Review

Measurements for active cigarette smoke exposure in prevalence and cessation studies: Why simply asking pregnant women isn’t enough

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Tobacco smoke exposure during and after pregnancy may cause maternal, fetal, and infant morbidity and mortality. The purpose of this review is to (a) describe existing methods of measuring active tobacco exposure among pregnant women and (b) illustrate the usefulness of these measures in validating self-reported smoking status among these women. Medline, PsycINFO, and Academic Search Elite were used to identify measures of cigarette smoking exposure, prevalence reports, cessation and validity studies, and research on deception about smoking during pregnancy. Review of the research on smoking cessation among pregnant women since 1966 revealed that 36% of studies (9 out of 25) located used only self-report to assess smoking status. The remaining 16 studies used either significant other reports or at least one type of biochemical test to confirm self-report. Deception rates were reported at baseline only, follow-up only, or both in 15 studies. Three federal agencies in the United States collect data on self-reported smoking during pregnancy. Smoking prevalence rates are inconsistent among these agencies. This article demonstrates that measuring smoking status during pregnancy via self-report alone leads to discrepancies in national prevalence rates, deceptions in clinical practice disclosure, and inconsistencies in research study results. Evaluation studies that confirm smoking status among pregnant women by biochemical methods provide more accurate prevalence rates and lead to the most effective behavioral interventions to achieve cessation. National statistics should carry a disclaimer indicating the likelihood of underestimation. Researchers and clinicians should be trained in best-practice, evidence-based behavioral methods to assess prenatal smoking status and to assist those who desire to quit.

Introduction

Active and passive tobacco exposure during and after pregnancy has long been known to cause maternal, fetal, and infant disease, disability, and even death (U.S. Department of Health and Human Services [USDHHS], 1990, 1996). Birth weights are consistently lower for infants born to women who smoke (Castles, Adams, Melvin, Kelsch, & Boulton, 1999; Horta, Victoria, Menezes, Halpern, & Barros, 1997; Odendaal, van Schie, & de Jeu, 2001). Although the risk is increased as the number of cigarettes smoked increases (England et al., 2001; Moore & Zaccaro, 2000), a low birth weight rate of 11% has been observed in the United States among the lightest smokers (i.e., those smoking one to five cigarettes daily), 61% higher than the rate among nonsmokers (USDHHS, 1998). Health risks include miscarriage, preterm births, infant respiratory problems (including asthma), earaches, learning and behavior problems, and possibly death (DiFranza & Lew, 1995; Horta et al., 1997; Olds, Henderson, & Tatelbaum, 1994; Orlebeke, Knol, & Verhulst, 1997). Additionally, nicotine is a neurotoxin that destroys fetal brain cells (Slotkin, 1998). To
ensure appropriate counseling and treatment for women of childbearing age, achieving accuracy in tobacco use assessment is especially important.

Cigarette smoking rates among women of childbearing age continue to increase, and women who smoke are often less educated and are underemployed (USDHHS, 1997b). The prevalence of current smoking is nearly three times higher among women with 9 to 11 years of education (32.9%) than among women with 16 or more years of education (11.2%). In addition, prevalence rates are higher among women living below the poverty level (29.6%) than among those living at or above the poverty level (21.6%). Differences in smoking prevalence among U.S. racial/ethnic populations also have been observed over time. Although the overall rate has declined in the past 30 years, current reports indicate that approximately 35% of American Indian/Alaska Native, 24% of White, 22% of Black, 14% of Hispanic, and 11% of Asian/Pacific Islander women smoke (USDHHS, 1997b).

Even when the recommended assessment and counseling guidelines are followed and best-practice methods for tobacco use intervention are provided to pregnant smokers, quit rates are low and recidivism after delivery is extremely high (Fiore, Bailey, & Cohen, 1996). The resulting costs to the individual and her family, the health care system, and society in general are substantial. Pregnant smokers with complicated deliveries use about 66% more health care resources than do nonsmokers (Adams, Solanki, & Miller, 1997). In addition, both mother and child are more likely to stay in the hospital longer. The attributable cost for direct medical expenditures of a complicated birth for smokers has been estimated as US$1.4–$2 billion. These costs are based on extrapolations of costs in 1987 and an estimated 19%–20% of pregnant women who smoked in 1995. A decrease of 1% in the U.S. smoking prevalence rate among pregnant smokers would result in 1,300 fewer low-birth-weight live births and save US$21 million in direct medical costs (Lightwood, Phibbs, & Glantz, 1999).

In 1995, it was estimated that the self-reported smoking prevalence among U.S. Medicaid-supported pregnant women (1.52 million) was approximately 29%, or 440,000 patients (Fiore et al., 1996). This report assumed a 10% deception rate. Two evaluation research studies of this population that included self-report and cotinine analysis found overall deception rates from 24% (Windsor et al., 1993) to 50% (Kendrick et al., 1995). Due to high rates of deception in the literature, particularly among Medicaid-supported pregnant smokers, Windsor and colleagues (2000) suggest applying deception rates (after entry into care) of at least 20% for the U.S. maternity cohort (~780,000) and 35% for Medicaid patients (~530,000).

Nondisclosure of cigarette smoking by pregnant women has direct implications for prenatal care practice and research. On a research level, deception produces underestimates of the prevalence of smoking during pregnancy if the rates are based on self-reported data not biochemically confirmed. On a practice level, health care professionals will not be able to provide evidence-based treatments to patients if they are not aware of the patients’ routine exposure to this risk factor. Currently accepted clinical practice methods for smoking cessation among pregnant women include psychosocial interventions (the 5 A’s brief counseling intervention: ask, advise, assess, assist, and arrange) Clinicians may consider pharmacotherapy for pregnant smokers unable to quit using psychosocial interventions. This approach is recommended by the U.S. Public Health Service (Fiore et al., 2000).

The purpose of this review is to (a) describe existing methods of measuring active tobacco exposure among pregnant women and (b) illustrate the usefulness of these measures in validating self-reported smoking status among these women. We conducted an in-depth review of the scientific literature available on measurements of tobacco smoke exposure, smoking and pregnancy, and deception. Insight gained from this review is vitally important to research because it clarifies how to change current cigarette smoking assessment procedures to more accurately identify pregnant smokers and confirm cessation and, ultimately, increase opportunities for clinicians to implement the recommended evidence-based 5 A’s model of brief tobacco intervention (Fiore et al., 1996; Fiore et al., 2000) to reduce the potential health risks associated with active, and passive, tobacco smoke exposure during pregnancy.

**Method**

This review discusses methods used to measure cigarette smoke exposure in pregnant women and summarizes studies that focused on maternal smoking during pregnancy to describe either prevalence or cessation rates in this population. A limited number of observational studies that assessed the validity of self-reported smoking status among pregnant women are included.

Published studies were searched using Medline (1966–June 2003), PsycINFO (1978–2003), and Academic Search Elite (1967–2003). Unpublished study findings were obtained from colleagues. The strategy was the same for all three databases, and the search was limited to human studies and those published in English. The earliest year available for each database was searched through 2003 for key words including pregnancy, tobacco, cigarette smoking, cessation, deception, social desirability, self-report, significant other
reports, carbon monoxide, cotinine, and thiocyanate. These key words were used alone and in combination with one another. Approximately 217 studies were identified. Studies were excluded from this review if they did not specifically focus on pregnant women or if they did not focus only on active cigarette use. Of the 217 identified studies, 25 matched the criteria for inclusion in this review.

**Results**

**Measurements of cigarette smoke exposure**

This section describes several measures of cigarette exposure including self-reports, significant other reports, and biochemical tests. If available, studies that determined the accuracy of these measures among pregnant women are highlighted.

**Self-reports.** Self-reported data may be derived from written or oral questionnaires of patients’ tobacco exposure. Self-report is the least expensive type of measurement (Aday, 1991; Windsor, Baranowski, Clark, & Cutter, 1994), and subject responses are immediately available for review. Major disadvantages of self-report include (a) the respondent may be unable to accurately recall exposure (recall bias), (b) the respondent may be unwilling to disclose the desired information, or (c) the respondent may purposely be dishonest about exposure (deception bias) (Haley & Hoffman, 1985; Luepker, Pallonen, Murray, & Pirie, 1989; Murray, O’Connel, Schmidt, & Perry, 1987; Solberg, 1997). Table 1 summarizes the nine published smoking cessation studies among pregnant women that used self-report only to measure tobacco exposure at the onset of, and during, care (Dolan-Mullen, Ramirez, & Groff, 1994; Windsor & Orleans, 1986; Windsor, Boyd, & Orleans, 1998). In a maternity clinical setting, smoking status is typically assessed through patient self-report.

**Significant other reports.** In several smoking cessation studies among nonpregnant subjects, significant other reports have been used to verify the participant’s self-report (Cummings, Emont, Jaen, & Scandra, 1988; Marlett, Curry, & Gordon, 1988; McLaughlin, Dietz, Mehl, & Blot, 1987). The smoker is asked to provide the name and contact information of the spouse or partner, friend, family member, or coworker who can corroborate the self-reported smoking status. This method of corroboration is advantageous because it is less expensive than biochemical validation. A disadvantage is that the significant other may have limited exposure to the smoker. If the significant other lives with the subject, however, the smoking status would likely be known. However, the significant other may inadvertently or purposely provide a false report of smoking status (Emont, Collins, & Zywiak, 1991). Only one study in the literature on smoking cessation during pregnancy used key informants to validate self-reported smoking status (Valbo & Nylander, 1994). During a randomized controlled trial conducted at the University National Hospital in Norway, significant other reports were used to corroborate self-reported smoking status. Partners or close family members who accompanied the women to their ultrasound examination (at the 32nd-week visit) and had witnessed the patient’s response to smoking gave the reports. Of the 104 women in this study who smoked heavily (≥20 cigarettes per day), 20% of the experimental group (n=54) and 4% of the usual-care group (n=50) quit smoking. Because no independent testing of patients was performed, the accuracy of the significant other report validation is not known.

**Biochemical tests.** Biochemical tests used to detect the presence of carbon monoxide (CO), thiocyanate, or cotinine in body fluids (saliva, urine, blood, or expired air) have been used to measure active, and passive, tobacco exposure among pregnant women. These biochemical markers have been compared to determine which best distinguishes smokers from nonsmokers (Jarvis, Pedoe, Feyerabend, Vesey,

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**Table 1.** Smoking cessation studies for pregnant women: Self-report measurement only.

<table>
<thead>
<tr>
<th>Study</th>
<th>Sample size</th>
<th>Quit rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Donovan, 1977</td>
<td>E = 263, C = 289</td>
<td>Not reported</td>
</tr>
<tr>
<td>Baric et al., 1976</td>
<td>E = 63, C = 47</td>
<td>E = 14%, C = 4%</td>
</tr>
<tr>
<td>Loeb et al., 1983</td>
<td>E = 500, C = 500</td>
<td>E = 15%, C = 14%</td>
</tr>
<tr>
<td>Lilley &amp; Forster, 1986</td>
<td>E = 74%, C = 73%</td>
<td>E = 5.4%&lt;sup&gt;a&lt;/sup&gt;, C = 1.4%</td>
</tr>
<tr>
<td>MacArthur et al., 1987</td>
<td>E = 493, C = 489</td>
<td>E = 9%, C = 6%</td>
</tr>
<tr>
<td>Gilles et al., 1988</td>
<td>E = 450, C = 390</td>
<td>E = 7.4%, C = 3.4%</td>
</tr>
<tr>
<td>Messimer et al., 1989</td>
<td>E = 57%, C = 60</td>
<td>E = 26.3%&lt;sup&gt;b&lt;/sup&gt;, C = 13.3%&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>King et al., 1992</td>
<td>E = 951, C = 211</td>
<td>E = 5%&lt;sup&gt;b&lt;/sup&gt;, C = 5%&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Lillington et al., 1995</td>
<td>E = 79, C = 146</td>
<td>E = 12%&lt;sup&gt;b&lt;/sup&gt;, C = 12%&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Saloojee, 1987). Clear differences in the biochemical test values according to exposure level are demonstrated in Table 2.

**Carbon monoxide.** CO is a poisonous gas that replaces oxygen in blood and reduces the flow of oxygen to the fetus. Two methods are used to measure CO levels: expired-air CO and carboxyhemoglobin (COHb). A portable CO analyzer with additional supplies (t valves and mouthpieces) and maintenance (calibration kits) provides an instant CO value measured in parts per million (ppm). The common cutoff for a maternity patient to be considered a smoker is at least 10 ppm (Jarvis et al., 1987; Vitalograph, 1998). Several factors can influence the amount of CO absorbed by the smoker, including the type of cigarette consumed, the depth of inhalation, and the frequency and number of smoking events. CO measurement also may be influenced by environmental exposures (i.e., marijuana use or second-hand smoke). CO has a half-life of 3–5 hours and cannot be used to detect active tobacco exposure from the previous day.

The accuracy of expired-air CO measurement to assess tobacco smoke exposure in late pregnancy was examined at a Jerusalem community hospital (Seidman et al., 1999). A total of 68 patients and newborns provided air and blood samples to be tested for expired-air CO, COHb, and cotinine. A strong correlation was observed in levels of expired-air CO, COHb, and cotinine between mother and newborn. Seidman et al. concluded that expired-air CO measurement was not only a valid measurement of tobacco exposure but also a less expensive and less invasive measurement.

**Thiocyanate.** Thiocyanate testing for tobacco exposure is measured from traces of hydrogen cyanide in tobacco inhaled when a cigarette is smoked. Cyanide is metabolized in the liver and eliminated through the kidneys. Thiocyanate is in all body fluids (serum, urine, and saliva) and is measured by mass spectrophotometry analysis in micrograms per milliliter (µg/ml). In addition to tobacco, however, thiocyanate is influenced by consumption of certain foods such as nuts, beer, and green leafy vegetables. Despite these influences, thiocyanate is a good test to confirm smoking status because of its long life in body fluids (10–14 days without fluctuation). Active exposure (cutoff ≥ 100 µg/ml) can be detected, even if a smoker quits 1 week prior to testing.

The accuracy of salivary thiocyanate among pregnant women enrolled in a smoking cessation intervention study was determined by Windsor and colleagues (1989). Patients provided written self-reports and a saliva sample at the first prenatal visit, at a midpoint visit, and within 2–4 weeks following delivery. All participants were told that the saliva sample would validate their self-report. The deception rate was only 6%. Saliva is easier to collect than blood or urine, salivary thiocyanate has a long half-life, and the test is much less expensive than that for cotinine. In an earlier study, researchers confirmed that the accuracy of thiocyanate to measure tobacco smoke exposure does not differ if serum or saliva samples are collected face-to-face or via mail (Sexton, Nowicki, & Hebel, 1986).

**Cotinine.** Cotinine is a metabolite of nicotine that can be measured in serum, saliva, and urine. Salivary cotinine is the most sensitive and specific of the three measures. Cotinine is not influenced by environmental exposures other than tobacco and has a half-life of 12–18 hours. It is measured in nanograms per milliliter (ng/ml), with a usual cutoff value of at least 20 ng/ml for smokers. Cotinine testing is expensive, however, and requires special laboratory techniques (immunoassay or gas chromatography) and refrigeration storage, although short-term storage can be achieved in a cool environment.

<table>
<thead>
<tr>
<th>Biochemical markers</th>
<th>No exposure</th>
<th>Passive exposure</th>
<th>Active exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thiocyanate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Serum (mmol/l)</td>
<td>49.9</td>
<td>–</td>
<td>123.9</td>
</tr>
<tr>
<td>Saliva (mmol/l)</td>
<td>1.3</td>
<td>–</td>
<td>2.5</td>
</tr>
<tr>
<td>Urine (mmol/l)</td>
<td>75.2</td>
<td>–</td>
<td>153.2</td>
</tr>
<tr>
<td>Cotinine (ng/ml)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saliva</td>
<td>1.7</td>
<td>8</td>
<td>330</td>
</tr>
<tr>
<td>Serum</td>
<td>1.5</td>
<td>7.3</td>
<td>294</td>
</tr>
<tr>
<td>Urine</td>
<td>4.8</td>
<td>12.9</td>
<td>1448</td>
</tr>
<tr>
<td>Carbon monoxide</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ECO (ppm)</td>
<td>5.6</td>
<td>10.6</td>
<td>21.3</td>
</tr>
<tr>
<td>COHb (%)</td>
<td>0.9</td>
<td>–</td>
<td>4.1</td>
</tr>
</tbody>
</table>

Note. COHb, carboxyhemoglobin; ECO, expired-air carbon monoxide. Dashes represent missing values.

Source: Jarvis et al., 1987.
Cotinine is considered the measure of choice to estimate daily nicotine consumption (Cummings & Richard, 1988; Jarvis et al., 1987).

Etzel (1990) reviewed the literature to evaluate the relationship between saliva concentration and self-reported tobacco smoke exposure in both active and passive smokers. For the 22 articles included in the final analysis, specific information regarding population studied, reported tobacco smoke exposure, method of measurement, and cotinine concentration was assessed. Results indicated that the salivary cotinine test provided a clear distinction between passive (5–10 ng/ml) and active (>10 ng/ml) levels of tobacco exposure. In addition, Etzel suggested that, based on salivary cotinine concentrations, the four categories of tobacco smoke exposure were A (cotinine = 0 ng/ml; no active, no passive), B (cotinine < 10 ng/ml; no active, some passive), C (cotinine = 10–100 ng/ml; infrequent active, some passive), and D (cotinine > 100 ng/ml; regular active, some passive).

Sensitivity and specificity. Jarvis et al. (1987) examined the sensitivity and specificity of cotinine, CO, and thiocyanate (Table 3). Expired-air CO and COHb had about the same specificity, but COHb was more sensitive. Serum thiocyanate tests were most often used because this test is more sensitive and specific than those for urinary or salivary thiocyanate. Salivary cotinine was the most sensitive and specific of the three cotinine tests. Jarvis et al. concluded that although cotinine is the measure of choice, testing expired-air CO is considerably cheaper and simpler to use in most clinical settings.

Prevalence studies of smoking during pregnancy

Three U.S. federal agencies routinely collect information on tobacco exposure during pregnancy: the National Center for Health Statistics (NCHS), the National Institute on Drug Abuse (NIDA), and the Substance Abuse and Mental Health Agency (SAMHSA). The rates reported by these agencies are based on self-report only and do not include biochemical confirmation, which may explain inconsistencies in smoking prevalence rates across the agencies. Additional inconsistencies may be attributed to differences in sampling and data collection procedures at each agency. The NCHS includes birth certificate data from all U.S. births. The SAMHSA data are from the National Households Survey on Drug Abuse, an interview survey that randomly selects households for participation; and the NIDA data are from the National Pregnancy and Health Survey. The data from all reporting agencies suggest that smoking during pregnancy continues to decline.

In 2001, the NCHS collected tobacco use data on birth certificates from 49 states (no data from California) and the District of Columbia. Results indicated that, in 2001, 12% of women giving birth reported that they smoked, compared with 12.2% in 2000 and 19.5% in 1989, when these data were first collected (USDHHS, 2002). The rate of cigarette use by pregnant women was observed by NIDA to be even higher (20.5%) (USDHHS, 1996). SAMHSA assessed past-month cigarette use among respondents aged 15–44 years and reported that 19.8% of pregnant women smoked, compared with 29.5% of nonpregnant women in the same age group (USDHHS, 1999).

Racial/ethnic differences in smoking prevalence rates are shown in Table 4. Compared with the NCHS data, the prevalence rates of smoking during pregnancy are consistently higher for all races and ethnic groups in the SAMHSA data for the same year. This finding further demonstrates how lack of biochemical confirmation of self-report can lead to discrepancies in national rates. NIDA does not report data on smoking during pregnancy by race category.

Table 3. Sensitivity and specificity of each biochemical marker.

<table>
<thead>
<tr>
<th>Biochemical marker</th>
<th>Cutoff value</th>
<th>Sensitivity (% CIG SM)</th>
<th>Specificity (% NONSM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thiocyanate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Serum (mmol/l)</td>
<td>78</td>
<td>86</td>
<td>79</td>
</tr>
<tr>
<td>Saliva (mmol/l)</td>
<td>1.64</td>
<td>86</td>
<td>63</td>
</tr>
<tr>
<td>Urine (mmol/l)</td>
<td>118</td>
<td>63</td>
<td>63</td>
</tr>
<tr>
<td>Cotinine (ng/ml)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saliva</td>
<td>14.2</td>
<td>99</td>
<td>82</td>
</tr>
<tr>
<td>Serum</td>
<td>13.7</td>
<td>97</td>
<td>81</td>
</tr>
<tr>
<td>Urine</td>
<td>49.7</td>
<td>98</td>
<td>83</td>
</tr>
<tr>
<td>Carbon Monoxide</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ECO (ppm)</td>
<td>10</td>
<td>88</td>
<td>84</td>
</tr>
<tr>
<td>COHb (%)</td>
<td>1.7</td>
<td>92</td>
<td>82</td>
</tr>
</tbody>
</table>

Note: COHb, carboxyhemoglobin; ECO, expired-air carbon monoxide. The cutoff values were chosen to minimize the number of misclassifications.

Source. Information compiled from Jarvis et al., 1987.

CIG SM = cigarette smoker.

NONSMA = nonsmoker.
Cessation studies of smoking during pregnancy

The 15 cessation studies selected for inclusion in this review are randomized evaluation research studies that focused on pregnant women and used biochemical testing to assess or validate active cigarette smoke exposure. These studies are presented according to the type of biochemical measurement used and the point of data collection (baseline or follow-up) that the deception rate represents. The point of data collection is important because high deception at baseline may influence early treatment opportunities and recruitment for research studies. High deception at follow-up has a direct impact on the conclusions drawn regarding the effectiveness of intervention methods. Table 5 summarizes these findings.

Salivary thiocyanate. Only one study used salivary thiocyanate to verify self-report and found no deception. Researchers conducted a three-phase study in Birmingham, Alabama, to evaluate the efficacy of low-cost, self-help smoking cessation methods for public health clinic populations (Windsor et al., 1985). The first phase, a natural history study, established the normal smoking cessation rate for public health maternity patients. Approximately 27% had quit prior to the initial prenatal visit. Phase two, a formative evaluation (pilot study), was conducted with 30 pregnant smokers to guide development and revision of materials and methods, as well as to allow the interventionists to practice and refine the protocol. The final phase evaluated the smoking cessation methods by using a prospective randomized pretest-posttest design. Survey data and a saliva sample for thiocyanate analysis were collected on all participants during the initial visit and during the last month of pregnancy or 48 hours postpartum. Self-report and thiocyanate levels (cutoff=100 μg/ml) determined quit status. A total of 22 maternity patients self-reported cessation, and the thiocyanate test confirmed all 22 had indeed quit, with a deception rate of 0% at follow-up.

Urinary cotinine. Eight studies used urinary cotinine to verify self-reported smoking status; two reported deception rates for baseline data only, five for follow-up only, and one for both. The two studies that reported only baseline deception rates had remarkably different findings. The first was a prospective randomized clinical trial for smoking cessation among prenatal patients in a Los Angeles-based health maintenance organization and used urinary cotinine to confirm continuous abstinence prior to the 20th week of pregnancy through delivery (Ershoff, Dolan-Mullen, & Quinn, 1989). Data on smoking status and consumption were collected at entry into prenatal care by intake survey and during


<table>
<thead>
<tr>
<th>Racial/Ethnic Group</th>
<th>NCHS (N=3,498,174)</th>
<th>SAMHSA (N=1,448,431)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All races</td>
<td>12</td>
<td>32</td>
</tr>
<tr>
<td>White</td>
<td>13</td>
<td>32</td>
</tr>
<tr>
<td>Black</td>
<td>9</td>
<td>28</td>
</tr>
<tr>
<td>American Indian/Alaska Natives</td>
<td>20</td>
<td>47</td>
</tr>
<tr>
<td>Asian or Pacific Islanders</td>
<td>3</td>
<td>–</td>
</tr>
<tr>
<td>Hispanic</td>
<td>3</td>
<td>24</td>
</tr>
<tr>
<td>Native Hawaiian/Pacific Islanders</td>
<td>–</td>
<td>54</td>
</tr>
<tr>
<td>Asian</td>
<td>–</td>
<td>22</td>
</tr>
<tr>
<td>Non-Hispanic/more than one race</td>
<td>–</td>
<td>72</td>
</tr>
</tbody>
</table>

Note. All values in percentages. NCHS, National Center for Health Statistics; SAMHSA, Substance Abuse and Mental Health Agency. Dashes indicate that data were not described as this category.

Table 5. Summary of deception rates from smoking cessation studies for pregnant women.

<table>
<thead>
<tr>
<th>Study</th>
<th>Sample size</th>
<th>Measurement</th>
<th>Deception rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Windsor et al., 1985</td>
<td>E₁=103, E₂=102, C=104</td>
<td>Salivary thiocyanate</td>
<td>O₀=0%</td>
</tr>
<tr>
<td>Ershoff et al., 1989</td>
<td>E₁=126, C=116</td>
<td>Urinary cotinine</td>
<td>O₉=4%</td>
</tr>
<tr>
<td>Petersen et al., 1992</td>
<td>E=71, C=78</td>
<td>Urinary cotinine</td>
<td>O₈=25%</td>
</tr>
<tr>
<td>O'Connor et al., 1992</td>
<td>E=100, C=109</td>
<td>Urinary cotinine</td>
<td>O₋₁₀₀=17%</td>
</tr>
<tr>
<td>Secker-Walker et al., 1994</td>
<td>E=188, C=226</td>
<td>Urinary cotinine</td>
<td>O₋₁₈₈=26%</td>
</tr>
<tr>
<td>Walsh et al., 1997</td>
<td>E=127, C=125</td>
<td>Urinary cotinine</td>
<td>O₋₁₂₇=21%</td>
</tr>
<tr>
<td>Ershoff et al., 1999</td>
<td>E₁=111, E₂=120, E₃=101</td>
<td>Urinary cotinine</td>
<td>O₋₁₁₁=29%</td>
</tr>
<tr>
<td>Moore et al., 2002</td>
<td>E=600, C=695</td>
<td>Urinary cotinine</td>
<td>O₋₆₀₀=28% O₋₆₀₀=35%</td>
</tr>
<tr>
<td>Kendrick et al., 1995</td>
<td>E=1,467, C=1,767</td>
<td>Urinary cotinine</td>
<td>O₋₁,₄₆₇=28%</td>
</tr>
<tr>
<td>Windsor et al., 1993</td>
<td>E=400, C=414</td>
<td>Salivary cotinine</td>
<td>O₋₄₀₀=28%</td>
</tr>
<tr>
<td>Gielen et al., 1997</td>
<td>E=125, C=121</td>
<td>Salivary cotinine</td>
<td>O₋₁₂₅=37% C=48%</td>
</tr>
<tr>
<td>Gebauer et al., 1998</td>
<td>E=84, C=94</td>
<td>Salivary cotinine</td>
<td>O₋₈₄=19%</td>
</tr>
<tr>
<td>Windsor et al, 2000</td>
<td>E=139, C=126</td>
<td>Salivary cotinine</td>
<td>O₋₁₃₉=24% O₋₁₃₉=10%</td>
</tr>
<tr>
<td>Price et al., 1991</td>
<td>E₁=71, E₂=52, C=70</td>
<td>Carbon monoxide</td>
<td>O₋₇₁=7%</td>
</tr>
<tr>
<td>Hartmann et al., 1996</td>
<td>E₁=107, C=100</td>
<td>Carbon monoxide</td>
<td>O₋₁₀₇=11%</td>
</tr>
</tbody>
</table>

Note. C=control group; E, experimental group; E₁=experimental group 1; E₂=experimental group 2; O₀=overall at baseline, O₋₁₀₀=overall at follow-up.
a telephone interview at approximately 26 weeks of pregnancy. At least seven urine samples (one per scheduled monthly clinic visit) were collected from each patient for cotinine analysis; patients were classified as early quitters, middle quitters, late quitters, early relapers, late relapers, or nonquitters. A deception rate of 4% was found at baseline. At follow-up, urinary cotinine tests confirmed that 22% of the experimental group vs. 8.6% of the control group quit prior to the 20th week of pregnancy.

The second study reporting baseline deception rates only was also a clinical trial that examined the effectiveness of low-cost, self-help program designed for pregnant women (Petersen, Handel, Kotch, Podedworny, & Rosen, 1992). Researchers conducted two prospective studies, one randomized and one nonrandomized, on patients enrolled in the Harvard Community Health Plan (a health maintenance organization). Smoking behavior was assessed by survey at the first visit and by telephone interview at 6 months gestation and 8 weeks postpartum. A deception rate of 25% was found at baseline. Urine was collected for cotinine analysis on 50% of the self-reported quitters at follow-up. Results at 8 weeks postpartum revealed significant differences between the control group (9.7%) and both experimental groups (group 1 = 29%, group 2 = 35.6%). Deception rates were not reported at follow-up for either study.

Deception rates for the five studies that reported this rate at follow-up ranged from 17% to 29%. One prospective randomized clinical trial was conducted at a teaching hospital in Ottawa, Canada (O’Connor et al., 1992). All patients completed a survey that inquired about smoking status at preintervention, 1 month postintervention, 36 weeks gestation, and 6 weeks postpartum. Urine was collected for cotinine analysis, and patients with values less than 64 ng/ml were considered quitters. The differences between the experimental group and the control group at 1 month postintervention (14.9% vs. 5%, respectively) and 6 weeks postpartum (13.8% vs. 5.2%, respectively) were statistically significant. A total of 8 of the 10 control quitters and 12 of the 22 experimental quitters relapsed during follow-up. A deception rate of 17% was found at follow-up. Studies with similar methods have observed higher deception rates (i.e., Ershoff et al., 1999 [21%]; Moore et al., 2002 [29%]; Secker-Walker et al., 1994 [26%]). In their study in New South Wales, Walsh, Redman, Brinsmead, Byrne, and Melmeth (1997) noted a significantly higher rate of deception among the control group at follow-up (52% for the control group vs. 12% for the experimental group).

The only study that reported both baseline and follow-up deception rates was a multistate demonstration project designed to increase smoking cessation among pregnant women receiving services from the Women, Infants, and Children (WIC) program in state public health clinics (Kendrick et al., 1995). A total of 64 clinics from three states (Colorado, Maryland, and Missouri) were randomly assigned to intervention or control status. Each state independently developed and integrated low-intensity interventions into routine prenatal care activities. Data collection included a survey at baseline and two follow-up observations, as well as urine samples to confirm self-reported smoking status via cotinine analyses. In all three states, pregnant smokers who attended the intervention clinics were more likely to self-report quitting when compared with those receiving care at the control clinics (Colorado: 65% vs. 48%, Maryland: 73% vs. 49%, Missouri: 76% vs. 47%). Deception rates ranged from 28% (baseline) to 49% (follow-up) for the intervention and control participants.

Salivary cotinine. Four studies used salivary cotinine to verify self-reported smoking status; none reported deception rates for baseline data only, three reported rates for follow-up only, and one reported rates for both. The first study that reported follow-up deception rates only was a prospective randomized clinical trial that included baseline and follow-up survey completion and saliva samples for cotinine analysis (cutoff < 30 ng/mL) for 814 patients (Windsor et al., 1993). An additional 100 patients were observed as historical control subjects. The experimental group (n = 400) reported a 14.3% quit rate; the control group (n = 414) reported a 8.5% quit rate. The overall deception rate at follow-up was 28% (32% for the experimental group vs. 17% for the control group). Compared with the other two studies with similar data collection methods, the rates reported by Windsor et al. were lower than those from Gielen et al. (1997; 37% for the experimental group vs. 48% for the control group) and higher than those from Gebauer, Kwo, Haynes, and Wevers (1998; 19%).

The fourth and most recent published randomized clinical trial that reported both baseline and follow-up deception rates was the pilot study for the Smoking Cessation or Reduction in Pregnancy Trial, a statewide evaluation research study conducted in Alabama. This study determined whether active cigarette smoke exposure assessments and patient education methods could be delivered routinely by Medicaid maternity care staff, and it documented the behavioral impact of these interventions among smokers. Of the 139 experimental group members, 17% were cotinine-confirmed quitters; 9% of control group members (n = 126) were confirmed quitters. The deception rate at baseline was substantially higher than at follow-up (24% vs. 10%, respectively; Windsor et al., 2000).
Carbon monoxide. Of the two studies using CO to verify self-reported smoking status, both reported deception rates for follow-up only. One was a pilot study to assist with the development of a video and to test a 102-item survey (Price et al., 1991). Participants completed a 90-item questionnaire and provided breath samples for CO analysis (cutoff ≤7 ppm) during the first visit and approximately 3 weeks prior to delivery. Only 56% of the participants completed the study. Some 9% (10 out of 109) self-reported quitting, and the deception rate at follow-up was 7%.

The other study using CO to verify self-report observed a slightly higher deception rate (Hartmann, Thorp, Pahel-Short, & Koch, 1996). Over 800 maternity care patients completed a smoking history and an attitudes and knowledge survey. Although more than 750 participants consented to CO breath measurement at baseline, only 32% were identified as smokers and recruited to participate in this prospective randomized clinical trial. All participants provided self-report of smoking status and CO breath measurement at entry and completion of prenatal care. Cessation results for the experimental group (20%) and the control group (10%) were confirmed with a CO level of 5 ppm or less. The overall deception rate at follow-up was 11.4% (12.5% for the experimental group vs. 9% for the control group).

Interpretation of the impact of intervention studies that use only self-reporting measures takes into account the potential for deception, as documented by those studies that verify self-report with biochemical testing. The results of studies that use biochemical testing at follow-up to confirm quit rates, therefore, could be considered more reliable.

Observational validity studies on self-reported smoking status during pregnancy

Five published studies were conducted for the purpose of validating self-reported smoking status during pregnancy. A 1997 study conducted in New Zealand compared cotinine-analyzed serum samples obtained during pregnancy with self-reported smoking status (Ford, Tappin, Schluter, & Wild, 1997). One-fourth of the pregnant smokers did not disclose their smoking behavior. The self-reported smoking prevalence rates were 19% during the first trimester and 16% during the third. The cotinine-confirmed smoking rates for the first and third trimesters were 31% and 28%, respectively.

A prospective study conducted in New South Wales examined the proportion of pregnant women misclassified as nonsmokers by usual-care midwives and compared self-reported data with a biochemical measure (Walsh, Redman, & Adamson, 1996). Patients were questioned about their smoking habits during their first prenatal care visit. Self-reported nonsmokers were approached by a midwife during their second visit to respond to first-visit questions regarding their smoking behavior and their behavior within the last week and to provide urine samples for cotinine analysis. Of the 166 women who were classified as self-reported nonsmokers, 9 (5%) had UCOT levels greater than 500 μmol/l. Based on the survey and the biochemical test, the estimated proportion of midwife-identified nonsmokers who could be reclassified as smokers was 7.4%.

In the United States, a retrospective comparison of end-of-pregnancy self-reports and salivary cotinine values was conducted to determine the rate of misclassification of smoking and nonsmoking status. Of the 107 self-reported quitters, 28 had a cotinine value consistent with that of a smoker, a deception rate of 26% (Boyd, Windsor, Perkins, & Lowe, 1998).

Another retrospective analysis of self-report and urinary and serum cotinine levels, obtained from a 1992 research study that focused on preeclampsia prevention and not on smoking, suggested that the accuracy of self-reported smoking status has not changed since the 1960s. Results indicated that 95% of those who self-reported as quitters were confirmed as such via cotinine (Klebanoff et al., 2001). Similar deception rates were observed in a Swedish retrospective study (Lindqvist, Lendahls, Tollbom, Aberg, & Hakannson, 2002). Smoking status information was obtained from 496 patient charts, and serum samples were tested for cotinine. Of the 407 self-reported nonsmokers, 6% had cotinine levels that suggested they were, in fact, smokers.

Survey design studies to improve disclosure of cigarette smoking during pregnancy

The effectiveness of methods to improve truthful disclosure and effectively identify pregnant smokers via self-report has been examined. A randomized clinical trial was conducted to examine disclosure among a multiethnic (50% White, 33% Black, 15% Hispanic, 3% “other”) group of adult maternity patients (age ≥18 years) in Texas during their first prenatal visit (Dolan-Mullen, Carbonari, Tabak, & Glenday, 1991). Rates of disclosure were compared by use of two channels of questions (written and oral) and two response formats (usual history question that elicits a yes-no response, and multiple-choice question with choice of five responses explicitly describing smoking status). Experimental questions were substituted for usual questions concerning smoking, alcohol, and other drugs on the patient history form. Each session lasted 40 minutes and was conducted by trained nurse educators. Results indicated that, across all races and regardless of channel (written or oral), multiple-choice questions improved disclosure by 40%. Urinary cotinine tests confirmed a deception rate of 3% among self-reported nonsmokers.
Researchers in northern California evaluated four questions used to assess smoking during pregnancy in an effort to improve the accuracy of smoking status on birth certificates (Kharrazi et al., 1999). Question 1 was a yes-no format, question 2 was a trimester-specific design, question 3 was multiple choice, and question 4 was month and grouped-month specific. Responses to questions 1 and 2 were compared with self-report obtained from telephone interviews during pregnancy. Responses to questions 3 and 4 were compared with midpregnancy serum cotinine levels. All questions were evaluated based on conciseness, response rate, data accuracy, and type of data requested. Although no question was observed to be superior, questions 1 and 2 were the most concise, and questions 3 and 4 were the most sensitive. The authors concluded that a combination of questions 2 and 4 (which ask about average number of cigarettes in the past three months and during each trimester) would most likely provide accurate data for birth certificate studies.

Discussion

Review of these reports illustrates that measuring smoking status among pregnant women by self-report alone leads to discrepancies in national prevalence rates, deception in clinical practice disclosure, and inconsistencies among research study results. Prevalence rates for smoking among pregnant women given in national statistics (12%-21%) are inaccurate (due to differences in data sampling and collection procedures) and underestimate the problem. Evaluated research studies that confirm smoking status among pregnant women by biochemical methods provide more accurate prevalence rates and demonstrate the most effective behavioral interventions to achieve cessation.

Information from evidence-based studies has been well documented in the scientific literature for decades and has led to the creation of national guidelines recommending best-practice methods for clinical assessment of tobacco use and counseling for pregnant women (Fiore et al., 1996; Fiore et al., 2000). The impact of maternity patient nondisclosure of cigarette smoking has been noted in these guidelines. In addition to recommending that clinicians follow the 5 A’s model to help maternity patients quit smoking, it is suggested that health care providers be aware that some pregnant women may try to hide their smoking status.

Many providers, however, are still not aware of these guidelines or, if aware, may not be able to incorporate this process into their busy clinical practices. Therefore, smoking goes undetected among many pregnant smokers. Even if the guidelines are followed and the first three steps of the appropriate assessment of tobacco use are conducted, counseling and treatment or intervention rarely occur and patients desiring to quit rarely receive the desired assistance in achieving cessation.

Most pregnant smokers who have knowledge of the risks of smoking say they want to quit. The majority of these women are at the stage in their lives where they are most motivated to quit, at least for the sake of their unborn child. That most are unable to quit, or stay quit, indicates that other, even stronger factors are mitigating achievement of that goal. The deterrents are most likely the physiological and psychological factors of addiction.

Reasons for smoking deception need to be researched further, particularly among pregnant smokers, for few if any such studies exist and none was found in this literature review. Multiple psychosocial factors influence deception about tobacco use among adults. Feelings of guilt and shame, the fear of being stigmatized, and simply having a deceptive nature are suggested reasons why smokers increasingly choose not to reveal their smoking status to physicians (Squire, 1991). Jackson (2000) noted that “self-report of smoking is a subject’s own account of an addictive behaviour; we do not expect high reliability from addicts.”

For decades, smoking has been recognized in the scientific community as an addiction (USDHHS, 1980), yet it is not universally treated as such. Standard medical practice does not follow this diagnosis (nicotine addiction), and few providers routinely confirm the patient’s claim of cessation with a urine test and provide counseling (Reidenberg, 1994). Nondisclosure of smoking status became so common in smoking treatment clinics that many researchers began using biological markers to confirm their patients’ claims to cessation (Kozlowski, Herman, & Frecker, 1980). Self-report alone does not accurately assess smoking status among this most vulnerable population and, if used without biochemical confirmation, could lead to underreported prevalence and cessation rates as well as untreated health care needs during prenatal care.

Recommendations

National statistics should carry a disclaimer indicating the likelihood of underestimation. All health care providers should be trained in best-practice, evidence-based behavioral methods and encouraged to follow the model for the sake of reaching those who desire to quit and are able to succeed in that goal. Research should focus on determining the most appropriate assessment of smoking status for women who are pregnant and addicted to nicotine, as well as the behavioral methods and materials most efficacious in addressing the underlying causes that lead to risk
taking and harmful behaviors and the most effective dissemination process for making those interventions available to clinicians.

References


