A dual-frame sampling methodology to address landline replacement in tobacco control research

Robert C McMillen,1,2 Jonathan P Winickoff,1,3 Karen Wilson,1,4 Susanne Tanski,1,5 Jonathan D Klein1

ABSTRACT

Objectives We assessed the comparability of self-reported smoking prevalence estimates from a dual-frame survey with those from two large-scale, national surveys.

Methods The Social Climate Survey of Tobacco Control (SCS-TC) obtained self-reported current smoking status via a dual-frame methodology in the fall of 2010. One frame used random digit dialling procedures and consisted of households with a landline telephone; the other frame consisted of a population-based probability-based online panel. Current smoking prevalence was compared with national estimates from the 2010 National Health Interview Survey (NHIS) and the 2009–2010 National Health and Nutrition Examination Survey (NHANES).

Results 18.3% (95% CI 17.0% to 19.6%) of SCS-TC respondents reported current smoking. NHIS and NHANES estimates found 19.4% (95% CI 18.8% to 20.1%) and 20.3% (95% CI 18.7% to 22.1%), respectively, reporting current smoking.

Conclusions Prevalence estimates for cigarette smoking obtained from the dual-frame SCS-TC are comparable to those from other national surveys. A mixed-mode approach may be a useful strategy to transition cross-sectional surveys with established trend data to newer dual-frame designs to maintain compatibility with surveys from previous years and to include the growing number of households that do not have landline telephones.

INTRODUCTION

Tobacco use is the leading preventable cause of disease and death in the USA. Approximately 443 000 people die prematurely from smoking or exposure to tobacco smoke each year, while 8.6 million live with a chronic illness caused by smoking.1 The Centers for Disease Control and Prevention support several telephone and household surveys to monitor cigarette smoking among US adults. We developed the National Social Climate Survey of Tobacco Control (SCS-TC) to complement these large-scale, national surveys by assessing the social and environmental factors related to tobacco use and tobacco counselling from healthcare providers. The flexibility to add survey items that assess current attitudes and practices enhances the pace of scientific discovery around emerging issues in tobacco control.2 The capacity to adapt this survey annually to address rapidly emerging issues and to report results within 3–6 months of data collection enhances the impact that this research has on tobacco control efforts. Our study of beliefs about “third-hand smoke”3 helped to drive an emerging area of research, while media coverage from Time, The Today Show, and national public radio introduced this term and concept to the US public. Other studies have used data from the SCS-TC to examine support for banning mentholated cigarettes,4 use of emerging tobacco products5 and child healthcare clinicians addressing parental smoking.5 6

Since 2000, this survey has used a random-digit-dialling (RDD) sample frame of households with landline telephones. However, wireless substitution of cell phones for landlines continues to increase, and 35.8% of US households are currently wireless only.7 In addition, wireless substitution is particularly problematic for surveys of tobacco use, as smoking status, and age, region, and several other demographic factors, vary by landline telephone status.8 For these reasons, wireless substitution has been identified as a major barrier to RDD landline sampling frames.9 10 Although one early investigation did not detect variations in smoking prevalence across landline-only and cell phone frames,11 the authors did predict that the rapid growth of wireless substitution, especially among young adults, could become a source of non-coverage. Indeed, significant variations have been detected as wireless substitution rates have increased.7 9

To address this increasing source of coverage bias, we added an additional probability-based internet panel frame to the SCS-TC in 2009. We continued to use an RDD frame to maintain compatibility with the SCS-TC from the previous 10 years. As recommended by guidelines for dual frame surveys, weighting adjustments were made for conditions in which these frames overlap and a respondent could be represented in both frames.8

To investigate the viability of this dual-frame approach for the SCS-TC, we assessed the comparability of self-reported smoking prevalence estimates from our dual-frame survey with those from two large-scale, national surveys. Specifically, we compared estimates from the SCS-TC to those from the National Health Interview Survey (NHIS) and the National Health and Nutrition Examination Survey (NHANES). We hypothesise that estimates from the dual-frame SCS-TC will be consistent with those from these two large-scale, national surveys.

METHODS

Dual-frame surveys representing national probability samples of non-institutionalised US adults were administered in 2010. The design included an RDD frame and an internet panel frame developed...
Brief report

from a probability sample of the general population to reduce
non-coverage issues arising from wireless substitution. We
retained the RDD frame to maintain the capacity to examine
trends with the RDD frames from previous survey administra-
tions. The Institutional Review Board at Mississippi State
University approved this study on 30 July 2010. More detailed
methods have been previously published.2

The RDD sample frame included households with listed and
unlisted landline telephones; five or more attempts were made
to contact selected adults who were not at home. Survey
Sampling, Inc provided the sample and the Survey Research
Laboratory at the Mississippi State University Social Science
Research Center administered the survey.

The probability-based internet panel sample frame included
an online survey, administered to a randomly selected sample of
a nationally representative research panel.12 This panel is based
on a sampling frame which includes listed and unlisted numbers
and those without landline telephones. Panel members are
recruited using an RDD frame and an address-based sample
frame, using the US Postal Service Delivery Sequence File pro-
vided by Marketing Solutions Group. The panel does not accept
self-selected volunteers,12 and provides sample coverage for
99% of US households, including low socio-demographic
households, households that did not have internet access prior
to recruitment, and younger adults.13 The use of RDD and
addressed-based frame recruiting provides this high-level of
coverage. Knowledge Networks provided this internet panel and
administered the survey to this panel.

Both survey frames were administered in the fall of 2010.
Data were weighted to adjust for age, race, gender and also region,
and for the frame overlap among internet panel respondents
who also had a landline telephone and were therefore also eli-
gible for the RDD frame. Overall weights were computed in
two steps. First, the two frames were weighted based on 2009
US Census estimates to be representative of the US population.
Second, three adjustments to these initial weights were com-
puted to account for the overlap in the two samples. Weights
from the RDD frame were multiplied by 0.818 to adjust for the overlap (81.8% of households in the internet panel frame had a
landline). Composite adjustments were then computed to
combine the two sampling frames. According to the American
Association for Public Opinion Research (AAPOR),14 observa-
tions from two sampling frames with overlap may be combined
using composite weights. Two compositing factors that sum to
one are typically selected. Given that the effective sample sizes
of the RDD frame and internet panel frame are similar, the two
compositing factors were set to 0.5. The weights of respondents
who were represented in both sampling frames (ie, landline
owners) were multiplied by the compositing factor. In the
final adjustment, a re-standardised weight was computed so that the
weighted sample size matched the sum for effective sample size
for both independent frames.

Self-reported smoking

Respondents in each of the surveys were asked, ‘Have you
smoked at least 100 cigarettes in your entire life?’ Respondents
who reported that they had were then asked, ‘Do you now
smoke cigarettes every day, some days, or not at all?’ Respondents who reported that they have smoked at least 100
cigarettes and now smoke every day or some days were catego-
rised as current smokers. Overall, current smoking prevalence
from the SCS-TC was compared with survey data on the ‘current smokers’ measure from the 2010 NHIS basic adult
module household interview, the 2009/10 NHANES sample
person household interview, and the 2010 core telephone inter-
view. The SCS-TC survey samples and the two national surveys
used the same protocol to assess ‘current smoking’. Estimates
from the SCS-TC and NHIS are from adults aged 18 years and
older; while the NHANES used this protocol to assess ‘current
smoking’ among adults aged 20 years and older.

Analyses

Descriptive and bivariate analyses examined overall and subpopu-
lation (sex, race and age) prevalence estimates for current
smoking from each of the surveys. To explore the possibility of
a ‘time-on-panel bias’, we performed logistic regression analyses
to examine the relationship of length of time on panel with self-
reported smoking in the SCS-TC panel frame.

RESULTS

In the RDD frame, of 2128 eligible respondents contacted,
1504 (70.7%) completed surveys.14 For the internet panel
frame, 2272 panelists were randomly drawn from the probability
panel; 1736 responded to the invitation, yielding a
final stage completion rate13 of 67.5%. The recruitment rate (com-
puted using the AAPOR response rate 3) for this study was
16.4% and the profile rate (at least one member of a recruited
household completed a profile survey for the panel) was 65.1%,
for a cumulative response rate15 of 7.2%. Length of time on the
panel for the internet panel frame ranged from 0.09 to
11.08 years, with a median length of time on the panel of
2.29 years. Table 1 shows the demographic characteristics of the
overall sample.

Table 1  Demographic characteristics of respondents

<table>
<thead>
<tr>
<th>Demographic variable</th>
<th>Overall N</th>
<th>Overall weighted (%)</th>
<th>RDD frame unweighted (%)</th>
<th>Internet panel frame unweighted (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Region</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Northeast</td>
<td>404</td>
<td>12.6</td>
<td>18.7</td>
<td>18.9</td>
</tr>
<tr>
<td>Midwest</td>
<td>589</td>
<td>18.4</td>
<td>25.5</td>
<td>22.4</td>
</tr>
<tr>
<td>South</td>
<td>1203</td>
<td>37.6</td>
<td>39.5</td>
<td>37.0</td>
</tr>
<tr>
<td>West</td>
<td>1007</td>
<td>31.4</td>
<td>16.4</td>
<td>21.7</td>
</tr>
<tr>
<td>Race</td>
<td></td>
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<tr>
<td>White</td>
<td>2346</td>
<td>74.2</td>
<td>87.2</td>
<td>73.8</td>
</tr>
<tr>
<td>African American</td>
<td>364</td>
<td>11.5</td>
<td>10.0</td>
<td>8.5</td>
</tr>
<tr>
<td>Other</td>
<td>454</td>
<td>14.3</td>
<td>2.7</td>
<td>17.7</td>
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<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18–24</td>
<td>440</td>
<td>13.7</td>
<td>8.3</td>
<td>8.1</td>
</tr>
<tr>
<td>25–44</td>
<td>1241</td>
<td>38.8</td>
<td>18.1</td>
<td>35.3</td>
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<td>45–65</td>
<td>1066</td>
<td>33.3</td>
<td>41.9</td>
<td>41.4</td>
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<td>65+</td>
<td>455</td>
<td>14.2</td>
<td>31.7</td>
<td>15.2</td>
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<td>Education</td>
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<td>Not a high school graduate</td>
<td>291</td>
<td>9.2</td>
<td>5.6</td>
<td>11.2</td>
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<td>High school graduate</td>
<td>903</td>
<td>28.5</td>
<td>28.6</td>
<td>29.0</td>
</tr>
<tr>
<td>Some college graduate</td>
<td>929</td>
<td>29.3</td>
<td>25.9</td>
<td>28.0</td>
</tr>
<tr>
<td>College graduate</td>
<td>1044</td>
<td>33.0</td>
<td>40.0</td>
<td>31.7</td>
</tr>
<tr>
<td>Sex</td>
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</tr>
<tr>
<td>Women</td>
<td>1523</td>
<td>52.3</td>
<td>36.2</td>
<td>46.7</td>
</tr>
<tr>
<td>Men</td>
<td>1675</td>
<td>47.6</td>
<td>63.8</td>
<td>53.3</td>
</tr>
</tbody>
</table>

RDD, random digit dialling.
Weighted estimates from the SCS-TC current smoking item found 18.3% (95% CI 17.0% to 19.6%) of respondents reported current smoking (see table 2). Weighted estimates from the NHIS and NHANES for current smoking were 19.4% (95% CI 18.8% to 20.1%) and 20.3% (95% CI 18.7% to 22.1%), respectively. SCS-TC estimates for self-reported current smoking did not statistically differ from those from the NHIS and NHANES.

Estimates by gender, race (non-Hispanic African American and non-Hispanic white) and age are also provided for each survey in table 2, along with CIs. In each survey, men reported higher rates of smoking than women, although only the NHIS detected a statistically significant difference. With the exception of the NHIS, all of the surveys detected higher rates of smoking than those from the NHIS and NHANES. Most gender, race and age estimates from the SCS-TC did not statistically differ from those of the NHIS and NHANES. However, the SCS-TC found 19.4% (95% CI 18.8% to 20.1%) of respondents reported current smoking among African American than white respondents. However, this difference was statistically significant only in the NHANES. Most gender, race and age estimates from the SCS-TC did not statistically differ from those of the NHIS and NHANES. However, the SCS-TC produced estimates for self-reported smoking among white adults that were slightly lower than those from the NHIS for young adults that were slightly lower than those from the NHANES. The SCS-TC and the NHIS produced similar estimates for African Americans, whereas the estimate from the NHANES was substantially higher.

Analyses by length of time on the panel did not detect a time-on-panel bias in the panel frame of the SCS-TC.

CONCLUSIONS
Estimates of self-reported smoking obtained from the SCS-TC are comparable to those from nationally representative household interview surveys among US adults. Overall estimates and those for gender, race and age were similar to those of large-scale, national surveys, demonstrating that the SCS-TC findings are consistent with two government-supported surveys that serve as the principal sources of information about tobacco use in the US population. Previous research using a different online panel has demonstrated that online panel studies can provide estimates of current smokers that closely match those from national household and telephone surveys.” This study demonstrates that a dual-frame approach that preserves the RDD frame of an extant cross-sectional survey and combines it with a probability-based frame can also produce similarly accurate estimates. The internet panel frame alone also produced an estimate for current smoking that closely matched estimates from the NHIS and NHANES, suggesting that perhaps the use of a mixed mode with an RDD frame is not necessary.

Although several studies demonstrate that using a dual frame of landline and cell phone numbers can provide valid, reliable and representative data, we selected a probability-based internet panel as a more cost-effective approach to reduce non-coverage bias. Cell phone frame surveys have unique challenges and costs due to the inherent mobility provided by the device. Our costs of conducting an RDD survey frame are comparable to the amount to contract Knowledge Networks for an internet panel survey, whereas cell phone frame surveys typically cost 35% more to conduct.

Although the use of a dual frame substantially reduces concerns about coverage bias due to wireless substitution, this study is subject to at least three limitations. First, the use of the internet panel raises some concern about the representativeness of the sample. However, several comparison studies have demonstrated that this panel, which was recruited from a population-based frame, yields results comparable to well designed RDD surveys in terms of demographics and outcome variables. Internet panels have also demonstrated less evidence of survey satisficing and social desirability than RDD surveys. More recently, Yeager and colleagues conducted a similar sample frame comparison study that also included benchmarks from the NHIS and the Current Population Survey, finding similar comparability for items examining current smoking, in addition to gender, age and education. Second, ongoing engagement may lead to panel conditioning and thereby reduce data reliability if respondents develop a

Table 2  Comparison of prevalence estimates of adult current smoking

<table>
<thead>
<tr>
<th></th>
<th>2010 SCS-TC, % (95% CI) (weighted N=3169)</th>
<th>2010 SCS-TC (RDD), % (95% CI) (weighted N=1456)</th>
<th>2010 SCS-TC (KN panel), % (95% CI) (weighted N=11715)</th>
<th>2010 NHIS, % (95% CI) (weighted N=89876)</th>
<th>2009/10 NHANES, % (95% CI) (weighted N=6218)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Current smoking prevalence</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>20.2 (18.2 to 22.2)</td>
<td>16.0 (13.2 to 18.8)</td>
<td>22.5 (19.7 to 25.3)</td>
<td>21.6 (20.6 to 22.6)</td>
<td>22.3 (20.2 to 24.5)</td>
</tr>
<tr>
<td>Women</td>
<td>16.6 (14.8 to 18.4)</td>
<td>13.6 (11.2 to 16.0)</td>
<td>18.3 (15.8 to 20.8)</td>
<td>17.4 (16.6 to 18.2)</td>
<td>18.5 (16.4 to 20.8)</td>
</tr>
<tr>
<td><strong>Race</strong></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>17.5 (16.0 to 19.0)</td>
<td>14.9 (12.9 to 16.9)</td>
<td>21.4 (15.7 to 27.1)</td>
<td>21.8 (20.9 to 22.7)</td>
<td>19.8 (17.8 to 21.9)</td>
</tr>
<tr>
<td>African American</td>
<td>19.7 (15.6 to 23.8)</td>
<td>17.1 (11.2 to 23.0)</td>
<td>26.6 (20.9 to 32.3)</td>
<td>20.3 (18.9 to 21.9)</td>
<td>28.1 (23.3 to 33.5)</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18–44</td>
<td>19.4 (17.5 to 21.3)</td>
<td>16.3 (13.7 to 18.9)</td>
<td>21.2 (18.4 to 24.0)</td>
<td>21.6 (20.5 to 22.6)</td>
<td>25.1 (22.5 to 28.0)</td>
</tr>
<tr>
<td>45–64</td>
<td>19.8 (17.4 to 22.2)</td>
<td>16.3 (12.9 to 19.7)</td>
<td>22.1 (18.9 to 25.3)</td>
<td>21.2 (20.2 to 22.3)</td>
<td>20.3 (17.7 to 23.0)</td>
</tr>
<tr>
<td>65+</td>
<td>11.0 (8.1 to 13.9)</td>
<td>6.9 (3.6 to 10.2)</td>
<td>13.1 (8.9 to 17.3)</td>
<td>9.5 (8.6 to 10.5)</td>
<td>7.7 (6.4 to 9.2)</td>
</tr>
</tbody>
</table>

KN, Knowledge Networks; NHANES, National Health and Nutrition Examination Survey; NHIS, National Health Interview Survey; RDD, random digit dialling; SCS-TC, Social Climate Survey of Tobacco Control.
time-on-panel bias’ in some variables, due to increased experience with completing surveys. However, our analyses of length of time on panel did not detect any time-on-panel bias in self-reported smoking items. Third, respondents from less educated or lower-income households in the internet panel may have lower levels of computer literacy. However, analyses did not detect higher levels of missing data among respondents with low levels of education or household income. Furthermore, the average length of time on the panel was 2.4 years for low-income adults and 2.3 years for adults with less education than a high-school degree, suggesting that most participants would have developed computer literacy.

Prevalence estimates obtained from the dual-frame SCS-TC are comparable to those from other national surveys. This approach may be a useful means to transition from cross-sectional surveys with established trend data to dual-frame designs that maintain compatibility with surveys from previous years and also include the growing number of households that do not have landline telephones.

**What this paper adds**

Population-based surveys are a critical component of surveillance and evaluation programmes. Many tobacco control programmes have relied on landline telephone surveys due to the cost efficiency and (formerly) high coverage rate of this approach. However, wireless substitution of cell phones for landlines continues to increase, and 35.8% of US households are currently wireless only. In addition, wireless substitution is particularly problematic for surveys of tobacco use, as smoking status varies by landline telephone status. This study demonstrates that a dual-frame approach that preserves the random digit dialling frame of an extant cross-sectional survey and combines it with a probability-based frame can also produce similarly accurate estimates. This mixed-mode approach can be a useful strategy to transition cross-sectional surveys with established trend data to newer dual-frame designs to both maintain compatibility with surveys from previous years and include the growing number of households that do not have landline telephones.

**Acknowledgements** The authors are supported by the American Academy of Pediatrics Julius B. Richmond Center of Excellence.

**Contributors** All authors participated in the conceptual development, the study design, the writing and editing of the article. In addition, RM was responsible for drafting of the manuscript and for data analysis. All authors read and approved the final manuscript.

**Funding** This work was supported by the Flight Attendant Medical Research Institute and the American Legacy Foundation.

**Competing interests** None.

**Ethics approval** Mississippi.

**Provenance and peer review** Not commissioned; internally peer reviewed.

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Tob Control 2015 24: 7-10 originally published online April 17, 2013
doi: 10.1136/tobaccocontrol-2012-050727

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