Propensity-score Adjusted Estimates for Selected Health Outcomes From the Research and Development Survey

Data Evaluation and Methods Research

Vital and Health Statistics

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Abstract

Objective

To evaluate the quality of web surveys, the National Center for Health Statistics' Division of Research and Methodology has been conducting a series of studies with survey data from commercially recruited panels, referred to as the Research and Development Survey (RANDS). This report describes the propensity-score adjusted estimates from the second round of RANDS (RANDS 2) using the 2016 National Health Interview Survey (NHIS).

Methods

RANDS 2 was fielded in 2016 using the Gallup Panel. Propensity score adjustment of the RANDS 2 weights provided by Gallup, Inc. was used to calculate 11 selected health outcome estimates. The propensity of being in the RANDS 2 sample compared with the 2016 NHIS was obtained using a combined file of NHIS and RANDS 2 surveys. A logistic regression model was then fitted using selected demographic variables. The Gallup panel weights were adjusted using an inverse of the odds of being in the RANDS 2 sample. Relative biases, mean squared errors, and the 11 health outcomes were estimated using the adjusted weights and the Gallup panel weights and compared with NHIS.

Results

Propensity score adjustment resulted in smaller relative biases for 7 of the 11 health outcomes compared using the Gallup weights. The variance estimates also changed because the propensity score adjustment leads to higher estimates. Propensity score adjustment rendered 9 (compared with 5 before the adjustment) of the 11 *t* tests nonsignificant at a 95% confidence level when comparing RANDS 2 and NHIS estimates.

Conclusion

The propensity score method improved some of the estimates of selected health outcomes in terms of smaller relative bias, although some differences remain. These findings are not necessarily generalizable to other applications of propensity-score adjustment models.

Keywords: health survey • jackknife • propensity score adjustment methods • web survey • National Health Interview Survey • Research and Development Survey

Introduction

The National Center for Health Statistics (NCHS), part of the Centers for Disease Control and Prevention (CDC), is the principal health statistics agency for the United States, providing quality information to help guide policy and conducting health research. In addition to data obtained through establishment surveys and the National Vital Statistics System, NCHS collects data through its population health surveys, such as the National Health Interview Survey (NHIS), National Health and Nutrition Examination Survey, and National Survey of Family Growth. These population health surveys are enhanced through record linkage to the National Death Index and other administrative data, such as Medicare claims.

Sample surveys are a major approach for collecting information to produce national estimates used for monitoring trends and for scientific research. In the past, surveys have mainly relied on three modes of data collection: face-to-face interviews, telephone interviews, and postal mail surveys. For many years, these traditional survey methods have been effective in collecting health-related information and have provided national estimates, such as the prevalence of certain health conditions. NHIS, for example, is based on mainly face-to-face interviews with possible follow-up telephone interviews. NHIS is a principal data source for providing official statistics of important health outcomes, such as health insurance coverage and prevalence of major diseases (for example, diagnosed

diabetes), and for monitoring progress toward achieving Healthy People 2030 objectives. Additional details can be found on the NHIS webpage at: https://www.cdc.gov/nchs/nhis/index.htm.

In the past 20 years, the field of survey methodology has experienced an innovative and challenging expansion to web surveys (1,2). Using e-mail and web-based technology to develop, administer, and implement web surveys is a natural extension of survey methods. Not only do web surveys advance the evolution of self-administered questionnaires, but the overall cost for web surveys is significantly lower than traditional data collection methods such as face-to-face interviews (2). Considering these changes, survey researchers have pursued alternative budget-friendly approaches for collecting information on the nation's health while retaining the scientific and methodological rigor of established, traditional surveys.

Statistical agencies have explored using web surveys as part of a mixed-mode strategy—the NCHS National Electronic Health Records Survey is an example, available from: https://www.cdc.gov/nchs/nehrs/about.htm. CDC also uses Internet panel surveys to monitor health issues of special populations, including pregnant people and health care personnel (3).

As the primary U.S. health statistical agency, NCHS is interested in the feasibility of using commercial probability-sampled web panels to provide information on a wide spectrum of health outcomes. As part of this continuing research agenda, a series of studies called the Research and Development Survey (RANDS) has been conducted since 2015 for investigating the use of web surveys to generate national health estimates. This report builds on earlier descriptive reports of NCHS RANDS (4,5), which described outcomes evaluated by RANDS and demonstrated some differences between RANDS and NHIS estimates.

To adjust for potential selection bias in web survey estimates, methods such as propensity score weighting have been used (6–8). This technique uses a reference data set, often an established high-quality probability survey, to minimize selection bias. Demographic variables are frequently specified in the propensity score model, although other variables can also be used (9). The approach has been generally applied to nonprobability sampled data, such as opt-in web surveys (10), but the method may also be able to improve estimates from recruited probability-sampled panels when a survey is designed for alignment with a specific reference data set, and a set of covariates can be used to obtain the propensity score weights.

This report describes the propensity-score adjusted estimates from RANDS 2 (fielded in spring 2016) using the 2016 NHIS as a reference survey. The estimates are also compared with corresponding estimates from the 2016 NHIS. The variance estimation method for the propensity-score adjusted estimates, and tests of difference using the estimated variances, are also discussed.

Methods

Data

NHIS

NHIS, which has been conducted annually since 1957, is a nationally representative complex sample survey of the U.S. noninstitutionalized civilian population that provides health information to inform policy and research (11). The NHIS sample design and survey instrument, or questionnaire, have changed several times since NHIS was first fielded. For example, in 2016, a new sample design was implemented in which sample areas or primary sampling units are selected to consider changes in the distribution of the U.S. population since the previous sample design, which had used commercial address lists as the main source of addresses for the NHIS sampling frame and had discontinued oversampling procedures for Black, Hispanic, and Asian people (12). Sample weights and variance units are provided with the NHIS public-use files for calculating nationally representative estimates and variance estimates that account for clustering and stratification. For the 2016 NHIS, initial sample weights were based on the inverse probability of selection into NHIS and adjusted for possible coverage errors and nonresponse, as well as being poststratified to U.S. census population control totals for the civilian noninstitutionalized population. The conditional response rate for the Sample Adult component (aged 18 and over) was 80.9%, and the unconditional or final response rate was 54.3% (11). In this report, data are used from the second quarter (Q2) of the 2016 NHIS.

RANDS

The RANDS questionnaire was administered by Gallup, Inc. to participants on its web panel (known as the Gallup Panel) in two rounds, RANDS 1 and RANDS 2. RANDS 2, fielded in spring 2016, was used for the current report. Subsequent rounds of RANDS have been conducted by another vendor; details are available from the RANDS website at: https://www.cdc.gov/nchs/rands/index.htm. The Gallup Panel during the RANDS 1 and 2 survey periods was a probability-based panel of U.S. adults aged 18 and over who were recruited at random using random digit dialing of landline and cell phone numbers. Address-based sampling is among current contact methods (visit https://www.gallup.com/174158/gallup-panel-methodology.aspx for more information). Invitations to participate in RANDS 2 were sent to a stratified random sample of the Gallup Panel, where sampling strata were formed to NCHS specifications by three-way cross-classifications of the panel participants: 1) age, grouped as 18–34, 35–54, and 55 and over; 2) education, grouped as high school diploma, including general equivalency degree or less; some college, including associate's degree; and bachelor's degree or higher; and 3) race and ethnicity, categorized as Hispanic, non-Hispanic White, non-Hispanic Black, and non-Hispanic other, including multiple race. In addition to the variables collected on RANDS 2 and baseline

panelist information from the Gallup Panel (as in age and race and ethnicity), Gallup provided sample weights calibrated to the U.S. noninstitutionalized adult population totals (by census region, age, race and ethnicity, sex, and educational attainment) for unbiased estimation, after considering sample selection probabilities and nonresponse adjustment within each cell (constructed by crossing census region, age, sex, and educational attainment).

RANDS 2 included 2,480 respondents. The conditional response rate, defined by the American Association for Public Opinion Research (AAPOR) as the number of eligible sample units that cooperate in a survey subject to conditions, was 31.9% (AAPOR response rate 2) (5). Although the Gallup Panel includes panelists with or without web access, RANDS 2 was a self-administered web survey and did not include respondents without web access.

The RANDS 2 questionnaire was drawn from items in the NHIS questionnaire with additional questions, known as probes, included to study cognitive response patterns (13), but these probes were not analyzed for this report. Health topics were selected for RANDS 2 to meet a variety of goals. While some topics were among the key health measures in the 2016 NHIS Early Release Program, other health topics were chosen specifically for studying probes. A full list of variables available in the first two rounds of RANDS is included in an earlier report (5).

Selected Health Outcomes

A subset of outcome variables was selected to demonstrate how the propensity score methods could improve the estimates. The RANDS 2 outcomes covered in this report, representing a range of health topics such as health care access, health behaviors, health conditions, and food security, include:

- Lack of health insurance coverage
- Difficulty in getting prescription medicine in the last 12 months
- Being obese
- Being a current smoker
- Consumption of 12 or more alcoholic beverage in any 1 year
- Current health status—fair or poor
- Hopelessness—all or most of the time in the past 30 days
- Ever diagnosed with diabetes
- Ever diagnosed with hypertension
- Ever diagnosed with asthma
- Worry about food running out

A description of how these outcomes were assessed is provided in Table A.

All estimates of proportions were multiplied by 100 and expressed as a percentage. All displayed percentages meet the NCHS data presentation standards for proportions (14). Item nonresponse for the selected health outcomes was treated as missing and excluded from denominators when calculating percentages; no values were missing for hopelessness. For the rest of the 10 outcomes, missing rates ranged from 0.01% (unweighted) for worry about food running out in NHIS to 3.47% (unweighted) for obesity in RANDS 2.

Estimation Using NHIS

Estimates of the 11 outcomes from NHIS were obtained by using sample adult weights adjusted for quarterly data. Variance estimates of the health outcomes were generated using the Taylor series approximation method with replacement stratified two-stage sampling design structure (stratum and primary sampling units, or PSUs), as recommended by NHIS (11).

Estimation Using RANDS 2

To improve the quality of nonprobability data, such as opt-in web survey estimates, estimates are commonly adjusted using an established higher-quality survey as the reference survey or benchmark. One statistical method for adjustment is based on the propensity score strategy (10,15). By concatenating the web and reference surveys and applying a propensity score model to the combined data, the odds of being in the web survey can be estimated by conditioning on selected covariates. To obtain point estimates, initial weights from the web survey can be further adjusted using a multiplicative factor of the inverse of the estimated odds of being in the web survey. A previous study showed that combining survey weighting, considering nonresponse adjustment and poststratification, with propensity score adjustment is better than survey weighting alone for producing unbiased estimates for nonprobability data (16).

This approach was used to align the data from Gallup with NHIS, adjusting the Gallup weights with the propensity of participation in the web survey relative to NHIS. Although the Gallup data were generated using a probability sample, they had a lower response rate and reduced coverage compared with NHIS.

Estimates from RANDS 2 were obtained in two ways: 1) using the weights (W_0^G) provided by Gallup and 2) using the Gallup weights adjusted using the propensity score approach (W_1^G). For the propensity score approach, the Gallup weights were adjusted by $(1 - \hat{p}_i) / \hat{p}_i$, where $\hat{p}_i$ is the estimated probability of a respondent i being included in RANDS 2 based on the combined file of NHIS and RANDS 2. Specifically, the propensity-score adjusted RANDS 2 weights, W_1^G, are

$$W_1^G = W_0^G \cdot \frac{1 - \hat{p}_i}{\hat{p}_i}$$

Table A. Measurement of selected health outcomes

Health outcome	Measurement
Lack of health insurance coverage	Defined as not having any health insurance at the time of interview, which is derived from responses to the following set of questions and indicated when all responses to the following questions are "No":
	"The next few questions are about health insurance, including health insurance obtained through employment, purchased directly, as well as government programs like Medicare and Medicaid that provide Medical care or help pay medical bills. Are you covered by any kind of health insurance or some other kind of health care plan?"
	"Do you have any of the following kinds of health insurance or health care coverage? Include those plans that pay for only one type of service, such as nursing home care, accidents, or dental care. Exclude private plans that only provide extra cash while hospitalized: Private Health Insurance, Medicare, Medi-Gap, Medicaid, SCHIP (CHIP/ Children's Health Insurance Program), Military health care (TRICARE/VA/CHAMP-VA), Indian Health Service, State-sponsored health plan, Other government program, Single service plan (e.g., dental, vision, prescriptions)."
Difficulty in getting prescription medicine in last 12 months	Based on a "yes" response to the survey question, "During the past 12 months, was there any time when you couldn't afford and didn't get prescription medicines?"
Being obese	Based on body mass index (BMI) and calculated from survey questions on height and weight. BMI was calculated as the ratio of self-reported weight (kg) to height (m) squared; a BMI value of 30 or greater was considered to be obese.
Being a current smoker	To determine smoking status, survey respondents were first asked, "Have you smoked at least 100 cigarettes in your entire life?" Respondents who answered "yes" were then asked, "Do you now smoke cigarettes every day, some days, or not at all?" Current smokers were defined as those who have smoked at least 100 cigarettes in their lifetime and still currently smoke every day or on some days.
Consumption of 12 or more alcoholic beverage in any 1 year	Based on a "yes" response to the survey question, "In any one year, have you had at least 12 drinks of any type of alcoholic beverage?"
Current health status—fair or poor	Based on responses to the survey question, "Would you say [subject's/your] health in general is excellent, very good, good, fair, or poor?" In the 2016 NHIS, this question was asked during a portion of the interview that allowed proxy responses. As a result, information for the sample adult may have been reported by another family member. For RANDS 2, this information was self-reported. The proportion of adults with a fair or poor health status was used in this analysis.
Hopelessness—all or most of the time, past 30 days	Respondents were asked how often they felt hopeless in the past 30 days; this is a component of psychological distress and was arbitrarily chosen for this analysis. The proportion of respondents who reported feelings of hopelessness "all of the time" or "most of the time" was used in this analysis.
Ever diagnosed with diabetes	Based on responses to the survey question: "Other than during pregnancy, have you ever been told by a doctor or other health professional that you have diabetes or sugar diabetes?" Respondents who answered "yes" were classified as having diabetes. For this question, a "borderline" response category was also used; this category was classified as a "no" response for this analysis.
Ever diagnosed with hypertension	Based on responses to the survey question, "Have you ever been told by a doctor or other health professional that you had hypertension, also called high blood pressure?" Respondents who answered "yes" were classified as having hypertension.
Ever diagnosed with asthma	Based on responses to the survey question, "Have you ever been told by a doctor or other health professional that you had asthma?" Respondents who answered "yes" were classified as having asthma.
Worry about food running out	Based on responses to the survey question, "I worried whether my food would run out before I got money to buy more." Worrying about food running out in the last 30 days is a component of food security. Response categories included "often true," "sometimes true," and "never true." The proportion of "often true" and "sometimes true" responses was used for this analysis.

SOURCE: National Center for Health Statistics, Research and Development Survey 2, 2016.

where the adjustment factor, $(1 - \hat{p}_i) / \hat{p}_i$, is used to further weight RANDS 2 to resemble the NHIS sample in terms of the covariates used in the propensity score model.

For the propensity-score adjusted weights, the probability p_i was estimated using logistic regression on the combined file with the following covariates: age, sex, race and ethnicity, education, family income, census region, marital status, and Internet use for health information. Missing values for the covariates were classified as a separate category for the logistic regression analysis to use all available cases. The logistic regression model was weighted using normalized weights for each survey—weights for each survey were adjusted to sum to the survey-specific unweighted sample size. The model converged after 12 iterations, and after comparing observed or predicted proportions by deciles of predictions, no large discrepancies were identified. Using this approach, the estimated propensity score ($\hat{p}_i$) is a predicted value from a specific logistic regression with the previously noted covariates. Details of the logistic regression can be found in Table B.

For the health estimates calculated using the Gallup weights (W_0^G), variances were estimated with the Taylor series approximation method considering the sampling design. As described earlier, a stratified sample was selected with unequal probabilities from the Gallup panel and calibrated to the U.S. noninstitutionalized civilian adult population.

For the health estimates calculated using the propensity-score adjusted weights (W_1^G), variances were estimated by applying the jackknife method. Details of the jackknife variance estimation methods are described in the Appendix.

To evaluate the effectiveness of the propensity score adjustment to the Gallup weights (W_0^G), the relative biases and mean squared errors of the RANDS 2 health estimates with respect to corresponding NHIS estimates were compared before and after the propensity score adjustment. The relative biases evaluated the biases compared with the NHIS estimates, and the mean squared errors considered both biases and variances to evaluate the effectiveness of the propensity score adjustment. A t test was used to test if the differences between the RANDS 2 and NHIS estimates were statistically significantly different from zero at the 0.05 level. The differences or bias between NHIS and RANDS 2 estimates could become smaller by applying additional propensity score adjustment, but at the same time, the variance could grow due to the additional nonconstant propensity score adjustment. As a result, statistical significance based on the t test was affected by both possible reductions in bias and increases in variance. As all variables were treated as binary, proportion estimates for RANDS 2 and NHIS were obtained using PROC SURVEYMEANS via SAS 9.4 (available from: https://support.sas.com/documentation/onlinedoc/stat/142/surveymeans.pdf), which incorporates the survey weights and the sample design into the estimation procedure.

Results

The detailed Table shows estimates of the 11 selected health outcomes and comparisons of the estimates in the following eight columns:

- (a) is the NHIS estimate and standard error in 2016 NHIS Q2 using the NHIS sample adult weights.
- (b) is the estimate and standard error from RANDS 2 using the Gallup weights.
- (c) is the estimate and standard error from RANDS 2 using propensity-score adjusted weights.
- (d) shows the relative biases (expressed as a percentage) of the RANDS 2 estimates using the Gallup weights (W_0^G) and the propensity-score adjusted weights (W_1^G), respectively, where the NHIS estimate is used as a benchmark. A negative value for the relative bias indicates an underestimation from RANDS 2 compared with NHIS.
- (e) shows estimated mean squared errors for RANDS 2 estimates based on Gallup weights (W_0^G) and propensity-score adjusted weights (W_1^G), respectively, with respect to the NHIS estimates.
- (f) shows the t statistics for testing differences between RANDS 2 estimates using Gallup weights (column b) and NHIS estimates (column a), assuming independence of the two sample estimates.
- (g) shows the t statistics for testing differences between RANDS 2 estimates based on propensity-score adjusted weights (column c) and NHIS estimates (column a), assuming independence of the two sample estimates.
- (h) shows the t statistics for testing differences between RANDS 2 estimates using propensity-score adjusted weights (column c) and NHIS estimates (column a) using the jackknife method, without assuming independence of the two sample estimates.

As seen in the detailed Table, the propensity score adjustment (W_1^G) resulted in a smaller magnitude of relative bias (when expressed as an absolute value) compared with the Gallup-weighted estimates (W_0^G) for seven outcomes: difficulty in getting prescription medicine—last 12 months; current smoker; consumption of 12 or more alcoholic beverages in any 1 year; hopelessness—all or most of the time, past 30 days; ever diagnosed with hypertension; ever diagnosed with asthma; and worry about food running out. In general, the propensity score adjustment improved some of the RANDS 2 estimates by reducing the bias between the RANDS 2 and NHIS estimates. However, the propensity score adjustment increased variances of the RANDS 2 estimates, so it did not perform as well in relation to the mean squared error criterion, with a smaller mean squared error for only 5 out of 11 outcomes (difficulty in getting prescription medicine—last 12 months; hopelessness—all or most of the time, past 30 days; ever diagnosed with hypertension; ever diagnosed with asthma; and worry about food running out). For these five outcomes, relative bias also decreased with

Table B. Weighted logistic regression for propensity score model, by regression coefficient, standard error, and *p* value for covariates, using combined file: National Health Interview Survey, Quarter 2 and Research and Development Survey 2, 2016

Variable	Estimate (logit)	Standard error	*p* value
Intercept.	-0.89	0.16	Less than 0.0001
Age (years)			
18–24.	-0.50	0.16	0.0023
25–44.	-0.42	0.11	0.0001
45–64.	-0.25	0.10	0.0152
65 and over (reference)	0.00	…	…
Sex			
Male.	0.22	0.08	0.0032
Female (reference)	0.00	…	…
Hispanic origin[1] and race			
Hispanic.	-0.09	0.13	0.4805
Non-Hispanic White (reference).	0.00	…	…
Non-Hispanic Black	-0.03	0.12	0.8146
Non-Hispanic other[2].	-1.49	0.23	Less than 0.0001
Missing	14.98	0.41	Less than 0.0001
Education			
Less than bachelor's degree.	0.35	0.09	0.0001
Bachelor's degree or higher (reference).	0.00	…	…
Missing	-11.22	0.30	Less than 0.0001
Family income (last calendar year)			
$0–$49,999 (reference)	0.00	…	…
$50,000–$99,999.	0.26	0.10	0.0124
$100,000 or higher	0.29	0.11	0.0088
Missing	0.66	0.13	Less than 0.0001
Census region			
Northeast (reference)[3]	0.00	…	…
Midwest[4]	-0.09	0.12	0.4458
South[5]	-0.06	0.12	0.5773
West[6]	0.02	0.12	0.8440
Missing	15.24	0.77	Less than 0.0001
Marital status			
Married[7].	0.01	0.09	0.9266
Not married (reference)	0.00	…	…
Missing	4.45	0.32	Less than 0.0001
Use of Internet for health information[8]			
Yes (reference).	0.00	…	…
No	-1.67	0.11	Less than 0.0001
Missing	-1.43	0.43	0.0010

… Category not applicable.
[1]Refers to adults who are of Hispanic or Latino origin and may be of any race or combination of races.
[2]Includes non-Hispanic adults who reported more than one race group and single race non-Hispanic adults who reported a race group that was neither White nor Black.
[3]Defined by the U.S. Census Bureau as including Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont.
[4]Defined by the U.S. Census Bureau as including Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin.
[5]Defined by the U.S. Census Bureau as including Alabama, Arkansas, Delaware, District of Columbia, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, and West Virginia.
[6]Defined by the U.S. Census Bureau as including Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming.
[7]Includes adults living with a partner.
[8]Based on responses to the survey question, "During the last 12 months have you ever used computers to do any of the following? Look up health information on the Internet."

SOURCES: National Center for Health Statistics, National Health Interview Survey, Quarter 2 and Research and Development Survey 2, 2016.

the propensity adjustment. Increased variance and reduced bias due to the propensity score adjustment may have impacted the results for the mean-squared error criterion. For the outcomes that had decreased mean squared error and decreased relative bias, some did not have much change in variance while others did.

Five of the 11 *t* tests of the difference between RANDS 2 estimates based on Gallup weights and the NHIS estimates (column f) were not statistically significant (lack of health insurance coverage; current smoker; consumption of 12 or more alcoholic beverages in any 1 year; current health status—fair or poor; and ever diagnosed with diabetes). Additional propensity score adjustment resulted in 9 nonsignificant *t* tests out of the 11 tests (column g). The differences using the Gallup weights (column f) that were nonsignificant remained so, and four of six differences that were significant using the Gallup weights were nonsignificant using the propensity adjusted weights (column g) (hopelessness—all or most of the time, past 30 days; ever diagnosed with hypertension; ever diagnosed with asthma; and worry about food running out). As noted earlier, *t* tests are affected by changes in both the RANDS 2 estimates and their variances, particularly for the propensity-score adjusted weights, which tended to have the greatest variance.

The differences found based on the *t* tests in column (h), which accounted for the dependence between the propensity-score adjusted RANDS 2 estimates and the NHIS estimates, were equivalent to the differences found based on the *t* tests in column (g), which are based on assumed independence between the propensity-score adjusted RANDS 2 estimates and the NHIS estimates.

The Figure shows the health estimates from the detailed Table in addition to 95% confidence intervals. Each horizontal bar shows a normal-based 95% confidence interval (2 • 1.96 • estimated standard error) for a health outcome estimate. The Figure shows, in some cases, that the propensity-score adjusted RANDS estimate is closer to the NHIS estimate than the original RANDS estimate. The Figure also shows the wider confidence intervals of the propensity-score adjusted estimates due to the increased variance estimates.

Discussion

A RANDS 2 objective was to explore health statistics using web surveys from commercially recruited probability panels to examine the feasibility of augmenting traditional NCHS surveys with relatively inexpensive and more timely data from web surveys. For this assessment, estimates of health outcomes from RANDS 2 using the Gallup weights were first compared with corresponding NHIS health estimates, assuming independence of the two samples. Propensity score adjustment to the RANDS 2 weights provided by Gallup was also examined for its ability to improve the estimation

by certain metrics, like relative bias or mean squared error. To calculate the weights used in the propensity score adjustment, propensity score models were fitted using the covariates age, sex, race and ethnicity, education, income, census region, marital status, and Internet use for health information. The inverse of the odds of being in RANDS 2 (relative to NHIS) was used to adjust the RANDS 2 weights provided by Gallup.

Eleven health outcomes were used to compare the relative closeness of estimates from RANDS 2 and NHIS. After the propensity score adjustment, about one-half (55%) of relative biases and mean squared errors decreased compared with those before the adjustment. While some RANDS 2 estimates were very close to the NHIS estimates (less than 5% relative bias) for a couple of outcomes (consumption of 12 or more alcoholic beverages in any 1 year and ever diagnosed with hypertension) after the propensity score adjustment, several RANDS 2 estimates demonstrated more relative bias compared with the NHIS estimates. This finding suggests that outcome-specific models for propensity score estimation rather than general models mainly using demographic variables may be required to align a specific variable to NHIS (17). Choosing more health-related variables as covariates may lead to models more useful for multiple outcomes. That is, separating the limited covariates in the propensity score adjustment from the possible need for specific models is difficult. Further calibration (including weight trimming), alternative applications of the estimated propensity scores, or other adjustment strategies may result in smaller bias and more efficient estimates.

Another finding concerns the variance estimation for the RANDS 2 estimates using the propensity score method. Propensity score adjustment increases the variance because the resulting weights are more varied. Increased variances from propensity score adjustment often induced statistically nonsignificant tests of the difference between RANDS 2 and NHIS estimates. This occurred both for estimates that appeared close (relative bias less than 5%) and for those where the relative biases were somewhat larger than 5%.

The variance component from NHIS is small. The decision based on the *t* tests in detailed Table column (h), which accounted for the dependence between the propensity-score adjusted RANDS 2 estimates and the NHIS estimates, was equivalent to the decisions based on the *t* tests in detailed Table column (g), which are based on assumed independence of the propensity-score adjusted RANDS 2 estimates and the NHIS estimates. This result suggests that simple tests, as in detailed Table column (g), could be used to test the difference between the propensity-score adjusted RANDS 2 estimates and the NHIS estimates under the assumption of independence between the two estimates, even though NHIS is used for the propensity score adjustment. Consequently, variance estimates from RANDS 2 using typical methods such as Taylor series approximation or the jackknife, rather than a jackknife approach that considers the NHIS sampling

Figure. Percent estimates and 95% confidence intervals for selected health variables: National Health Interview Survey, Quarter 2, 2016, RANDS 2, and RANDS 2 using propensity-score adjusted weights
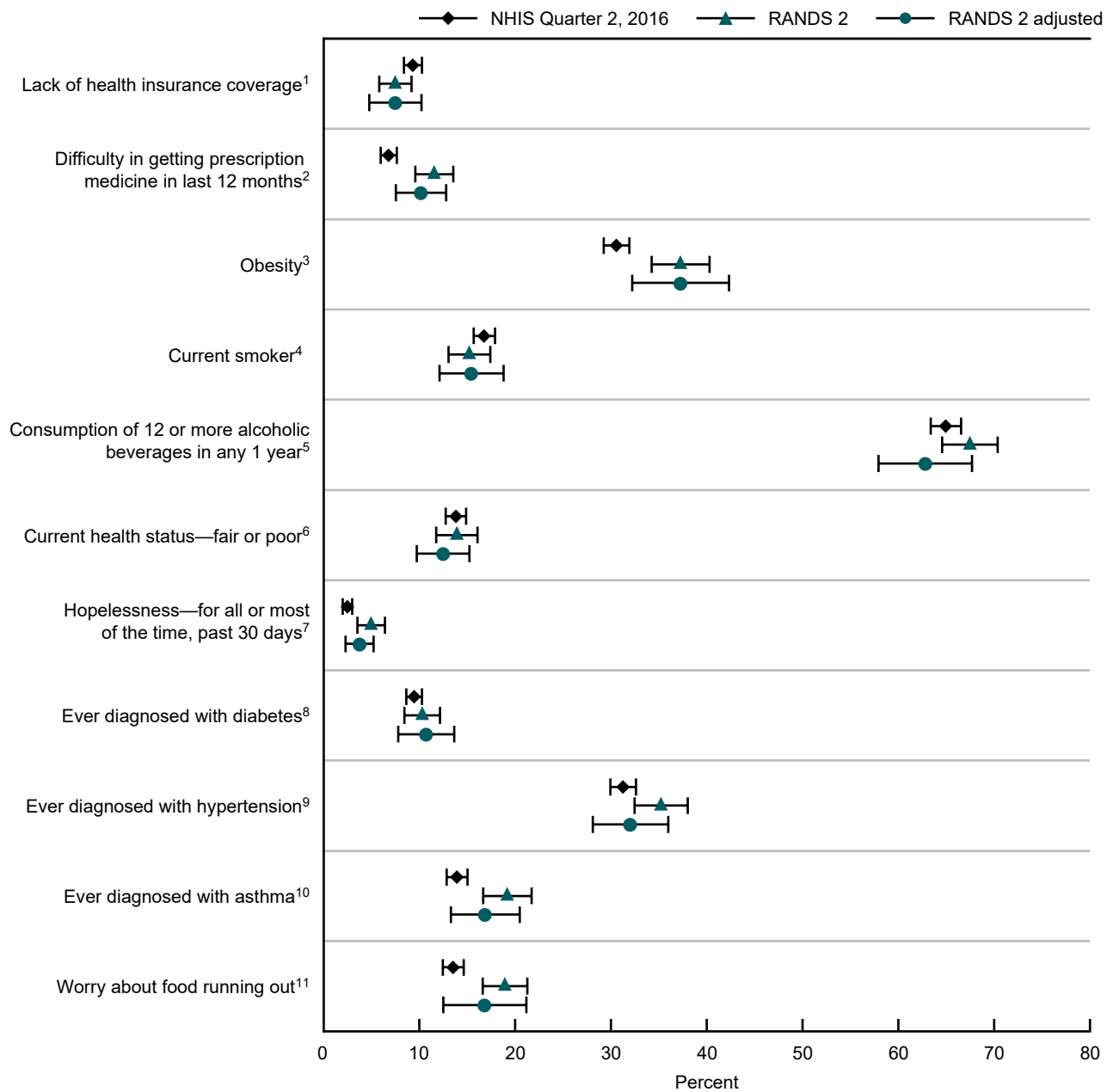
[1]Estimates based on two survey questions: "The next few questions are about health insurance, including health insurance obtained through employment, purchased directly, as well as government programs like Medicare and Medicaid that provide medical care or help pay medical bills. Are you covered by any kind of health insurance or some other kind of health care plan?" and "Do you have any of the following kinds of health insurance or health care coverage? Include those plans that pay for only one type of service, such as nursing home care, accidents, or dental care. Exclude private plans that only provide extra cash while hospitalized: private health insurance, Medicare, Medi-Gap, Medicaid, SCHIP ([state] CHIP/Children's Health Insurance Program), military health care (TRICARE/VA/CHAMP-VA), Indian Health Service, state-sponsored health plan, other government program, single service plan (e.g., dental, vision, prescriptions)."
[2]Estimates based on the survey question, "During the past 12 months, was there any time when you couldn't afford and didn't get prescription medicines."
[3]Calculated from responses to survey questions on height and weight. Obesity is indicated by a body mass index of 30.0 or higher. Note that self-reported height and weight may differ from actual measurements.
[4]Estimates based on the following survey questions: "Have you smoked at least 100 cigarettes in your entire life?" Respondents who answered "yes" were asked, "Do you now smoke cigarettes every day, some days, or not at all?" Current smokers are defined as those who have smoked at least 100 cigarettes in their lifetime and still currently smoke every day or on some days.
[5]Estimates based on the survey question, "In any one year, have you had at least 12 drinks of any type of alcoholic beverage?"
[6]Estimates based on the survey question, "Would you say [subject's/your] health in general is excellent, very good, good, fair, or poor?"
[7]Estimates based on the survey question, "During the past 30 days, how often did you feel hopeless?"
[8]Estimates based on the survey question, "Other than during pregnancy, have you ever been told by a doctor or other health professional that you have diabetes or sugar diabetes?"
[9]Estimates based on the survey question, "Have you ever been told by a doctor or other health professional that you had hypertension, also called high blood pressure?"
[10]Estimates based on the survey question, "Have you ever been told by a doctor or other health professional that you had asthma?"
[11]Estimates based on the survey question, "I worried whether my food would run out before I got money to buy more. Please indicate whether the statement was often true, sometimes true, or never true for you in the last 30 days." The proportion of "often true" and "sometimes true" responses was used in this data.
NOTE: RANDS is Research and Development Survey, and NHIS is National Health Interview Survey.
SOURCES: National Center for Health Statistics, National Health Interview Survey, Quarter 2 and Research and Development Survey 2, 2016.

variation, can generally be applied to these data. Using the jackknife approach to test a difference between two correlated estimates could be interpreted as a generalized *t* test and can be applied to any test of difference between two estimates, as in two estimates from paired samples (see detailed description in the Appendix). This may not be true for a wider range of outcomes than were tested here. Further calibration steps, like trimming of extreme weights, could be beneficial in obtaining more efficient estimates with less bias given the remaining significant differences, in addition to the adjustment using the raw propensity scores.

Other issues, such as coverage, sampling variability, and mode effects, will also affect differences between estimates from RANDS and NHIS. As with other surveys (18,19), many reasons may underlie differences between two sets of estimates from RANDS and NHIS. The propensity score method applied using largely demographic covariates improved some of the estimates of the selected health outcomes, yet some differences remain (17). These findings are not necessarily generalizable to other applications of propensity score adjustment methods. Identifying additional health-related covariates for propensity score adjustment and including them on both data sources may reduce biases of web panel survey estimates relative to those from NHIS.

References

1. Baker R, Blumberg SJ, Brick JM, Couper MP, Courtright M, Dennis JM, et al. AAPOR report on online panels. Public Opin Q 74(4):711–81. 2010.

2. Tourangeau R, Conrad FG, Couper MP. The science of web surveys. New York, NY: Oxford University Press. 2013.

3. Black CL, Yue X, Ball SW, Fink RV, de Perio MA, Laney AS, et al. Influenza vaccination coverage among health care personnel—United States, 2017–18 influenza season. Morb Mortal Wkly Rep 67(38):1050–4. 2018.

4. Parker J, Miller K, He Y, Scanlon P, Cai B, Shin H-C, et al. Overview and initial results of the National Center for Health Statistics' Research and Development Survey. Stat J IAOS 36(4):1199–211. 2020.

5. He Y, Cai B, Shin H-C, Beresovsky V, Parsons V, Irimata K, et al. The National Center for Health Statistics' 2015 and 2016 Research and Development Surveys. National Center for Health Statistics. Vital Health Stat 1(64). 2020.

6. Austin PC. An introduction to propensity score methods for reducing the effects of confounding in observational studies. Multivariate Behav Res 46(3):399–424. 2011.

7. Capacci S, Mazzocchi M, Brasini S. Estimation of unobservable selection effects in on-line surveys through propensity score matching: An application to public acceptance of healthy eating policies. PLoS One 13(4):e0196020. 2018.

8. Taylor H. Does internet research work? Comparing online survey results with telephone survey. Int J Market Res 42(1):51–63. 2000.

9. Rubin DB, Thomas N. Matching using estimated propensity scores: Relating theory to practice. Biometrics 52(1):249–64. 1996.

10. Lee S, Valliant R. Estimation for volunteer panel web surveys using propensity score adjustment and calibration adjustment. Sociol Methods Res 37(3):319–43. 2009.

11. National Center for Health Statistics. Survey description, National Health Interview Survey, 2016. 2017.

12. Parsons VL, Moriarity C, Jonas K, Moore TF, Davis KE, Tompkins L. Design and estimation for the National Health Interview Survey, 2006–2015. National Center for Health Statistics. Vital Health Stat 2(165). 2014.

13. Scanlon PJ. The effects of embedding closed-ended cognitive probes in a web survey on survey response. Field Methods 31(4):328–43. 2019.

14. Parker JD, Talih M, Malec DJ, Beresovsky V, Carroll M, Gonzalez JF Jr, et al. National Center for Health Statistics data presentation standards for proportions. National Center for Health Statistics. Vital Health Stat 2(175). 2017.

15. Elliott MR, Valliant R. Inference for nonprobability samples. Statist Sci 32(2):249–64. 2017.

16. Dugoff EH, Schuler M, Stuart EA. Generalizing observational study results: Applying propensity score methods to complex surveys. Health Serv Res 49(1):284–303. 2014.

17. Li Y, Irimata KE, He Y, Parker J. Variable inclusion strategies through directed acyclic graphs to adjust health surveys subject to selection bias for producing national estimates. J Off Stat 38(3):875–900. 2022.

18. Li C, Balluz LS, Ford ES, Okoro CA, Zhao G, Pierannunzi C. A comparison of prevalence estimates for selected health indicators and chronic diseases or conditions from the Behavioral Risk Factor Surveillance System, the National Health Interview Survey, and the National Health and Nutrition Examination Survey, 2007–2008. Prev Med 54(6):381–7. 2012.

19. Nelson DE, Powell-Griner E, Town M, Kovar MG. A comparison of national estimates from the National Health Interview Survey and the Behavioral Risk Factor Surveillance System. Am J Public Health 93(8):1335–41. 2003.

20. Kott PS. The delete-a-group jackknife. J Off Stat 17(4):521–6. 2001.

21. Quenouille MH. Notes on bias in estimation. Biometrika 43(3/4):353–60. 1956.

22. Tukey JW. Bias and confidence in not-quite large samples. Ann Math Stat 29:614. 1958.

23. Rust K. Variance estimation for complex estimators in sample surveys. J Off Stat 1(4):381–97. 1985.

24. Rust KF, Rao JN. Variance estimation for complex surveys using replication techniques. Stat Methods Med Res 5(3):283–310. 1996.

25. Efron B, Stein C. The jackknife estimate of variance. Ann Stat 9(3):586–96. 1981.

26. Fenwick I. Techniques in market measurement: The jackknife. J Mark Res 16(3):410–4. 1979.

27. Miller RG. The jackknife—A review. Biometrika 61(1): 1–15. 1974.

28. Wolter KM. Introduction to variance estimation. 2nd ed. New York, NY: Springer. 2007.

Table. Percentage, standard error, relative bias, mean squared error, and *t* test *p* value, by weighting method: National Health Interview Survey, Quarter 2 and Research and Development Survey 2, 2016

Health outcome	NHIS Q2, 2016 Sample adult weights (a)		RANDS 2 Gallup weights (W_0^G) (b)		RANDS 2 adjusted[1] Propensity-score adjusted weights (W_1^G) (c)		Relative bias (percent)[2] (d)		Mean squared error (percent) (e)		(b) − (a) (f)	(c) − (a) using[3] v_j^G (g)	(c) − (a) using[4] $v_j^{GN}(\theta)$ (h)
	Percent	SE	Percent	SE	Percent	SE	W_0^G	W_1^G	W_0^G	W_1^G	*p* value of *t* test[5]		
Lack of health insurance coverage[6]	9.31	0.48	7.46	0.85	7.46	1.40	-19.87	-19.92	4.15	5.39	0.06	0.21	0.20
Difficulty in getting prescription medicine in last 12 months[7]	6.77	0.42	11.53	1.01	10.12	1.34	70.31	49.53	23.68	13.04	0.00	0.02	0.02
Obesity[8]	30.56	0.68	37.23	1.54	37.25	2.58	21.83	21.87	46.86	51.33	0.00	0.01	0.01
Current smoker[9]	16.74	0.57	15.20	1.12	15.41	1.71	-9.20	-7.90	3.63	4.68	0.22	0.47	0.46
Consumption of 12 or more alcoholic beverages in any 1 year[10]	64.95	0.81	67.46	1.48	62.79	2.49	3.86	-3.33	8.49	10.9	0.14	0.41	0.41
Current health status—fair or poor[11]	13.78	0.54	13.88	1.10	12.44	1.41	0.73	-9.73	1.22	3.79	0.94	0.37	0.37
Hopelessness—all or most of the time, past 30 days[12]	2.46	0.26	4.95	0.73	3.73	0.74	101.22	51.81	6.73	2.16	0.00	0.12	0.12
Ever diagnosed with diabetes[13]	9.42	0.41	10.27	0.95	10.68	1.48	9.02	13.39	1.63	3.79	0.41	0.41	0.41
Ever diagnosed with hypertension[14]	31.24	0.68	35.21	1.42	32.01	2.00	12.71	2.47	17.78	4.61	0.01	0.72	0.71
Ever diagnosed with asthma[15]	13.90	0.56	19.16	1.28	16.84	1.83	37.84	21.17	29.31	12.01	0.00	0.12	0.12
Worry about food running out[16]	13.51	0.56	18.91	1.19	16.80	2.20	39.97	24.30	30.58	15.62	0.00	0.15	0.14

[1]Adjusted by $(1 - \hat{p}_i)/\hat{p}_i$, where $\hat{p}_i$ is the estimated probability of a respondent *i* being included in the Gallup sample.
[2]Relative to the NHIS estimate: Relative bias (percent) = 100 • (Gallup estimate – NHIS estimate)/NHIS estimate.
[3]Jackknife variance estimator of the sampling variance without considering the sampling variation of the NHIS sample used to obtain the propensity scores.
[4]Jackknife variance estimator of the sampling variance considering the sampling variation of the NHIS sample used to obtain the propensity scores.
[5]Test of the difference between percent 1 and percent 2, *t* = (percent 1 – percent 2)/standard error (percent 1 – percent 2).
[6]Estimates based on responses to the following survey questions: "The next few questions are about health insurance, including health insurance obtained through employment, purchased directly, as well as government programs like Medicare and Medicaid that provide medical care or help pay medical bills. Are you covered by any kind of health insurance or some other kind of health care plan?" and "Do you have any of the following kinds of health insurance or health care coverage? Include those plans that pay for only one type of service, such as nursing home care, accidents, or dental care. Exclude private plans that only provide extra cash while hospitalized: private health insurance, Medicare, Medi-Gap, Medicaid, SCHIP ([state] CHIP/Children's Health Insurance Program), military health care (TRICARE/VA/CHAMP-VA), Indian Health Service, state-sponsored health plan, other government program, Single service plan (e.g., dental, vision, prescriptions)."
[7]Estimates are based on responses to the survey question, "During the past 12 months, was there any time when you couldn't afford and didn't get prescription medicines?"
[8]Calculated from responses to survey questions regarding height and weight. Obesity is indicated by a body mass index of 30.0 or higher. Self-reported height and weight may differ from actual measurements.
[9]Estimates based on responses to the following survey questions: "Have you smoked at least 100 cigarettes in your entire life?" Respondents who answered "yes" were asked, "Do you now smoke cigarettes every day, some days, or not at all?" Current smokers were defined as those who have smoked at least 100 cigarettes in their lifetime and still currently smoke every day or on some days.
[10]Estimates based on responses to the survey question, "In any one year, have you had at least 12 drinks of any type of alcoholic beverage?"
[11]Estimates based on responses to the survey question, "Would you say [subject's/your] health in general is excellent, very good, good, fair, or poor?"
[12]Estimates based on responses to the survey question, "During the past 30 days, how often did you feel hopeless?"
[13]Estimates based on responses to the survey question, "Other than during pregnancy, have you ever been told by a doctor or other health professional that you have diabetes or sugar diabetes?"
[14]Estimates based on responses to the survey question, "Have you ever been told by a doctor or other health professional that you had hypertension, also called high blood pressure?"
[15]Estimates based on responses to the survey question, "Have you ever been told by a doctor or other health professional that you had asthma?"
[16]Estimates based on responses to the survey question, "I worried whether my food would run out before I got money to buy more. Please indicate whether the statement was often true, sometimes true, or never true for you in the last 30 days." The proportion of "often true" and "sometimes true" responses was used in this table.

NOTE: NHIS Q2 is National Health Interview Survey, Quarter 2, and RANDS 2 is Research and Development Survey, round 2.

SOURCES: National Center for Health Statistics, National Health Interview Survey, Quarter 2 and Research and Development Survey 2, 2016.

Appendix. Variance Estimation

Jackknife Variance Estimation With Propensity-score Adjusted Weights

Variances of health estimates using propensity-score adjusted weights (W_1^G) for the Research and Development Survey 2 (RANDS 2) were estimated by applying the jackknife method (20–28). Initially proposed as a bias reduction technique for serially correlated data by Quenouille (21), the jackknife method has been used for interval estimation as suggested by Tukey (22). Typical variance estimators used for propensity-score adjusted estimates, such as Taylor series approximations or replicate methods such as jackknife, would underestimate the variance of the estimates, because the estimators ignore the variance components due to sampling variation in the reference survey, which is the National Health Interview Survey (NHIS).

In the following formula, h indicates the RANDS 2 sampling strata and i indicates the ith RANDS 2 respondents, also known as the primary sampling unit (PSU). For the RANDS 2 data, the jackknife variance estimator of the sampling variance can be expressed without considering the sampling variation of the NHIS sample used to obtain the propensity scores as

$$v_J^G(\hat{\theta}) = \sum_{h=1}^{H^G} \left(\frac{n_h - 1}{n_h} \right) \sum_{i=1}^{n_h} \left(\hat{\theta}_{(h_G, -i)} - \hat{\theta}_G \right)^2$$

where H^G is the total number (equal to 36) of sampling strata in RANDS 2 and n_h is the number of respondents (PSUs) in the h stratum, with

$$\sum_{h=1}^{H^G} n_h = n^G$$

and the number of PSUs equal to 2,480. $\hat{\theta}_{(h_G, -i)}$ is the variance estimator based on RANDS 2 with the ith respondent, or PSU, from stratum h omitted, and $\hat{\theta}_G$ is the variance estimator based on the entire RANDS 2 sample. After omitting each PSU within each stratum, the corresponding RANDS 2 weight (the propensity-score adjusted weight) was adjusted.

The above variance estimator underestimates the true variance, because it ignores variance components due to the NHIS sampling variation for the propensity score estimates. When considering sampling variation in the NHIS sample for the propensity score estimates, the jackknife variance estimator can be expressed as

$$v_J^{GN}(\hat{\theta}) = \sum_{h=1}^{H^G} \left(\frac{n_h - 1}{n_h} \right) \sum_{i=1}^{n_h} \left(\hat{\theta}_{(h_G, -i)} - \hat{\theta}_G \right)^2 + \sum_{h=H^G+1}^{H^G+H^N} \left(\frac{n_h - 1}{n_h} \right) \sum_{i=1}^{n_h} \left(\hat{\theta}_{(h_N, -i)} - \hat{\theta}_G \right)^2$$

where $\hat{\theta}_{(h_N, -i)}$ is the estimator based on RANDS 2 with the ith PSU omitted from NHIS stratum h. $H^G + H^N$ is the total number of strata in the combined file (equal to 88), with H^N being the number of strata (52) for variance estimation for NHIS, and

$$\sum_{h=1}^{H^N} n_h = n^H$$

being the number of PSUs (653) in the NHIS file. The total number of PSUs in the combined file, $n^G + n^N$, is 3,133. Note that a PSU for RANDS 2 is at respondent level, while a PSU for NHIS is a cluster (a county or a group of counties). The second term of the righthand side of the jackknife variance estimator equation is the additional variance contribution due to the sampling error of the propensity score estimates.

Test of Difference Using Jackknife Method

Because the propensity scores used for the weight adjustment were estimated from the combined file of NHIS and RANDS 2 samples, the two sets of estimates are correlated. The variance of the difference, $\hat{\delta} = \left(\hat{\theta}_G - \hat{\theta}_N \right)$, where $\hat{\theta}_G$ is the estimate based on the entire RANDS 2 sample and $\hat{\theta}_N$ is the estimate based on the entire NHIS sample, was directly estimated by applying the jackknife method:

$$v_J(\hat{\delta}) = \sum_{h=1}^{H^G + H^N} \left(\frac{n_h - 1}{n_h} \right) \sum_{i=1}^{n_h} \left(\hat{\delta}_{(h, -i)} - \hat{\delta} \right)^2$$

where $\hat{\delta}_{(h, -i)}$ is the estimator of difference with the ith PSU (individual respondent for RANDS 2 and a cluster for NHIS samples) from stratum h omitted from the combined file of NHIS and RANDS 2 samples. In this way, the variance of the difference can be estimated without assuming independence or estimating correlation between the two estimates.

Variance Estimates

The Appendix Table shows the variance estimates of the 11 selected health outcomes from RANDS 2 with propensity-score adjusted weights by three different methods, assuming the adjusted weights from the calibration are the true sampling weights: column

(a) is the Taylor series approximation (with replacement); (b) is the jackknife approach without considering NHIS sampling variation; and (c) is the jackknife approach considering NHIS sampling variation. Variance estimates using the jackknife approach without considering NHIS sampling variation (b) are generally close to those obtained using Taylor series approximation (a), with a few exceptions. Variance estimates using the jackknife approach considering NHIS sampling variation (c) are slightly larger than or equal to the variance estimates using the jackknife approach without considering NHIS sampling variation (b). The two jackknife estimates are virtually the same, and a meaningful increase in variance was not observed when NHIS sampling variation was considered for the propensity score method.

Table. Variance estimate as percentage of outcome estimate using propensity-score adjusted weight, by variance estimation method: Research and Development Survey 2, 2016

Health outcome	Taylor series approximation, with replacement	Jackknife Without considering NHIS sampling variation	Jackknife Considering NHIS sampling variation
	(a)	(b)	(c)
Lack of health insurance coverage[1]	1.36	1.39	1.40
Difficulty in getting prescription medicine in last 12 months[2]	1.33	1.33	1.34
Obesity[3]	2.47	2.56	2.58
Current smoker[4]	1.69	1.70	1.71
Consumption of 12 or more alcoholic beverages in any 1 year[5]	2.43	2.47	2.49
Current health status—fair or poor[6]	1.39	1.40	1.41
Hopelessness—all or most of the time, past 30 days[7]	0.74	0.73	0.74
Ever diagnosed with diabetes[8]	1.47	1.47	1.48
Ever diagnosed with hypertension[9]	2.06	1.95	2.00
Ever diagnosed with asthma[10]	1.80	1.82	1.83
Worry about food running out[11].	2.15	2.17	2.20

[1]Estimates based on responses to the following survey questions: "The next few questions are about health insurance, including health insurance obtained through employment, purchased directly, as well as government programs like Medicare and Medicaid that provide medical care or help pay medical bills. Are you covered by any kind of health insurance or some other kind of health care plan?" and "Do you have any of the following kinds of health insurance or health care coverage? Include those plans that pay for only one type of service, such as nursing home care, accidents, or dental care. Exclude private plans that only provide extra cash while hospitalized: private health insurance, Medicare, Medi-Gap, Medicaid, SCHIP ([state] CHIP/Children's Health Insurance Program), military health care (TRICARE/VA/CHAMP-VA), Indian Health Service, state-sponsored health plan, other government program, single service plan (e.g., dental, vision, prescriptions)."
[2]Estimates based on responses to the survey question, "During the past 12 months, was there any time when you couldn't afford and didn't get prescription medicines?"
[3]Calculated from responses to survey questions regarding height and weight. Obesity is indicated by a body mass index of 30.00 or higher. Self-reported height and weight may differ from actual measurements.
[4]Estimates based on responses to the following survey questions: "Have you smoked at least 100 cigarettes in your entire life?" Respondents who answered "yes" were asked "Do you now smoke cigarettes every day, some days, or not at all?" Current smokers were defined as those who have smoked at least 100 cigarettes in their lifetime and still currently smoke every day or on some days.
[5]Estimates based on responses to the survey question, "In any one year, have you had at least 12 drinks of any type of alcoholic beverage?"
[6]Estimates based on responses to the survey question, "Would you say [subject's/your] health in general is excellent, very good, good, fair, or poor?"
[7]Estimates based on responses to the survey question, "During the past 30 days, how often did you feel hopeless?"
[8]Estimates based on responses to the survey question, "Other than during pregnancy, have you ever been told by a doctor or other health professional that you have diabetes or sugar diabetes?"
[9]Estimates based on responses to the survey question, "Have you ever been told by a doctor or other health professional that you had hypertension, also called high blood pressure?"
[10]Estimates based on responses to the survey question, "Have you ever been told by a doctor or other health professional that you had asthma?"
[11]Estimates based on responses to the survey question, "I worried whether my food would run out before I got money to buy more. Please indicate whether the statement was often true, sometimes true, or never true for you in the last 30 days." The proportion of "often true" and "sometimes true" responses was used in this table.

NOTE: NHIS is National Health Interview Survey.

SOURCES: National Center for Health Statistics, Research and Development Survey 2 and National Health Interview Survey, Quarter 2, 2016.

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