Apparent Underreporting of Cigarette Consumption among Mexican American Smokers

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Abstract: To determine the accuracy of self-report of cigarette consumption among Mexican American smokers, we compared self-reported cigarette use and serum cotinine concentrations in a sample of 547 participants in the Hispanic Health and Nutrition Examination Survey (HHANES). We defined underreporting of cigarette use as a cotinine to cigarette-per-day ratio of > 0.142 μM/l which represented a substantial discrepancy between self-reported consumption and serum cotinine. Of the 98 men and 97 women who reported smoking one to nine cigarettes/day, 20.4 percent and 24.7 percent, respectively, underreported their cigarette consumption. Underreporting was less common among men and women smoking 10 to 19 cigarettes/day (8.3 percent and 10.8 percent, respectively) and 20 or more cigarettes/day (2.2 percent and 2.9 percent, respectively). Comparison of underreporters to other smokers by demographic characteristics within sex and cigarettes/day categories showed no differences. Differences in cotinine metabolism and extremely efficient smoking are alternative explanations that can not be ruled out with these data. We believe, however, that a proportion of Mexican American light smokers may underreport the quantity of cigarettes smoked per day, and may truly be moderate or heavy smokers. (Am J Public Health 1990; 80:1057–1061.)

Introduction

Over the past three decades, epidemiological surveys have relied on self-reported smoking behavior to determine current smoking prevalence, and to quantify tobacco consumption in cigarettes per day.[1–3] Because of possible deception in reporting smoking status, biochemical tests to validate self-reported cessation from cigarette smoking have become necessary measures in evaluating programs to help smokers quit.[4] Studies evaluating the relation between biochemical measurements and self-reported cigarette consumption among known smokers indicate that serum levels of nicotine and of its principal metabolite cotinine plateau above 20 cigarettes per day.[5,6] Behavioral factors related to the way a cigarette is smoked may be more important in maintaining a smoker's nicotine level than the actual nicotine delivery of a given cigarette brand as determined by a cigarette smoking machine and reported by the Federal Trade Commission.[7]

Regional and national surveys have consistently shown that Mexican Americans differ in their smoking behavior when compared to Whites who are not Hispanic.[8–13] Men of both groups smoke in similar proportions and smoking rates are higher among White women, but Mexican American smokers report an average of 10 to 12 cigarettes per day compared to 19 to 23 for Whites and 14 to 15 cigarettes per day for Blacks.[13,14] Because the proportion of light smokers among Mexican Americans is substantially greater than among Whites, we hypothesized that underreporting may partly account for this difference.

To compare self-reported cigarette use with a biological marker of smoking behavior, we evaluated the serum cotinine levels in 547 Mexican American smokers who participated in the Hispanic Health and Nutrition Examination Survey (HHANES) in the Southwestern states.

Methods

Southwestern HHANES

The Mexican American portion of HHANES was conducted in the Southwestern states of Arizona, California, Colorado, New Mexico and Texas between 1982–1983 by the National Center for Health Statistics (NCHS). A stratified probability sample of the civilian, noninstitutionalized Mexican American population living in these states was generated using a four-stage process.[15] HHANES included both a household interview and a medical examination, conducted in either Spanish or English. Data on smoking behavior and demographic information were collected. A total of 4,735 Mexican Americans age 20 to 74 years were selected for the survey, with 3,324 (70.2 percent) completing the physical examination portion where blood was drawn. Details of the sample design, operational plan, and quality control procedures are described elsewhere.[15]

The Cotinine Sample

The study population in this report is a subsample of the examined HHANES Mexican American population. Eligibility was based on current smoking status and the availability of 0.5 ml of frozen serum in 1986. Stratifying by sex (male/female) and the number of self-reported cigarettes smoked (1 to 9, 10 to 19, ≥ 20), persons were randomly selected from those with available serum in order to have 90 to 98 subjects per cell. Due to the limited number of women smoking 20 or more cigarettes per day, only 70 persons could be selected for that cell. Table 1 shows the distribution of the cotinine sample in the six cells with the corresponding total number of examined Mexican American HHANES smokers in each cell. The proportion of persons by cell selected from the total sample ranged from 44 percent to 80 percent.

Cotinine Analysis

Measurement of the concentration of cotinine in the serum of persons who reported smoking more than five cigarettes per day was performed using automated capillary gas chromatographic techniques described in detail in other publications.[16,17] Cotinine, principal metabolite of nicotine,

TABLE 1—Demographic Characteristics of Sample Selected for Cotinine Measurements from Mexican American Smokers in Southwest HHANES

	Self-Reported Cigarettes per Day					
	1 to 9		10–19		≥ 20	
	Men	Women	Men	Women	Men	Women
HHANES denominator (n)	221	197	153	123	207	87
cotinine sample (n)	98	97	96	93	93	70
% age (years):						
20–39	62	61	55	47	46	51
40–74	38	39	45	53	54	49
mean age (years)	37.9	37.6	39.6	41.3	43.3	41.6
% with education (years):						
0–11	72	64	68	63	66	61
≥ 12	28	36	31	37	34	39
mean education (years)	7.7	8.9	8.6	86	9.0	9.1
% acculturation tertile						
low	45	31	24	20	32	19
middle	35	34	30	38	37	26
high	20	35	46	42	31	56
% with income						
below poverty	36	31	34	33	32	34
at or above poverty	64	69	66	67	68	66
% with blood drawn:						
in morning	58	58	62	58	63	54
in afternoon	42	42	39	42	37	46
mean cigarettes/day	4.1	4.2	12.7	11.0	24.0	24.3

has a half-life averaging 19 hours, compared to a half-life of two hours for nicotine.[18,19] There are no data on possible ethnic or racial differences in the metabolism of nicotine among habitual smokers.

Excess serum on HHANES participants was stored at the Centers for Disease Control laboratory at a temperature of minus 70 degrees Celsius. Samples were shipped to San Francisco for cotinine assessment on dry ice and thawed prior to analysis. Cotinine analyses were completed within five years of serum collection, and concentrations of cotinine in frozen serum have been found to be stable over at least a five-year period (unpublished data, N.L. Benowitz). Serum cotinine concentration from smokers reporting one to five cigarettes per day was assayed by the same capillary column gas chromatography method, but modified with a sample concentration step to increase sensitivity. Standards of 0.001 (0.2), 0.003 (0.5), 0.006 (1.0), 0.028 (5.0), and 0.057 μM/l (10 ng/ml) were used. The limit of detection was about 0.001 μM/l (0.2 ng/ml). Results from these two methods for measuring cotinine on the same sample are identical.

Based on data from studies[20] conducted with heavy smokers (average of 36 cigarettes per day) who were restricted to 15, 10, and 5 cigarettes per day, a maximum serum cotinine level of 0.142 μM/l (25 ng/ml) per cigarette smoked was achieved by these extremely efficient smokers. This corresponds to an intake of nicotine of approximately 3 mg per cigarette. Thus, we have defined underreporting of self-reported cigarette consumption as a serum cotinine per cigarette value exceeding 0.142 μM/l (25 ng/ml) per cigarette. In support of this cutoff are the data of Shiffman, et al,[21] who measured cotinine levels in smokers who habitually smoke no more than five cigarettes per day. The average cotinine level per cigarette smoked was 0.08 μM/l (SD = 0.067) (14.0 ng/ml; SD = 11.8), which is nearly identical to the 0.07 μM/l (SD = 0.031) (12.5 ng/ml; (SD = 5.4) value for more dependent smokers reported by Benowitz and colleagues.[19]

Data Analysis

Data were analyzed using SPSSX.[22] Comparisons of proportions were made with chi squares and means were compared by t test and analysis of variance. An acculturation scale modified from Cuellar and colleagues[23] was used to divide the population into low, middle, and high tertiles for the purpose of these analyses. The poverty threshold defined in 1982 dollars by the Bureau of the Census was used to categorize the sample by income.[24]

Results

The demographic characteristics of the 547 Mexican American smokers are shown in Table 1 stratified by sex and self-reported cigarettes per day. This sample of smokers is not representative of Mexican Americans in the Southwest US because of the criteria used for selection. Light smokers (1–9 cigarettes/day) were younger than moderate (10–19 cigarettes/day) and heavy smokers (≥ 20 cigarettes per day). Acculturation scores were lower among men compared to women for each category of smokers and among light smokers compared to moderate and heavy smokers. Distribution by years of education completed, income below or above the poverty level, and the time blood was drawn were similar by sex and category of smokers.

Data from smokers who underreported cigarette consumption, as defined by a cotinine per cigarette ratio exceeding 0.142 μM/l (25 ng/ml) per reported cigarette, as shown in Table 2. Of the 98 men and 97 women light smokers, 20 (20.4 percent) and 24 (24.7 percent), respectively, exceeded 0.142 μM/l per cigarette with a mean cotinine per cigarette almost twice the threshold. Mean cotinine levels for light smokers were 4.3 times greater for men and 4.9 times greater for women who underreported than among the other smokers. Among moderate smokers the proportion underreporting cigarette consumption decreased to 8.3 percent for men and 10.8 percent for women. Heavy smokers were the least likely to be classified as underreporters with only two men (2.2

TABLE 2—Serum Cotinine in Mexican American Smokers: Underreporters and Other Smokers

| | Self-Reported Cigarettes/Day | | | | | |
| | 1 to 9 | | 10–19 | | ≥ 20 | |
	men	women	men	women	men	women
total n	98	97	96	93	93	70
Percent underreporters	20.4	24.7	8.3	10.8	2.2	2.9
Mean cotinine (μM/l)	1.018	1.206	2.055	2.039	2.909	3.108
Mean cotinine/cigarette	0.255	0.270	0.185	0.196	0.145	0.155
Percent other smokers	79.6	75.3	91.7	89.2	97.8	97.1
Mean cotinine (μM/l)	0.238	0.242	0.943	0.774	1.349	1.410
Mean cotinine/cigarette	0.049	0.054	0.073	0.069	0.059	0.064

percent) and two women (2.9 percent). Comparison of the demographic characteristics of the 66 smokers classified as underreporting cigarette consumption to the other smokers by smoker category and sex show no differences by any of the variables examined including acculturation score. None of the 66 smokers classified as underreporters used cigars, pipes, or smokeless tobacco.

Among the underreporting light and moderate smokers, 36 indicated that they smoked a greater number of cigarettes in the past than at the time of the survey. If this number is used as an alternative value for self-reported consumption, then the proportion of underreporters among self-reported light smokers would decrease to 6.1 percent for men and to 15.5 percent for women. A similar decrease in underreporters would occur among moderate smokers to 3.1 percent of men and 7.5 percent of women. None of the four underreporting heavy smokers reported smoking a greater number of cigarettes in the past than at the time of the survey.

In order to quantify the number of cigarettes underreported by these smokers, an average minimum increase in serum cotinine of 0.057 μM/l (10 ng/ml) per cigarette smokes was estimated to occur.[20] A range of underreported cigarettes per day was derived from the expected minimum increase (0.057 μM/l) and the expected maximum (0.142 μM/l) increase in serum cotinine. Among the men and women light smokers, we estimated that they were actually smoking from 3 to 14 and from 4 to 17 more cigarettes per day, respectively. Among moderate smokers the estimated range of additional cigarettes smoked per day was 3 to 25 for men and 4 to 26 for women.

The average serum cotinine of the Mexican American smokers in this sample are shown in Table 3 by sex and smoker category. The overall values for moderate and heavy smokers are somewhat lower than the average level of 1.47 μM/l (259 ng/ml) reported among 450 smokers of 10 or more cigarettes per day who were volunteers at the blood banks in Bergen County, New Jersey (ethnicity not stated, but presumably mostly Whites).[6] Pearson correlations between cotinine levels and self-reported cigarettes per day are weak for moderate and heavy smokers and stronger for light smokers. Analysis of variance showed that serum cotinine increases with number of cigarettes smoked per day (F $(2,545)$ = 104.7, p < .0001), age (F $(1,432)$ = 8.5, p = .004), and acculturation level (F $(2,545)$ = 3.5, p = .03) related. Sex, educational level, poverty status, and time blood was drawn did not have a consistent influence on cotinine concentration.

Discussion

The measurement of cotinine concentration in blood, urine, or saliva has been used predominantly to verify self-reported smoking status among persons claiming to have quit using cigarettes.[25–29] Use of cotinine measurements to evaluate underreporting in the quantity of self-reported cigarettes smoked per day has not been previously conducted. Applying this method to analysis of a sample of HHANES Mexican American smokers indicates that at least 20.4 percent of men and 24.7 percent of women who reported smoking less than 10 cigarettes per day may be underreporting their actual consumption.

TABLE 3—Serum Cotinine (μM/l) by Demographic Characteristics and Cigarette Consumption in HHANES Mexican American Smokers

| | | Self-Reported Cigarettes/Day | | | | | |
| | | 1 to 9 | | 10–19 | | ≥ 20 | |
		men	women	men	women	men	women
total n		98	97	96	93	93	70
Mean cotinine (μM/l)		0.40	0.48	1.03	0.91	1.38	1.46
Correlation to cotinine	r	.51	.50	.25	.20	.19	.25
	p	<.01	<.01	<.01	<.03	<.04	<.02
Age (years)							
20–39		0.37	0.37	1.07	0.84	1.27	1.40
40–74		0.44	0.65	0.99	0.98	1.48	1.52
Acculturation							
low		0.48	0.28	0.97	0.83	1.35	1.38
middle		0.32	0.63	1.02	0.93	1.35	1.17
high		0.35	0.52	1.07	0.93	1.46	1.62

We initiated this research to validate biochemically the finding in the Southwest HHANES (and other surveys) that Mexican Americans are mostly light or moderate smokers. Our findings support an overall lower level of dependence on nicotine as compared to another large community sample of non-Hispanic smokers.[6] However, a subset of those Mexican American smokers who report less than 10 cigarettes per day are more dependent on nicotine than the self-reported number of cigarettes would indicate. If a substantially greater proportion of Mexican American smokers are moderate or heavy smokers, then the related health risks for cardiovascular disease and cancer are greater than that determined by self-report. This could also have implications for planning and conducting smoking cessation interventions among Mexican Americans. The need to intensify ongoing community interventions based on culturally appropriate self-help methods[30] or to complement this with individualized or physician-mediated interventions must be considered since many Mexican Americans may not be light smokers.

The proportion of underreporting among light and moderate smokers was reduced by more than half when the maximum number of cigarettes smoked in the past was used in place of the self-reported number at the time of the survey. This may reflect the desire among many smokers to smoke less and the accurate reporting of past history may actually represent current habits. Regardless, the maximum number of cigarettes smoked per day in the past may be an important additional measure of self-reported smoking behavior among Mexican Americans.

Coultas and colleagues recently found discrepancies between self-reported and validated cigarette smoking in a community survey of New Mexico Hispanics.[31] Their study found that among former smokers older than 18 years of age, the proportion with a salivary cotinine greater than 0.11 μM/l (20 ng/ml) (defined as current smoker) was as high as 21.4 percent. Our study expands on these findings in that we are estimating a similar rate of apparent underreporting in self-reported number of cigarettes consumed among Mexican American light smokers. The substantial level of inconsistencies between the number of self-reported cigarettes smoked and the results of cotinine concentrations may also reflect a tendency among Latinos to give socially desirable responses.[32]

The use of a cotinine per cigarette ratio exceeding 0.142 μM/l (25 ng/ml) as the cutoff to define underreporting is conservative. In another study, nine heavy smokers (average 36 cigarettes per day) were restricted to five cigarettes per day and only two were able to achieve cotinine to cigarette ratios exceeding 0.142 μM/l per cigarette.[19] In contrast, people who are carefully documented as smoking five or fewer cigarettes per day have intakes of nicotine and levels of cotinine per cigarette similar to heavy smokers during unrestricted smoking.[20] Considering these data, we conclude that in setting the criterion at 0.142 μM/l per cigarette we are probably underestimating the prevalence of possible underreporting.

It is possible that some underreporters in HHANES were extraordinarily efficient in smoking cigarettes, but this is unlikely to fully explain our results given that heavy smokers with restricted access to cigarettes were unable to achieve comparable cotinine levels. Another possible alternative explanation for our findings involves ethnic or racial differences in the metabolism of nicotine and clearance of cotinine. Wagenknecht and colleagues[33] have proposed that higher serum cotinine levels among Black compared to White smokers (despite fewer self-reported cigarettes consumed per day) were due to racial differences in the metabolism of nicotine and not to a reporting bias. If Mexican Americans metabolize nicotine more slowly, our results would be partly accounted for without underreporting. Alternatively, light and moderate smokers for any ethnic group may have a much slower metabolism of nicotine or a slower clearance of cotinine than the average habitual smoker.

Several limitations in this study need to be considered. Although HHANES results are generalizable to Mexican Americans in the Southwestern states, our study selected smokers based on availability of frozen serum and may not apply to all smokers. Given that 42 percent of HHANES Mexican American smokers reported smoking less than 10 cigarettes per day, the highest estimates of underreporting apply to a substantial proportion of this population. However, it is possible that if smokers had been informed that a biochemical validation test would be conducted, underreporting would be less frequent. The HHANES Puerto Rican and Cuban American samples were not evaluated in this study, but the proportion of light smokers in those Latino subgroups is less than among Mexican Americans, and thus underreporting may be less common. Finally, our observations in Mexican Americans may be a phenomenon of all light cigarette smokers' self-reporting on quantity independent of ethnicity. In fact, Warner[34] has suggested that survey reports of cigarette consumption underestimate consumption estimates based on production and sales. A more recent comparison concluded that there was no apparent increase in underreporting cigarette smoking in surveys since 1975.[35] The magnitude of underreporting is greater among light smokers, and thus studies using cotinine measurements and applying the method described in this paper may be more important in these populations.

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NIH Consensus Development Conference Announced on Hyperparathyroidism

Hyperparathyroidism is increasingly being recognized in asymptomatic patients, as a result of widespread use of multiphasic screening tests that lead to detection of hypercalcemia. Physicians are often uncertain about the diagnosis and management of patients with subtle or absent signs and symptoms but with a clear biochemical diagnosis of hyperparathyroidism. Especially difficult are decisions about indications for surgery and how patients should be monitored to detect silent organ damage, particularly progressive bone loss.

Because of these issues, the National Institute of Diabetes and Digestive and Kidney Diseases and the Office of Medical Applications of Research at the National Institutes of Health will co-sponsor a consensus development conference on Diagnosis and Management of Asymptomatic Primary Hyperparathyroidism. The meeting will be held October 29–31 at NIH, Masur Auditorium, in Bethesda, MD.

To register for this conference or to obtain further details, contact: Conference Registrar, Prospect Associates, Suite 500, 1801 Rockville Pike, Rockville, MD 20852. Tel: (301) 468-MEET.