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SHPRC ***Research Short Notes***
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The Survey & Health Policy Research Center *RSN* is a valuable source of information that can be used for conducting surveys or writing research papers.

Using Total Representativeness Rates Alongside Response Rates

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Introduction

For more than two decades, the American Association of Public Opinion Research (AAPOR) response rates (RR1-RR6), the number of complete interviews divided by the number of eligibles in a sample, have been widely used among researchers for monitoring a survey during data collection or for reporting after a survey as a survey quality measure obliquely indicating nonresponse bias (see AAPOR, 2023). In the deterministic view that respondents and nonrespondents are fixed in the population, the formula of nonresponse bias can be expressed as the product of the proportion of nonrespondents relative to the population size and the statistical difference between respondents and nonrespondents (see Groves et. al, 2009, p189). The factor term "proportion of nonrespondents" in the formula has motivated researchers to obtain higher AAPOR response rates to reduce nonresponse bias. However, the AAPOR response rates have revealed three important weaknesses. Firstly, response rates cannot predict the nonresponse bias of individual survey estimates by themselves. Secondly, increasing response rates does not guarantee the reduction of nonresponse bias (Groves, 2006). Thirdly, as the response rates have been recently dropping seriously across countries regardless of data collection modes (face-to-face, telephone, and web surveys), they are increasingly losing their role as a survey quality measure, especially if the response rate is meager (e.g., less than 15% in RR1), it makes doubts about the survey quality and even becomes reluctant to make it public. Thus, another measure of survey quality is essential to compensate for these weaknesses in the AAPOR response rates. I suggest an intuitive quality measure, called a *total representativeness rate* (TRR), which can be used or publicly reported alongside AAPOR response rates. As defined and illustrated below, the TRR expressed as a single percentage, calculated based on the mean absolute difference between the respondent and population percentages divided by the mean population percentage, can confidently report that the data quality is still good, even if the response rate is low, or vice versa. TRR also eliminates the need for lengthy descriptions to indicate the representativeness of a sample of respondents. Furthermore, after poststratification weighting, it can be used to obtain a total accuracy rate of weighted sample estimates. The TRR entirely differs from the representativeness indicators (R-indicators) of Schouten et. al. (2009), which use estimated response probabilities and serve as counterparts to response rates.

Representativeness and Mean Absolute Difference

What is the representativeness, which is a popular term among researchers? As an illustration, consider a survey result with respondent percentages for gender, as given in Table 1. Can one say that the sample of respondents in the survey is "representative" of the population for gender? One can say that the sample of respondents is "representative" because he or she thinks the gender percentages of respondents are somewhat close to those in the population. However, this is a subjective judgment. For an objective one, the exact definition of representativeness should be presented and the extent of representativeness should also be presented numerically, especially by a single rate like a response rate. However, such surveys are rare.

Table 1. Respondent and Population Percentages for Gender

Gender	Respondent (%)	Population (%)
Male	54	47
Female	46	53
Total	100	100

On the other hand, can one say that only gender is enough to describe the representativeness of the population in a survey? The answer would be "No" and one is likely to add other demographic variables such as geographical location, age, race, ethnicity, income, employment status, level of education, marital status, etc.

Given these, before defining the TRR, I introduce the concept of *mean absolute difference*, which is the difference (e.g., 54% minus 47% equals 7% for males) between the respondent and population percentages for each category, such as male or female in Table 1. This arises because of coverage, sampling, measurement, and nonresponse errors. The respondent percentages are unweighted values before the weighting adjustment. Population percentages as benchmark values can usually be provided from the Census, large-scale surveys, administrative data, or databases. Population percentages include information from both respondents and nonrespondents in the sample and serve as true or near-true percentages not only in the deterministic view that respondents and nonrespondents are fixed in the population but also in the nondeterministic view that each person is potentially a respondent or a nonrespondent in the one. Regarding the representativeness of respondents, in addition to gender, one can select more survey variables in the questionnaire, including demographic variables. One can find absolute differences between the respondent and population percentages for the distinct categories classified (or defined) within the selected survey variables. It does not consider the relationship between the variables or the priorities among the variables in finding absolute differences. Then one can calculate the mean of the absolute differences. This is called the *mean absolute difference* between the respondent and population percentages.

The *mean absolute difference* between the respondent and population percentages for categories of multiple variables can be given as

$$\sum_{i=1}^{I}\sum_{j=1}^{J_i} \left|p_{ij} - P_{ij}\right| \Big/ \sum_{i=1}^{I} J_i \qquad (1)$$

where i = Survey variable

I= Total number of survey variables selected
j= A category within a survey variable
J_i = Total number of categories within a survey variable
$\sum_{i=1}^{I} J_i$ = Total number of categories within multiple variables
P_{ij} = Population percentage of a category within a survey variable
p_{ij} = Respondent percentage of a category within a survey variable

$$\sum_{j=1}^{J_i} P_{ij} = 100\,(\%)$$

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For a single survey variable, the formula (1) reduces to

$$\sum_{j=1}^{J} \left| p_j - P_j \right| \Big/ J \tag{2}$$

where j= A category within a single survey variable
J = Total number of categories within a single survey variable
P_j = Population percentage of a category within a single survey variable
p_j = Respondent percentage of a category within a single survey variable

$$\sum_{j=1}^{J} P_j = 100\,(\%)$$

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To clarify the meaning of "representativeness," Definitions 1 and 2 can be given using the term *mean absolute difference*.

Definition 1. A sample of respondents of the target or achieved size is said to be representative of the population if the *mean absolute difference* between the respondent and population percentages for categories of a single survey variable, multiple survey variables, key survey variables, or demographic survey variables selected does not exceed a tolerance percentage.

Definition 2. A sample of respondents of the target or achieved size is said to be demographically representative of the population if the *mean absolute difference* between the respondent and population percentages for categories of demographic survey variables selected does not exceed a tolerance percentage.

A tolerance percentage in Definitions 1 and 2 that one can choose may be divided as follows:

80%+: almost perfectly representative
50-80%: highly representative
20-50%: moderately representative
Less than 20%: poorly representative

Depending on the selected survey variables, the *mean absolute difference* in Definitions 1 and 2 may not be within a certain range and fluctuate significantly. I define the TRR to avoid such a problem.

Total Representativeness Rates

The TRR, a single rate, can be expressed as the unweighted TRR in Definition 3 or the weighted TRR in Definition 4. To calculate the TRR, one can select any number of survey variables that consist of multiple, key, demographic variables, or any combination of those in the questionnaire. The "total" represents all the survey variables selected. The TRR always lies between 0 and 100. As given in Definition 3. the unweighted TRR is calculated based on the *unweighted mean absolute difference* in the nominator, which is the mean absolute difference (1) described above. In contrast, the weighted TRR is calculated based on the *weighted mean absolute difference* in the nominator for reflecting the differences (variation) between population percentages for categories of survey variables (e.g., the differences between 47% and 53% in the population in Table 1). Each TRR introduces the mean population percentage in the denominator to find the *relative unweighted or weighted mean absolute difference*. I would recommend using the weighted TRR.

Definition 3. The unweighted total representativeness rate (UTRR) for categories of multiple, key, demographic survey variables, or any combination of those is defined by

$$
\begin{aligned}
UTRR &= 100-\left(\text{Relative Unweighted Mean Absolute Differece} \bullet 100\right) \\
&= 100-\left(\frac{\text{Unweighted Mean Absolute Difference}}{\text{Mean Population Percentage}}\times 100\right) \\
&= 100-\left(\frac{\sum_{i=1}^{I}\sum_{j=1}^{J_i}\left|p_{ij}-P_{ij}\right| \Big/ \sum_{i=1}^{I}J_i}{\sum_{i=1}^{I}\sum_{j=1}^{J_i}P_{ij} \Big/ \sum_{i=1}^{I}J_i}\bullet 100\right)
\end{aligned}
$$

$$= 100 - \left(\frac{\sum_{i=1}^{I} \sum_{j=1}^{J_i} \left| p_{ij} - P_{ij} \right|}{\sum_{i=1}^{I} \sum_{j=1}^{J_i} P_{ij}} \bullet 100 \right) \tag{3}$$

For a single survey variable, the formula (3) reduces to

$$100 - \left(\frac{\sum_{j=1}^{J} \left| p_j - P_j \right|}{\sum_{j=1}^{J} P_j} \bullet 100 \right) \tag{4}$$

Definition 4. The weighted total representativeness rate (WTRR) for categories of multiple, key, demographic survey variables, or any combination of those is defined by

$$\begin{aligned}
WTRR &= 100 - (\text{Relative Weighted Mean Absolute Differece} \bullet 100) \\
&= 100 - \left(\frac{\text{Weighted Mean Absolute Difference}}{\text{Mean Population Percentage}} \times 100 \right) \\
&= 100 - \left(\frac{\sum_{i=1}^{I} \sum_{j=1}^{J_i} P_{ij} \left| p_{ij} - P_{ij} \right| \Big/ \sum_{i=1}^{I} \sum_{j=1}^{J_i} P_{ij}}{\sum_{i=1}^{I} \sum_{j=1}^{J_i} P_{ij} \Big/ \sum_{i=1}^{I} J_i} \bullet 100 \right) \\
&= 100 - \left(\frac{\sum_{i=1}^{I} J_i \bullet \sum_{i=1}^{I} \sum_{j=1}^{J_i} P_{ij} \left| p_{ij} - P_{ij} \right|}{\left(\sum_{i=1}^{I} \sum_{j=1}^{J_i} P_{ij} \right)^2} \bullet 100 \right)
\end{aligned} \tag{5}$$

For a single survey variable, the formula (5) reduces to

$$100 - \left(\frac{J \bullet \sum_{j=1}^{J} P_j \left| p_j - P_j \right|}{\left(\sum_{j=1}^{J} P_j \right)^2} \bullet 100 \right) \tag{6}$$

Definition 5. The unweighted total unrepresentativeness rate (UTUR) is defined by

$$UTUR = 100 - UTRR = \frac{\sum_{i=1}^{I}\sum_{j=1}^{J_i} \left| p_{ij} - P_{ij} \right|}{\sum_{i=1}^{I}\sum_{j=1}^{J_i} P_{ij}} \bullet 100 \qquad (7)$$

Definition 6. The weighted total unrepresentativeness rate (WTUR) is defined by

$$WTUR = 100 - WTRR = \frac{\sum_{i=1}^{I} J_i \bullet \sum_{i=1}^{I}\sum_{j=1}^{J_i} P_{ij} \left| p_{ij} - P_{ij} \right|}{\left(\sum_{i=1}^{I}\sum_{j=1}^{J_i} P_{ij} \right)^2} \bullet 100 \qquad (8)$$

Definition 7. After poststratification weighting by some variables, the weighted total accuracy rate (WTAR) of weighted sample estimates (percentages) for categories of multiple, key, demographic survey variables, or any combination of those is defined by

$$WTAR \;=\; 100 - \left(\frac{\sum_{i=1}^{I} J_i \bullet \sum_{i=1}^{I}\sum_{j=1}^{J_i} P_{ij} \left| e_{ij} - P_{ij} \right|}{\left(\sum_{i=1}^{I}\sum_{j=1}^{J_i} P_{ij} \right)^2} \bullet 100 \right) \qquad (9)$$

where i = Survey variable

I = Total number of survey variables selected

j = A category within a survey variable

J_i = Total number of categories within a survey variable

P_{ij} = Population percentage of a category within a survey variable

e_{ij} = Weighted sample estimate (percentage) of a category within a survey variable

On the other hand, the standard deviation of absolute differences (SDAD), which represents the variation between respondent and population percentages, can be calculated by

$$SDAD = \sqrt{\sum_{i=1}^{I}\sum_{j=1}^{J_i} \left[\left| p_{ij} - P_{ij} \right| - \left\{ \sum_{i=1}^{I}\sum_{j=1}^{J_i} \left| p_{ij} - P_{ij} \right| / \sum_{i=1}^{I} J_i \right\} \right]^2 \Big/ \sum_{i=1}^{I} J_i} \qquad (10)$$

Illustrations

Kim and Couper (2021, 2024) conducted national RDD telephone and smartphone web surveys for the adult population, and these surveys had low AAPOR response rates. With the details of final disposition distributions and response rates, they provided a lengthy discussion of the representativeness of an RDD sample of respondents. I will show how to report the TRR alongside response rates, with only a few lines, as below.

Telephone Survey

Kim and Couper (2021) conducted a national RDD telephone survey (interviewer-administered) for their study and reported respondent and population percentages for 3 demographic survey variables, as presented in Table 2. Their telephone survey had 968 completed interviews and a response rate (RR1) of 10.6%, which is comparatively low and creates doubts about the survey quality. For the details, see Table 2 and Table 3 on pages 1225-1226 of Kim and Couper (2021).

The UTRR for 15 categories of 3 demographic survey variables was 75.6%, whereas the WTRR was 67.1%. Using WTRR, one can report publicly as follows:

"An RDD telephone survey with completed interviews of 968 (8.5%) out of an initial RDD sample size of 15,000 (100.0%) obtained a response rate of 10.6% (RR1). Despite a low response rate, the total representativeness rate across 15 categories within 3 demographic variables was 67.1%, which indicates a total unrepresentativeness rate of 32.9 %. Thus, a sample of respondents of size 968 was highly demographically representative of the adult population."

Smartphone Web Survey

Kim and Couper (2024) conducted a national RDD smartphone web survey (self-administered) using a commercial SMS text messaging service for their study. They obtained respondent and population percentages for 5 demographic survey variables in Table 3. Also, they produced weighted sample estimates after poststratification weighting and population percentages, as shown in Table 4. Their web survey had 1,532 completed interviews and a response rate (RR1) of 7.6%, which is very low. For the details, see Table 2 and Table 3 on pages 1252-1253 of Kim and Couper (2024).

The UTRR for 23 categories of 5 demographic survey variables was 69.8%, whereas the WTRR was 60.8%. WTAR, calculated across 23 categories within 5 demographic variables after poststratification weighting for three demographic variables (gender, age, and education), was 96.8%. Using WTRR and WTAR as well as SDAD, one can report publicly as follows:

"An RDD smartphone web survey, which had completed interviews of 1,532 (5.1%) out of an initial RDD sample size of 30,000 (100.0%), obtained a response rate of 7.6% (RR1) and showed a total representation rate of 60.8% (standard deviation of absolute differences of 7%) across 23 categories within 5 demographic variables. Thus, the total unrepresentativeness rate was 39.2% and the respondents were highly demographically representative of the adult population. After poststratification weighting for three demographic variables (gender, age, and education), the total accuracy rate across 23 categories within 5 demographic variables was 96.8%, close to 100%."

Table 2. Respondent and Population Percentages in a National RDD Telephone Survey

Variables	Respondent Percentage (Signed Difference)	Adult Population Percentage
Administrative Divisions		
8 Cities		
Seoul	27.4 (8.1)	19.3
Pusan	6.2 (-0.5)	6.7
Incheon	6.2 (0.5)	5.7
5 other cities	12.2 (-1.0)	13.2
9 Provinces		
Gyeonggi	25.6 (0.6)	25.0
Gyeongnam	3.3 (-3.1)	6.4
Gyeongbuk	3.6 (-1.6)	5.2
6 other provinces	15.4 (-3.1)	18.5
Gender		
Male	59.6 (9.8)	49.8
Female	40.4 (-9.8)	50.2
Age groups		
19 – 29	32.7 (14.9)	17.8
30 – 39	19.9 (2.6)	17.3
40 – 49	16.5 (-3.1)	19.6
50 – 59	15.8 (-4.0)	19.8
60 or older	15.1 (-10.4)	25.5

Note. The respondent percentage is an unweighted sample estimate. The signed difference is between the respondent percentage and the adult population percentage.

Table 3. Respondent and Population Percentages in a National RDD Smartphone Web Survey

Variables	Respondent Percentage (Signed Difference)	Adult Population Percentage
Administrative Divisions		
8 Cities		
Seoul	22.9 (3.7)	19.2
Pusan	5.2 (-1.5)	6.7
Incheon	5.4 (-0.3)	5.7
5 other cities	13.9 (0.9)	13.0
9 Provinces		
Gyeonggi	27.3 (2.0)	25.3
Gyeongnam	5.2 (-1.2)	6.4
Gyeongbuk	4.4 (-0.8)	5.2
6 other provinces	15.7 (-2.8)	18.5
Gender		
Male	50.9 (1.3)	49.6
Female	49.1 (-1.3)	50.4
Age groups		
19–29	33.7 (16.7)	17.0
30–39	23.9 (7.9)	16.0
40–49	19.2 (0.1)	19.1
50–59	13.6 (-6.3)	19.9
60 or older	9.6 (-18.4)	28.0
Level of education		
High school graduate or less	23.2 (-26.0)	49.2
Two/three-year degree	18.2 (3.5)	14.7
Four-year degree	46.2 (15.5)	30.7
Postgraduate degree	12.4 (7.0)	5.4
Current marital status		
Married	49.9 (-8.5)	58.4
Widowed	1.2 (-6.3)	7.5
Divorced	4.0 (-2.0)	6.0
Single	44.9 (16.8)	28.1

Note. The respondent percentage is an unweighted sample estimate. The signed difference is between the respondent percentage and the adult population percentage.

Table 4. Weighted Sample Estimates after Poststratification Weighting and Population Percentages in a National RDD Smartphone Web Survey

Variables	Weighted Sample Estimate (Signed Difference)	Adult Population Percentage
Administrative Divisions		
8 Cities		
Seoul	21.6 (2.4)	19.2
Pusan	5.5 (-1.2)	6.7
Incheon	5.4 (-0.3)	5.7
5 other cities	11.6 (-1.4)	13.0
9 Provinces		
Gyeonggi	26.7 (1.4)	25.3
Gyeongnam	6.5 (0.1)	6.4
Gyeongbuk	5.3 (0.1)	5.2
6 other provinces	17.4 (-1.1)	18.5
Gender		
Male	49.5 (-0.1)	49.6
Female	50.5 (0.1)	50.4
Age groups		
19–29	17.1 (0.1)	17.0
30–39	15.7 (-0.3)	16.0
40–49	18.9 (-0.2)	19.1
50–59	19.8 (-0.1)	19.9
60 or older	28.5 (0.5)	28.0
Level of education		
High school graduate or less	49.2 (0.0)	49.2
Two/three-year degree	14.7 (0.0)	14.7
Four-year degree	30.7 (0.0)	30.7
Postgraduate degree	5.4 (0.0)	5.4
Current marital status		
Married	60.5 (2.1)	58.4
Widowed	5.3 (-2.2)	7.5
Divorced	7.4 (1.4)	6.0
Single	26.8 (-1.3)	28.1

Model-Assisted Total Representativeness Rates

Unweighted TRR or weighted TRR can be calculated using a statistical model. For this, one first finds the equation of a linear regression line for population percentages as values of the independent variable (X) and respondent percentages as values of the dependent variable (Y). The equation can be written in the form $y = \hat{\alpha} + \hat{\beta}x$ where $\hat{\alpha}$ and $\hat{\beta}$ are the estimates of regression coefficients. Second, one obtains predicted respondent percentages by inputting the population percentages into the equation. Third, one calculates the unweighted TRR or the weighted TRR using predicted respondent and population percentages. I call this model-assisted TRR.

Illustration

I illustrate how to calculate model-assisted TRR for a national RDD smartphone web survey Kim and Couper (2024) conducted for the adult population. Figure 1 represents a scatter plot and a fitted simple regression model for respondent and population percentages, shown in Table 3. The fitted model was $y = 0.8325x + 3.6407$. It had a coefficient of determination of 0.6709 and was significant at a 1% significance level.

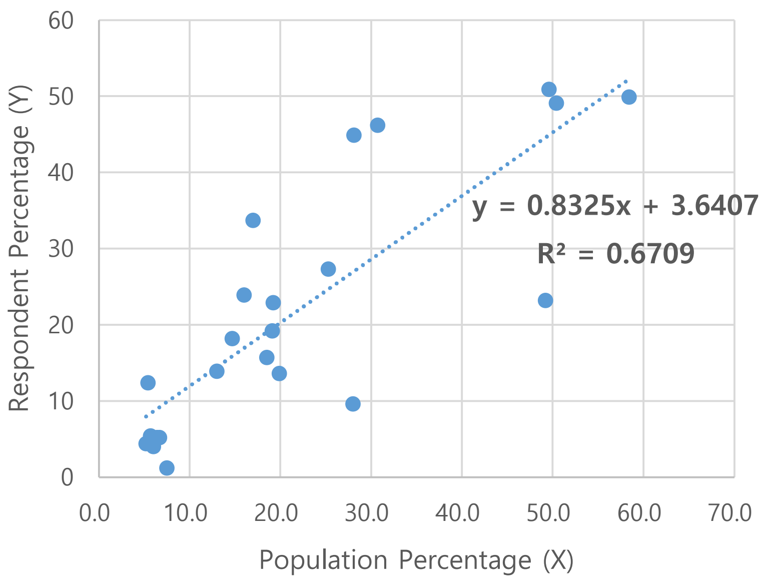

Figure 1. Scatter Plot and Fitted Regression Model of Respondent and Population Percentages in a National RDD Smartphone Web Survey

Table 5 shows predicted respondent percentages obtained by substituting population percentages in the fitted equation. When calculating by using predicted respondent and population percentages in the table, the model-assisted UTRR for 23 categories of 5 demographic survey variables was 90.2% and the model-assisted WTRR was 87.2%. These values are higher than the UTRR of 69.8% and the WTRR of 60.8%.

Table 5. Predicted Respondent Percentages and Population Percentages in a National RDD Smartphone Web Survey

Variables	Predicted Respondent Percentage (Signed Difference)	Adult Population Percentage
Administrative Divisions		
8 Cities		
Seoul	19.6 (0.4)	19.2
Pusan	9.2 (2.5)	6.7
Incheon	8.4 (2.7)	5.7
5 other cities	14.5 (1.5)	13.0
9 Provinces		
Gyeonggi	24.7 (-0.6)	25.3
Gyeongnam	9.0 (2.6)	6.4
Gyeongbuk	8.0 (2.8)	5.2
6 other provinces	19.0 (0.5)	18.5
Gender		
Male	44.9 (-4.7)	49.6
Female	45.6 (-4.8)	50.4
Age groups		
19–29	17.8 (0.8)	17.0
30–39	17.0 (1.0)	16.0
40–49	19.5 (0.4)	19.1
50–59	20.2 (0.3)	19.9
60 or older	27.0 (-1.0)	28.0
Level of education		
High school graduate or less	44.6 (-4.6)	49.2
Two/three-year degree	15.9 (1.2)	14.7
Four-year degree	29.2 (-1.5)	30.7
Postgraduate degree	8.1 (2.7)	5.4
Current marital status		
Married	52.3 (-6.1)	58.4
Widowed	9.9 (2.4)	7.5
Divorced	8.6 (2.6)	6.0
Single	27.0 (-1.1)	28.1

Note. The predictive respondent percentage is an unweighted sample estimate. The signed difference is between the predictive respondent percentage and the adult population percentage.

Conclusions

The AAPOR response rates have been widely used among researchers for more than two decades. Despite this popularity, they have some important weaknesses. One is that higher response rates do not guarantee low nonresponse bias. Another is that there has been a serious decline in response rates across countries, if response rates are low, it raises doubts regarding the survey quality. To compensate for these weaknesses in the AAPOR response rates. I suggested total representativeness rates. As illustrated, they can be easily and conveniently used or publicly reported alongside AAPOR response rates, even if the response rate is low, or vice versa. Also, after applying poststratification weighting, the total accuracy rate of weighted sample estimates can be calculated using a similar method. In addition, model-assisted total representativeness rates are available as predictive values. Using the total representativeness rates would benefit researchers in delivering confidence in their survey quality to the public.

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