Assessment of Smoking Behaviors and Alcohol Use in the National Social Life, Health, and Aging Project

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Objectives. The National Social Life, Health, and Aging Project (NSHAP) assessed smoking behaviors and alcohol use as factors directly related to physical health, well-being, and social relationships. We describe self-report measures of tobacco and alcohol use, as well as an established biological marker of tobacco exposure, cotinine, collected in Wave 1 of NSHAP.

Methods. We compare smoking behaviors and alcohol use by gender and age group. We report on derived measures of alcohol consumption and tobacco exposure widely used in medical and substance use literature, compare current and past users, and describe associations between self-reported smoking status and cotinine.

Results. Men are more likely than women to report alcohol use, potential problem drinking, and ever smoking. Alcohol use and smoking are lower among older age groups. Although current smoking is less prevalent than in the general U.S. adult population, 50% of current and 29% of past smokers have lifetime exposure of 40 pack-years or more. Cotinine is directly related to number of cigarettes per day but with considerable unexplained variation. Cotinine levels contradict self-report in fewer than 4% of nonsmokers.

Conclusion. NSHAP provides data useful for investigation of smoking and alcohol use and their association with health and social factors.

Key Words: Smoking behavior—Tobacco—Alcohol use—Cotinine—Older adult.

The National Social Life, Health, and Aging Project (NSHAP) assessed health-related behaviors as factors directly related both to physical health and well-being and to social relationships. Two key health-related behaviors included in the NSHAP survey are smoking and alcohol use. The impact of these behaviors on health is well established. In NSHAP, one of the primary interests is in how the degree to which individuals engage in these behaviors mediates the relationship between social relationships and health. Higher quality social relationships, for instance, are associated with lower risk of problem drinking (Grzywacz & Marks, 2000). Both close and distant ties in social networks influence smoking behavior, and conversely, smoking influences the quality of social relationships, with smokers having more peripheral positions in their social networks than nonsmokers (Christakis & Fowler, 2008).

In this paper, we describe the measures of smoking behaviors and alcohol use collected in the first wave of NSHAP, including their distributions by gender and age. We describe construction of widely used derived measures that are readily obtained from the NSHAP core variables, discuss key properties of these variables, and present examples of associations among them. In addition to self-report of tobacco use, NSHAP provides a biological marker of this activity, cotinine, which we describe in detail, with examination of its relation-ship to selected self-reported smoking behaviors. Other health-related behaviors assessed by NSHAP, but not considered here, include physical exercise, sleep, elements of sexual behavior, and certain aspects of health care utilization.

The remainder of the article is organized as follows. A Methods section briefly summarizes relevant aspects of the survey design, data collection methods, biomasure processing, and the data analytic approach, followed by separate sections for alcohol consumption, self-reported smoking behaviors, and the biological marker of tobacco exposure, cotinine. Each of the domain-specific sections includes a description of the measures and their properties, their distributions by age group and gender, selected associations among the measures, response rates, and a brief discussion.

Methods

Study Design and Data Collection

NSHAP Wave 1 data were collected during in-home interviews, conducted in 2005–2006 with a probability sample of 3,005 community-dwelling U.S. residents, aged 57–85 years. The NSHAP study design is described in detail in O’Muircheartaigh and colleagues (this issue) and Smith and colleagues (this issue). We briefly reiterate
features of the design and data collection methods that apply to measures of smoking behaviors and alcohol use. In addition to self-report measures of these domains, respondents provided a saliva specimen, which was assayed for cotinine, a biological measure of tobacco exposure. The NSHAP sample was constructed to make comparisons by gender and age group (ages 57–64, 65–74, and 75–85 years) and was stratified accordingly.

Self-report measures were collected primarily through computer-assisted in-person interviews, supplemented by a leave-behind questionnaire. In order to obtain as much information as possible within the time constraints of the in-home interview, certain sections were modularized to apply to a subset of respondents or to be administered partly or wholly through the leave-behind questionnaire, or both. Biomeasures were modularized as well. Respondents were randomized to paths that determined which modules they received and the mode of administration. All measures of smoking behaviors and alcohol use, including the biomarker of tobacco exposure, were in the core set of measures, which NSHAP sought to obtain from all respondents. Moreover, all these measures were collected in the home, with one exception: A screening instrument for problem drinking behavior was administered to all respondents in the leave-behind instrument.

Biomeasure Processing
NSHAP obtained cotinine levels through collection of saliva specimens, a stable and noninvasive method that is well accepted by respondents (Binnie et al., 2004). Saliva specimen collection and processing are described by Gavrilova and colleagues (this issue). Salivary enzyme immunoassay for cotinine concentration was conducted at Salimetrics, LLC. Details of the assay, as well as additional information about processing and properties of the measure, are described in Iqbal, Mendoza, Curran, and Lindau (2007).

Data Analysis
Smoking behaviors and alcohol use are compared by gender and age group, overall and within each gender group. Prevalences with 95% confidence intervals (CIs) are given for levels of categorical and ordinal variables, with associations tested using the Pearson chi-square statistic, corrected for survey design with the second-order correction of Rao and Scott (1987). CIs are based on a logit transform to ensure that the confidence limits fall between zero and one. Means, standard deviations, and quartiles are provided for continuous variables, with associations evaluated through linear regression. For variables with skewed distributions, square root or logarithmic transformations were applied before analysis to achieve approximate normality. Linear, logistic, ordinal logistic (McCullagh & Nelder, 1989), and generalized ordered logit regression (Williams, 2006), which includes partial proportional odds models as a special case, were used to further evaluate associations and estimate adjusted effects. All analyses accounted for the survey sampling design through incorporation of sampling strata and clusters as well as weights that adjusted for differential probability of selection and differential nonresponse. Standard errors were computed using the Taylor linearization method (Binder, 1983). Weighted estimates are presented unless otherwise noted. Results are not adjusted for multiple testing. Analyses were conducted using Stata 10.0 (StataCorp, 2007).

Alcohol Consumption
Among many available instruments, NSHAP adopted two well-established approaches to assessment of alcohol consumption behavior that were also used in the Health and Retirement Survey (HRS) 2002 (National Center for Health Statistics, 2002). The first utilizes the quantity-frequency (QF) approach (Room, 1990) and the second assesses potential problem drinking behavior through a four-item screening instrument, the CAGE (Cut back, Annoyed, Guilt, Eye-opener) assessment (Ewing, 1984). The QF approach incorporates two domains: (a) quantity of alcohol intake within a reference period and (b) frequency of alcohol consumption within a reference period, as well as an additional question on frequency of consuming four or more drinks on one occasion as an indicator of high-risk drinking behavior (Dawson, 2003). The QF approach is recommended, albeit with limitations, when a quick and easy measure is needed due to time constraints (Sobell & Sobell, 2003).

Measures
All respondents were asked whether they ever drank alcoholic beverages such as beer, wine, or liquor. Respondents who stated “no” or “don’t know” or who refused to answer were then asked if they had ever drunk alcohol. Those who responded “yes” on this item were asked, “Have you drunk alcohol in the last three months?” Only respondents who indicated that they drank currently or within the past three months were then asked the three QF questions: “In the last three months (the reference period), on average, how many days per week have you had any alcohol to drink?” with response options 0 (none or less than one day a week), 1, 2, …, 7 (the frequency component). Next, respondents were asked to indicate how many drinks they had on those days (the quantity component). The quantity and the frequency components allow measurement of the volume consumed by multiplying the number of drinks per day by the number of drinking days per week. Finally, respondents were asked to indicate on how many days in the same reference period they had four or more drinks on one occasion.

The CAGE, a widely used clinical screening instrument that has been used effectively with older adults (Beuillens & Aertgeerts, 2004; Friedmann et al., 1999), was used to screen for problematic drinking. It is a brief, four-question instrument, which Mayfield, Mcleod, and Hall (1974) found
easy to administer and less intimidating than the full or shortened version of the Michigan Alcoholism Screening Test (Pokorny, Miller, & Kaplan, 1972; Seltzer, 1971). Respondents were asked whether they had ever felt that they should cut down on drinking, whether people had ever annoyed them by criticizing their drinking, whether they had ever felt bad or guilty about drinking, and whether they had ever had a drink first thing in the morning (eye opener) to steady their nerves or get rid of a hangover. A total of two or more positive responses have long been used to indicate alcohol abuse and dependence, with the cutpoint based on a sensitivity analysis (Fiellin, Reid, & O’Connor, 2000; Mayfield et al., 1974). The National Institute on Alcohol Abuse and Alcoholism (NIAAA), in contrast, recommends a screening cutpoint of one positive response for clinical use (Bradley, Kivlahan, Bush, McDonell, & Fihn, 2001; NIAAA, 2005), and Friedmann and colleagues (1999) found this cutpoint more suitable for screening elderly hospital emergency department patients. In our survey, the CAGE instrument was self-administered in the leave-behind instrument.

**Results**

The main descriptive findings for drinking behavior are summarized in Table 1. The results are presented for men and women separately stratified by three age groups. The first distribution shown in Table 1 describes the drinking status variable that was constructed from the first three questions on drinking behavior included in the interview. Its values are “current drinker,” “former drinker,” and “never drinker.” Current alcohol consumption differs substantially, comparing men with women across all age groups included in the NSHAP survey. For example, 55% of women versus 72% of men in the youngest age group indicated current alcohol use. Additionally, women were significantly more likely than men to report never consuming alcohol. Reported alcohol use also declines across age groups among both women and men.

Figure 1 presents the distribution of volume of alcohol consumed, calculated by multiplying the two components (quantity × frequency), and also presents the frequency component of this measure for men and women separately. As seen in the top panel of Figure 1, frequency of drinking was significantly higher among men than among women. Women were more likely than men to drink one or fewer days per week (58% vs. 43%) and less likely to drink daily (14% vs. 19%). Frequency of drinking also was significantly higher among older compared with younger men but did not differ by age among women (not shown). Quantity, in terms of the number of drinks consumed on days the respondent drank, was also significantly higher among men and decreased across age group for both men and women (not shown).

A number of characteristics of the composite volume measure are illustrated in the parallel boxplots in the lower panel of Figure 1. Most notably, consumption was higher among men than among women at all frequencies of drinking, and variability of consumption increased with frequency, particularly among men. By definition, minimum volume consumed is the number of days per week each person drinks, which is realized when the number of drinks per day equals one. For women, this is also the median value among those who drink five or more days a week. For men, in contrast, the median is two drinks per day, except at the lowest frequency. Note that volume consumed is zero when the respondent drinks on average less than one day a week, no matter how heavily. The overwhelming majority for whom volume consumed was zero reported drinking three or fewer drinks on the occasional days when they drank, but 15 (2.4%) respondents with this score reported an average of four or more drinks per occasion.

The last question included in the in-person interview deals with risk behavior; the respondents were asked about consumption of four or more alcoholic drinks on one occasion during the prior three months. The response to this question was an open-ended count, but due to its skewed distribution, we generated an ordinal scale with four categories as shown in Table 1, with cutpoints chosen to correspond roughly to once a month and once a week. The majority (77.2%) did not engage in heavy drinking behavior, but men were significantly more likely than women at all ages to report doing so. This risk behavior decreased across age groups, particularly for men.

As for the CAGE, a consistent and significant gender difference was observed across all four items, similar to what was found among the in-person interview questions (Table 1). For example, only 12% of women as compared with 36% of men aged 57–64 years had ever felt that they should cut down on drinking. Among men and women, positive responses to all CAGE items declined with age, although this trend does not reach statistical significance among women due to their low overall frequency of positive response. The four self-administered CAGE items were summed and then dichotomized at two alternative cutoffs that are used to indicate potential alcohol abuse and dependence: two or more positive answers (Fiellin et al., 2000) and one or more positive answers (Friedmann et al., 1999). These variables are also described in Table 1. Consistent with the other alcohol consumption measures, we found a significant gender difference for both. There is also evidence for a significant inverse relationship between age and potential alcohol abuse. When comparing CAGE responses with self-reported drinking status, 4.3% of individuals who reported never drinking in the face-to-face interview responded positively to at least one CAGE item, and 1.2% met the two or more positive response criterion for potential alcohol abuse.

Response rates were 98%–99% for drinking items asked in the in-person interview. Response rates for the CAGE screening items, which were self-administered in the leave-behind questionnaire for all respondents, ranged from 88% to 93% on returned surveys and 76% to 80% overall. In regard to
Table 1. Drinking Behavior by Gender and Age Group in NSHAP Wave 1

<table>
<thead>
<tr>
<th>Significant Factorsb</th>
<th>Total</th>
<th>Women</th>
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<th>Men</th>
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<td></td>
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<td>57–64 Years</td>
<td>65–74 Years</td>
<td>75–85 Years</td>
<td>57–64 Years</td>
<td>65–74 Years</td>
<td>75–85 Years</td>
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<td>Drinking status</td>
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<tr>
<td>Never drinker</td>
<td>G, A, A (F), A (M)</td>
<td>15.1 (12.8–17.7)</td>
<td>17.7 (13.0–23.6)</td>
<td>22.0 (17.5–27.2)</td>
<td>31.4 (25.7–37.8)</td>
<td>5.0 (3.6–7.0)</td>
<td>8.1 (6.4–10.2)</td>
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<tr>
<td>Former drinker</td>
<td>G, A, A (M)</td>
<td>26.8 (24.6–29.1)</td>
<td>27.3 (21.1–34.4)</td>
<td>25.1 (21.5–29.1)</td>
<td>28.9 (24.6–33.6)</td>
<td>23.0 (19.4–27.0)</td>
<td>27.0 (22.7–31.8)</td>
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<tr>
<td>Current drinker</td>
<td>G, A, A (M)</td>
<td>58.2 (55.0–61.3)</td>
<td>55.0 (47.4–62.4)</td>
<td>52.9 (47.3–58.5)</td>
<td>39.6 (33.9–45.7)</td>
<td>72.0 (67.6–76.1)</td>
<td>64.9 (60.2–69.3)</td>
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<tr>
<td>How many days in past 3 months did you have four or more drinks?</td>
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<tr>
<td>None</td>
<td>G, A, A (M)</td>
<td>76.5 (74.1–78.7)</td>
<td>83.5 (78.9–87.3)</td>
<td>88.9 (84.2–92.3)</td>
<td>91.3 (85.2–95.0)</td>
<td>61.0 (56.2–65.6)</td>
<td>70.3 (65.1–75.0)</td>
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<tr>
<td>1–3</td>
<td>G, A, A (M)</td>
<td>12.2 (10.7–13.9)</td>
<td>12.6 (9.8–16.2)</td>
<td>5.5 (3.1–9.5)</td>
<td>6.6 (3.3–12.7)</td>
<td>17.5 (13.0–23.1)</td>
<td>13.8 (10.4–18.1)</td>
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<tr>
<td>4–12</td>
<td>G, A, A (M)</td>
<td>7.6 (6.2–9.4)</td>
<td>3.3 (1.4–7.4)</td>
<td>5.2 (2.7–9.6)</td>
<td>1.6 (0.5–5.4)</td>
<td>14.6 (10.6–19.7)</td>
<td>9.6 (6.5–13.9)</td>
</tr>
<tr>
<td>&gt;12</td>
<td>G, A, A (M)</td>
<td>3.6 (2.5–5.3)</td>
<td>0.6 (0.1–2.8)</td>
<td>0.5 (0.1–3.3)</td>
<td>0.6 (0.1–4.0)</td>
<td>6.9 (3.4–13.7)</td>
<td>6.3 (4.3–9.3)</td>
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<tr>
<td>CAGE problem drinking screen</td>
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</tr>
<tr>
<td>Ever felt that you should cut down on drinking?</td>
<td>G, A, A (M)</td>
<td>19.8 (18.0–21.7)</td>
<td>12.2 (8.2–17.8)</td>
<td>9.5 (6.9–13.1)</td>
<td>5.6 (3.9–8.2)</td>
<td>35.6 (30.9–40.5)</td>
<td>27.1 (23.3–31.2)</td>
</tr>
<tr>
<td>Anyone ever annoyed you by criticizing your drinking?</td>
<td>G, A, A (M)</td>
<td>8.3 (6.8–10.1)</td>
<td>5.7 (3.1–10.1)</td>
<td>4.3 (2.2–8.3)</td>
<td>1.5 (0.6–4.0)</td>
<td>15.8 (10.7–22.7)</td>
<td>11.0 (7.8–15.4)</td>
</tr>
<tr>
<td>Ever felt bad or guilty about drinking?</td>
<td>G, A, A (M)</td>
<td>12.6 (11.0–14.5)</td>
<td>8.8 (5.2–14.5)</td>
<td>6.1 (3.6–10.3)</td>
<td>5.6 (3.8–8.3)</td>
<td>22.4 (19.3–26.0)</td>
<td>16.3 (12.9–20.3)</td>
</tr>
<tr>
<td>Ever drink in the morning to steady nerves or end hangover?</td>
<td>G, A, A (M)</td>
<td>3.8 (3.0–4.8)</td>
<td>2.4 (1.0–5.8)</td>
<td>1.8 (0.8–3.7)</td>
<td>1.0 (0.3–3.2)</td>
<td>8.2 (5.5–12.1)</td>
<td>3.9 (2.2–6.6)</td>
</tr>
<tr>
<td>One or more positive responses</td>
<td>G, A, A (M)</td>
<td>22.8 (20.9–24.9)</td>
<td>15.3 (10.5–21.9)</td>
<td>12.1 (8.7–16.7)</td>
<td>7.4 (5.4–10.1)</td>
<td>39.8 (35.3–44.4)</td>
<td>31.4 (27.0–36.2)</td>
</tr>
<tr>
<td>Two or more positive responses</td>
<td>G, A, A (M)</td>
<td>12.8 (11.2–14.7)</td>
<td>7.6 (4.9–11.4)</td>
<td>5.5 (3.4–8.7)</td>
<td>3.7 (2.4–5.6)</td>
<td>25.8 (21.1–31.1)</td>
<td>17.8 (14.5–21.6)</td>
</tr>
</tbody>
</table>

Notes: NSHAP = National Social Life, Health, and Aging Project. Estimates are percent (95% confidence intervals).

* Estimates are weighted to account for differential probabilities of selection and differential nonresponse. All estimates account for survey sampling design through incorporation of sampling strata and clusters.

b Notation for significant factors (p ≤ .05): G = gender; A = age group; A (F) = age group among females; A (M) = age group among males.
missing values, nondrinkers were most likely to leave all items blank (never drinker, 17%; past drinker, 11%; and current drinker, 2%), which would be expected if nondrinkers considered the questions to be irrelevant. However, a small but non-negligible proportion of respondents (6.3%) answered some but not all the items, most often with some “no” responses co-occurring with skipped items, which argues against regarding lack of response as a “no.”

Discussion: Alcohol Consumption

The most consistent finding concerning alcohol consumption was the difference across gender. Women in all age groups consumed less alcohol than men in terms of quantity, frequency, volume of alcohol use, and alcohol abuse. The evidence found in NSHAP for a gender difference in alcohol intake is consistent with findings from recent research using data from The Health and Retirement Survey (United States) and the English Longitudinal Study of Aging (Lang, Guralnik, Wallace, & Melzer, 2007).

Attention should be paid to the volume consumed measure that takes into account the average frequency and quantity of alcohol consumption. Although volume consumed is a commonly used indicator, interpretation of its value can be misleading. Very different patterns of drinking can yield identical values (Dawson, 2003; Sobell & Sobell, 2003). For example, data for a person who drinks one drink every day will generate the same volume of alcohol intake as data for a person who drinks seven drinks only one day a week. Therefore, evaluation of a drinking pattern should be based on the frequency and quantity components with supplemental information from the risk behavior measure.

Cigarette Smoking and Other Tobacco Use

Smoking assessment for adults typically includes information on smoking status (never, current, or ex-smoker), initiation, cessation, and intensity, which in turn yield measures of duration, cumulative exposure, and elapsed time since cessation (Leffondré, Abrahamowicz, Siemiatycki, & Rachet, 2002)—all of which have been linked to disease risk.

Measures

NSHAP assessed cigarette smoking status and history and current use of other tobacco products (pipe, cigars, snuff, and chewing tobacco). Smoking status was ascertained through two survey items. Respondents were first asked, “Do you smoke cigarettes now?” Those who answered “yes” were classified as current smokers. All others were asked, “Did you ever smoke cigarettes regularly?” and were classified as past or never smokers according to their response. Respondents who identified themselves as current cigarette smokers were asked the age when they began smoking regularly and the average number of cigarettes per day they usually smoke. Similarly, past smokers were asked the age when they began,
the age when they quit, and, on average, how many cigarettes per day they had usually smoked. Current use of other forms of tobacco was assessed by asking respondents, “Do you use any of the other following tobacco products regularly now? pipe, cigar, snuff, chewing tobacco, none,” with instructions to choose all that apply. Note that for the variable assessing the age of initiation of regular smoking, responses from smokers and nonsmokers are in separate variables, which were merged to apply to both groups before analysis or subsequent variable derivation. The same is true for the variable assessing the number of cigarettes per day. All items concerning cigarette smoking are drawn from Established Populations for Epidemiologic Studies of the Elderly (Taylor, Wallace, Ostfeld, & Blazer, 1998). The other tobacco items were newly developed for NSHAP.

Combining responses to the smoking history items yields a number of variables useful for describing and evaluating smoking behavior, including smoking duration in years, elapsed time since quitting for past smokers, and pack-years. For current smokers, smoking duration is calculated as current age minus age when first smoked regularly, and, for past smokers, as the difference between age last smoked and age first smoked. Pack-years is calculated as the number of years smoked times the average number of packs per day (20 cigarettes = 1 pack) (National Cancer Institute, 2007). Pack-years is often categorized for analysis, with 20 and 40 pack-years as commonly used risk thresholds (e.g., Cruickshanks et al., 1998; Straus, McAlister, Sackett, & Deeks, 2002; Sturmer, Glynn, Lee, Christen, & Hennekens, 2000), whereas the Centers for Disease Control and Prevention (CDC) designates ≥25 pack-years as “heavy smoking” in its report “Cigarette Smoking Among Adults—United States, 2004” (CDC, 2005).

Results

The main descriptive findings for smoking are summarized in Table 2. A minority of respondents (15%) reported current smoking. 44% claimed to be past smokers, and 41% responded that they had never smoked regularly. Overall, smoking status differed significantly by gender, age group, and age group within gender. Prevalence of current smoking was similar for men and women and decreased with age for both—from 17% in women and 20% in men at ages 57–64 years to 8% and 9%, respectively, at ages 75–85 years. Among men, there was a complementary increase in the proportion who reported past smoking, whereas the prevalence of never smoking was similar across age groups. In contrast, women in the oldest age group were significantly less likely to be past smokers and more likely to have never smoked than their younger counterparts.

Fifty percent of current smokers and 29% of past smokers met or exceeded the widely used high-risk threshold of 40 pack-years. Men had higher cumulative exposure to cigarettes by this measure than did women. For current smokers, this gender difference was a consequence of longer duration and higher intensity (cigarettes per day) among men, whereas for past smokers, only intensity differed by gender. On average, men started smoking regularly at a younger age than women (age 17 among men vs. ages 19–21 years among women, across age groups), but men who had quit smoking also did so at a younger age than women (42.5 vs. 44.7 years) and had correspondingly longer elapsed time since quitting.

Current smokers had smoked an average of 47.6 years and past smokers an average of 25 years. Smoking duration increased significantly with age for both men and women among past smokers and, as would be expected, among current smokers. Smoking intensity (cigarettes per day), in contrast, varied by age only among current male smokers—exhibiting a decreasing trend with age. The net effect for this subgroup was a significant association between age and cumulative exposure, with the youngest most likely to have reached ≥40 pack-years and the oldest most likely to be below 20 pack-years. Past smokers reported significantly higher smoking intensity than current smokers (on average, 22 vs. 16.7 cigarettes per day), which may be due in part to different reference periods and changes in smoking patterns over a lifetime. Nevertheless, current smokers had higher cumulative exposure whether pack-years was treated continuously or categorized. Note that among current smokers, smoking duration confounds with age due to the longer duration of opportunity for older respondents to smoke. This confounding does not occur with pack-years.

Current use of other tobacco products was reported by 4.7% (95% CI 3.8%–5.9%) of respondents—cigars 2.2% (1.6%–2.8%), chewing tobacco 1.6% (1.1%–2.5%), pipe 1.1% (0.7%–1.6%), and snuff 0.9% (0.5%–1.5%). Use of these products was more prevalent among men than among women (8.4% [6.7%–10.4%] vs. 1.3% [0.7%–2.6%]) but did not differ significantly by age group and was only moderately associated with cigarette smoking, being more prevalent among past smokers (never smokers 3.4% [2.3%–5.1%], past smokers 5.9% [4.6%–7.6%], and current smokers 4.7% [2.6%–8.2%]). A very small proportion of respondents (0.7% [0.4%–1.2%]) reported current use of two or more of these tobacco products. Response rates for all self-report smoking items were 98%–99%.

Discussion: Smoking

Self-reported rates of current smoking were lower and prevalence of past smoking higher in the NSHAP population than in the general U.S. adult population, based on estimates from 2004 National Health Interview Survey (NHIS) data (CDC, 2005). In NSHAP, 16% of men and 14% of women are current smokers; 53% of men and 36% of women are past smokers. In the general adult population, however, 21% were current and 22% past smokers. In the general population, adults 65 years or older had the lowest
## Table 2. Smoking Behavior by Gender and Age Group in NSHAP Wave 1a

<table>
<thead>
<tr>
<th>Significant Factors</th>
<th>Total</th>
<th>Women</th>
<th>57–64 Years</th>
<th>65–74 Years</th>
<th>75–85 Years</th>
<th>Men</th>
<th>57–64 Years</th>
<th>65–74 Years</th>
<th>75–85 Years</th>
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<tbody>
<tr>
<td><strong>Lifetime smoking status by self-report, % (95% CI)</strong></td>
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</tr>
<tr>
<td>G, A, A (F), A (M)</td>
<td>40.6</td>
<td>46.0</td>
<td>47.2</td>
<td>59.9</td>
<td>32.3</td>
<td></td>
<td>27.5</td>
<td>32.5</td>
<td></td>
</tr>
<tr>
<td>Regularly</td>
<td></td>
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<td></td>
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<td></td>
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<td></td>
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<tr>
<td>Former smoker</td>
<td></td>
<td>44.1</td>
<td>37.1</td>
<td>37.2</td>
<td>47.8</td>
<td></td>
<td>32.3</td>
<td>40.6</td>
<td></td>
</tr>
<tr>
<td>Current smoker</td>
<td>15.2</td>
<td>17.0</td>
<td>15.6</td>
<td>8.3</td>
<td>20.0</td>
<td></td>
<td>16.0</td>
<td>56.5</td>
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<tr>
<td><strong>Current smoking status based on salivary cotinine, % (95% CI)</strong></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Nonsmoker G, A, A (M)</td>
<td>79.8</td>
<td>80.1</td>
<td>82.9</td>
<td>91.3</td>
<td>70.7</td>
<td></td>
<td>76.2</td>
<td>86.8</td>
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<tr>
<td>Passive smoker</td>
<td>0.7</td>
<td>0.5</td>
<td>0.6</td>
<td>1.4</td>
<td>1.4</td>
<td></td>
<td>0.7</td>
<td>0.3</td>
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<tr>
<td>Occasional smoker</td>
<td>1.8</td>
<td>2.1</td>
<td>1.5</td>
<td>2.2</td>
<td>2.2</td>
<td></td>
<td>2.1</td>
<td>1.4</td>
<td></td>
</tr>
<tr>
<td>Regular smoker</td>
<td>17.7</td>
<td>17.3</td>
<td>15.0</td>
<td>7.6</td>
<td>25.7</td>
<td></td>
<td>21.0</td>
<td>11.6</td>
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</tr>
<tr>
<td><strong>Smoking history, M (SE), first quartile, median, third quartile</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Age when first smoked regularly</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>G, A, A (F)</td>
<td>18.4</td>
<td>19.0</td>
<td>20.1</td>
<td>20.8</td>
<td>17.3</td>
<td></td>
<td>17.3</td>
<td>17.4</td>
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<tr>
<td>Cigarettes per day (20 per pack)</td>
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<td></td>
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<tr>
<td>Among current smokers G, A, A (M)</td>
<td>16.6</td>
<td>16.5</td>
<td>13.6</td>
<td>11.5</td>
<td>20.5</td>
<td></td>
<td>26.4</td>
<td>25.3</td>
<td></td>
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<tr>
<td>Years smoked</td>
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<td></td>
</tr>
<tr>
<td>Among current smokers G, A, A (M)</td>
<td>47.6</td>
<td>40.8</td>
<td>48.2</td>
<td>56.5</td>
<td>43.8</td>
<td></td>
<td>21.0</td>
<td>24.3</td>
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<tr>
<td>Among past smokers G, A, A (M)</td>
<td>25.0</td>
<td>22.9</td>
<td>24.9</td>
<td>29.6</td>
<td>21.0</td>
<td></td>
<td>26.3</td>
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<tr>
<td>Age when last smoked regularly</td>
<td></td>
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<tr>
<td>G, A, A (F), A (M)</td>
<td>43.4</td>
<td>41.5</td>
<td>44.9</td>
<td>49.9</td>
<td>38.7</td>
<td></td>
<td>44.0</td>
<td>46.6</td>
<td></td>
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<tr>
<td>Years since last smoked</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G, A, A (F), A (M)</td>
<td>24.7</td>
<td>19.3</td>
<td>23.8</td>
<td>29.4</td>
<td>21.9</td>
<td></td>
<td>25.5</td>
<td>32.4</td>
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<tr>
<td>Cumulative exposure: Pack-years</td>
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<tr>
<td>Continuous value, M (SE), first quartile, median, third quartile</td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Among current smokers G</td>
<td>39.6</td>
<td>34.7</td>
<td>33.8</td>
<td>33.3</td>
<td>45.0</td>
<td></td>
<td>43.4</td>
<td>46.4</td>
<td></td>
</tr>
<tr>
<td>Among past smokers G</td>
<td>30.7</td>
<td>24.4</td>
<td>27.8</td>
<td>29.1</td>
<td>30.5</td>
<td></td>
<td>34.4</td>
<td>37.6</td>
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<tr>
<td>Categorical levels, % (95% CI)</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Among current smokers &lt;30 G, A (M)</td>
<td>25.0</td>
<td>29.0</td>
<td>34.3</td>
<td>30.8</td>
<td>15.2</td>
<td></td>
<td>19.4</td>
<td>36.2</td>
<td></td>
</tr>
<tr>
<td>20–39</td>
<td></td>
<td>25.1</td>
<td>29.2</td>
<td>28.9</td>
<td>178.0</td>
<td></td>
<td>29.8</td>
<td>9.5</td>
<td></td>
</tr>
<tr>
<td>≥40</td>
<td></td>
<td>49.9</td>
<td>44.8</td>
<td>36.9</td>
<td>670.0</td>
<td></td>
<td>50.8</td>
<td>54.3</td>
<td></td>
</tr>
</tbody>
</table>

(Continued)
rate of smoking (8.8%), which was realized in NSHAP only at ages 75–85 years. Although these rates are not directly comparable, the fact that the NHIS interval includes all ages >85, and thus spans the NSHAP age interval, suggests consistency between NSHAP and NHIS estimates.

Based on a review of approaches used in 40 articles published in epidemiological and clinical journals in 2000, Leffondré and associates (2002) used data from a case-control study of lung cancer to investigate how modeling smoking history impacts estimated effects of cigarette smoking. Variations included criteria used to distinguish between current and ex-smokers, whether never smokers were included when modeling continuous smoking exposure, replacing intensity and duration by a single measure (e.g., pack-years), and simultaneous modeling of several time-related smoking variables. They found that estimated effects may depend substantially upon modeling strategies and make specific recommendations for use of smoking history variables in analysis. Although NSHAP differs in design and focus from the Leffondré study, these issues are still pertinent and worthy of consideration in working with smoking data from the NSHAP study.

Salivary Cotinine

Salivary cotinine provides an objective measure of tobacco exposure that can be used to detect and quantify second-hand exposure, validate self-reported nonsmoking status, and classify smokers as occasional or regular. Cotinine is a primary metabolite of nicotine that has a half-life of 16–18 hr and can be detected in urine, saliva, or serum; it provides a reliable means of determining tobacco use or exposure over the prior two or three days (Iqbal et al., 2007; Montalto & Wells, 2007).

A number of factors, including body mass index (BMI) and recent food consumption, are known to affect nicotine metabolism and cotinine concentrations (Hukkanen, Jacob, & Benowitz, 2005) and may contribute to what is often wide variation in cotinine at the same nominal exposure level—for example, among smokers who report smoking one pack of cigarettes per day.

Measures

In the NSHAP core data set, salivary cotinine concentrations are reported in nanograms per milliliter (ng/ml) for each of two duplicate assays performed on the individual saliva samples. Iqbal and associates (2007) provide information on details of the assay. The core data set also includes gender-specific derived variables, described in the following, that classify respondents as nonsmokers, passive smokers, occasional smokers, and regular smokers, based on their mean cotinine concentrations. NSHAP recorded the time of cotinine measurement and queried respondents about the elapsed time since last food or drink consumption other than water, which enables incorporation of these potential modifying factors in analysis. In addition, a series of variables

Table 2. Smoking Behavior by Gender and Age Group in NSHAP Wave 1 (Continued)
mark the status of the saliva sample and assay results (Iqbal et al., 2007). In particular, flags for each of the duplicate assays identify (a) values below the lower limit of sensitivity of the assay (0.05 ng/ml), which have been recoded as 0; (b) values that are a “lower bound” on the true value; and (c) values missing due to insufficient sample quantity or a technical problem with the sample. The lower bound flag indicates that the cotinine concentration remained above the upper assay limit of 200 ng/ml after final dilution to 1:20. Values flagged as lower bounds have all been set to the fixed value, 200 ng/ml, and thus are not approximations of the true cotinine concentration. To place this in context, note that the maximum cotinine concentration in the NSHAP sample is over 2,400 ng/ml. Additionally, a variable that reports the status of the saliva sample identifies 20 samples that were not continuously frozen during transport. Calculation of mean cotinine concentration from the duplicate assays is left to individual users, who may choose different options for dealing with these special cases.

Imputed smoking status is derived from respondents’ mean cotinine concentrations, based on the Wells–Stewart method described in a 1992 Environmental Protection Agency (EPA) report on passive smoking (U.S. EPA, 1992, p. 453). Under this method, cutoffs that divide smoking categories are calculated separately for men and women as percentages of the observed mean for self-reported smokers in the sample. Individuals with cotinine concentrations at or above 30% of this mean value are classified as regular smokers; those with concentrations between 10% and 30% of it are classified as occasional smokers. The EPA report does not address the boundary between passive exposure and nonexposed nonsmokers. Empirically determined lower bounds for passive smoking in the literature have ranged from 7 to 44 ng/ml and higher (e.g., Binnie et al., 2004; Etter, Vu Due, & Pernegen, 2000; Etzel, 1990), with 10 ng/ml generally recognized as sensitive and specific for delineating nonsmokers from current smokers (Ogden, Morgan, Heavner, Davis, & Steichen, 1997). In NSHAP, the value that best separates nonsmokers and passive smokers is 15 ng/ml for both men and women, providing 91.4% sensitivity and 96.4% specificity for self-reported nonsmoking in men, and 95.9% sensitivity and 96.6% specificity in women. Cotinine values with the lower bound flag, aforementioned, were excluded from these calculations.

Results

Figure 2 displays the distribution of salivary cotinine concentrations among women on the logarithmic scale. Vertical lines separate imputed smoking categories and mark the mean concentration for self-reported smokers. Notable features of the distribution include its clear delineation as a mixture of three distinct components. The single bar on the far left corresponds to cotinine concentrations below the level of sensitivity of the assay (19% of women). Moving to the right, the majority of women (65%) are seen to have detectable concentrations below the level of passive exposure, with values that follow a unimodal, mildly right-skewed distribution. These two components comprise nonsmokers with, at most, minimal passive exposure to tobacco. The third component corresponds to the continuum of exposure from passive through occasional and regular smoking (16% of women) and exhibits...
a unimodal distribution, moderately skewed to the left. The
distribution for men is similar to that of women.

Table 2 presents the main descriptive results for cotinine,
first in terms of imputed smoking status and then as a measure
of the magnitude of recent exposure among self-reported cur-
rent smokers. Cotinine concentrations indicate regular smok-
ing in 17.7% and occasional smoking in 1.8% of respondents,
whereas concentrations consistent with passive exposure
were observed in fewer than 1%. Age and gender trends were
analogous to those for self-reported smoking status, although
the age trend among women did not reach statistical signifi-
cance ($p = .11$). Moreover, cotinine classification was consis-
tent with self-reported smoking status and use of other tobacco
products for the vast majority of respondents. Of particular
interest, cotinine concentrations were below levels indicative
of smoking, occasional or regular, for 97.9% (95% CI 97.2%–
98.4%) of respondents who reported no current cigarette or
other tobacco use. Breaking this down further, self-report of
no tobacco use was validated for 99.8% (99.0%–99.9%) of
never smokers and 96.2% (94.8%–99.2%) of past smokers.
Among current smokers, mean cotinine concentration was
346 ng/ml (median 309 ng/ml) overall and decreased with age
in both men and women. For comparison, the mean concen-
tration among respondents reporting no tobacco use was 5.6
ng/ml, and the 75th percentile of the distribution was less than
0.4 ng/ml across age groups for both men and women.

Figure 3 illustrates several features of the relationship
between cotinine and smoking behavior. Salivary cotinine
increased significantly with both current smoking intensity
(cigarettes per day) and cumulative lifetime exposure
(pack-years), although cotinine concentrations exhibited
considerable variation at any given level of either variable
(cigarettes per day: adjusted $R^2 = .18$, pack-years: adjusted
$R^2 = .16$). In contrast, pack-years was a very strong predic-
tor of current smoking intensity, explaining over 90% of the
variation in number of cigarettes per day ($R^2 = .93$), thus

![Figure 3. Salivary cotinine, smoking intensity, and cumulative exposure among current smokers.](image-url)
suggesting a mechanism for the significant association between short-term and cumulative lifetime exposure.

Although the mixture distribution for cotinine is most evident on the logarithmic scale, the square root transformation yields better symmetry within each smoking group (albeit with multiple high outliers among nonsmokers) and is more suitable for analysis.

**Explanation of Missing Data**

Cotinine values are provided for 2,260 (75.7%) respondents. Missing data resulted primarily from failure to obtain a saliva specimen (respondent refused: 9.2%, respondent tried but was unable to do: 2.2%) or insufficient sample for assay (11.4%). Cotinine was the last of five assays conducted on each salivary specimen, and adequacy rates declined with each successive assay (Gavrilova et al., this issue); overall, 86.9% of saliva specimens processed for analysis were sufficient for cotinine assay. Values were missing for an additional 1.4% of respondents due to equipment problems during saliva collection (n = 7), loss of specimens in transit (n = 25, 1.0%), inability to identify the sample (n = 6), and a technical problem with the sample (n = 1). Cooperation rates during saliva collection did not differ significantly by gender, age group, or smoking status; cooperation is discussed in detail by Gavrilova and associates (this issue). Among respondents who were willing to provide a sample, women and those in the oldest age group were most likely to be unable to do so. Likewise, a larger proportion of processed samples were insufficient for assay among women (17.9% vs. 8.1%, p < .0001). None of these sources of missingness differed significantly by smoking status.

It should also be noted that among the values of cotinine obtained, 16.8% were below the limit of sensitivity of the assay for both duplicates and have been assigned the value of 0. These nondetectable concentrations were more common in women and with increasing age. The gender difference remained after controlling for smoking status. Consistent with the nature of the measurement, nondetectable concentrations occurred almost entirely among self-reported nonsmokers (never or past).

**Discussion: Cotinine and Self-Reported Smoking Behavior**

Self-reported nonsmoking was validated by cotinine levels for the vast majority of past and never smokers, taking into account use of other tobacco products. This high level of agreement speaks not only to the validity of self-reported smoking status among NSHAP respondents but also to the success of the EPA-recommended method for deriving cutpoints from cotinine concentrations to determine smoking, or exposure, categories. NSHAP provides these gender-specific cotinine-based classification variables in its core data set. Molander, Hansson, and Lunell (2001) found that older adults, aged 65–76 years, had significantly decreased clearance of cotinine compared with adults aged 22–43 years, but the difference was not clinically important. When investigating cotinine concentrations, factors such as body habitus and timing of the most recent meal should be considered as potential modifiers. NSHAP reports BMI, which can be used for this purpose, as well as elapsed time since last food or beverage.

It is striking that cotinine concentrations, which measure tobacco exposure within the past two or three days, exhibit a significant positive association with pack-years, a measure of cumulative lifetime exposure—apparently due to a strong association between lifetime exposure and current smoking intensity. In contrast, less variation in cotinine is explained by current smoking intensity than might be expected. Several aspects of smoking behavior, in addition to factors that affect nicotine metabolism and cotinine clearance, may account for this unexplained variation. The manner in which a person smokes, or smoking topography (e.g., number and frequency of puffs, portion of cigarette smoked, depth of inhalation), affects the amount of nicotine absorbed (Strasser, Pickworth, Patterson, & Lerman, 2004), so that persons who smoke the same number of cigarettes per day may have very different cotinine levels. In addition, patterns of smoking (e.g., continuously vs. at fixed periods during the day) could lead to differences in the elapsed time since the last cigarette was smoked at the time of cotinine measurement (Campuzano et al., 2004).

**Conclusions**

NSHAP successfully acquired a range of measures of smoking behaviors and alcohol use. These variables will serve as important modifying or explanatory factors when examining key questions concerning social relationships, health, and sexuality. The measures are well established and have been used extensively in medical, social science, and other fields of research. The data are of high quality, with response rates that generally meet, or exceed, those of other comparable studies. Prevalences for selected measures were compared with those from other large national surveys and found to be similar.

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