 2005.
¶Collapsed categories are used for χ^2 test.
Missing data: Sample population—4 records with no deprivation data, 1 record with no maternal age; screened population—18 records with no maternal age, 787 (3.7%) with no deprivation data, 746 with no self reported smoking data (that is, not linked records); West of Scotland—38 with no region data; Scottish data—163 with no deprivation data.

smokers who were not offered smoking cessation services because, at the time of asking, the to-be relapsers were in fact former smokers, although they are arguably in need of such services.

Extrapolation of the sample results to all pregnant smokers in Scotland is based on two assumptions, the first being that the study population accurately represents the population from which it was drawn (West of Scotland). The study sample is similar to the screened sample in all characteristics tested, which suggests successful random selection of the sample from the screened population. Differences between the study population and the West of Scotland will therefore reflect differences between the screened and non-screened women. Only if such differences are also related to the accuracy of self reported smoking will there be potential to introduce bias; differences that differentiate screened and non-screened women that relate only to self reported smoking status but not the accuracy of self reporting will not introduce bias. The data suggest that neither self reported smoking status nor maternal age were related to the decision to opt for screening in this setting (table 5), as the study sample and the population of the West of Scotland have similar profiles. A major strength of these data is the high screening rate (70% of all women were screened), reducing the potential for differences between the screened and target population. Indeed the lack of a maternal age effect is consistent with the continued monitoring of this screened population. The sample population had a slightly different area deprivation profile compared with the population of the West of Scotland (52% in the West of Scotland from deprivation categories 4+5 compared with 51% of the sample population). However, there is little difference in the percentages; the significance of the result is related to the large sample size rather than an important difference in deprivation profile. Other factors that may be related to a decision to opt for screening include ethnicity and religion. Ethnicity is unlikely to have a large impact on the data as there was very little representation of black and ethnic minority populations in Scotland at the time of data collection (2% non-white people in the 2001 census, General Register Office for Scotland). Catholic women are likely to be underrepresented in the screened population. Although there are substantial numbers of Catholics in Scotland (about 16% at the 2001 census), it is unlikely that the accuracy of self reported smoking status provided by pregnant Catholic women would be substantially different from that of the rest of the population and therefore these factors are unlikely to introduce bias. There may be yet other differences between the population of screened and non-screened women that we were not able to investigate that also relate to the accuracy of self reported smoking. However, given the high screening rate (70%), these differences are unlikely to bias the findings significantly.

The second assumption made is that differences between the West of Scotland and the Scottish population that also relate to the accuracy of self report are accounted for in generating the projected figures. Differences between the pregnant women from these two populations are expected because the West of Scotland includes some of the more deprived areas of the

WHAT IS ALREADY KNOWN ON THIS TOPIC

Self reported smoking during pregnancy is known to be an inaccurate method of identifying smokers

Self reported smoking in Scotland is used to generate smoking prevalence and, largely, to target smoking cessation services

WHAT THIS STUDY ADDS

Reliance on self reported smoking during pregnancy underestimates the true smoking prevalence in Scotland by 17%

Each year in Scotland twice as many pregnant smokers from more deprived areas go undetected compared with pregnant smokers in the least deprived areas

Reliance on self reporting results in a failure to detect over 2400 pregnant smokers each year in Scotland who are therefore not offered smoking cessation services

country. The projected figures take account of area deprivation, smoking status, and maternal age, which probably accounts for the major differences between east and west Scotland. Again religion (Catholicism in the West of Scotland) is unlikely to be related to the accuracy of self report.

Some errors in the recording or transcribing of the self reported smoking status at the booking appointment will have happened. It is not likely that these recording errors would be systematic (that is, by deprivation or smoking status), and such errors are therefore unlikely to bias these finding away from the null hypothesis. The recording of self reported smokers with a serum cotinine concentration below the cut-off value for non-smokers may slightly underestimate the true prevalence of smokers.

For 9% of the routinely collected data used for this study there was no valid information about self reported smoking status (the information was either not requested or not recorded), compounding the problem of inaccurate self reported data. There is some evidence that the issue of smoking is not necessarily given high priority in the relationship between midwife and expectant mother,[14] possibly explaining cases of missing data. Similar problems with data quality have also been highlighted with routinely collected self reported data in other regions.[35] The poor quality and accuracy of routinely collected self reported smoking data in pregnant women shown in this study and elsewhere[35] call for better methods of routinely identifying smokers during pregnancy. The current policy in Glasgow is for all women to provide self reported smoking status and undergo a carbon monoxide breath test at maternity booking. If implemented fully, this could increase the identification of pregnant smokers from 75% to about 95%.[33 36] Further studies are required to determine if offering routine biochemical validation (such as carbon monoxide breath tests) to all pregnant women at maternity booking would be the most cost effective method to identify smokers, to monitor targets, and to increase the reach of specialist smoking cessation support. Accurate smoking information also refines the estimation of individual fetal risks of Down's syndrome by prenatal screening,

since maternal smoking causes changes in the levels of the biochemical markers used in the screening test[37] (discussed further in a subsequent paper).

In conclusion, reliance on self reporting to measure smoking during pregnancy significantly underestimates the number of pregnant smokers in Scotland, with more than 2400 unrecognised pregnant smokers a year who will not be offered smoking cessation services. Reliance on self reporting resulted in twice as many undetected smokers in the most deprived areas compared with the least deprived areas. Overall, these figures call for more accurate methods of identifying pregnant smokers, especially when such data are used to inform policy and provide patient care.

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