Telephone Coverage and Health Survey Estimates: Evaluating the Need for Concern About Wireless Substitution

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There were 158 million users of wireless (i.e., cellular, mobile) telephones in the United States in 2003.[1] That was approximately 1 wireless telephone for every 2 persons in the United States, and 46.6% of all US telephones were wireless.[1] Moreover, wireless telephones were used for 43% of all long-distance calls, and more minutes per person per month were logged on wireless telephones than on landline (i.e., wired, fixed) telephones.[2,3] It is perhaps not surprising, then, that some wireless telephone users have substituted a wireless telephone for their residential landline telephone.

This wireless substitution has potential implications for the representativeness of most current random-digit-dialed (RDD) household telephone surveys because the sampling frames for these surveys have traditionally been limited to landline telephones. Noncoverage of households without landline telephones has always been a concern of telephone survey researchers, and several studies have been undertaken to examine the potential noncoverage bias in health-related telephone surveys.[4–7] These studies, conducted with data from 1998 or earlier, have demonstrated that noncoverage effects tend to be small in general population surveys of health risk indicators.

With wireless substitution, however, the characteristics of the non–landline telephone population may be changing. Previously, adults living without a landline telephone usually did so because they could not afford a telephone. Now, a growing proportion of adults living without a landline telephone may have chosen to do so because of lifestyle preferences. We felt it was time to use the most recent national data available to revisit the relation between telephone ownership and health-related variables.

METHODS

Data Source

The National Center for Health Statistics of the Centers for Disease Control and Prevention

Objectives. We sought to determine whether the exclusion of adults without landline telephones may bias estimates derived from health-related telephone surveys.

Methods. We took data from the 2004 and 2005 National Health Interview Survey and used logistic regression to compare the odds of behavioral risk factors and health care service use for adults with landline telephones to those for adults with only wireless telephones and adults without any telephone service.

Results. When interviewed, 7.2% of adults, including those who did and did not have wireless telephones, did not have landline telephones. Relative to adults with landline telephones, adults without landline telephones had greater odds of smoking and being uninsured, and they had lower odds of having diabetes, having a usual place for medical care, and having received an influenza vaccination in the past year.

Conclusions. As people substitute wireless telephones for landline telephones, the percentage of adults without landline telephones has increased significantly but is still low, which minimizes the bias resulting from their exclusion from telephone surveys. Bias greater than 1 percentage point is expected only for estimates of health insurance, smoking, binge drinking, having a usual place for care, and receiving an influenza vaccination. (*Am J Public Health.* 2006;96:926–931. doi:10.2105/AJPH.2004.057885)

includes a series of questions on the National Health Interview Survey (NHIS) to identify families that had substituted wireless telephone service for their residential landline telephones. The NHIS is a continuous multistage probability household survey that collects comprehensive health-related information from a large sample of households representing the civilian noninstitutionalized household population of the United States.[8] The face-to-face survey interview is administered by trained field representatives from the US Census Bureau.

For many years, the NHIS has included questions on residential telephone numbers to permit recontact of participants. In 2004 and 2005, additional questions confirmed that the telephone number provided was a landline telephone. All respondents were also asked whether "anyone in your family has a working cellular telephone." A family was defined as a group of 2 or more related persons living together in the same housing unit.[9] Families were identified as *wireless families* if anyone in the family had a working cellular telephone. Households (which can be composed of more than 1 family) were identified as *wireless-only*

if they included at least 1 wireless family and if there were no working landline telephones inside the household. Persons were identified as wireless-only if they lived in a wireless-only household. A similar approach was used to identify adults living in households without any telephone service. Household telephone status (rather than family telephone status) was used because most telephone surveys draw samples of households rather than families.

Between January 2004 and June 2005, the household telephone status was determined for 100 918 adults from 56 178 families. (The NHIS data files include an additional 996 adults from 615 families, but there were insufficient data to determine household telephone status.) Response rates for 2005 are not yet available. In 2004, interviews were completed for 86.5% of eligible families.

From each family identified by the NHIS, 1 adult was randomly selected for a detailed interview about health and health care service use. Between January 2004 and June 2005, these detailed interviews were completed for 46 486 adults. Household telephone status was available for 46 257 of

these adults. The overall response rate for the adult interview in 2004 was 72.5%.[9]

Analyses

The NHIS Early Release Program produces and releases estimates for 15 key health and health care access measures only 6 months after NHIS data collection has been completed for each quarter.[10] Data for all but 1 of these measures are analyzed here; "personal care needs" was not included because the indicator is limited to adults aged 65 years and older. Specifications for these variables are available elsewhere.[10] Prevalence estimates and 95% confidence intervals (CIs) are presented for all adults, adults with landline telephones (who may or may not have wireless telephones in addition to landline telephones), adults with only wireless telephones, and adults without any telephone service.

Because final weights for the 2005 NHIS are not yet available, preliminary sampling weights were provided by the Early Release Program and were calibrated to Census 2000–based totals for gender, age, and race/ethnicity. These Early Release weights are preliminary, and estimates on the basis of these weights may differ slightly from final NHIS estimates published later. All confidence intervals and statistical tests were calculated using SUDAAN,[11] which takes into account the complex design of the NHIS sample.

The statistical significance of prevalence differences among the 3 mutually exclusive telephone groups was identified with logistic regression analyses for correlated data (i.e., for data from complex surveys). The regression models predicted health and health care service use from telephone status. The reported odds ratios were adjusted to account for group differences in race/ethnicity, age, gender, education, employment status, household size and composition, household poverty status (relative to the federal poverty level), geographic region, metropolitan statistical area status, and home ownership. These concomitant variables were chosen because they have been used to adjust the sampling weights of major RDD health surveys such as the Behavioral Risk Factor Surveillance System, the National Immunization Survey, the National Survey of Children with Special Health Care Needs, and the National Survey of America's Families. Statistically

significant adjusted odds ratios would indicate that telephone status still accounted for variance in measures of health and health care service use after control for the other characteristics.

Finally, to determine whether noncoverage of households without landline telephones results in substantial bias for general population telephone surveys of adults' health and health care service use, prevalence differences between all adults and adults with landline telephones were also examined. The statistical significance of differences between all adults and adults with landline telephones was identified by computing 95% CIs from the standard error of the difference between the 2 groups. The calculation of the standard error of the difference assumed a binomial normal distribution and accounted for nonindependence of the 2 groups by incorporating their covariance.

This method for comparing prevalence estimates for all adults to estimates for adults with landline telephones is mathematically similar to a comparison of prevalence estimates for adults with landline telephones with adults without landline telephones. However, for telephone survey researchers who want to know whether the noncoverage of households without landline telephones will bias their prevalence estimates, the former analysis provides not only a determination of statistical significance, but also an estimate of the magnitude of the bias and its 95% confidence limits.

RESULTS

To examine the statistical significance of trends in the prevalence of wireless-only

adults, estimates from the first half of 2004, the second half of 2004, and the first half of 2005 were compared using the Student *t* test. The percentage of adults who lived in households with only wireless telephone service increased significantly from the first half of 2004 to the second half ($t=3.38$, $P<.01$), and again from the second half of 2004 to the first half of 2005 ($t=3.65$, $P<.01$). In just 1 year, this prevalence estimate increased by nearly 50%, from 4.5% to 6.7% (Table 1). Over this same period, the estimate of the percentage of adults who lived in households without any telephone service (landline or wireless) at the time of the interview remained relatively unchanged ($t=1.24$, $P=.21$) at approximately 1.7%.

Bivariate analyses were conducted to identify differences between demographic subgroups in the percentage of adults with only wireless telephone service. As shown in Table 2, the prevalence of wireless substitution was greater for certain demographic subgroups, including men, adults aged 24 years or younger, adults in poverty, adults renting their home, adults living alone, and adults living with unrelated roommates. Relative to adults with only wireless telephones, adults without any telephone service had less education, and they were more likely to be older, unemployed, and poor.

Even when adjusted to account for these demographic and socioeconomic covariates, the logistic regression analyses revealed that relative to adults with landline telephones, adults with only wireless service had significantly greater odds of having had 5 or more

TABLE 1—Household Telephone Status and Date of Interview: United States, January 2004–June 2005

Date of Interview	Survey Sample Size, No. of Adults	Adults in Households With Landline Telephones, % (95% CI)[a]	Adults in Households With Only Wireless Telephones, % (95% CI)	Adults in Households With No Telephone Service, % (95% CI)
January 2004–June 2004	30 102	94.0 (93.6, 94.5)	4.5 (4.0, 4.9)	1.5 (1.3, 1.7)
July 2004–December 2004	37 202	92.7 (92.1, 93.2)	5.5 (5.0, 5.9)	1.8 (1.6, 2.1)
January 2005–June 2005	33 614	91.6 (91.1, 92.1)	6.7 (6.2, 7.2)	1.7 (1.5, 1.9)
January 2004–June 2005	100 918	92.8 (92.4, 93.1)	5.6 (5.3, 5.8)	1.7 (1.5, 1.8)

Note. CI = confidence interval.
[a]Includes adults in households that also have wireless telephone service.
Source. Centers for Disease Control and Prevention, National Center for Health Statistics. National Health Interview Survey, 2004–2005.

TABLE 2—Household Telephone Status and Selected Demographic Characteristics: United States, January 2004–June 2005

	Adults in Households With Landline Telephones (n = 93 354), % (95% CI)[a]	Adults in Households With Only Wireless Telephones (n = 5614), % (95% CI)	Adults in Households With No Telephone Service (n = 1950), % (95% CI)
Race/ethnicity			
Hispanic	89.6 (88.8, 90.3)	7.2 (6.6, 7.8)	3.2 (2.8, 3.7)
White, non-Hispanic	93.6 (93.2, 93.9)	5.2 (4.9, 5.5)	1.2 (1.1, 1.3)
Black, non-Hispanic	91.5 (90.8, 92.3)	5.6 (5.0, 6.2)	2.9 (2.5, 3.3)
Other single race, non-Hispanic	93.0 (91.7, 94.3)	5.2 (4.1, 6.3)	1.8 (1.1, 2.4)
Multiple race, non-Hispanic	88.3 (86.0, 90.7)	9.3 (7.2, 11.3)	2.4 (1.2, 3.5)
Age, y			
18–24	83.5 (82.2, 84.8)	13.6 (12.5, 14.8)	2.9 (2.4, 3.3)
25–44	90.8 (90.4, 91.3)	7.2 (6.8, 7.6)	2.0 (1.8, 2.2)
45–64	95.9 (95.7, 96.2)	2.8 (2.6, 3.0)	1.3 (1.1, 1.4)
≥65	98.3 (98.1, 98.6)	0.9 (0.7, 1.0)	0.8 (0.7, 1.0)
Gender			
Men	91.7 (91.3, 92.1)	6.4 (6.1, 6.7)	1.9 (1.7, 2.1)
Women	93.8 (93.5, 94.1)	4.8 (4.5, 5.0)	1.4 (1.3, 1.6)
Education			
Eighth grade or less	91.0 (89.8, 92.1)	4.2 (3.6, 4.7)	4.9 (3.9, 5.9)
Some high school	89.2 (88.4, 90.0)	6.6 (6.0, 7.2)	4.2 (3.7, 4.7)
High-school graduate or GED	92.7 (92.2, 93.1)	5.4 (5.0, 5.8)	1.9 (1.7, 2.1)
Some post–high school, but no degree	92.1 (91.5, 92.7)	7.0 (6.4, 7.5)	0.9 (0.8, 1.1)
4-year college degree or higher	95.3 (94.8, 95.7)	4.4 (4.0, 4.8)	0.4 (0.3, 0.5)
Employment status last week			
Working at job or business	92.1 (91.7, 92.4)	6.5 (6.2, 6.9)	1.4 (1.3, 1.6)
Keeping house	93.5 (92.8, 94.1)	4.3 (3.8, 4.8)	2.3 (1.9, 2.7)
Going to school	88.0 (85.6, 90.4)	9.8 (7.7, 11.9)	2.1 (1.3, 2.9)
Something else (including unemployed)	94.8 (94.5, 95.2)	3.0 (2.8, 3.3)	2.1 (1.9, 2.4)
Household size			
1	86.8 (86.1, 87.5)	9.8 (9.2, 10.5)	3.4 (3.0, 3.7)
2	93.1 (92.7, 93.6)	5.4 (5.0, 5.9)	1.4 (1.2, 1.6)
3	92.8 (92.2, 93.4)	5.7 (5.2, 6.3)	1.5 (1.2, 1.7)
4	95.7 (95.2, 96.2)	3.3 (2.8, 3.8)	1.0 (0.8, 1.2)
≥5	94.6 (93.9, 95.3)	3.8 (3.3, 4.4)	1.6 (1.2, 1.9)
Household structure			
Living alone	86.9 (86.2, 87.6)	9.8 (9.1, 10.4)	3.4 (3.0, 3.7)
Living with roommate/roommates	68.1 (62.9, 73.4)	27.9 (23.1, 32.7)	4.0 (2.0, 5.9)
Living with spouse or related adults	94.7 (94.4, 95.1)	4.1 (3.8, 4.4)	1.2 (1.0, 1.3)
Living with children	93.9 (93.5, 94.3)	4.6 (4.2, 4.9)	1.5 (1.3, 1.7)
Household poverty status[b]			
Poor	82.8 (81.4, 84.1)	9.9 (8.9, 11.0)	7.3 (6.4, 8.2)
Near poor	88.8 (88.0, 89.6)	8.4 (7.6, 9.1)	2.9 (2.4, 3.3)
Not poor	94.4 (94.1, 94.8)	5.0 (4.7, 5.3)	0.6 (0.5, 0.7)
Geographic region			
Northeast	95.8 (95.8, 96.4)	3.1 (2.6, 3.5)	1.1 (0.8, 1.4)
Midwest	92.5 (91.8, 93.2)	6.2 (5.6, 6.8)	1.3 (1.0, 1.5)
South	91.3 (90.7, 91.9)	6.4 (5.9, 6.9)	2.3 (2.0, 2.5)
West	92.8 (92.2, 93.4)	5.5 (5.0, 6.1)	1.7 (1.4, 2.0)

Continued

alcoholic drinks on 1 occasion, being a current smoker, experiencing serious psychological distress, having had an HIV test, having financial barriers to obtaining needed medical care, and being uninsured (Table 3). They also had significantly lower odds of having a usual place for medical care, having received an influenza vaccination in the past 12 months, and having ever received a diagnosis of diabetes. These differences between adults with only wireless service and adults with landline telephones mirror differences observed between adults with no telephone service and adults with landline telephones, with only a few exceptions: adults with no telephone service did not differ from adults with landline service on reports of HIV testing, serious psychological distress, or financial barriers to care.

Estimates for health and health care service use measures derived for adults with landline telephones showed relatively small differences from estimates for all adults (Table 4). However, because of the large sample size of the NHIS, and because of a statistical strategy that compared the overall sample (all adults with known telephone status) with a large subset of the same sample (adults with landline telephones), even small differences between estimates with overlapping CIs were statistically significant. The noncoverage of adults without landline telephones in RDD surveys would result in statistically significant biased estimates for 2 behavioral risk factors (prevalence of adult smokers and prevalence of binge drinkers), 2 measures of health status (prevalence of psychological distress and diabetes) and all 6 health care service use measures. The magnitudes of these differences, however, were quite small, with differences of 1.6 percentage points or less.

DISCUSSION

This study is not the first to use data from a large-scale face-to-face survey to consider the relation between telephone ownership and health-related variables. Rather, it updates the work of Thornberry and Massey[7] (who used the 1985–1986 NHIS), Ford[5] (1988–1991 National Health and Nutrition Examination Survey), Anderson et al.[4] (1991–1994 NHIS), and McAuliffe et al.[6] (1995–1998 National Household Survey on Drug Abuse). Despite

TABLE 2—Continued

Metropolitan statistical area status			
Metropolitan	92.0 (91.6, 92.4)	6.3 (6.0, 6.7)	1.7 (1.5, 1.8)
Not metropolitan	94.8 (94.3, 95.3)	3.5 (3.1, 3.9)	1.7 (1.4, 2.0)
Home ownership status			
Home owned or being bought	96.7 (96.5, 97.0)	2.6 (2.4, 2.8)	0.6 (0.5, 0.7)
Renting	81.7 (80.8, 82.5)	13.9 (13.1, 14.7)	4.4 (4.0, 4.8)
Other arrangement	85.9 (83.4, 88.4)	9.0 (6.9, 11.2)	5.1 (3.7, 6.4)

Note. CI = confidence interval; GED = general equivalency diploma.
Source. Centers for Disease Control and Prevention, National Center for Health Statistics. National Health Interview Survey, 2004–2005.
[a]Includes adults in households that also have wireless telephone service.
[b]Poverty status is on the basis of household income and household size using the US Census Bureau's poverty thresholds. *Poor* households are defined as those below the poverty threshold. *Near poor* households have incomes of 100% to less than 200% of the poverty threshold. *Not poor* households have incomes of 200% of the poverty threshold or greater.

changes in telephony over the past 5 to 10 years and the growth of the wireless-only population, the results are quite similar to those of these previous studies: noncoverage of households without landline telephones continues to result in minimal bias for general population telephone surveys of adults.

This is not to say that adults without landline telephones do not differ from adults with landline telephones in their health and health care service use. Indeed, adults with only wireless service and adults without any telephone service had greater odds of smoking and being uninsured, and they had lower odds of ever having diabetes, having a usual place for medical care at the time of the interview, and having received an influenza vaccination in the past year. These differences existed even when we controlled for a myriad of demographic characteristics commonly used to adjust the sampling weights of major RDD health surveys.

Despite these significant differences, noncoverage bias was generally minimal. As explained by Anderson et al.,[4] 2 factors determine the degree of noncoverage bias in a telephone survey: (1) the magnitude of the difference between persons with and without landline telephones, and (2) the percentage of persons without landline telephones in the population of interest. For a general sample of adults in the United States, both factors remain sufficiently small that noncoverage bias

TABLE 3—Prevalence Rates and Relative Odds of Various Health and Health Care Service Use Measures, by Household Telephone Status: United States, January 2004–June 2005

	Adults in Households With Landline Telephones (n = 41 605 Adults), % (95% CI)[a]	Adults in Households With Only Wireless Telephones (n = 3472 Adults)		Adults in Households With No Telephone Service (n = 1180 Adults)	
		% (95% CI)	OR (95% CI)[b]	% (95% CI)	OR (95% CI)[b]
Health-related behaviors					
5 or more alcoholic drinks in 1 day at least once in past year	18.0 (17.4, 18.5)	37.6 (35.4, 39.9)	1.71 (1.53, 1.91)[c]	23.0 (19.8, 26.3)	1.22 (1.00, 1.49)
Current smoker	19.7 (19.2, 20.2)	32.9 (30.9, 35.0)	1.43 (1.28, 1.59)[c]	36.9 (33.4, 40.3)	1.36 (1.15, 1.61)[c]
Engaged in regular leisure-time physical activity	30.5 (29.8, 31.1)	34.7 (32.2, 37.1)	1.11 (1.00, 1.24)	20.0 (16.6, 23.4)	0.85 (0.69, 1.04)
Health status					
Health status described as excellent or very good	61.4 (60.8, 62.1)	66.3 (64.4, 68.3)	0.91 (0.83, 1.01)	49.2 (45.3, 53.0)	0.91 (0.77, 1.07)
Experienced serious psychological distress in past 30 days	2.8 (2.6, 3.0)	4.4 (3.6, 5.1)	1.29 (1.02, 1.62)[c]	7.8 (5.9, 9.6)	1.13 (0.85, 1.49)
Obese (adults aged 20 years or older)	25.0 (24.4, 25.5)	23.1 (21.2, 25.1)	1.00 (0.90, 1.12)	23.3 (20.4, 26.1)	0.76 (0.65, 0.90)[c]
Asthma episode in past 12 mo	3.7 (3.5, 3.9)	3.7 (3.0, 4.3)	0.90 (0.71, 1.13)	4.8 (3.4, 6.2)	1.06 (0.76, 1.47)
Ever diagnosed with diabetes	7.4 (7.1, 7.7)	3.0 (2.3, 3.7)	0.74 (0.58, 0.94)[c]	5.2 (3.8, 6.5)	0.57 (0.43, 0.77)[c]
Health care service use					
Has usual place to go for medical care	85.8 (85.3, 86.3)	67.4 (65.5, 69.3)	0.71 (0.64, 0.79)[c]	63.9 (60.3, 67.5)	0.71 (0.60, 0.86)[c]
Received influenza vaccine during past 12 mo	27.7 (27.2, 28.2)	14.2 (12.8, 15.7)	0.79 (0.70, 0.90)[c]	12.2 (10.1, 14.3)	0.58 (0.47, 0.71)[c]
Ever received pneumococcal vaccination	17.3 (16.9, 17.8)	7.9 (6.8, 8.9)	0.93 (0.77, 1.11)	7.3 (5.6, 9.0)	0.53 (0.40, 0.71)[c]
Ever been tested for HIV	34.1 (33.4, 34.8)	44.7 (42.5, 46.9)	1.23 (1.12, 1.35)[c]	37.7 (34.1, 41.3)	0.96 (0.82, 1.12)
Failed to obtain needed medical care in past 12 mo because of financial barriers	6.5 (6.2, 6.8)	13.4 (12.0, 14.8)	1.42 (1.23, 1.64)[c]	14.8 (12.5, 17.1)	1.05 (0.85, 1.29)
Currently uninsured	14.8 (14.3, 15.3)	31.1 (29.1, 33.1)	1.37 (1.23, 1.52)[c]	43.9 (40.3, 47.5)	1.59 (1.34, 1.90)[c]

Note. CI = confidence interval; OR = odds ratio.
Source. Centers for Disease Control and Prevention, National Center for Health Statistics. National Health Interview Survey, 2004–2005.
[a]Includes adults in households that also have wireless telephone service.
[b]Odds ratios were adjusted for the variables in Table 2. Adults with landline telephone service were the referent group.
[c]This confidence interval does not include 1.00 and indicates a statistically significant odds ratio, $P < .05$.

TABLE 4—Prevalence Rates for Various Health and Health Care Service Use Measures by Household Telephone Status: United States, January 2004–June 2005

	All Adults With Known Household Telephone Status (n = 46 257 Adults), % (95% CI)	Adults in Households With Landline Telephones (n = 41 605 adults), % (95% CI)	Difference, % (95% CI)
Health-related behaviors			
5 or more alcoholic drinks in 1 day at least once in past year	19.3 (18.7, 19.9)	18.0 (17.4, 18.5)	1.35 (1.06, 1.64)[a]
Current smoker	20.9 (20.4, 21.4)	19.7 (19.2, 20.2)	1.17 (0.97, 1.36)[a]
Engaged in regular leisure-time physical activity	30.5 (29.8, 31.2)	30.5 (29.8, 31.1)	0.07 (–0.22, 0.36)
Health status			
Health status described as excellent or very good	61.5 (60.9, 62.1)	61.4 (60.8, 62.1)	0.08 (–0.18, 0.34)
Experienced serious psychological distress in past 30 days	3.0 (2.8, 3.2)	2.8 (2.6, 3.0)	0.19 (0.11, 0.27)[a]
Obese (adults aged 20 years or older)	24.8 (24.3, 25.3)	25.0 (24.4, 25.5)	–0.15 (–0.34, 0.05)
Asthma episode in past 12 mo	3.7 (3.5, 3.9)	3.7 (3.5, 3.9)	0.02 (–0.01, 0.05)
Ever diagnosed with diabetes	7.1 (6.8, 7.4)	7.4 (7.1, 7.7)	–0.32 (–0.39, –0.25)[a]
Health care service use			
Has usual place to go for medical care	84.2 (83.7, 84.8)	85.8 (85.3, 86.3)	–1.59 (–1.84, –1.34)[a]
Received influenza vaccine during past 12 mo	26.5 (26.0, 27.1)	27.7 (27.2, 28.2)	–1.16 (–1.32, –0.99)[a]
Ever received pneumococcal vaccination	16.5 (16.1, 17.0)	17.3 (16.9, 17.8)	–0.79 (–0.92, –0.66)[a]
Ever been tested for HIV	34.8 (34.2, 35.5)	34.1 (33.4, 34.8)	0.75 (0.57, 0.94)[a]
Failed to obtain needed medical care in past 12 mo because of financial barriers	7.1 (6.8, 7.4)	6.5 (6.2, 6.8)	0.59 (0.48, 0.70)[a]
Currently uninsured	16.4 (15.9, 16.9)	14.8 (14.3, 15.3)	1.59 (1.36, 1.82)[a]

Note. CI = confidence interval.
Source. Centers for Disease Control and Prevention, National Center for Health Statistics. National Health Interview Survey, 2004–2005.
[a] This confidence interval does not include 0.0 and indicates a statistically significant difference, $P < .05$.

was minimal for most of the selected measures of health and health care service use.

Exceptions

One important exception was lack of health insurance. The present results revealed statistically significant bias of greater than 1 percentage point on this variable; no previous studies of telephone ownership considered this measure. Surprisingly, the elevated odds of being uninsured among adults without landline telephones remained statistically significant after adjustments for related variables such as age, income, and employment status. Perhaps both lack of insurance and lack of a landline telephone are related to some lifestyle variable not assessed here, such as a tendency to change jobs and residences. The differences in health insurance coverage between persons with and without landline telephones may

also explain why persons without landline telephones were less likely to have a usual place for health care, less likely to have received preventive health services such as vaccinations or diabetes screening, and more likely to experience financial barriers to obtaining needed medical care.

The bias revealed for smoking behavior was expected. Several studies comparing telephone survey estimates of current smoking behavior to face-to-face survey estimates have revealed that face-to-face surveys can produce slightly higher estimates.[12–14] This difference has been attributed to higher smoking rates for adults without landline telephones,[5,13] and as with health insurance and usual place for health care, these differences remained after control for demographic factors. The observed relation between smoking and telephone coverage may be caused by geographic factors: smoking rates

are higher and landline telephone coverage rates are lower in the Southern states and on American Indian reservations.[13,15,16]

Limitations

The estimates of noncoverage bias presented here are on the basis of a sample survey that was subject to its own forms of nonrandom error, including nonresponse bias, survey design flaws, data-processing mistakes, and respondent classification and reporting errors. For the topics covered here, a particular concern is respondents' willingness to accurately report the presence or absence of telephones in their households. Estimates of the prevalence of adults without landline telephones would be too high if some respondents refused to acknowledge owning a landline telephone in order to avoid telemarketers, surveyors, or other unwanted calls.

Surveyors should also note that the noncoverage of adults classified here as wireless-only cannot be completely eliminated simply by randomly dialing personal wireless telephone numbers. The assignment of wireless-only status to adults in this research was based on the presence of wireless telephones in the household; information on the personal ownership of the wireless telephones and their primary use (personal or business) was not obtained or considered in making this assignment. The NHIS respondents classified as wireless-only were not necessarily wireless telephone owners themselves.

Noncoverage Bias and Wireless Substitution

If wireless substitution becomes more prevalent, will noncoverage bias increase? As noted earlier, the degree of noncoverage bias is determined by the magnitude of the difference between adults with and without landline telephones, and by the percentage of adults without landline telephones in the population.[4] To date, increases in wireless substitution have added to the magnitude of the second factor. As the prevalence of wireless-only adults grew from 4.5% in the first half of 2004 to 6.7% in the first half of 2005, the percentage of adults without landline telephones also grew from 6.0% to 8.4%. If wireless substitution becomes more prevalent, we would expect this trend to continue.

However, the impact of increases in the prevalence of adults without landline telephones may be offset by decreases in the differences between adults with and without landline telephones. With a few exceptions (e.g., HIV testing, binge drinking), the magnitude of the difference between adults with landline telephones and adults with only wireless telephones was generally lower than the magnitude of the difference between adults with landline telephones and adults with no telephone service. For example, although the odds that an adult with only wireless service was uninsured were 37% greater than the odds that an adult with a landline telephone was uninsured, the odds that an adult with no telephone service was uninsured were 59% greater than the odds that an adult with a landline telephone was uninsured. If wireless substitution becomes more prevalent and these wireless-only adults constitute a greater proportion of the nonlandline population—three fourths of adults without landline telephones already have wireless telephones—the magnitude of the first factor may decrease. This prediction, that adults with and without landline telephones will become less different over time if wireless substitution becomes more prevalent, is also based on an assumption that the decision to have only a wireless telephone is merely correlated with health and health care service use and is not a direct cause of (or consequence resulting from) one's health.

Noncoverage and Nonresponse

Regardless of the future impact of wireless substitution, the noncoverage rate is likely to remain smaller than the nonresponse rate. All survey researchers have had increasing difficulties achieving high response rates, especially within the past 10 years. Even the NHIS, a high-quality face-to-face survey, was having difficulties with response: interviews were not completed in 2004 for 1 in 4 eligible adults.[9] Telephone survey nonresponse rates are even greater, in part because RDD surveyors have had difficulty navigating the new technologies used by potential respondents to avoid unwanted telephone calls.[17,18] These nonresponse rates should easily outweigh noncoverage rates in the foreseeable future.

It is reassuring, then, that recent studies directly comparing estimates from telephone surveys to face-to-face surveys generally reveal few statistically significant differences and even fewer practically significant differences.[14,19–21] Similarly, with the possible exception of insurance status, we believe that the differences in Table 4 do not reach the level of practical significance. In other words, noncoverage bias is not presently a reason to reject the continued use of general population telephone surveys to help guide public health policy and program decisions. Of course, close and continued monitoring of telephone ownership in this rapidly changing technological environment will be necessary to ensure continued confidence in this conclusion. ∎

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