Practice of Epidemiology

Declining Estimated Prevalence of Alcohol Drinking and Smoking among Young Adults Nationally: Artifacts of Sample Undercoverage?

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A growing concern in public health surveillance surveys that rely on random digit dialing for sampling is the exclusion of adults in cell-phone-only households. The purpose of this study was to examine whether recent increases in wireless substitution have affected estimates of tobacco and alcohol use in the Behavioral Risk Factor Surveillance System (BRFSS) in a subpopulation with notable cell-phone usage (i.e., young adults). BRFSS data from 2001–2005 were examined. Analyses were limited to participants aged 18–24 years, and the sample contained approximately 18,500 persons in each year. Prevalence estimates were generated with SUDAAN software for three health behaviors: cigarette smoking, binge drinking, and heavy alcohol consumption. In addition, the authors examined sample completeness for young adults relative to US Census estimates. Overall, prevalences of all three health behaviors among young adults were fairly stable between 2001 and 2003 but significantly decreased between 2003 and 2005. These trends are not replicated in national surveys that use area probability samples. The authors found a declining trend in the sample completeness ratio for young adults; it declined from 0.32 in 2001 to 0.15 in 2005. Given the high prevalence of wireless substitution among young adults and the declining sample completeness ratio, the authors suspect that the observed decreases in prevalence are artifacts of undercoverage.

A growing concern in traditional random digit dialing (RDD) surveys that generate a random sample of household landline telephone numbers, such as the Behavioral Risk Factor Surveillance System (BRFSS) surveys, is the exclusion of adults living in cell-phone-only households (1, 2). Indeed, the percentage of adults who live in cell-phone- or wireless-only households increased by more than 300 percent between early 2003 (2.9 percent) and late 2006 (11.8 percent) (3). Existing indicators suggest that this pattern of adoption of wireless-only communication will continue (1–3). Given that RDD sampling frames are limited to landline telephones, wireless substitution has important implications for the generalizability of such surveys. Specific subpopulations, such as males, minorities, and persons living at or near the poverty line, are more likely to live in cell-phone-only households, and wireless substitution is particularly high among young adults (persons aged 18–24 years) (1, 3). Indeed, the percentage-point increase in wireless substitution between early 2003 and late 2006 for young adults was more than double that of adults overall, and as of late 2006, more

Abbreviations: BRFSS, Behavioral Risk Factor Surveillance System; RDD, random digit dialing.

Editor’s note: An invited commentary on this article appears on page 20, and the authors’ response appears on page 23.
than one in four young adults lived in a wireless-only household (3). Interestingly, the percentage of young adults participating in the BRFSS has been decreasing over the last few years (4). This may be a function of nonresponse (e.g., refusal) and/or undercoverage bias related to wireless substitution.

As the number of wireless-only households increases, it raises questions about the impact their exclusion from RDD surveys will have over time on various prevalence estimates for certain populations, such as young adults. In due course, the effect of wireless substitution could mask or exaggerate real variations in prevalence estimates. Given the recent proliferation of wireless substitution overall and the high rate of wireless substitution among young adults, we decided to analyze the prevalence of three health behaviors—cigarette smoking, heavy alcohol consumption, and binge drinking—estimated from the BRFSS during the time period of rapid growth in wireless substitution. We focused on these behaviors because cigarette smoking and excessive alcohol consumption are the first and third leading preventable causes of death in the United States, respectively (5), and the highest rates of cigarette and alcohol use are found among young adults (6, 7).

**MATERIALS AND METHODS**

We analyzed 5 years of BRFSS data, ranging from 2001 through 2005. The BRFSS, which is supported by the Centers for Disease Control and Prevention, compiles data from state-based RDD telephone surveys of the adult population. The BRFSS collects data on health care utilization and risk behaviors from a representative sample of civilian noninstitutionalized adults (aged ≥18 years) in each of the 50 states and the District of Columbia. A detailed description of the survey design and sampling procedures is provided elsewhere (8).

While BRFSS is a state-based surveillance system, methodological research has demonstrated that when data from all 50 states are combined, BRFSS provides national estimates on a par with those of the National Health Interview Survey for standardized questions (9). Thus, we pooled data across all 50 states and the District of Columbia. We limited our analyses to young adults aged 18–24 years. Across the 5-year period, the sample size was approximately 18,500 per year and ranged from 18,290 (2005) to 18,909 (2004).

Declining participation in RDD surveys can be a function of both changes in coverage and nonresponse. While raw data (i.e., the number of cases) provide some information regarding the completeness of a sample, their value is limited because the probabilities of selection for all sample members are rarely equal. Thus, to further examine declining participation, we calculated a sample completeness ratio according to US Census methods (10). To calculate the sample completeness ratio, we utilized the BRFSS’s sample weights. The chief purpose of survey sample weights is to adjust for any bias that may have resulted from the sampling method (e.g., oversampling). Adjusting for varying probabilities of selection is a fundamental starting point, and a base weight for each sampled unit is often calculated that represents the reciprocal of its probability of selection. Subsequently, the sum of the base weights provides another indicator of participation, controlling for any differential probabilities of selection. Thus, we calculated our sample completeness ratio, by age group, by dividing the sum of the base weights by the count of adults for each respective age group according to the 2000 Census (11). Therefore, the sample completeness ratio highlights both coverage and nonresponse error (10) and provides a useful measure of BRFSS data survey quality.

We used standard measures to define current smoking, binge drinking, and heavy drinking. Cigarette smoking was defined as having smoked 100 cigarettes in one’s lifetime and currently smoking every day or on some days. Binge drinking was defined as having consumed five or more alcoholic beverages on one or more occasions during the past 30 days. Heavy drinking was defined as having consumed more than two drinks per day for men or more than one drink per day for women during the previous 30 days.

Data were analyzed with SUDAAN statistical software, which corrects for the complex sample design (12). State data were combined for all years to produce national estimates; each state was treated as a separate stratum. The BRFSS final sample weights, which adjust for the varying probabilities of selection within each state and nonresponse, were utilized to generate prevalence estimates with 95 percent confidence intervals. We also conducted two-sample t tests to examine differences between annual estimates by gender and race and overall (13).

**RESULTS**

Table 1 shows the proportions of young adults in the BRFSS sample from 2001 to 2005 and in the US population according to US Census data (14). Currently, persons aged

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<table>
<thead>
<tr>
<th>Age Group</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>US population*</td>
<td>13.2</td>
<td>13.2</td>
<td>13.3</td>
<td>13.3</td>
<td>13.1</td>
</tr>
<tr>
<td>Behavioral Risk Factor Surveillance System sample</td>
<td>8.7</td>
<td>7.6</td>
<td>6.9</td>
<td>6.2</td>
<td>5.1</td>
</tr>
<tr>
<td>Sample completeness ratio, by age group (years)†</td>
<td>18–24</td>
<td>0.32</td>
<td>0.29</td>
<td>0.24</td>
<td>0.20</td>
</tr>
<tr>
<td>25–44</td>
<td>0.36</td>
<td>0.33</td>
<td>0.29</td>
<td>0.26</td>
<td>0.22</td>
</tr>
<tr>
<td>45–64</td>
<td>0.40</td>
<td>0.39</td>
<td>0.37</td>
<td>0.37</td>
<td>0.34</td>
</tr>
<tr>
<td>≥65</td>
<td>0.35</td>
<td>0.34</td>
<td>0.32</td>
<td>0.32</td>
<td>0.31</td>
</tr>
</tbody>
</table>

* Source: US Census Bureau (14).
† Calculated as the sum of weights before adjustments for nonresponse and coverage divided by the count of young adults in the 2000 US Census.
18–24 years make up approximately 13 percent of the total US population, and this proportion remained fairly stable over the 5-year study period. Conversely, during the same time period, the proportion of young adults in the BRFSS sample declined at an average of 0.9 percent per year, from 8.7 percent in 2001 to 5.1 percent in 2005. However, given that young adults make up a small proportion of the total US population, these small declines over time have led to increased underrepresentation of the young adult population. This is further illustrated by examining the sample completeness ratio by age group. While the sample completeness ratio declined overall across the 5-year period, the magnitude of the decline was associated with and varied by age, with the greatest decline being noted for persons aged 18–24 years.

As table 2 shows, the BRFSS data indicated no significant changes in current cigarette smoking prevalence from 2001 through 2003 for young adults. However, from 2003 through
2005, there were a number of significant changes. Overall, the proportion of young adults who were current cigarette smokers declined between 2003 (28.9 percent) and 2005 (26.1 percent) ($p < 0.01$) and from 2003 (28.9 percent) to 2004 (26.6 percent) ($p < 0.01$). Significant declines were also noted for males and Whites.

As with cigarette smoking prevalence, estimates for binge drinking and heavy alcohol consumption remained unchanged between 2001 and 2003 and then significantly decreased between 2003 and 2005 (see table 2). Overall, the proportion of young adults who reported binge drinking declined from 30.1 percent in 2003 to 25.3 percent in 2005 ($p < 0.01$), and the proportion reporting heavy alcohol consumption declined from 10.5 percent (2003) to 7.9 percent (2005) ($p < 0.01$). Significant declines between 2003 and 2005 for binge drinking and heavy alcohol consumption were noted for male, female, and White young adults.

**DISCUSSION**

Our analyses of BRFSS data found that the prevalences of current cigarette smoking, binge drinking, and heavy drinking among young adults in the United States decreased significantly between 2003 and 2005. Given the burden of cigarette smoking and excessive alcohol consumption in US morbidity and mortality, this should certainly be welcome news.

However, we believe that these declines are probably artifacts of sample undercoverage, for several reasons which bear further discussion. First, wireless substitution increased overall among adults from 2003 to 2005 (3) and did so most greatly in the young adult population (from 6.0 percent to 17.5 percent)—the same period for which we observe declines in sample completeness ratio and prevalences of smoking and drinking. While data on wireless substitution prior to 2003 are scant and not available for specific age groups, data from the Bureau of Labor Statistics’ Consumer Expenditure Interview Survey estimated that less than 1 percent of households reported having only a cell-phone bill during the first half of 2001; this rose to 3 percent by the end of 2002 (15). Second, research has shown that relative to adults with landline telephones, adults in cell-phone-only households are more likely to smoke cigarettes and binge drink (1). Third, the declining trends in alcohol and tobacco use noted in the BRFSS are not replicated in national household surveys that use area probability samples, such as the National Health Interview Survey and the National Survey of Drug Use and Health. Those surveys are not subject to undercoverage as a result of wireless substitution. Indeed, as figure 1 shows, the estimates for these three behaviors between 2003 and 2005 are virtually unchanged in these two household-based surveys (the National Health Interview Survey and the National Survey of Drug Use and Health), which use standardized measures within surveys over time. Fourth, it is important to note that the use of sample weights will not correct for undercoverage in the sampling frame if the noncovered population is somehow different (e.g., more likely to smoke) than the covered population. Indeed, Blumberg et al. (16) created additional sample weight adjustments for persons living in cell-phone-only households, based on the demographic characteristics of the cell-phone-only population, and found that even after adjustment for demographic characteristics (e.g., age), differences still existed for smoking and binge drinking, in addition to other health behaviors (i.e., receiving influenza or pneumococcal vaccine and having had a human immunodeficiency virus test), and that these differences may bias estimates by 1 percentage point or greater. We believe that the exclusion of cell-phone-only households could be affecting the BRFSS estimates of young adult smoking and alcohol use similarly and that the declines in prevalence may be an indicator of increased coverage bias among young adults.

Given the growing use of privacy features (e.g., caller identification) and wireless telephone technologies, RDD surveys have become increasingly difficult to implement with confidence. If the growth in cell-phone-only households continues, undercoverage bias will pose a serious threat to the validity of RDD surveys. We believe that the generalizability of surveys like those of the BRFSS may be compromised for certain population subgroups, specifically young adults. Public health professionals who utilize these data should be cautioned about drawing conclusions, especially regarding trends over time, for this particular population group.

Data collected from standardized surveillance systems should be considered in the context of coverage limitations. The Centers for Disease Control and Prevention recommends that such data systems monitor whether subgroups are systematically excluded and subsequently modify data collection procedures as needed to ensure generalizability (17). Indeed, we believe that with respect to RDD surveys for health surveillance purposes, it may be time to supplement data collection with cell-phone-only telephone surveys to improve coverage of select populations and reduce error. However, challenges to including cell phones in RDD surveys still need to be addressed. These challenges include weighting methodology, Federal Communications Commission restrictions on using automatic dialers, and other methodological and logistical issues (18). Lastly, methodological research on the impact of wireless substitution in RDD studies should be expanded, given the frequent use of RDD sampling for the selection of population-based controls in epidemiologic case-control studies (19, 20).

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