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# Estimates of Nondisclosure of Cigarette Smoking Among Pregnant and Nonpregnant Women of Reproductive Age in the United States

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Although clinic-based studies have used biochemical validation to estimate the percentage of pregnant women who deny smoking but are actually smokers, a population-based estimate of nondisclosure of smoking status in US pregnant women has not been calculated. The authors analyzed data from the 1999–2006 National Health and Nutrition Examination Survey and estimated the percentage of 994 pregnant and 3,203 nonpregnant women 20–44 years of age who did not report smoking but had serum cotinine levels that exceeded the defined cut point for active smoking (nondisclosure). Active smoking was defined as self-reporting smoking or having a serum cotinine concentration that exceeded the cut point for active smoking. Overall, 13.0% (95% confidence interval (CI): 8.8, 17.1) of pregnant women and 29.7% (95% CI: 27.3, 32.1) of nonpregnant women were active smokers. Nondisclosure was higher among pregnant active smokers (22.9%, 95% CI: 11.8, 34.6) than among nonpregnant smokers (9.2%, 95% CI: 7.1, 11.2). Among pregnant active smokers, nondisclosure was associated with younger age (20–24 years). Among nonpregnant active smokers, nondisclosure was associated with Mexican-American and non-Hispanic black race/ethnicity. Studies and surveillance systems that rely on self-reported smoking status are subject to underestimation of smoking prevalence, especially among pregnant women, and underreporting may vary by demographic characteristics.

pregnancy; smoking; tobacco; women

Abbreviations: CI, confidence interval; NHANES, National Health and Nutrition Examination Survey.

Smoking is the leading cause of preventable death among women, and maternal smoking is one of the most prevalent preventable causes of infant morbidity and mortality in the United States (1). Public health surveillance and evaluation of cessation interventions require accurate assessment of smoking status. Although biochemical validation of smoking status is the gold standard, many surveillance systems rely on self-reporting because of the expense and logistical difficulties of obtaining biochemical verification. Clinic-based studies, however, have found that relying on self-reported smoking status, especially among pregnant women, can result in an underestimation of smoking prevalence of 24%–28% (2–4). Therefore, population-based estimates of the rate of nondisclosure among pregnant women in the United States are needed. In the present study, we estimated the percentage of pregnant and nonpregnant female smokers aged 20–44 years who did not disclose their smoking in a health interview questionnaire but whose serum cotinine levels were consistent with active smoking. Demographic characteristics of women who disclosed and did not disclose their smoking status were also examined to assess for differential underreporting.

## MATERIALS AND METHODS

We analyzed data from the 1999–2006 National Health and Nutrition Examination Survey (NHANES), a nationally representative sample of the US civilian noninstitutionalized population. The sampling strategy involved a complex, stratified, multistage probability cluster design. Participants

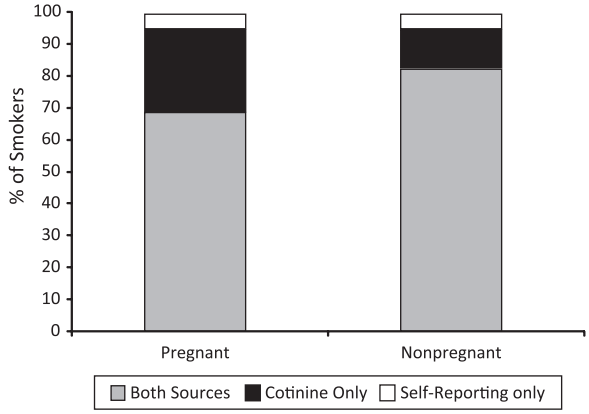


**Figure 1.** Method of determination of smoking status among women 18–44 years of age in the National Health and Nutrition Examination Survey, 1999–2006.

were interviewed in their homes and subsequently received a physical examination (up to 2 weeks later) and had their blood drawn in a specially equipped mobile examination center. Additional information on NHANES can be found on the study's Web site (http://www.cdc.gov/nchs/nhanes.htm).

In this analysis, the sample included women 20–44 years of age who participated in the 1999–2000, 2001–2002, 2003–2004, and 2005–2006 NHANES surveys. Females <20 years of age were not asked the same tobacco questions as older women and therefore were not included in our analyses. The eligible sample included 4,619 females aged 20–44 years with known pregnancy status (confirmed by urine pregnancy tests). Women were excluded if they did not answer the question about current smoking ($n = 4$), had missing cotinine values ($n = 284$), had used other forms of tobacco or nicotine replacement (e.g., pipes, cigars, nicotine patch, or nicotine gum) ($n = 46$), or had kidney disease ($n = 26$) or had used anticonvulsant medications ($n = 74$), as these can interfere with nicotine metabolism. Some women fell into multiple exclusion categories. The final sample included 4,197 women.

In the health interview questionnaire, women were asked, ''Have you smoked at least 100 cigarettes in your entire life?'' and, ''Do you now smoke cigarettes?'' Those who reported that they had smoked at least 100 cigarettes and now smoke ''every day'' or ''some days'' were categorized as self-reported smokers. Women who reported that they had smoked cigarettes regularly in the past but did not currently smoke and had quit smoking were categorized as quitters. Blood samples taken during the examination were analyzed for serum cotinine concentrations by using a high-performance liquid chromatography/atmospheric pressure ionization tandem mass spectrometry method (5). Race/ethnicity-specific cut points to classify active smokers were based on recommendations from an analysis that used an NHANES sample of male and nonpregnant female smokers (6). Because optimal cut points for pregnant women have not been established, we used the same cut points for both pregnant and nonpregnant women: ≥5.0 ng/mL for non-Hispanic white women; ≥6.0 ng/mL for non-Hispanic black women; ≥1.0 ng/mL for Mexican-American women; and ≥3.0 ng/mL for women in other racial/ethnic groups (6). A second analysis was conducted with a previously recommended cut point of ≥10.0 ng/mL (7). Because it is unlikely that a nonsmoker would falsely report smoking, women who reported smoking but whose cotinine values were below the cut points were also categorized as active smokers. Nondisclosure of smoking status was classified as not reporting smoking but having cotinine concentrations that were above the cut point for active smoking.

Characteristics of smokers who disclosed and did not disclose their smoking were compared by age, race/ethnicity, educational level, type of health insurance, self-reported quitting, and month of pregnancy when interviewed. All analyses were stratified by pregnancy status. Statistical differences ($P < 0.05$) were determined by chi-square tests for independence. Logistic regression was used to estimate independent associations between demographic variables and smoking and between demographic variables and nondisclosure. All data were weighted to adjust for survey design, except when reporting percentages of smoking by method of determination. Data were analyzed using SAS Survey Procedures, version 9 (SAS Institute, Inc., Cary, North Carolina).

## RESULTS

Overall, 13.0% (95% confidence interval (CI): 8.8, 17.1) of pregnant women and 29.7% (95% CI: 27.3, 32.1) of nonpregnant women were active cigarette smokers. Among the 125 pregnant active smokers, 92 (73.6%) were identified through self-reporting (68.6% both sources, 5.0% self-reporting only) and 119 (95.0%) were identified by cotinine concentration (68.6% both sources, 26.4% cotinine level only). Among the 888 nonpregnant active smokers, 782 (88.1%) were identified through self-reporting (82.9% both sources, 5.2% self-reporting only) and 842 (94.7%) were identified by cotinine concentration (82.8% both sources, 11.9% cotinine level only) (Figure 1).

Compared with pregnant women who did not smoke, pregnant smokers were more likely to be non-Hispanic black, to be 20–24 years of age, to have Medicaid or another source of government-funded health insurance, and to have <12 years of education (Table 1). In a logistic regression model that adjusted for all demographic variables simultaneously, these associations remained statistically significant (data not shown). Compared with nonpregnant women who did not smoke, nonpregnant smokers were more likely to be non-Hispanic white, to be 20–24 years of age, to have Medicaid or another source of government-funded health insurance, and to have <12 years of education (Table 1). In a logistic regression model that adjusted for all demographic variables simultaneously, these associations remained statistically significant (data not shown).

The percentage of pregnant smokers who did not disclose that they smoked (22.9%, 95% CI: 11.8, 34.6) was higher than the percentage of nonpregnant smokers who did not

**Table 1.** Characteristics of Women 20–44 Years of Age, by Smoking Status and Pregnancy Status, in the National Health and Nutrition Examination Survey, 1999–2006

| | Pregnant | | | Nonpregnant | | |
|---|---|---|---|---|---|---|
| | Smokers[a], % ($n$ = 125) | Nonsmokers, % ($n$ = 869) | $P$ Value | Smokers[a], % ($n$ = 888) | Nonsmokers, % ($n$ = 2,315) | $P$ Value |
| Age, years | | | <0.01 | | | 0.05 |
| 20–24 | 47.4 | 25.0 | | 21.4 | 17.5 | |
| 25–29 | 28.0 | 32.4 | | 15.8 | 16.0 | |
| 30–44 | 24.5 | 42.6 | | 62.9 | 66.4 | |
| Race/ethnicity | | | 0.03 | | | <0.01 |
| Mexican-American or other | 16.8 | 30.7 | | 14.5 | 24.0 | |
| Non-Hispanic white | 60.0 | 56.9 | | 73.7 | 63.1 | |
| Non-Hispanic black | 23.2 | 12.5 | | 11.8 | 13.0 | |
| Insurance | | | <0.01 | | | <0.01 |
| Medicaid/government | 50.3 | 22.4 | | 17.7 | 8.7 | |
| Private | 32.1 | 63.6 | | 52.7 | 72.0 | |
| Uninsured | 17.6 | 13.9 | | 29.6 | 19.3 | |
| Education, years | | | <0.01 | | | <0.01 |
| <12 | 32.6 | 18.3 | | 22.7 | 12.8 | |
| ≥12 | 67.4 | 81.7 | | 77.3 | 87.2 | |
| Reported prior smoking but quit | 11.5 | 27.9 | <01 | 4.3 | 17.6 | <0.01 |

[a] Smokers were defined as those who self-reported smoking or had a cotinine concentration above the threshold for active smoking (≥5.0 ng/mL for Non-Hispanic whites, ≥6.0 ng/mL for non-Hispanic blacks, ≥1.0 ng/mL for Mexican Americans, and ≥3.0 ng/mL for other races/ethnic groups).

disclose that they smoked (9.2%, 95% CI: 7.1, 11.2). Compared with pregnant smokers who did disclose their smoking habits, pregnant smokers who did not disclose their smoking habits were more likely to be 20–24 years of age (Table 2). After adjusting for race/ethnicity, type of health insurance, and educational level, this association remained statistically significant. In addition, after adjustment for the other demographic variables, Mexican-American pregnant smokers were found to be more likely not to disclose smoking than were white pregnant smokers (data not shown). The average month of pregnancy during which the women were interviewed was 5.0 months for smokers who disclosed their smoking habit and 5.6 for those who did not disclose their smoking habit. Compared with nonpregnant smokers who disclosed that they smoked, nonpregnant smokers who did not disclose that they smoked were more likely to be Mexican-American or non-Hispanic black (Table 2). After adjusting for age, type of health insurance, and educational level, these associations remained statistically significant (data not shown). For both groups of women, approximately one-half of smokers who denied current smoking reported that they had smoked in the past but had quit (Table 2).

In the second analysis. in which we used a cotinine concentration cut point of ≥10.0 ng/mL for active smoking, 12.0% (95% CI: 7.9, 16.0) of pregnant women and 29.2% (95% CI: 26.8, 31.5) of nonpregnant women were categorized as active smokers. Among 114 pregnant smokers, 92 (80.7%) reported smoking and 106 (93.0%) had cotinine levels ≥10.0 ng/mL. Among 858 nonpregnant smokers, 782 (91.1%) reported smoking and 858 (100%) had cotinine levels ≥10.0 ng/mL. The percentage of smokers who did not disclose their smoking status was 16.3% (95% CI: 6.1, 26.5) for pregnant women and 7.4% (95% CI: 5.2, 9.6) for nonpregnant women. Risk factors for smoking and for nondisclosure were no different in the second analysis than in the main analysis in both the pregnant and nonpregnant groups (data not shown).

## DISCUSSION

The present study found that pregnant women had a higher prevalence of nondisclosure of cigarette smoking than did nonpregnant women, and the rate of nondisclosure varied by demographic characteristics for both groups. The level of underreporting of smoking in pregnant women in this population-based sample was consistent with those in previous studies among pregnant women in clinical settings (2–4). The present findings were also consistent with a recent population-based study in the west of Scotland that, in a random sample of all births occurring in 2004, compared self-reported smoking status of pregnant women at maternity booking (8–12 weeks of gestation) with serum cotinine levels from prenatal screening (15–16 weeks of gestation) and found that self-reporting of smoking led to an underestimation of smoking prevalence during pregnancy of 25% (8). Also consistent with a previous study was the finding in our study that a large percentage of women who did not admit to smoking had been former smokers (9). This may reflect the fact that women who report that they have quit smoking are still trying to quit and either continue to smoke

**Table 2.** Characteristics of Smokers[a] 20–44 Years of Age, by Smoking Disclosure Status and Pregnancy Status, in the National Health and Nutrition Examination Survey, 1999–2006

| | Pregnant Smokers | | | Nonpregnant Smokers | | |
|---|---|---|---|---|---|---|
| | % Who Disclosed ($n$ = 92) | % Who Did Not Disclose ($n$ = 33) | $P$ Value | % Who Disclosed ($n$ = 782) | % Who Did Not Disclose ($n$ = 106) | $P$ Value |
| Age, years | | | <0.01 | | | 0.14 |
| 20–24 | 38.6 | 77.2 | | 20.6 | 29.2 | |
| 25–29 | 32.7 | 12.4 | | 15.9 | 14.6 | |
| 30–44 | 28.7 | 10.4 | | 63.6 | 56.2 | |
| Race/ethnicity | | | 0.08 | | | <0.01 |
| Mexican-American or other | 12.1 | 32.6 | | 13.3 | 26.8 | |
| Non-Hispanic white | 63.6 | 47.9 | | 76.3 | 47.7 | |
| Non-Hispanic black | 24.3 | 19.5 | | 10.4 | 25.5 | |
| Insurance | | | 0.13 | | | 0.09 |
| Medicaid/government | 45.8 | 65.4 | | 17.0 | 24.1 | |
| Private | 35.0 | 22.2 | | 52.4 | 55.7 | |
| Uninsured | 19.1 | 12.3 | | 30.6 | 20.2 | |
| Education, years | | | 0.82 | | | 0.41 |
| <12 | 33.1 | 31.0 | | 23.0 | 19.1 | |
| ≥12 | 66.9 | 69.0 | | 77.0 | 80.9 | |
| Reported prior smoking but quit | 0.0 | 50.1 | | 0.0 | 47.1 | |

[a] Smokers were defined as those who self-reported smoking or had a cotinine concentration above the threshold for active smoking (≥5.0 ng/mL for Non-Hispanic whites, ≥6.0 ng/mL for non-Hispanic blacks, ≥1.0 ng/mL for Mexican Americans, and ≥3.0 ng/mL for other races/ethnic groups).

at lower levels or regress and have a few cigarettes intermittently.

Because NHANES is a nationally representative sample, our findings should be generalizable to both pregnant and nonpregnant women in the United States. However, despite combining samples from 4 NHANES surveys, the number of pregnant women in our study was small. Another limitation of this analysis is that the optimal cotinine cut point for pregnant women is unknown. Pregnant women metabolize cotinine at a faster rate than do nonpregnant women (10). Thus, our results likely underestimate the rate of nondisclosure for pregnant women. The results of the second analysis, which used a higher, uniform cotinine cut point, showed a lower estimate of nondisclosure in the pregnant population (16.3% vs. 23.2%) but did not substantially change nondisclosure estimates in the nonpregnant population. This might be at least partly explained by differences in the distribution of cotinine values in pregnant women and nonpregnant women, as pregnant women have lower cotinine concentrations for the same level of tobacco exposure and are more likely to be light smokers than are nonpregnant women. In the NHANES sample, the mean number of cigarettes smoked daily was 10.7 for pregnant smokers and 13.8 for nonpregnant smokers.

To our knowledge, this study was the first to apply the race- and ethnicity-specific cut points to pregnant and nonpregnant women based on the study by Benowitz et al. (6). Possible explanations for the different racial/ethnic cut points identified by Benowitz et al. include differences in patterns of smoking and differences in the rates of metabolism of nicotine and cotinine (11, 12). The researchers analyzed data from NHANES and used receiver operating characteristic curve analysis to identify the cut point that maximized the correct classification by using self-reported cigarette smoking as the classifier for each racial/ethnic group. Mexican Americans had lower levels of cotinine due to less daily smoking, and this may have resulted in their lower cotinine cut point to identify active smoking. Non-Hispanic blacks metabolize cotinine slower than do other racial/ethnic groups, and this could have resulted in the higher cut point needed to identify active smoking. Our finding that nonpregnant Mexican Americans were more likely to not disclose their smoking status might also reflect the fact that those who do not smoke every day are less likely to consider themselves smokers. At least 1 other study found that Hispanics were less likely to report that they smoked than were other racial/ethnic groups when self-reporting was compared with reports from a household proxy (13). It might also reflect misclassification among those exposed to significant amounts of secondhand smoke.

The results of this study may have implications for studies in which researchers examine the effect of smoking on pregnancy outcomes, as using self-reported prenatal smoking status might bias associations. For example, a recent study found that 23.4% of mothers delivering full-term low-birth-weight infants self-reported smoking during pregnancy, whereas

only 10.9% of mothers delivering full-term, normal-weight infants self-reported smoking (14). The crude odds ratio for smoking and full-term low birth-weight was 2.5. Assuming that 22.9% of mothers did not disclose their smoking habit (as found in this analysis) and assuming that nondisclosure rates did not differ by infant birth weight group, the true odds ratio would be 2.6. If nondisclosure rates did differ by outcome, the bias might be greater. For example, if 30% of mothers with low-birth-weight infants and 15% of mothers with normal-weight infants did not disclose their smoking status, the true odds ratio would be 3.1. Additional studies of pregnancy outcomes that also measure nondisclosure rates are needed to better understand the contribution of nondisclosure to risk estimates.

This study has important implications for studies that rely on self-reporting to assess smoking status among women of reproductive age, as approximately 1 in 4 pregnant smokers and 1 in 10 nonpregnant smokers deny smoking. In younger women and women of particular racial/ethnic backgrounds, nondisclosure rates could even be higher. The findings continue to have implications for disclosure within clinical settings. In addition, surveillance systems that rely on self-reported smoking status should consider reporting an additional estimate that accounts for nondisclosure.

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The findings and conclusions in this article are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

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