Assessing Different Methods of Addressing Nonresponse in the 2020 Census Post Enumeration Survey

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ABSTRACT

The Census Bureau conducted a Post-Enumeration Survey (PES) to assess coverage of the 2020 Census of U.S. household population. The PES used nonresponse adjustments to mitigate potential bias in survey estimates resulting from differing characteristics between responding and nonresponding housing units.

This study evaluates four nonresponse adjustment methods on 2020 Census data, simulating nonresponse based on three types of missingness and performs a dual-system estimation to determine the net error of each method.

Design and Methodology

- Generate population estimate with estimator; experiment uses the following data
  - 2020 Census PES Person P-Sample
  - 2020 Census Frame
  - 2020 Demographic Frame
  - Person and housing level auxiliary covariates
- Nonresponse simulated via Bernoulli distribution; probability simulated under three types of missingness:
  - Missing Completely At Random (*MCAR*)
  - Missing at Random (*MAR*)
  - Missing Not at Random (*MNAR*)
- Nonresponse simulated at household level; all individuals recorded in a household considered nonrespondents if household simulated to be nonresponding
- 33 responses drawn for each missingness
- Four nonresponse adjustment methods were evaluated:
  - Propensity Stratification Calibration
  - 1-Stage Calibration (calibrated towards the 2020 Demographic Frame)
  - 2-Stage Calibration (calibrated towards the 2020 Demographic Frame and using calculated Propensity Stratification weights)
  - Household Imputation (using the Demographic Frame to fill nonresponding housing units)

Results and Discussion

Table 1: Normalized RMSE of National Population Estimate

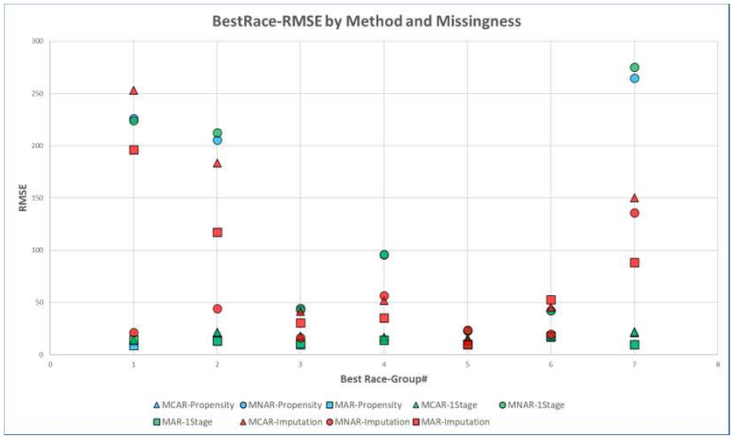
	Propensity Stratification	1-Stage Calibration	2-Stage Calibration*	Household Imputation
MAR	16.20	15.76	-	346.2
MNAR	397.4	403.2	-	106.0
MCAR	8.21	11.86	-	246.7

*suppressed

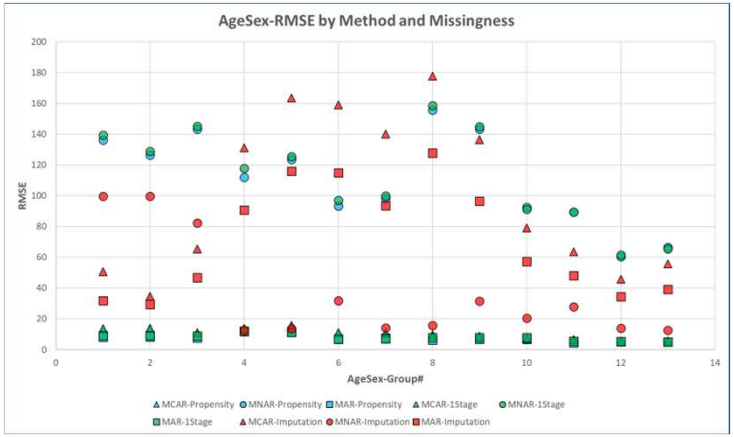
Performance Scale
Worst — Best

- Propensity Stratification Calibration and 1-Stage Calibration produced estimates closest to the baseline estimate, specifically on MCAR and MAR generated nonresponse, respectively.
- On average, nonresponse adjustment methods performed best when missingness was generated MCAR and MAR.

- All methods produced lower RMSE for three races across all missingness mechanisms
- Overall trends between methods consistent with national estimates given a race category



- Methods produce lower RMSE for the oldest age group, given MNAR



Formulas

$Nonresponse \sim Bernoulli(p_{missingness})$

Probability of response missing

- $MCAR$: $p_{missingness} \sim U(.8, .85)$
- MAR: $logit(p_{missingness}) = c_0 + \sum_{i \in X} c_i * x_i$
  X_1 observed variables vector
  $c_i \sim N(\mu_i, \sigma_i)$
  $logit(p) = \log(\frac{p}{1-p})$
- $MNAR$: $logit(p_{missingness}) = d_0 + \sum_{i \in Y} d_i * y_i$
  Y unobserved variables vector
  $c_i \sim N(\mu_i, \sigma_i)$

$Population\ Estimator$:

$$\widehat{N} = \sum_{i \in Census} \left(\frac{1}{p_{CensusCapture,i}}\right)$$

$$p_{match,i} = sigmoid\left(\sum_{i \in Sample} a_i * z_i\right)$$

X_2 observed variable vector

$sigmoid(x) = \frac{1}{1+\exp(-x)}$

$$\text{Normalized RMSE} = \sqrt{\frac{\sum_{k=1}^{n}(\hat{y}_i - y)^2}{y * n}}$$

$n = 33$ simulations

Conclusions

- Propensity Stratification and 1-stage Calibration methods produced lowest RMSE under MCAR and MAR
- Household Imputation performed the worst
- Some differential performance given an adjustment method was observed by race and age/sex groups, with younger people and white, black, and Hispanic groups performing the poorest
- 1-stage/2-stage calibration the most computationally intensive

The views expressed are those of the authors and not those of the U.S. Census Bureau.

The data in this presentation have been cleared for release under DRB Number CBDRB-FY24-0278