Can We Trust National Smoking Prevalence Figures? Discrepancies Between Biochemically Assessed and Self-Reported Smoking Rates in Three Countries

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Abstract

Background: National smoking prevalence estimates are the primary basis for assessing progress in tobacco control across the world. They are based on surveys of self-reported cigarette smoking. It has been assumed that this is sufficiently accurate for policy purposes, but this assumption has not been adequately tested.

Methods: We report data from the 2003 Health Survey for England, the U.S. National Health and Nutrition Examination Survey for 2001-2002, and the 2004 national smoking behaviors survey in Poland as examples of countries at different stages in the “tobacco epidemic.” Self-reported cigarette and total tobacco smoking prevalence were assessed by means of the standard questions used in each country. In subsamples, specimens were collected for analysis of cotinine (saliva, N = 1,613 in England; serum, N = 4,687 in the United States; and saliva, N = 388 in Poland) providing an objective means of determining active smoking. A cut point of 15 ng/mL was used to discriminate active smoking from passive smoke exposure.

Results: Self-reported cigarette smoking prevalence using the standard methods underestimated true tobacco smoking prevalence by an estimated 2.8% in England, 0.6% in the United States, and 4.4% in Poland. Cotinine concentrations in those misclassified as nonsmokers were indicative of high levels of smoke intake.

Interpretation: Underestimation of smoking prevalence was minimal in the United States but significant in England and Poland. A review of methodologies for assessing tobacco smoking prevalence worldwide is urgently needed.

(Cancer Epidemiol Biomarkers Prev 2007;16(4):820–2)

Introduction

Smoking prevalence is a vital marker of progress in tobacco control (1). Its assessment involves national surveys of self-reported cigarette smoking status. Two threats to the accuracy of prevalence estimates are (a) misreporting of smoking status and (b) the failure to include non-cigarette tobacco smoking. It is widely assumed that the level of misreporting is so low that it will not lead to significant distortion. However, when success or failure of tobacco control measures is typically measured by changes of a few percentage points, even low error rates can be important, if they differ over time or across countries. We present data from three countries in which we compare smoking prevalence assessed by cotinine measurement with estimates based on standard self-report measures of cigarette smoking.

Saliva or serum cotinine concentration is a quantitative marker of nicotine intake (2). A concentration of 15 ng/mL in saliva or serum is a conservative cut point for detecting active smoking (2, 3). Using cotinine to check smoking status, there is evidence that self-report is unreliable in specific populations where there is pressure not to admit smoking, such as patients with respiratory illness (4, 5) or cancer (6) or pregnant women (7-10).

Research on the use of cotinine to verify self-reported smoking status in population surveys is limited. A large study in Finland reported that male smoking prevalence would need to be adjusted from 32% to 34% because of elevated serum cotinine concentrations in putative nonsmokers (11). Another study in the United States found that only 1.4% of self-reported nonsmokers had serum cotinines higher than 15 ng/mL (12), which would suggest an upward revision in prevalence estimates of <1%. A review of earlier studies suggested that only a small percentage of self-declared nonsmokers had elevated cotinine levels in population surveys (13). The prevailing view is that the problem of misreporting is not sufficiently large to warrant routine biochemical verification in population surveys (14).

The problem of misclassification of smoking status may be different in different countries. To address this, we have analyzed data from the 2003 Health Survey for England and from the U.S. National Health and Nutrition Examination Survey (NHANES) 2001-2002, both of which incorporate cotinine measures. We also added saliva cotinine measurement to the 2004 national survey on smoking behaviors in Poland, a country with a much higher smoking prevalence (15).

The headline smoking prevalence figures are based on cigarettes only; however, cigar and pipe smoking also carry health risks and result in nicotine absorption (16, 17); therefore, we examined how far increased prevalence figures derived from cotinine concentrations could be attributed to exclusion of pipe and cigar smoking versus underreporting of any tobacco smoking.
Table 1. Smoking prevalence according to self-report, saliva cotinine, and self-report plus cotinine

<table>
<thead>
<tr>
<th>Smoking Prevalence</th>
<th>England, % (sample size)</th>
<th>USA, % (sample size)</th>
<th>Poland, % (sample size)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-reported cigarette smoking: total sample</td>
<td>24.7 (14,836)</td>
<td>21.7 (5,411)</td>
<td>—</td>
</tr>
<tr>
<td>Self-reported cigarette smoking: sample providing saliva sample</td>
<td>24.7 (1,613)</td>
<td>22.8 (4,687)</td>
<td>—</td>
</tr>
<tr>
<td>Self-reported smoking*: total sample</td>
<td>26.0 (14,836)</td>
<td>22.8 (5,411)</td>
<td>35.3 (1,005)</td>
</tr>
<tr>
<td>Self-reported smoking: sample providing saliva sample</td>
<td>26.2 (1,613)</td>
<td>24.2 (4,687)</td>
<td>37.6 (388)</td>
</tr>
<tr>
<td>Self-reported smoking or saliva cotinine ≥15 ng/mL</td>
<td>28.8 (1,613)</td>
<td>25.5 (4,687)</td>
<td>43.6 (388)</td>
</tr>
<tr>
<td>Saliva cotinine ≥15 ng/mL</td>
<td>27.5 (1,613)</td>
<td>23.4 (4,687)</td>
<td>41.8 (388)</td>
</tr>
</tbody>
</table>

Difference between self-reported cigarette smoking prevalence in the sample providing a specimen and prevalence of cotinine ≥15 ng/mL.

Underestimation of ‘at risk’ smoking prevalence

<table>
<thead>
<tr>
<th>England</th>
<th>USA</th>
<th>Poland</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.8</td>
<td>0.6</td>
<td>4.2</td>
</tr>
</tbody>
</table>

* Includes pipe and cigar smoking.

Material and Methods

England. The Health Survey for England is an annual household survey that includes a representative sample of adults aged 16 and above. Data collection involves an initial interview at home followed by a visit from a research nurse about 1 week later. Smoking behavior in those aged 16 and above was ascertained at the initial interview and again at the nurse visit. A saliva sample for cotinine was collected at the nurse visit in a random subsample.3

A total of 14,836 people aged 16 years and above were interviewed, and 11,408 participated at the nurse visit. Respondents were asked if they used cigarettes, pipes, or cigars “... at all these days.” This standard question was used to determine whether they were current cigarette smokers or current tobacco smokers. Ex-smokers were defined as those who reported being ex–regular cigarette smokers at interview and who also denied any current tobacco use at the nurse visit.

In one sixth of participants, additional measures were taken, including a saliva sample that was analyzed for cotinine by rapid gas-liquid chromatography with nitrogen detection (18). One nonsmoking Nicotine Replacement Therapy (NRT) user was excluded from the analysis. There were 1,613 usable saliva samples.

The mean age of the sample was 48 years (SD, 18.5); 56% were female; 64% were married or cohabiting; 57% had the equivalent of “O” level education (post-16 qualification) or above; 44% were from manual occupational groups. The corresponding figures for those providing usable saliva samples were similar: mean age, 48 years (SD, 17.5); 55% female; 67% married or cohabiting; 60% “O” level or above; 44% manual occupational groups.

United States. The NHANES target population is the civilian noninstitutionalized U.S. population. NHANES 2001-2002 oversampled African Americans and Mexican Americans, as well as persons aged 60 and above. Respondents were interviewed in their homes and then invited to attend a Mobile Examination Center (MEC) for objective measures about 2 weeks later. Smoking behavior in those aged 20 and above was ascertained in detail at the initial interview using standard questions for determining national prevalence. At the MEC visit, a serum sample for cotinine was taken, and respondents were asked about the use of cigarettes and other tobacco products and NRT over the past 5 days. Self-reported smoking for the whole sample was based on responses at initial interview. Among respondents who provided a cotinine sample, self-reported smoking was derived from cigarette, pipe, or cigar use at the MEC. Users of smokeless tobacco products and NRT were excluded from the analyses.

Ex-smokers were those who reported being ex–cigarette smokers at interview and who also denied any smoking in the past 5 days at the MEC. There were 5,411 respondents in the total sample aged 20 and above (mean age, 50; SD, 19.5); 53% were female, and 69% had high school education or above. A total of 5,027 people attended the MEC, providing 4,687 usable serum samples. Cotinine was analyzed by means of high-performance liquid chromatography/tandem mass spectrometry.

Poland. Data were obtained from an annual survey on smoking behaviors and attitudes that is based on a representative random sample of households. The survey was conducted by the Cancer Centre and Institute of Oncology in collaboration with the public opinion research center (TNS OBOP).

The 2004 survey interviewed 1,005 people aged 15 and above. The sample was obtained from the Postcode Address File (PÁLK) that is available for the general Polish population at the Central Statistical Office. Sampling was based on a random-route method, with random selection of “starting point” addresses and then, according to predefined procedures, selection of other addresses. Sampling was conducted in three strata (rural, towns up to 100,000 inhabitants, towns with more than 100,000 inhabitants) in all the biggest administrative units (voivodeships). In selected households, 15-year-old and older inhabitants were randomly selected from within the household to participate.

Respondents were asked, “Have you ever smoked at least 10 cigarettes, pipes, cigars, etc. in your lifetime? Yes/No.” Those who answered yes were asked, “Do you smoke now? Yes/No.” These questions defined whether they were classified as smokers, ex-smokers, or never smokers. Pipe and cigar smoking is extremely rare, and thus, separate figures are not given for cigarette versus total tobacco smoking. Respondents were invited to provide a saliva sample, and 388 agreed and provided a sample volume sufficient for analysis. Cotinine was assayed using the method previously described for the English sample. The sample consisted of 55% women. The mean age was 46.1 years (SD, 18.9); 57% were married or living with a partner; 23% completed only primary education; 29% completed vocational or “gymnasium” education; 32% had completed secondary education; and 15% completed postsecondary or university education; 33% were in employment or self-employed. The corresponding figures for those that provided a saliva specimen were very similar: 54% female; mean age 46.0 (SD, 19.3); 55% were married or living with a partner; 22% completed primary education; 27% completed gymnasium or secondary education; 15% completed post-secondary education; and 33% were in employment or self-employed.

Statistical Analyses. Simple percentages are presented for prevalence figures and means and SD for cotinine concentrations. Unweighed data are used because (a) the samples are
Results

England. In the English sample, cigarette smoking prevalence in the total sample was 24.7%. A further 24.4% were ex-smokers. The current self-reported tobacco smoking prevalence, including pipes and cigars, was 26.0%. In the sample from whom saliva specimens were obtained, cigarette smoking prevalence was identical at 24.7%; ex-smokers were 24.7%, and self-reported current tobacco smokers comprised 26.2% (Table 1).

Of the self-reported ex- or never smokers, 2.7% had cotinine concentrations above the smoking cut point of 15 ng/mL (1.9% of those said they had never smoked and 4.4% of "ex-smokers"). However, 3.2% of those who reported being tobacco smokers had cotinine concentrations below 15 ng/mL. This resulted in 27.5% being classified as "inhaling tobacco smokers" according to their saliva cotinine concentrations (Table 1). The prevalence of any tobacco smoking, defined as the percentage of self-reported smokers plus those with a saliva cotinine concentration ≥15 ng/mL, was 28.8%. The mean cotinine concentration in self-declared nonsmokers with cotinine concentrations of at least 15 ng/mL was 128 ng/mL (SD, 110.8).

United States. In the U.S. sample, the prevalence of self-reported cigarette smoking was 21.7% (Table 1) and was slightly higher (22.8%) for respondents among whom cotinine was measured. Self-reported total smoking, including pipes and cigars, was 22.8%, and in the subsample with cotinine assays, it was slightly higher at 24.2%; 1.3% of nonsmokers had cotinine concentrations above 15 ng/mL (2.4% of self-reported ex-smokers and 0.7% of self-reported never smokers). The mean cotinine concentration in these nonsmokers was 210 ng/mL (SD, 229.0). About 10.1% of self-reported smokers had cotinine <15 ng/mL, so the prevalence of adults with cotinines above this threshold (excluding sniffers, chewers, and NRT users from consideration) was 23.4%. The prevalence of smoking, defined as cotinine above 15 ng/mL, or self-reported smoking was 25.5%.

Poland. Tobacco smoking prevalence in the whole Polish sample by self-report was 35.3%. A further 20.5% were ex-smokers. The self-reported smoking prevalence in the 388 who provided a saliva sample was slightly higher at 37.6%, and 21.1% were ex-smokers.

Of the self-reported ex- or never smokers, 9.5% had cotinine concentrations above the cut point for smoking (8.0% of self-declared never smokers and 12.2% of ex-smokers); 4.8% of self-declared smokers had cotinine concentrations below 15 ng/mL. Thus, 41.8% were classified as smokers by cotinine, and the prevalence of smoking defined in terms of self-report or an elevated cotinine was 43.6%. In the self-declared nonsmokers with cotinines above the smoking cut point, the mean cotinine was 212 ng/mL (SD, 150.4 ng/mL).

Discussion

Self-reported cigarette smoking prevalence underestimated true tobacco smoking prevalence minimaly in the U.S. sample but by 4% in the Polish sample. Those who were misclassified had cotinine concentrations indicative of substantial levels of active smoking, which could not be due to passive exposure. In England, about half of the underestimate of smoking prevalence was attributable to pipe and cigar smoking and the rest to misreporting. In Poland, the underestimate seemed to be mostly based on misreporting, although it is possible that the requirement to have smoked at least 100 cigarettes in their lifetime may have misclassified some adolescent smokers. In theory, some nonsmokers may have been using NRT, but incidence is very low in Poland, and the misreporting rate was almost as high for self-declared never smokers as ex-smokers.

A failure of self-report to accurately capture smoking status is just one of a number of onserous thes to the validity of national prevalence surveys and comparisons made using these. We have not considered the role played by different age ranges canvassed in different countries, different questions, nor the fact that some countries only present daily smoking figures.

In conclusion, our data indicate that headline figures for cigarette smoking prevalence in England and Poland underestimate the rate of active tobacco smoking. The degree of underestimation was greater in Poland than in England. Our findings indicate the need for an urgent review of methods of estimating smoking prevalence that takes into consideration all forms of tobacco smoking and correction using a biochemical marker. Such a review should also examine other issues such as the definition of a smoker and the age range canvassed.

References

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