Nonresponse Bias Analysis of BMI Data in the Eating & Health Module

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Abstract: This paper presents analysis on the respondents who did not report height and/or weight in the American Time Use Survey Eating & Health Module. Analyses focusing on correlations between BMI and time use could be biased if those who do not report height and/or weight differ significantly in other observable characteristics from the rest of the survey respondents. Results show that any item nonresponse bias using the Eating & Health Module height and weight data appears to be small. As a consequence, the Eating & Health Module data can be used in analyses of body mass index (BMI) and time use patterns.

Keywords: time use, American Time Use Survey, Eating & Health Module, nonresponse bias, item nonresponse, Body Mass Index, BMI, dissimilarity index, paradata

Introduction

The USDA Economic Research Service (ERS) Eating & Health Module, a supplement to the American Time Use Survey (ATUS), collected information on respondents' height and weight in order to have data on time use and Body Mass Index (BMI) for obesity research. Some respondents refused to report their height and/or their weight, and so a BMI could not be calculated. Bias would occur if those with missing BMI had different time use patterns than other respondents, resulting in under- or over-estimates of average time spent in various activities.

Eating & Health Module

The Bureau of Labor Statistics (BLS) ATUS is a continuous survey program that began in 2003, collecting time use data for almost every day of the year, with U.S. Census Bureau conducting the interviews.[2] One individual age 15 or older from each sampled household is interviewed about his or her activities for the 24-hour period from 4 a.m. the day before the interview to 4 a.m. of the interview day. The ATUS data also include demographic, labor force participation, and household information. The Eating & Health Module supplement (EH Module) developed by ERS and funded by ERS and National Cancer Institute, was fielded from January 2006 to December 2008, producing 3 full years of data. Over 2006-08 the ATUS and EH Module resulted in 37,832 completed interviews of individuals age 15 or over.[3] Weighting factors were calculated by the U.S. Census Bureau so that when applied to the individual respondent data, the ATUS and EH Module produce nationally representative estimates.

The EH Module contains questions on eating patterns; height, weight, and health status; Supplemental Nutrition Assistance Program (formerly Food Stamp Program)[4] participation and income; meals obtained at school by household children; and grocery shopping and meal preparation. Since the ATUS is a time use survey, it does not include food intake information. Nonetheless, the data provide important information on eating/drinking duration, frequency, and context that allow for the characterization of eating patterns of different groups.

Collecting height and weight information in order to calculate BMI allows for research on time use patterns by BMI. Because obesity is the most common food and nutrition-related health problem in the United States, understanding patterns of activities and time spent in various activities helps to understand how behavior of those who are obese differ from that of others.

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[1] The views expressed here are those of the author and are not necessarily those of the Economic Research Service or the U.S. Department of Agriculture.
[2] The ATUS conducts interviews every day of the year except on Thanksgiving and Christmas.
[3] A small number of respondents completed the ATUS survey but did not complete the EH Module questions. Over 2006-08, there were a total of 82 of these cases, 0.2 percent.
[4] As of October 1, 2008, the Food Stamp Program was renamed as the Supplemental Nutrition Assistance Program (SNAP).

Relevant Literature

Considerable research had been conducted on *unit nonresponse* in household surveys, the situation in which the sampled individual or household does not participate in the survey. The concern is that estimates using the survey data will have an increased variance, and in addition, there may be bias in the estimates, that is, a difference between an estimate using survey data and the actual population value, if those who do not participate have different characteristics related to the survey topic than those who do respond to the survey. The literature in this area is extensive, and good overviews are provided by Groves (2006), Groves, et al. (2002), and Bethlehem, Cobben, and Schouten (2011).

In the area of nonresponse in time use data, Abraham, Maitland, and Bianchi (2006) investigated unit nonresponse in the ATUS, and concluded, "We find little support for the hypothesis that busy people are less likely to respond to the ATUS but find considerable support for the hypothesis that people who are weakly integrated into their communities are less likely to be contacted." (p. 676) However, reweighting the estimates to account for this nonresponse produced only modest differences in time use.

Abraham, Helms, and Presser (2008) also looked at nonresponse in the ATUS in relation to estimates of time spent in volunteer work and unit nonresponse. They investigated whether the social processes that lead to survey participation also lead to volunteering, which would result in an overrepresentation of volunteers in the ATUS. They concluded that indeed there is a connection between the causes of volunteering and the causes of survey participation, meaning that time use estimates would contain bias in time spent in volunteering and other prosocial activities. However, they do not recommend an adjustment for the bias.

O'Neill and Sincavage (2004) conducted a response analysis survey on ATUS nonrespondents in order to understand respondent refusals. They found that one-third of the ATUS nonrespondents experienced CPS-related participant fatigue, and stated "…that their decision not to participate in ATUS was because of their previous CPS participation. Several nonrespondents stated that they were tired of the Census Bureau calling them and they felt that participating in CPS was doing more than their share of the work." (p. 6)

Item nonresponse occurs when an individual or household participates in a survey, but does not provide information for one or more questions. The respondent may think that the information requested by the question is too sensitive to reveal, such as income.[5] The individual may think that the question is not directly related to the survey topic, and so not important to answer. Or, the individual may not know the answer and does not want to spend time researching the answer. It is also possible that the individual does not know the answer and cannot obtain the answer. The research on item nonresponse is not as extensive as that on unit nonresponse, however Bethlehem, Cobben, and Schouten (2011, chapter 14), Dixon (2005), and Mason, Lesser, and Traugott (2002) provide good overviews.

Fricker and Tourangeau (2010) investigated nonresponse, reluctant respondents, and data quality in the Current Population Survey and in the ATUS. Although their focus was unit nonresponse and data quality, they studied item nonresponse as well. Their data quality indicators for ATUS were "(1) total number of diary activities reported; (2) missing diary reports of basic daily activities; (3) round values for activity durations; and (4) item nonresponse on ATUS labor-force questions." (p. 941) Among their findings was that respondents with high nonresponse propensity scores had fewer activities reported in their time diaries. In addition, they examined respondents who were *refusal conversions*, that is, those who originally refused to participate in the ATUS but later agreed to be interviewed. They found that data quality was worse for refusal conversion respondents than for others.

Another area of research is late respondents and data quality. Triplett et al. (1996) studied late respondents (converted-refusal cases) using the 1993-94 time diary study conduced by the Environmental Protection Agency. They concluded that the converted-refusal respondents consistently provided less information than other respondents. Friedman, Clusen, and Hartzell (2003) investigated the characteristics of late respondents to the Health Care Survey of Department of Defense Beneficiaries—are the characteristics of late respondents different from other respondents? They used the "continuum of resistance" model that posits "…individuals who require the most contacts before participating in a survey are also the most resistant to being interviewed, and the most resistant a

[5] Tourangeau, Rips, and Rasinski (2000, chapter 9) provide a good discussion of sensitive questions and nonresponse.

respondent, the more similar he is to the most resistant individuals in the population—the nonrespondents." (p. 992) They studied these late respondents, those who needed the most callbacks before participating, as a way of gaining insight into nonrespondents. They found that indeed the late respondents had different characteristics than non-late respondents, and also late respondents were more likely to have "don't know," "not applicable," or just blank responses. As a consequence, their responses may be less reliable than non-late respondents.

Missing BMI—Characteristics of Respondents

The Eating & Health Module asked ATUS respondents their height and weight, which allows the calculation of body mass index (BMI):[6]

> *I'm going to switch topics and ask you a few final questions about your physical health that might affect how you use your time. In general, would you say that your health is Excellent, Very Good, Good, Fair, or Poor? How tall are you without shoes? How much do you weigh without shoes?*

Although EH Module BMI is calculated from self-reported height and weight in ATUS, researchers have found that differences between self-reported BMI and measured BMI are small, and also that self-reported values are acceptable to use for analysis of nonelderly adults.[7] In addition, the expected underreporting of BMI (through underreporting of weight and overreporting of height) in the EH Module data does not appear to be large.[8] So while the EH Module BMIs should not be used to obtain an official measure of obesity in the United States, the data are suitable for analyzing time use behavior as it relates to BMI.[9]

Missing Values for Height and/or Weight
Over the three years of Eating & Health Module data, only 1,848 respondents, 4.88 percent of 37,832 completed interviews, did not report height and/or weight, and so have a missing BMI value. ERS did not impute BMI for any of the missing values. An additional 347 respondents (0.92 percent) reported being pregnant when the interviewer stated, "Since pregnancy effects weight, please let me know if you are currently pregnant," and so the EH Module survey did not ask their weight as including BMI for pregnant women would confound BMI analysis. These respondents who reported being pregnant and so have missing BMIs are not included in the analysis presented here.

Item nonresponse is considered a source of nonsampling error.[10] Respondents who are willing to participate in the American Time Use Survey may be unwilling to answer sensitive questions. Because of concern about sensitivity, the general health, height, weight, and income questions were placed at the end of the survey instrument.[11] Respondents with missing BMI may have declined reporting height and/or weight perceiving them as not relevant to a time use survey.[12] It is also possible that some individuals, such as growing teenagers and elderly individuals with age-related weight loss, may not know their current height and/or weight.

It is useful to start with a basic description of BMI non-response in the ATUS. Table 1[13] shows the cell counts of the missing BMIs,[14] and Table 2 summarizes cell counts by year. The breakout by type of nonresponse is shown in

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[6] Height and weight are bottom- and top-coded for confidentiality. The EH Module includes a screening question for pregnancy as pregnant women were not asked their weight and so have missing BMIs.
[7] Cawley and Burkhauser, 2006. Kuczmarski, Kuczmarski, and Najjar, 2001. Danubio et al., 2008.
[8] Pinkston and Steward, 2009.
[9] This research does not address whether BMI should be adjusted to correct for underreporting of weight and overreporting of height due to self-reporting. See Pinkston and Steward (2009) and Danubio et al. (2008) for discussions of BMI bias correction.
[10] ERS and BLS concluded that including height and weight in the EH Module would not lead to unit nonresponse, that is, that sampled individuals would refuse to be interviewed for the ATUS because they did not want to be asked their height and weight. This is because the ATUS is not a health survey, and so individuals would not expect that height and weight questions would be asked. For a discussion of how the topic of a survey can lead to nonresponse of individuals concerned about sensitive questions, see Tourangeau, Groves, and Redline (2010).
[11] See Vernon (2005) for discussion of pretest of EH Module. A text version of the questionnaire is at http://stats.bls.gov/tus/ehmquestionnaire.pdf
[12] Dixon (2002) found that some respondents in the Current Population Survey respond to labor force questions, indicating that they agree with the purpose of the survey, but not to demographic questions that they may perceive as not relevant.
[13] All estimates presented in this report were calculated using the ATUS data and the EH Module data for 2006-08. The ATUS Respondent, Activity, Activity Summary, Roster, Who, and ATUS-Current Population Survey files were used, along with the

Table 3. Because some respondents did not report height, some did not report weight, and some did not report either, the sum of missing height and missing weight is greater than the total number of missing BMI. For height and especially for weight, more respondents refused to report values than those who answered that they did not know their height and/or weight. However, whereas a "refusal" is a refusal to answer the question, a "don't know" response may be a soft refusal, so it is unclear how to interpret the "don't know" responses.

Table 1—Cell counts of respondents by BMI status and by gender.
2006-08 ATUS and EH Module data, cell counts (unweighted), age 15 and over, pregnant women excluded.

	Men	Women	Total
Missing BMI	389	1,459	**1,848**
Underweight (BMI<18.5)	148	471	**619**
Normal weight (18.5≤BMI<25.0)	4,669	8,498	**13,167**
Overweight (25.0≤BMI<30.0)	6,814	5,649	**12,463**
Obese (30.0≤BMI)	4,407	4,981	**9,388**
Total	**16,427**	**21,058**	**37,485**

Table 2—Cell counts of missing BMI respondents by year.
2006-08 ATUS and EH Module data, cell counts (unweighted), age 15 and over, pregnant women excluded.

	2006	2007	2008	Total
Missing BMI	588	593	667	1848
% of Total	4.6%	4.9%	5.3%	4.9%
Total respondents	12,764	12,108	12,613	37,485

Table 3—Missing height and weight respondents by type of nonresponse.
2006-08 ATUS and EH Module data, cell counts (unweighted), age 15 and over, pregnant women excluded.

	Don't Know	Refused	Total
Missing height	381	478	859
Missing weight	466	1,083	1,549

Survey characteristics of BMI nonrespondents
A way to describe Missing BMI respondents is by their characteristics as an ATUS respondent. Perhaps the Missing BMI respondents are reluctant to be interviewed and so are "uncooperative respondents." An indicator of a reluctant respondent is the number of call attempts the Census Bureau made in order to obtain a completed interview.[15, 16]

ATUS Methodology Call History and Case History files, and the EH Module Respondent and Replicate Weights files. The dataset used contains 37,832 respondents, with a total of 753,604 activities. Excluding respondents who reported being pregnant results in a total of 37,485 respondents. All estimates and unweighted counts are for individuals age 15 and over. All calculations were done using SAS 9.2. Estimation procedures outlined in the *ATUS User's Guide* (http://stats.bls.gov/tus/atususersguide.pdf) and the *EH Module User's Guide* (http://ers.usda.gov/Publications/AP/AP047/) were followed. Averages were calculated as the mean unless otherwise stated. Standard errors were calculated according to Section 7.5 of the *ATUS User's Guide*. The EH Module Replicate Weights were used to calculate standard errors.

[14] Body Mass Index is calculated as: weight (lb) / [height (in)]^2 x 703. Adult BMI groups are Underweight (BMI < 18.5), Normal weight (18.5 ≤ BMI < 25), Overweight (25 ≤ BMI < 30), and Obese (30 ≤ BMI). For purposes of interpreting BMI, Centers for Disease Control defines adults as those age 20 and over, and uses a different interpretation for youth and teens. However, here these adult groupings are, for convenience of exposition, used for all respondents age 15 and older as the focus is on the missing BMIs for the entire dataset, and not on analyzing time use patterns of those who are, say, overweight. In analysis by BMI, ERS uses the CDC adult and youth/teen definitions.

[15] Each sampled designated person is assigned a diary day of the week, and so the interview would be the next day. (E.g., Monday is the diary day so Tuesday is the interview day.) If the designated person is not reached or the interview cannot be completed, call attempts are made on the interview day for up to eight weeks.

[16] The number of attempted calls also includes times that the respondent's case file was opened. So, an actual call may not have been made as the file may have been viewed or queued up for a call. The cases with high maximum call attempts, such as the case of 94 call attempts, does not actually represent 94 calls being made to the respondent. Information from Mary Dorinda Allard, Director, BLS Division of Labor Force Statistics, in a discussion on March 11, 2011.

Using the ATUS Call History data, one of the ATUS survey methodology files, I find that the average number of call attempts appear to be higher for those respondents with missing BMI, 7.1 (weighted mean) call attempts versus 6.8 for the total population, however these averages are not statistically different at the 90 percent level, so the number of call attempts for those with missing BMI is about the same as for others. (Table 4) Related to call attempts is the number of weeks (1-8) that were needed to successfully complete the interview. On average, the Missing BMI respondents took longer, 2.4 weeks (weighted mean) and is statistically different from the total population mean of 2.2 weeks weeks. Their median was higher as well, 2 weeks versus one week for the other groups. The higher average number of weeks to interview may indicate that these respondents were reluctant to participate in the survey.

Table 4—Call attempts and weeks called by BMI group.
2006-08 ATUS and EH Module data, age 15 and over, pregnant women excluded.

	Total population	**Missing BMI**	**Under-weight**	**Normal weight**	**Over-weight**	**Obese**
Number of call attempts						
mean (unweighted)	6.7	7.0	6.5	6.8	6.8	6.5
mean (weighted)	6.8 (0.06)	7.1 (0.20)	6.8 (0.44)	6.9 (0.09)	6.8 (0.10)	6.6 (0.10)
median (unweighted)	4	4	4	4	4	4
median (weighted)	4	5	4	4	4	4
75th percentile (unwgtd)	9	9	8	9	9	8
75th percentile (weighted)	9	10	9	9	9	9
minimum	1	1	1	1	1	1
maximum	94	72	42	94	78	86
Number of weeks call attempts made						
mean (unweighted)	2.2	2.4	2.2	2.2	2.2	2.2
mean (weighted)	2.2 (0.01)	2.4 (0.05)	2.3 (0.12)	2.2 (0.02)	2.3 (0.02)	2.2 (0.02)
median (unweighted)	1	2	1	1	1	1
median (weighted)	1	2	1	1	1	1
75th percentile (unwgtd)	3	3	3	3	3	3
75th percentile (wgtd)	3	3	3	3	3	3
minimum	1	1	1	1	1	1
maximum	8	8	8	8	8	8

Note: Variables TUATTMPTNO and TUATTMWEEK from ATUS Call History file used. Standard errors are in parenthesis.

I looked at late respondents since those are likely to be similar to nonrespondents. Since the 75th percentile number of weeks call attempts were made is 3 weeks, late respondents are defined as those who needed to be called 4 or more weeks to participate in the ATUS. Table 5 shows that 24.1 percent (weighted percent) of missing BMI respondents were late respondents, a higher share than late respondents with a BMI value (19.7 percent). So, the missing-BMI group has a higher share of those reluctant to be interviewed.

Table 5—Missing BMI by late respondent status—call attempts for 4+ weeks before interview.
2006-08 ATUS and EH Module data, age 15 and over, pregnant women excluded.

	Missing BMI			**Total Population, non-missing BMI**		
	Unweighted	Unweighted	Weighted	Unweighted	Unweighted	Weighted
	N	*percent*		*N*	*percent*	
Late Respondent (4+ weeks)	405	21.9	24.1 (1.26)	6,762	19.0	19.7 (0.30)
Not late respondent	1443	78.1	75.9 (1.26)	28,875	81.0	80.3 (0.30)

Note: Standard errors are in parenthesis.

Another indicator of an uncooperative respondent is the number of activities that the respondent reported in the time diary. The mean number of activities reported across the total population was 19.7 (weighted), with a median of 19 activities, a minimum of 5 and a maximum of 91.[17] (Table 6) Looking at the number of activities in the time diaries, the Missing BMI group does indeed have fewer activities as measured by mean, median, and by maximum value.

Table 6—Number of diary activities by BMI group.
2006-08 ATUS and EH Module data, age 15 and over, pregnant women excluded.

	Total population	Missing BMI	Under-weight	Normal weight	Over-weight	Obese
Mean (unweighted)	19.9	18.6	19.8	20.7	19.7	19.3
Mean (weighted)	19.7 (0.05)	18.7 (0.22)	19.2 (0.46)	20.3 (0.08)	19.5 (0.09)	19.3 (0.10)
Median (unweighted)	19	17	19	19	19	18
Median (weighted)	19	17	18	19	18	18
75th percentile (unwgtd)	24	23	24	25	24	23
75th percentile (weighted)	24	23	23	24	24	24
Minimum	5	5	6	5	5	5
Maximum	91	58	91	75	81	85

Note: Standard errors are in parenthesis.

Another indicator of lack of respondent cooperation is whether the respondent answered other sensitive questions. Income is well documented as a sensitive question that can be problematic in household surveys. The EH Module benefited from several rounds of cognitive pre-testing, in which ERS was able to craft income questions that produced a high response rate.[18] The first question asked if household income is above or below the dollar amount of 185 percent of the poverty threshold for the respondent's household size. If the respondent answered "below" or gave a "don't know" or "refused," answer, then the second question was asked, whether the household's income was above or below the dollar amount of 130 percent of the poverty threshold for the respondent's household size. Looking at respondents who did not report household income for the 185 percent question,[19] 43 percent (weighted) of those who did not report BMI also did not report income. (Table 7) This is considerably larger than and statistically different from the 10 percent of respondents who reported height and weight but did not report income.

Table 7—Respondents with missing BMI by reporting or not reporting income.
2006-08 ATUS and EH Module data, age 15 and over, pregnant women excluded.

	Income reported	Income missing
Missing BMI count	1,103	745
Total population, non-missing BMI count	32,718	2,919
Missing BMI row % unweighted	59.7%	40.3%
Total population, non-missing BMI row %, unweighted	91.8%	8.2%
Missing BMI row %, weighted	57.2% (1.67%)	42.8% (1.67%)
Total population, non-missing BMI row %, weighted	89.6% (0.20%)	10.4% (0.20%)

Note: Standard errors are in parenthesis.

[17] Note that BLS ATUS excludes interviews that have fewer than 5 reported activities, and/or where reported activities do not cover at least 21 hours of the day. There is no constraint on the maximum number of diary activities. Email correspondence from Rachel Krantz-Kent, Manager, American Time Use Survey, October 7, 2010.
[18] The EH Module income questions had a nonresponse rate of 10 percent, which is lower than the CPS income nonresponse rate of 13 percent. Using household earnings, ERS and BLS imputed income for some respondents, yielding only 6 percent with missing income in the released EH Module data. See Hamrick (2010) for more information.
[19] Used here is the original missing values for variable EEINCOME1, that is, EEINCOME1 without the values that were imputed for those who did not report income. The flag EXINCOME1 was used to remove imputed values. EUINCOME2 (more/less than 130 percent poverty threshold) was not used here.

As a final indicator, I looked at time diary quality. Using the ATUS Case History data, an ATUS survey methodology file, time diary quality as reported by the Census interviewer can be used to evaluate whether the missing BMI observations were from uncooperative respondents. After each ATUS interview is completed, the Census interviewer answers two data quality questions: "Is there any reason the information from this interview should NOT be used?" and "Why do you think the data should not be used?"[20]

In only 275 cases of the 37,484 completed interviews, the Census interviewer thought that the respondent's time diary was not of good quality. (Table 8) The unweighted share of those with missing BMI and no diary quality issues (97.7 percent) is less than for those with a BMI value (99.4 percent) as expected. In addition, the weighted share of those with missing BMI and no diary quality issue is 98.2 percent, lower and statistically different from the 99.3 percent for those with a BMI value and no diary quality issue. Although the number and percent of respondents with diary quality issues is very small, these results contribute to understanding the missing BMI respondents.

Table 8—Missing BMI respondents by diary quality.
2006-08 ATUS and EH Module data, age 15 and over, pregnant women excluded.

	No diary quality issue	**Diary quality problems**				**Total**
		intentionally wrong	could not remember	deliberately long durations	other reason	
Missing BMI count	1,806	4	19	11	8	1,848
Total population, non-missing BMI count	35,404	32	85	77	39	35,637
Missing BMI row % unweighted	97.7%	0.2%	1.0%	0.6%	0.5%	100%
Total population, non-missing BMI row %, unweighted	99.4%	0.1%	0.2%	0.2%	0.1%	100%
Missing BMI row %, weighted	98.2% (0.37)	0.2% (0.16)	0.9% (0.26)	0.4% (0.15)	0.3% (0.12)	100%
Total population, non-missing BMI row %, weighted	99.3% (0.06)	0.1% (0.02)	0.2% (0.04)	0.3% (0.04)	0.1% (0.03)	100%

Note: Variable TUDQUAL2 from ATUS Case History data file. Standard errors are in parenthesis.

Missing BMI—Time Use Profiles

Having an understanding of the characteristics of those with missing BMI is useful, however more important to time use research is whether these missing BMIs cause bias in time use estimates. The ATUS and EH Module data exist in order to analyze Americans' time spent in various activities. Are the respondents who did not report height and/or weight different with respect to their time use patterns than others? Results above found that on average those who do not report height and/or weight reported fewer activities in their diaries, but what are the time duration differences?

In looking at time use by the ATUS major activity groups,[21] (Table 9) the most striking difference between the Missing BMI group and the other BMI groups is the long amount of time those who did not report height and/or weight spend in Personal care, 586 minutes (9.8 hours), which includes sleeping. The Missing BMI group also had a high average time spent in household activities and caring for household members on an average day, however since the majority of the Missing BMI group is female this is not surprising. Interestingly, the Missing BMI group had the highest average time spent in Other activities. Other activities include gaps in the time diary that the ATUS

[20] See American Time Use Survey Questionnaire, June 2010, http://stats.bls.gov/tus/tuquestionnaire.pdf.
[21] For definitions of the major activity groups, see *ATUS User's Guide* Appendix H: Bridge between published tables activity categories and ATUS coding lexicon activity categories, http://stats.bls.gov/tus/atususersguide.pdf

interviewer was not able to code due to insufficient detail, respondent refusal, or respondent unable to recall activity. The higher average Other Activities time is consistent with the concept of uncooperative respondents.

Looking at the major activity groups by gender, the Male Missing BMI group has an average Personal Care time about the same as Underweight males. (Table 10) The average time males with Missing BMI spent in Eating & drinking is the shortest of the BMI groups, and the time spent in Other activities, that is, diary gaps, is the longest, although not statistically different from the total population or BMI group means. The Female Missing BMI group has a high average time spent in Personal care, the lowest average time spent in Eating and drinking, and the most time in the Other category, just as the case with the Missing BMI Males.

Table 9—Time spent in major activities by BMI group.
2006-08 ATUS and EH Module data, population (weighted), age 15 and over, pregnant women excluded.

minutes	**Total population**	**Missing BMI**	**Under-weight**	**Normal weight**	**Over-weight**	**Obese**
Personal care	562.1	586.2	591.5	567.2	554.1	558.8
	(0.86)	(4.86)	(7.33)	(1.66)	(1.48)	(1.99)
Household activities	111.6	120.9	100.1	112.8	111.8	108.8
	(0.89)	(4.29)	(6.10)	(1.38)	(1.46)	(1.97)
Caring for household members	31.2	41.8	27.5	33.0	28.2	30.8
	(0.42)	(2.68)	(4.14)	(0.69)	(0.72)	(1.01)
Caring for non-household members	12.8	12.7	13.5	11.6	13.6	13.4
	(0.35)	(1.55)	(3.27)	(0.54)	(0.70)	(0.70)
Paid Work	226.1	198.8	153.7	209.3	245.7	233.8
	(1.77)	(7.97)	(12.12)	(3.18)	(3.09)	(3.56)
Educational	27.8	26.0	83.6	44.2	17.0	15.7
	(0.72)	(3.68)	(9.17)	(1.66)	(1.24)	(1.22)
Purchasing goods	38.0	40.9	43.5	38.1	37.5	37.5
	(0.46)	(2.05)	(4.48)	(0.77)	(0.89)	(0.97)
Purchasing services	7.3	8.4	10.7	7.0	7.4	7.3
	(0.23)	(0.95)	(2.58)	(0.38)	(0.40)	(0.40)
Purchasing household services	1.3	0.9	0.3	1.3	1.3	1.5
	(0.08)	(0.25)	(0.22)	(0.15)	(0.15)	(0.20)
Government & civic	0.7	0.5	1.5	0.5	0.6	0.9
	(0.07)	(0.29)	(0.68)	(0.11)	(0.11)	(0.20)
Eating & drinking	73.9	65.5	71.8	75.6	75.5	71.4
	(0.40)	(1.63)	(3.03)	(0.75)	(0.74)	(0.72)
Leisure	285.7	284.1	284.2	270.3	286.2	307.3
	(1.38)	(5.86)	(11.57)	(2.33)	(2.49)	(2.78)
Sports	22.6	13.2	19.9	27.4	23.6	16.6
	(0.46)	(1.39)	(3.34)	(0.86)	(0.92)	(0.84)
Religious	9.5	10.5	7.8	9.2	9.4	10.2
	(0.22)	(1.04)	(1.75)	(0.39)	(0.40)	(0.43)
Volunteer	10.0	7.2	6.7	10.7	10.4	9.2
	(0.35)	(0.96)	(1.68)	(0.58)	(0.60)	(0.64)
Phone & Mail	7.1	6.4	10.0	8.3	6.3	6.5
	(0.19)	(0.84)	(1.33)	(0.35)	(0.28)	(0.37)
Other	12.2	15.8	13.5	13.7	11.5	10.3
	(0.34)	(1.51)	(3.26)	(0.66)	(0.63)	(0.45)
Total	1440.0	1440.0	1440.0	1440.0	1440.0	1440.0

Note: Activities listed are ATUS major activity groups. Travel time included with each activity. Standard errors in parenthesis.

Table 10—Time spent in major activity groups, by gender.
2006-08 ATUS and EH Module data, population (weighted), age 15 and over, pregnant women excluded.

	Men						Women					
minutes	**Total population**	**Missing BMI**	**Under-weight**	**Normal weight**	**Over-weight**	**Obese**	**Total population**	**Missing BMI**	**Under-weight**	**Normal weight**	**Over-weight**	**Obese**
Personal care	551.5	592.4	592.8	563.9	545.3	541.8	572.2	584.1	591.0	569.4	566.8	578.0
	(1.35)	(10.99)	(11.28)	(2.92)	(2.12)	(2.62)	(1.25)	(5.11)	(8.93)	(1.81)	(2.48)	(2.95)
Household activities	85.0	60.2	61.7	81.6	91.0	82.9	137.1	141.4	115.2	133.9	142.2	138.1
	(1.17)	(5.85)	(10.44)	(2.21)	(1.91)	(2.32)	(1.36)	(5.31)	(7.71)	(1.93)	(2.63)	(2.72)
Caring for household members	20.3	18.7	12.6	17.2	20.6	23.5	41.6	49.6	33.5	43.7	39.2	39.1
	(0.50)	(3.41)	(4.09)	(0.78)	(0.63)	(1.31)	(0.63)	(3.39)	(5.26)	(1.01)	(1.38)	(1.54)
Caring for non-household members	10.7	6.6	10.6	9.9	10.9	11.5	14.8	14.7	14.7	12.8	17.5	15.5
	(0.47)	(1.76)	(4.42)	(0.71)	(0.80)	(0.98)	(0.54)	(2.02)	(4.10)	(0.80)	(1.17)	(1.00)
Paid Work	271.1	254.0	159.1	244.0	285.4	284.8	182.9	180.3	151.6	185.8	187.6	176.3
	(2.51)	(19.92)	(25.46)	(5.26)	(4.75)	(5.31)	(2.28)	(8.78)	(16.02)	(3.71)	(4.51)	(4.69)
Educational	25.5	37.3	105.3	45.8	14.6	16.1	30.0	22.2	75.0	43.0	20.6	15.2
	(1.02)	(9.16)	(19.40)	(2.45)	(0.29)	(1.69)	(1.03)	(4.15)	(10.65)	(2.22)	(2.30)	(1.83)
Purchasing goods	30.3	26.1	29.7	27.00	31.9	32.0	45.3	45.8	48.9	45.6	45.7	43.8
	(0.68)	(4.10)	(7.78)	(1.10)	(1.13)	(1.22)	(0.66)	(2.49)	(5.50)	(1.08)	(1.29)	(1.48)
Purchasing services	5.2	6.2	8.8	5.0	5.3	4.9	9.4	9.2	11.5	8.4	10.5	10.0
	(0.27)	(1.81)	(3.79)	(0.56)	(0.44)	(0.46)	(0.37)	(1.10)	(3.30)	(0.51)	(0.77)	(0.73)
Purchasing household services	1.6	0.4	0	1.4	1.7	1.8	1.1	1.1	0.4	1.3	0.7	1.2
	(0.14)	(0.20)	(0)	(0.31)	(0.24)	(0.34)	(0.08)	(0.32)	(0.31)	(0.13)	(0.10)	(0.20)
Government & civic	0.7	1.3	0.6	0.5	0.6	0.9	0.6	0.3	1.8	0.5	0.5	1.0
	(0.12)	(1.06)	(0.44)	(0.14)	(0.16)	(0.32)	(0.09)	(0.14)	(0.92)	(0.14)	(0.15)	(0.25)
Eating & drinking	76.1	59.8	67.5	77.7	77.3	74.2	71.9	67.4	73.5	74.1	72.8	68.1
	(0.58)	(2.39)	(5.41)	(1.20)	(0.98)	(1.06)	(0.54)	(2.01)	(3.52)	(0.90)	(1.12)	(1.01)
Leisure	299.8	331.4	343.7	295.5	291.3	312.9	272.1	268.2	260.8	253.2	278.7	300.9
	(2.20)	(15.09)	(23.90)	(3.98)	(3.60)	(4.06)	(1.81)	(6.24)	(13.11)	(2.84)	(3.40)	(3.97)
Sports	29.8	15.1	19.1	35.8	30.4	24.2	15.8	12.6	20.2	21.7	13.8	8.0
	(0.78)	(3.08)	(5.50)	(1.49)	(1.44)	(1.47)	(0.50)	(1.57)	(4.06)	(0.92)	(0.95)	(0.57)
Religious	7.9	11.5	6.2	7.7	7.8	7.8	11.1	10.2	8.5	10.2	11.7	12.9
	(0.31)	(2.64)	(2.32)	(0.56)	(0.44)	(0.53)	(0.33)	(1.08)	(2.11)	(0.51)	(0.68)	(0.68)
Volunteer	9.2	3.5	5.7	8.7	10.3	9.0	10.7	8.5	7.1	12.1	10.5	9.5
	(0.49)	(1.17)	(3.14)	(0.76)	(0.85)	(0.99)	(0.47)	(1.18)	(1.87)	(0.82)	(0.84)	(0.85)
Phone & Mail	3.9	3.7	6.4	5.0	3.8	2.8	10.2	7.3	11.5	10.5	10.1	10.7
	(0.20)	(1.18)	(2.42)	(0.43)	(0.32)	(0.27)	(0.31)	(1.06)	(1.65)	(0.50)	(0.51)	(0.69)
Other	11.4	12.0	10.2	13.2	11.8	8.8	13.0	17.2	14.8	14.0	11.0	11.9
	(0.51)	(2.69)	(4.54)	(1.11)	(0.97)	(0.59)	(0.43)	(1.84)	(3.58)	(0.83)	(0.66)	(0.73)
Total	1440.00	1440.00	1440.00	1440.00	1440.00	1440.00	1440.0	1440.0	1440.0	1440.0	1440.0	1440.0

Note: Activities listed are ATUS major activity groups. Travel time included with each activity. Standard errors in parenthesis.

Measure of Dissimilarity

The difference between the Missing BMI group and the other BMI groups can be measured systematically over the 17 major time use activities by using the weighted absolute-deviation index (WADI),[22] a measure of dissimilarity of time use "activity profiles" across groups. The WADI is defined as:[23]

$$WADI = \frac{\sum_{i=1}^{k} |a_i - b_i|}{\sum_{i=1}^{k} (a_i + b_i)}$$

where i = activity
k = number of activities
a_i = time in minutes spent in activity i by group a
b_i = time in minutes spent in activity i by group b

The absolute difference in times spent is divided by the total time spent in activity i by the two groups, then that is weighted by the fraction of activity i's time by total available time to groups a and b (1440 + 1440 = 2880, 1440 is the total minutes in a day). These terms are then summed over all activities.

The smaller the WADI is, the smaller the difference between the two groups, and a WADI=0 would indicate no difference in activity profiles. Stewart (2006) recommends using this index over other dissimilarity indices as it is not sensitive to the level of aggregation of activities (e.g., ATUS major groups of 2-digit activity codes versus ATUS 4-digit activity code groups) and also because short-duration activities receive little weight. The index value is "equal to the average proportional difference in the time spent in all activities." (p. 59)

WADIs by BMI group are in Table 11. Overall, the WADIs are small, indicating little difference between the activity profiles of the Missing BMI group and those of other BMI groups.[24] Among the BMI groups, the Missing BMI group had the lowest WADI with the Normal weight group both for the total population and for men. This means that looking at the time use profile of those with Missing BMI, their time use resembled that of Normal weight individuals the most. For women, the lowest WADI was with the Overweight group, which indicates that the activity profile of women with missing BMI is closest to that of overweight women.

Table 11—Measure of dissimilarity by BMI group.
2006-08 ATUS and EH Module data, population (weighted), age 15 and over, pregnant women excluded.

	Total	Missing BMI	Under-weight	Normal weight	Over-weight	Obese
Total Population WADI	0.0356	na	0.0600	0.0407	0.0513	0.0494
Men WADI	0.0626	na	0.0758	0.0566	0.0801	0.0692
Women WADI	0.0190	na	0.0586	0.0343	0.0250	0.0298

Note: Shading indicates smallest index among the BMI groups.

There is always the possibility that the long Personal Care times are due to unobserved characteristics. For example, the Missing BMI respondents could be more likely to suffer from depression or other illnesses at the time of the ATUS interview, which could result in longer sleep times and fewer activities in the time diary. However, the longer average times engaged in Personal Care may also indicate that the Missing BMI group are uncooperative respondents, that is, those who cannot remember, do not want to make the effort to remember, or do not want to disclose their activities in detail. Reporting longer sleep times allows the respondent to cover a large block of time with one activity. This is consistent with the analysis above on indicators of uncooperativeness. As a consequence, any nonresponse bias of underreported sleep time may be one of sleep time *as reported*, and not *actual* sleep time, since the Missing BMI group has a disproportionate share of uncooperative respondents.

[22] Note that weighting with respect to the WADI means applying the share of time spent on an activity of total time to each difference, whereas weighted elsewhere in this report indicates that sample weights were used to produce national estimates.
[23] From Stewart (2006).
[24] The mean BMI for those who reported height and weight age 15 and older is 27.13; for men, 27.60; and for women 26.66.

Conclusions

The 4.9 percent of Eating & Health Module respondents who did not report height and/or weight had disproportionately higher indicators of being reluctant or uncooperative respondents. It took more weeks to interview these respondents, indicating that they were reluctant to participate in the survey. They were more likely to have time diaries with little detail as measured by the number of activities in the diary, and they were more likely to have poor quality time diaries. They were less likely to answer another sensitive question on the survey, income. These findings indicate that the respondent's lack of reporting height and/or weight had less to do with the height and weight questions, but was more about the respondent's view of participating in the survey.

The time use profiles of the total population and of men with missing BMI closely resembled those of respondents with normal weight. For women, the missing BMI time profile closely resembled that of women who were overweight. This suggests that those who did not report height and weight are unlikely to be at either end of the BMI spectrum, that is, unlikely to be severely underweight or morbidly obese, mitigating any bias. Since the missing BMI respondents have time profiles close to those in the middle BMI groups (normal weight and overweight), excluding their time diaries in analysis is unlikely to produce bias in time use estimates. As a consequence of these findings, any item nonresponse bias in the Eating & Health Module height and weight data appears to be small, allowing for analysis of time use by BMI.

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