The Validity of Self-Reported Nicotine Product Use in the 2001–2008 National Health and Nutrition Examination Survey

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Background: Many researchers rely on high-quality face-to-face national surveys conducted by the federal government to estimate the prevalence of nicotine product use, but some scholars have suggested that adults' self-reports in such surveys are intentionally distorted by social desirability response bias, thus raising questions about the validity of those data.

Objectives: To assess the validity of face-to-face survey self-reports by comparing them with physiological tests.

Research Design: Respondents in the National Health and Nutrition Examination Survey provided self-reports of nicotine product use and gave blood samples that were analyzed for levels of serum cotinine, an indicator of nicotine exposure.

Subjects: Nationally representative samples of thousands of American adults in National Health and Nutrition Examination Survey surveys conducted in 2001–2002, 2003–2004, 2005–2006, and 2007–2008.

Measures: Serum cotinine levels and self-reports of nicotine product use.

Results: On average, only 1.17% to 1.25% of adult respondents said that they did not use a product containing nicotine, but had elevated cotinine levels. After eliminating the potential influence of passive smoking, these figures dropped to 0.89% to 0.94%. This small discrepancy between the 2 assessments could be due to measurement error in the cotinine test results or to recent use of cotinine-elevating medication.

Conclusions: These data do not support the claim that a substantial number of adult respondents intentionally under-report nicotine consumption in face-to-face interviews. The remarkable accuracy of self-reports of nicotine consumption seen here justifies confidence in self-reports of this behavior in such surveys.

Key Words: smoking, cotinine, surveys, validity, face-to-face, social desirability

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Surveys such as the Center for Disease Control and Prevention's National Health and Nutrition Examination Survey (NHANES) and National Health Interview Survey involve face-to-face interviews with area-probability samples of thousands of American adults. As a result, they are among the most trusted sources of information about health behaviors and health status. Yet, some researchers have suggested that these face-to-face surveys underestimate the proportion of people who smoke cigarettes,[1] under the assumption that some respondents find it socially embarrassing to admit that they currently smoke. According to this logic, social desirability response bias leads some smokers to claim that they do not smoke when interviewed.

Many past studies challenge the assertion that reports of smoking by adults are substantially biased by social desirability concerns. Aguinis et al[2] meta-analyzed studies that used the Bogus Pipeline technique to assess intentional misreporting of smoking, and they concluded that the technique did not significantly increase reports of smoking among adults. Other research[3] compared NHANES respondents' self-reports in face-to-face interviews with the results of blood tests that assessed levels of serum cotinine, a metabolite of nicotine. The average percent of NHANES respondents said to have under-reported smoking was quite small– only 0.97%, in surveys done between 1988 and 1994. A meta-analysis of many studies[4] compared self-reports to chemical measures and found similarly minimal under-reporting.

However, these studies only analyzed data collected before 1994,[2–4] and numerous studies have documented an increase in antitobacco legislation and business practices since the tobacco companies' "global settlement" in 1997.[5] Thus, it is possible that social desirability pressures have increased over time, leading respondents to be less willing to admit whether they smoke.

Indeed, in a recent article published in *Medical Care*, Klein et al[1] reported analyses of NHANES data collected in 2001–2002 and reached the conclusion that social desirability bias does distort adults' reports of their smoking behavior during face-to-face interviews. Klein et al[1] reported that 4.5% of respondents said that they were not cigarette smokers during a household interview and yet had serum cotinine levels above the threshold indicating recent smoking. The authors concluded that this discrepancy was evidence that

4.5% of adults intentionally misreported their smoking behavior because of social desirability response bias.

Several features of Klein et al's[1] analysis limit the validity of their conclusion that smoking self-reports in the NHANES were distorted, however. The NHANES has collected data from respondents in 2 ways: during an interview administered face-to-face in respondents' homes, and during a later interview with respondents at a Mobile Examination Center (MEC), at which time a physical examination was also conducted.[6,7] At the end of the household interviews, which asked about cigarette smoking, respondents were asked whether they would be willing to visit the MEC, undergo a physical examination, and complete another interview. For most respondents, the MEC visit occurred between 2 and 9 weeks after the household interview, at which time respondents were asked about use of products containing nicotine, and the blood samples were taken. These blood sample measurements of cotinine are elevated by pipe smoking, cigar smoking, consumption of chewing tobacco, snuff, nicotine gum, patches, or inhalers, or nicotine-containing medications.[8–10] The face-to-face self-reports and the blood tests analyzed by Klein et al[1] were not directly comparable because (1) they compared measures collected weeks or months apart, and (2) the self-reports asked only about cigarette smoking but the blood test could detect other sources of nicotine consumption.

Furthermore, Klein et al's[1] results contradict those of other studies that have analyzed the same 2001–2002 NHANES dataset. West et al[11] compared the results of the MEC interview to the blood tests collected on the same day, and found that 0.6 percentage points more respondents had elevated cotinine levels than said during the interview that they had smoked cigarettes, pipes, or cigars during the 5 prior days, a finding consistent with those of other studies.[3,4] However, by focusing on aggregate statistics, West et al's[11] analytic method did not assess the proportion of individual respondents who were tobacco users but denied being one. A significant number of survey respondents report recent smoking and yet have cotinine levels below 15 ng/mL (ie, false negatives),[3,4,8] so the proportion of respondents who had cotinine levels above 15 mg/mL but denied tobacco use may have been substantial in the data West et al[11] examined. Moreover, West et al[11] omitted respondents from their analysis who reported using smokeless tobacco and examined only the 2001–2002 NHANES survey, which limits the generalizability of their findings.

All of these problems are overcome in new analyses reported here of 4 NHANES surveys conducted between 2001 and 2008. We compared self-reports of nicotine consumption from all sources collected during the MEC interview to cotinine levels in blood samples collected from the same people at the same time. We also explored whether our conclusions about correspondence varied depending on the cut-point used in the cotinine analysis. Finally, we compared our method's results with those obtained when comparing smoking reports during the household interview to the blood samples ("Klein et al's[1] method"), and when using reports of cigarette, pipe, or cigar smoking in the MEC interview but dropping respondents reporting recent use of smokeless tobacco ("West et al's[11] method").

METHODS

Study Population and Procedures

The NHANES is an area-probability sample survey conducted continuously over 2-year periods.[6,7] Response rates and sample sizes for the 2001–2002, 2003–2004, 2005–2006, and 2007–2008 surveys are presented in Table 1. During household computer-assisted personal interviews, adults ages 20 and older were asked cigarette smoking. During the computer-assisted personal interview conducted on the day of the MEC examination, adults ages 20 or older were asked about nicotine use (Respondents ages 18 and 19 were interviewed using Audio Computer-Assisted Self-Interviewing. Because the present study was intended to investigate the validity of self-reports in face-to-face interviews, respondents ages 18 and 19 were excluded from our analyses, as did Klein et al.[1] and West et al).[11] Immediately after the MEC interview, blood samples were drawn and were subsequently analyzed to determine the concentration of cotinine. The analyses reported here were conducted using the appropriate weight, strata, and psu variables.

Measures

During the household interview, respondents were asked, "Have you smoked at least 100 cigarettes in your entire life?" Respondents who said "yes" were then asked, "Do you now smoke cigarettes some days, most days, or not at all?" Respondents who said "no" to the first question or who said they smoked "not at all" in response to the second were considered nonsmokers in our analysis (mirroring Klein et al's[1] approach). To assess passive smoking, all household

TABLE 1. No. Respondents and Response Rates for NHANES Surveys

No. Respondents Providing Data

Survey Year	Self-Reported Smoking in Household Interview	Self-Reported Nicotine Product Use in MEC Interview	Provided Serum Cotinine During MEC Exam	Self-Reported Nicotine Product Use and Provided Serum Cotinine in MEC	Cumulative Response Rate for MEC Exam
2001–2002 NHANES	5460	4620	4686	4370	80%
2003–2004 NHANES	5039	4314	4476	4140	76%
2005–2006 NHANES	4979	4354	4484	4170	77%
2007–2008 NHANES	5935	5233	5336	4981	75%

MEC indicates Mobile Examination Center; NHANES, National Health and Nutrition Examination Survey.

interview respondents were also asked "Does anyone who lives here smoke cigarettes, cigars, or pipes anywhere inside this home?"

During the MEC interviews, respondents were asked whether they used "any product containing nicotine including cigarettes, pipes, cigars, chewing tobacco, snuff, nicotine patches, nicotine gum, or any other product containing nicotine" during the prior 5 days. Respondents' levels of serum cotinine[6] were compared with self-reports of nicotine use twice, first using Klein et al's[1] cut-point (15 ng/mL), and then using a more conservative, lower cut-point (10 ng/mL) that has also been used in previous research.[3]

RESULTS

Of the respondents who gave a blood sample, 29.11% said that during the prior 5 days, they used a product containing nicotine (None of the results reported here significantly varied across the 4 NHANES surveys conducted from 2001 to 2008, and so we only discuss results combining all of these respondents). Of the 70.89% of MEC respondents who said that they did not use any nicotine product, 98.34% had cotinine levels below 15 ng/mL, meaning that their blood test results matched their self-reports (see row 9, column 2 in Table 2). Thus, for only 1.65% of the respondents who denied being exposed to nicotine did the blood sample suggest otherwise. These people constitute 1.17% (95% confidence interval: 0.99%–1.35%) of the sample of respondents who provided both a self-report and a blood sample (see row 13, column 1 in Table 3). When using a lower and more conservative cotinine cut-point (10 ng/mL), this number was virtually identical (1.25%, 95% confidence interval: 1.06%–1.44%; see row 13, column 2 in Table 3).

This small percentage of respondents may not be completely attributable to dishonest reporting, because these peo-

ple's cotinine levels could have been elevated because of exposure to passive smoke in their homes. And in fact, of the 1.17% who apparently under-reported nicotine product use, 24.16% also reported living with a smoker. After removing these respondents from the seemingly under-reporting group, only 0.89% of individuals denied nicotine product use but had elevated cotinine levels using the 15 ng/mL cut-point, and 0.94% when using the 10 ng/mL cut-point.

These estimates of underreporting are much smaller than those found when comparing reports made during the household interview with blood test results, as Klein et al[1] did (5.18%; compare rows 13 and 15 in Table 3). In addition, the estimates we generated are slightly lower than when focusing only on self-reports of smoking and dropping the respondents who reported using smokeless tobacco, as West et al[11] and others[3] did (1.20%; compare rows 13 and 14 in Table 3).

DISCUSSION

These analyses of NHANES data collected between 2001 and 2008 suggest that if any nicotine product users under-reported this behavior, the proportion of people who did so was exceedingly small: 0.89% to 0.94% of respondents said they had not used a nicotine product yet manifested elevated cotinine levels after eliminating the influence of passive smoking. This very small upper bound on the rate of intentional misreporting was consistent across the years we examined and is consistent with previous research documenting similarly low upper bounds on rates in earlier NHANES surveys.[3,11]

Although it is tempting to think that the 0.89% to 0.94% of respondents who denied nicotine exposure but had elevated serum cotinine were all intentionally misrepresenting their behavior, in fact there are several other plausible explanations for this discrepancy. For example, the 0.88% to

TABLE 2. Cotinine Concentrations Among Respondents Who Reported Not Using Nicotine Products During the Past 5 Days

NHANES Years	Cotinine Concentrations			Cotinine Concentrations		
	>15.0 ng/mL	≤15.0 ng/mL	Total	>10.0 ng/mL	≤10.0 ng/mL	Total
2001–2002						
Percent	1.41%	98.59%	100.00%	1.48%	98.52%	100.00%
N (unweighted)	59	3181	3240	64	3176	3240
2003–2004						
Percent	1.74%	98.26%	100.00%	1.92%	98.08%	100.00%
N (unweighted)	64	2967	3031	72	2959	3031
2005–2006						
Percent	1.83%	98.12%	100.00%	1.90%	98.10%	100.00%
N (unweighted)	60	3021	3081	64	3017	3081
2007–2008						
Percent	1.60%	98.40%	100.00%	1.77%	98.23%	100.00%
N (unweighted)	66	3570	3636	72	3564	3636
2001–2008 combined						
Percent	1.65%	98.34%	100.00%	1.77%	98.23%	100.00%
N (unweighted)	249	12,739	12,988	272	12,716	12,988

All percentages are weighted.
Includes respondents aged 20 or over who provided both a self-report during the MEC interview and a blood sample during the MEC exam.
MEC indicates Mobile Examination Center; NHANES, National Health and Nutrition Examination Survey.

TABLE 3. Percent of All Respondents Who Said They Did Not Use Products Containing Nicotine But Who Had Elevated Cotinine Concentrations

| | | Cotinine Cut-Point Used | | |
| | Nicotine Products Described in | | | |
Calculation Method	Self-Reports	15 ng/mL	10 ng/mL	*N*
2001–2002 NHANES				
Present study's method*	All products containing nicotine	0.99%	1.05%	4370
West et al[11] (2007) method†	Cigarettes, pipes, and cigars only	1.02%	1.07%	4285
Klein et al[1] (2007) method‡	Cigarettes only	4.49%	4.63%	4685
2003–2004 NHANES				
Present study's method*	All products containing nicotine	1.21%	1.33%	4140
West et al[11] (2007) method†	Cigarettes, pipes, and cigars only	1.25%	1.38%	4044
Klein et al[1] (2007) method‡	Cigarettes only	5.90%	6.20%	4474
2005–2006 NHANES				
Present study's method*	All products containing nicotine	1.31%	1.35%	4170
West et al[11] (2007) method†	Cigarettes, pipes, and cigars only	1.34%	1.39%	4086
Klein et al[1] (2007) method‡	Cigarettes only	5.14%	5.32%	4483
2007–2008 NHANES				
Present study's method*	All products containing nicotine	1.16%	1.28%	4981
West et al[11] (2007) method†	Cigarettes, pipes, and cigars only	1.19%	1.31%	4847
Klein et al's[1] (2007) method‡	Cigarettes only	5.20%	5.61%	5334
2001–2008 NHANES combined				
Present study's method*	All products containing nicotine	1.17%	1.25%	17,661
West et al's[11] (2007) method†	Cigarettes, pipes, and cigars only	1.20%	1.29%	17,262
Klein et al's[1] (2007) method‡	Cigarettes only	5.18%	5.44%	18,976

Only includes respondents age 20 or over. All values are weighted.
*Self-reports provided during the MEC interview. Includes respondents who provided both a self-report and a blood sample in the MEC.
†Self-reports provided during the MEC interview. Respondents reporting use of smokeless tobacco treated as missing data. Includes respondents who provided both a self-report and a blood sample in the MEC.
‡Self-reports provided during the household interview. Includes respondents who provided a self-report in the household and a blood sample in the MEC.
MEC indicates Mobile Examination Center; NHANES, National Health and Nutrition Examination Survey.

0.94% of people could have had elevated cotinine levels due to measurement error in the cotinine assessments, exposure to environmental smoke outside of the home, or to medications that they took that increased their cotinine levels.[8,12–14] Measurement error has been documented in many serum cotinine tests, which occurs partly because the half-life of cotinine varies with the quantity of nicotine the respondent has ingested and his or her metabolism. For example, many daily smokers manifest elevated cotinine levels up to 7 days after quitting, whereas many light smokers manifest elevated cotinine levels for only 2 days after quitting (p. 152).[8] Some subpopulations, such as African-Americans or pregnant women, metabolize nicotine at different rates from other subpopulations (p. 151).[8,15] All this suggests that serum cotinine levels above 15 ng/mL do not constitute a perfect indicator of a respondent's tobacco use, so we should not conclude that all the 0.88% to 0.94% of respondents necessarily intentionally under-reported.

The rate of under-reporting of smoking found in the present study was substantially smaller than the rate reported by Klein et al[1] using the same dataset. As noted, Klein et al[1] compared respondents' levels of serum cotinine, which do not reflect only cigarette smoking, to self-reports about only cigarette smoking collected weeks or months earlier. This method cannot be relied on to detect intentional misreporting. In the NHANES dataset analyzed by Klein et al,[1] 1.66% of

respondents said during their household interviews that they did not smoke cigarettes, but 2 to 9-weeks later, just before their MEC exams, these people said that they had smoked cigarettes during the 5 prior days. Other analyses have documented nearly identical results in the 1988–1994 NHANES surveys.[3] Additionally, 2.83% of respondents said they smoked cigars and/or smoked pipes and/or used dip or snuff and/or chewed tobacco, but said they did not smoke cigarettes. Thus, their cotinine levels could have been elevated as compared with their cigarette smoking self-reports for all of these reasons. If people who used cotinine-enhancing medications or who are exposed to high levels of passive smoke are added to this number, it grows even larger.

As researchers continue to explore these issues in future research, it will be wise to recognize that serum cotinine levels cannot be used to assess the accuracy of self-reports of cigarette smoking in particular. Cotinine levels will be elevated by smoking cigars and pipes, so people whose cotinine levels are elevated for these reasons and deny smoking cigarettes would be incorrectly classified as intentional misreporters. Therefore, as in the present analyses, researchers should be sure to acquire self-reports of nicotine consumption from all sources on the same day as the blood tests to fairly assess the extent of deceit.

One interpretation of our finding of overall low levels of under-reporting is that they constitute a tribute to the

success of face-to-face interviewing. Some earlier studies have suggested that face-to-face surveys are especially likely to elicit honest reports of sensitive attributes.[16] Therefore, if the NHANES surveys had instead been conducted by telephone, we might have observed more evidence of intentional misreporting, because earlier studies indicate that social desirability pressures are more likely to distort answers given in that mode.[16] And perhaps if the measurement of smoking self-reports had been done via anonymous, self-administered paper and pencil or Audio Computer-Assisted Self-Interviewing Questionnaires, the 0.88% to 0.94% figures would have dropped to 0, because these modes appear to be even more likely to elicit honest responses than does face-to-face interviewing.[17–24]

However, an alternative explanation for our findings is that nicotine product use among adults is not subject to social desirability pressures. Thus, instead of thinking of our findings as specific to the face-to-face interviewing mode, these findings may be generalizable to other modes as well. Consistent with this reasoning, studies using the Bogus Pipeline have indicated that among adults, people feel no pressure to deny smoking cigarettes.[2] Therefore, the same absence of intentional misreporting observed here may appear even in surveys done by telephone. Regardless, we have shown that at least in the NHANES, honesty (and accuracy) appears to be prevalent in reports of nicotine use.

Researchers rely heavily on self-reported data to monitor the prevalence of risky health behaviors, such as the use of products containing tobacco. Therefore, the present study's evidence of minimal influence of social desirability response bias in reports of the use of products containing nicotine in national face-to-face surveys conducted between 2001 and 2008 is reassuring for researchers using such surveys to track this behavior in the population of American adults.

ACKNOWLEDGMENTS

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