Evaluation of the Current Weighting Methodology for BRFSS and Improvement Alternatives

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Joint Statistical Meetings

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Mansour Fahimi, Darryl Creel, and Paul Levy

RTI International

Michael Link and Ali Mokdad

BSB, CDC

Presentation Outline

- Current weighting methodology for BRFSS
- Possible areas of improvement/current shortfalls
- Alternative weighting schemes
- Evaluation criteria
- Results
- Additional weighting enhancements
- Summary

Design of BRFSS

- A monthly, state-based RDD sample design to secure about 300,000 interviews each year:
  - 2004 state sample sizes ranged from 2,656 in AK to 18,587 in WA;
  - A median state-level sample size of 5,903; and
  - A median state-level response rate of 52.7%.
- One adult aged 18 or older is chosen at random for interview.

Current Weighting Methodology for BRFS

- Design (base) weights calculated to reflect design features:
  - Geographic stratification: state or region
  - Telephone bank stratification: listed and unlisted telephone banks
- Household level adjustments to reflect subsampling for:
  - Multiple telephones lines
  - Multiple adults
- Poststratification/benchmarking to match published totals:
  - Geographic: state and region
  - Demographics: gender by age, or gender by age by race/ethnicity

Possible Areas of Improvement

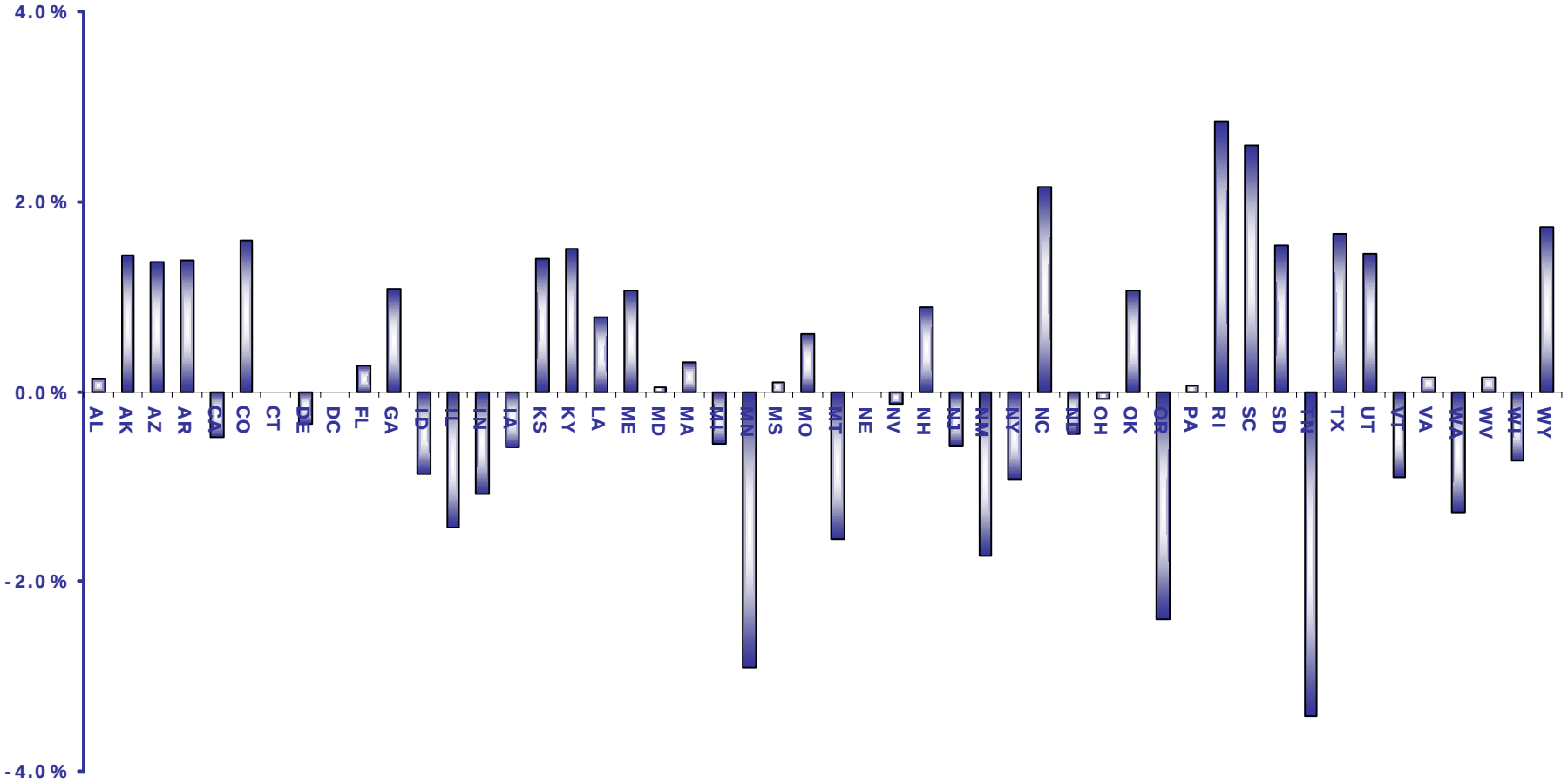
- Advantage is not taken from more comprehensive weighting techniques:
  - Too few variables are included in the weighting (balancing) process
  - There are no adjustments related to the socioeconomic status of respondents (germane to BRFSS)
- The current methodology is not applied uniformly across all states:
  - Many states do not use race/ethnicity for weighting and those that do only use two crude categories: Non-Hispanic White vs. Others
  - Certain states do not use detailed age classification

Implications

- BRFSS weighted estimates need to track more published figures in each state by:
  - Demographic indicators:
    - Race/ethnicity
    - Age
    - Gender
  - Socioeconomic indictors:
    - Employment status
    - Educational attainment
    - Marital status

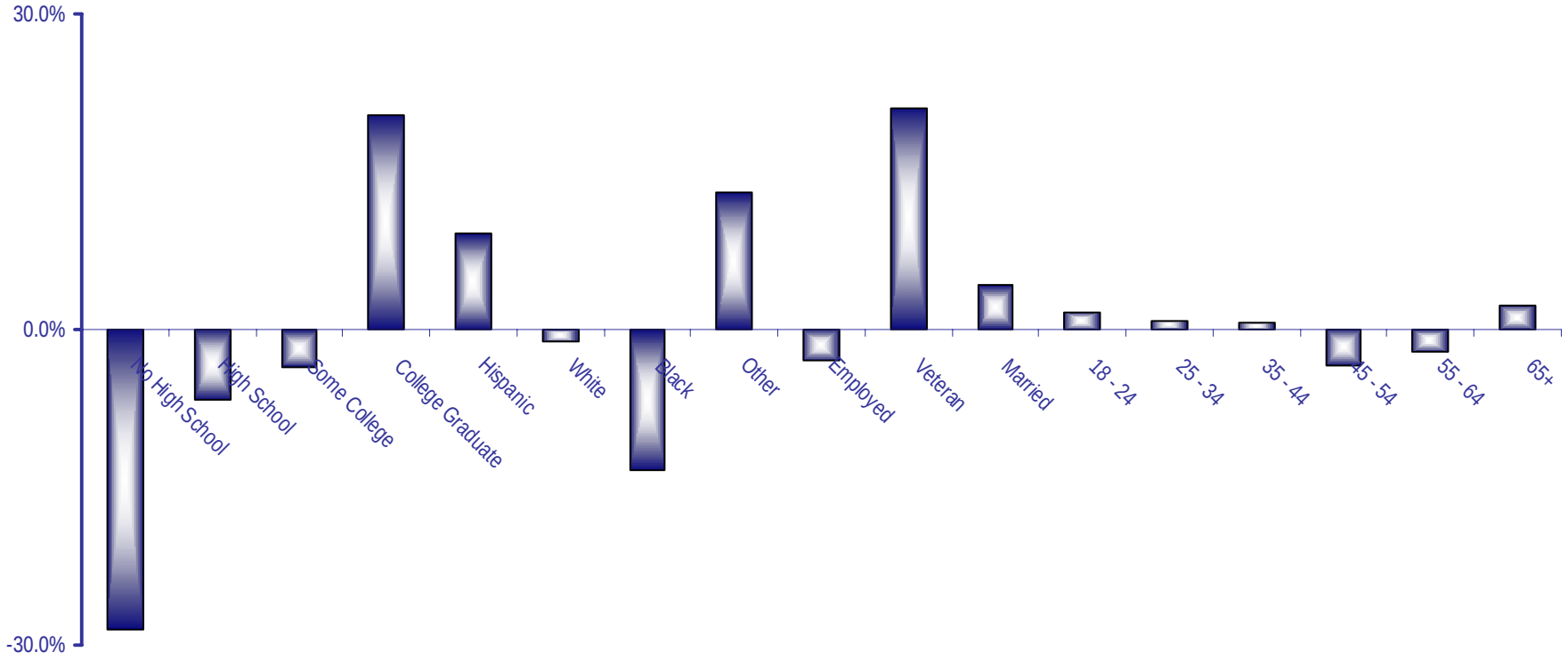
Relative Difference Between BRFSS and CPS Estimates

(Population Proportions by States)



Relative Difference Between BRFSS and CPS Estimates

(Population Proportions by Demographics and Socioeconomic Indicators)



Motivation for Alternative Weighting Methodology

If certain geographic, socioeconomic, and demographic indicators are associated with behavioral risk factors, they should be used in the weighting process to reduce coverage bias and increase stability of survey estimates over time.

Important Predictors of Key Outcome Measures

General Health	Health Plan	Exercise	Smoking
Employment	Income	Education	Education
Education	Age	Income	Veteran
Income	Employment	Employment	Age
Age	Education	Race	Race
Race	Marital Status	Age	Employment
Marital Status	Race	Marital Status	Marital Status
State	State		Income
			Gender
			State

Important Predictors of Key Outcome Measures

Alcohol	Asthma	Diabetes	Flu Shot
Employment	Employment	Age	Age
Age	Gender	Employment	Employment
Marital Status	State	Gender	Marital Status
State	Age	Income	Veteran
Income	Marital Status	State	
Race	Veteran	Race	
Education	Education	Martial Status	
Gender	Income	Veteran	
Veteran	Race	Education	

An Alternative Weighting Methodology

- Raking (Iterative Proportional Fitting – IPF) along multiple dimensions
- Including more variables in the weighting process
  - Educational attainment
  - Employment status
  - Marital status
- Using more detailed classification of variables
- Applying the weighting process uniformly across all states

Potential Raking Alternatives

(Amongst 255 Potential Raking Dimensions)

First Dimension	Second Dimension
Race * Age Group * Employment * Marital Status	State * Gender * Education
Race * Education * Employment * Marital Status	State * Gender * Age Group
Gender * Race * Age Group * Marital Status	State * Education * Employment
Gender * Race * Education * Age Group	State * Employment * Marital Status
State * Gender * Employment * Marital Status	Race * Education * Age Group
State * Gender * Employment * Marital Status	Gender * Race * Education * Age Group

Evaluation of the Raking Options

- Comparisons of population estimates BRFSS vs. CPS:
  - Population distribution by state
  - Demographic indicators
  - Socioeconomic indicators
- Evaluation of variance inflation due to weighting (unequal weighting effect – UWE)
- Evaluation of mean square error ratios (MSER)

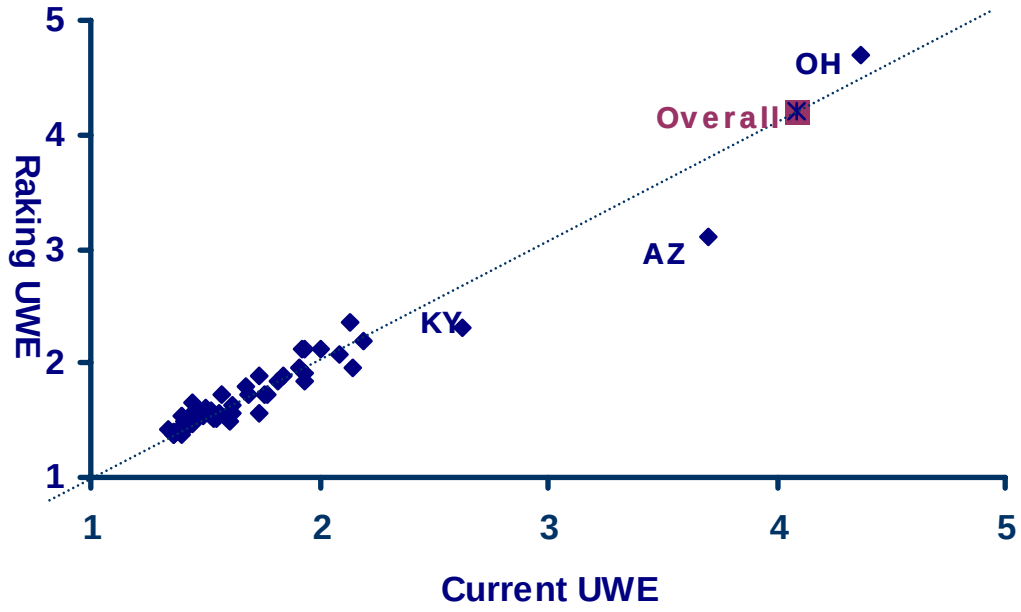
Tracking Published Estimates
(Pros)

- Under the new weighting alternative BRFSS and CPS estimates match exactly on:
  - Detailed age categories
  - Detailed race/ethnicity categories
  - Educational attainment categories
  - Marital status
  - Employment status
  - Proportion of adults in each state
  - Gender

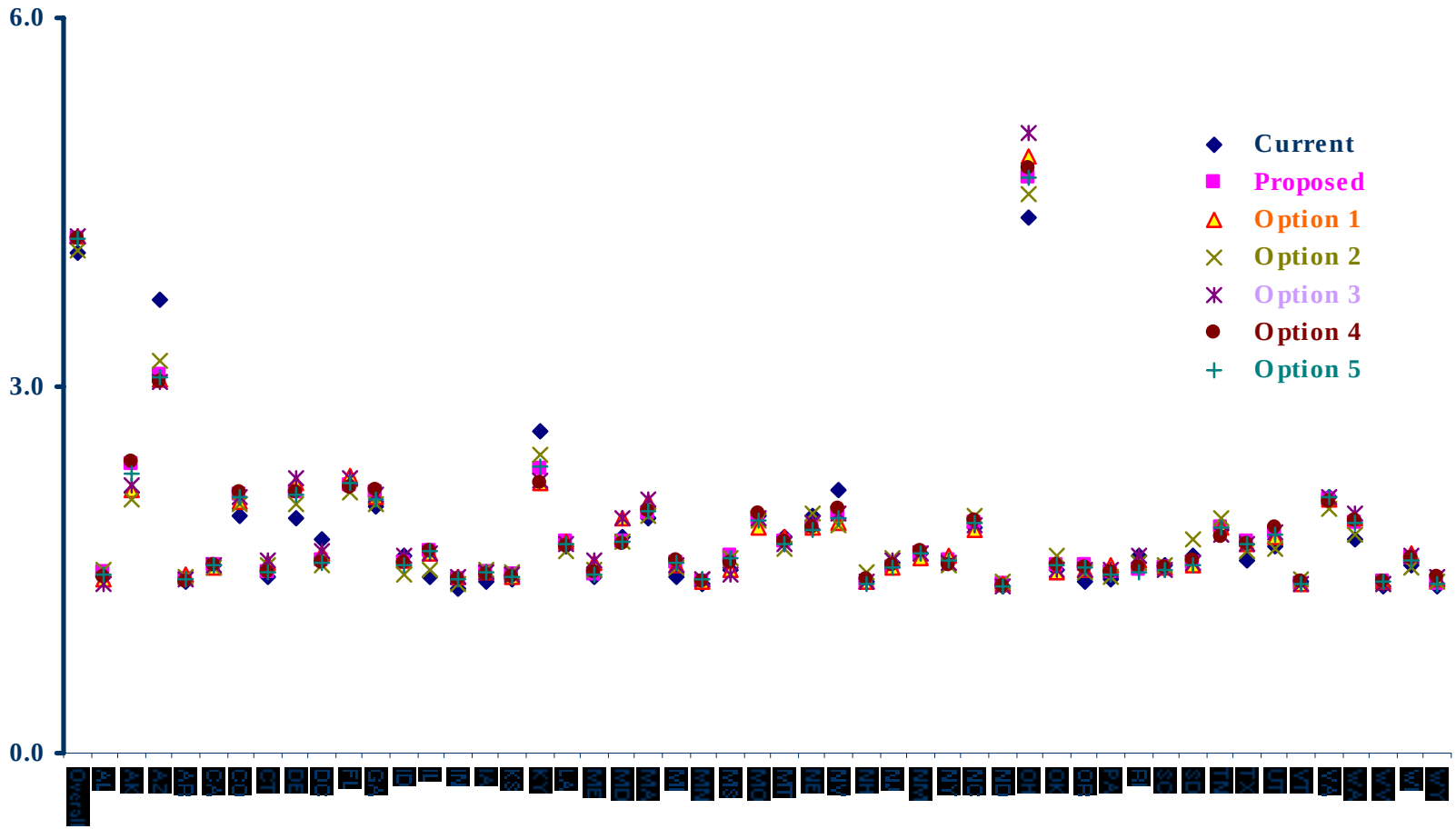
Variance Inflation Due to Weighting (Cons)

- Variance inflation due to unequal weighting (UWE) can be measured by:

$$UWE = 1 + ((cv(w))^2 = \frac{n\sum_{i=1}^{n} w_i^2}{\left(\sum_{i=1}^{n} w_i\right)^2}$$



Variance Inflation Due to Weighting (Cons)



Bias Reduction vs. Variance Inflation

(Mean Square Error Ratio: MSER)

- Mean Square Error Ratio (MSER) is an indicator that takes into account the negative effect of variance inflation as well as the positive gain due to bias reduction:

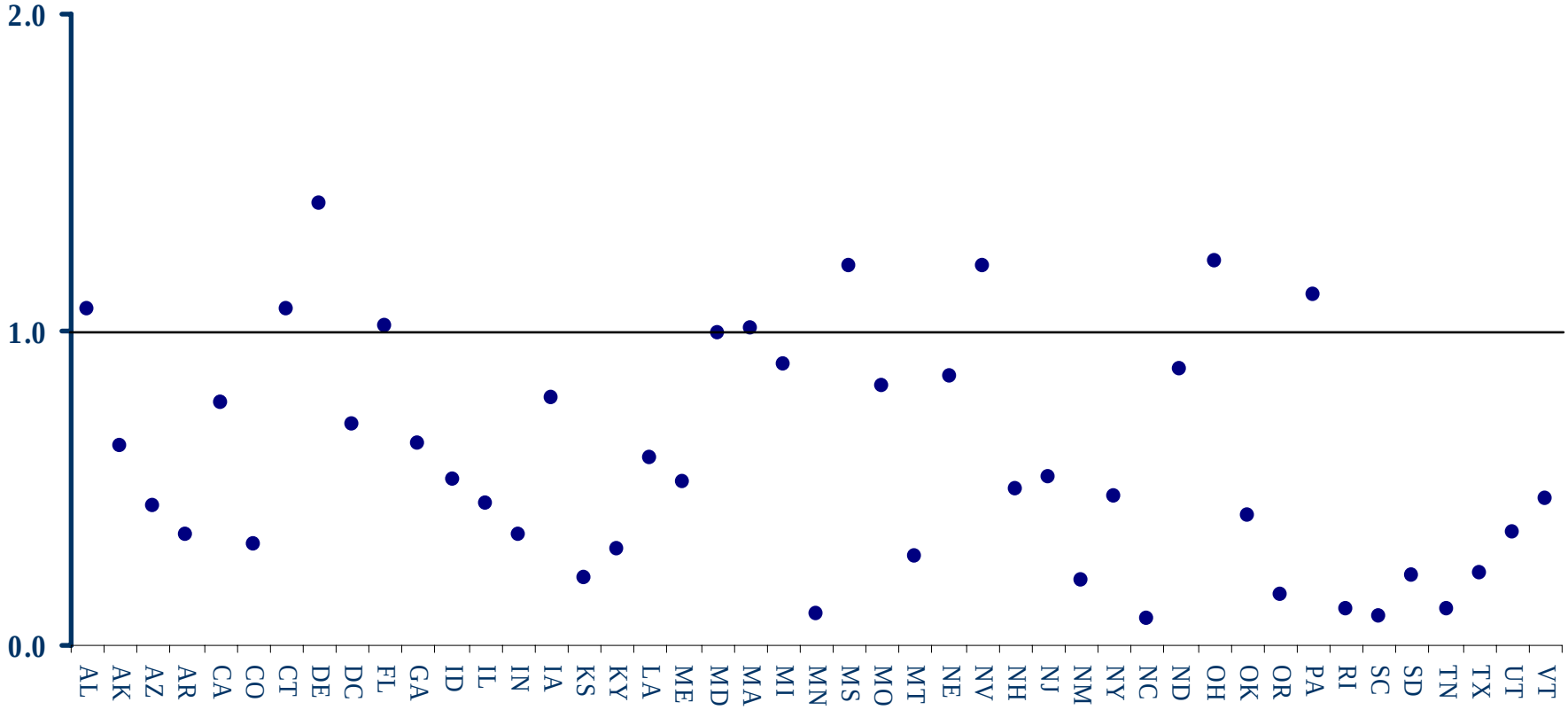
$$MSER(\hat{p}) = \frac{MSE(\hat{p}_{New})}{MSE(\hat{p}_{Old})}$$

- Assuming the bias reduction under the raking methodology will render the resulting point estimate unbiased:

$$MSER(\hat{p}) = \frac{V(\hat{p}_{New})}{V(\hat{p}_{Old}) + (\hat{p}_{Old} - \hat{p}_{CPS})^2}$$

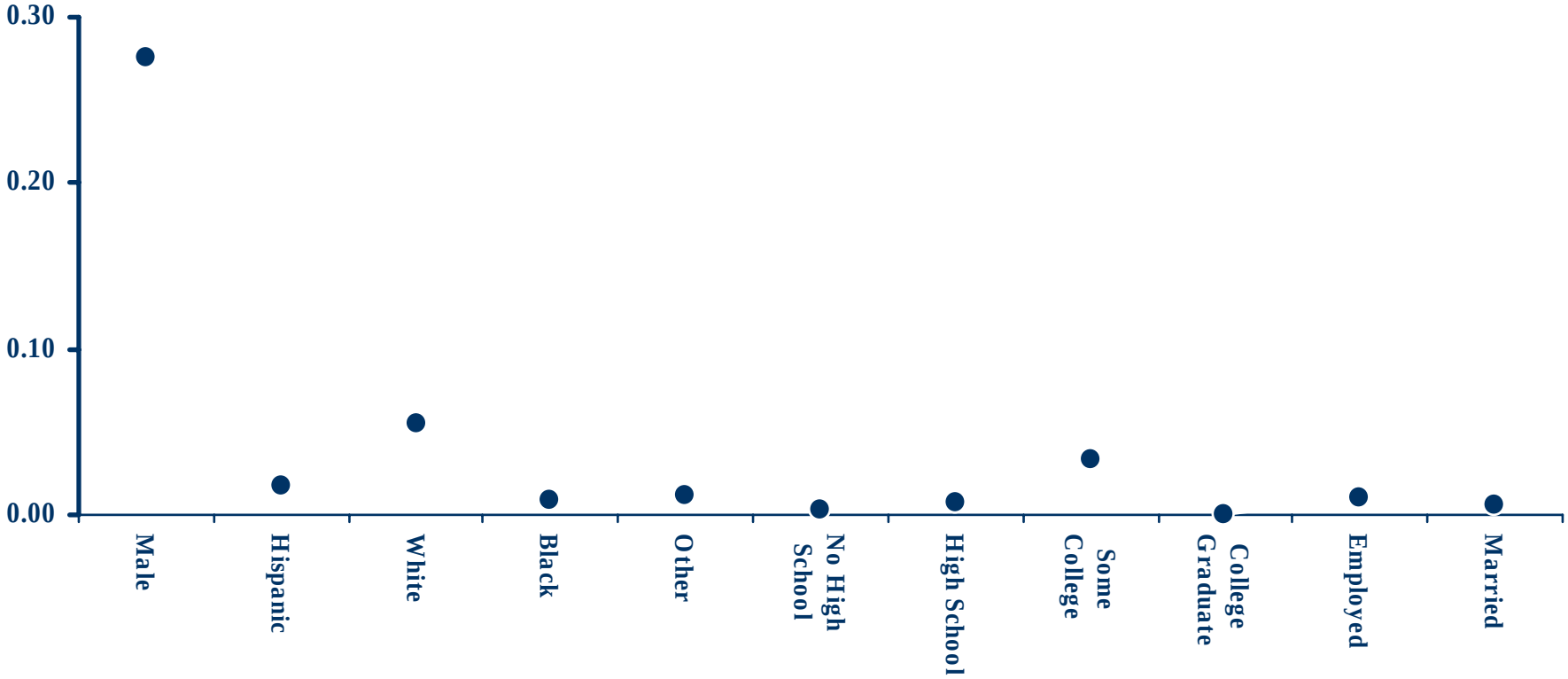
Mean Square Error Ratio

(Proportion of adults by States)



Mean Square Error Ratio

(Demographic and Socioeconomic Indicators)

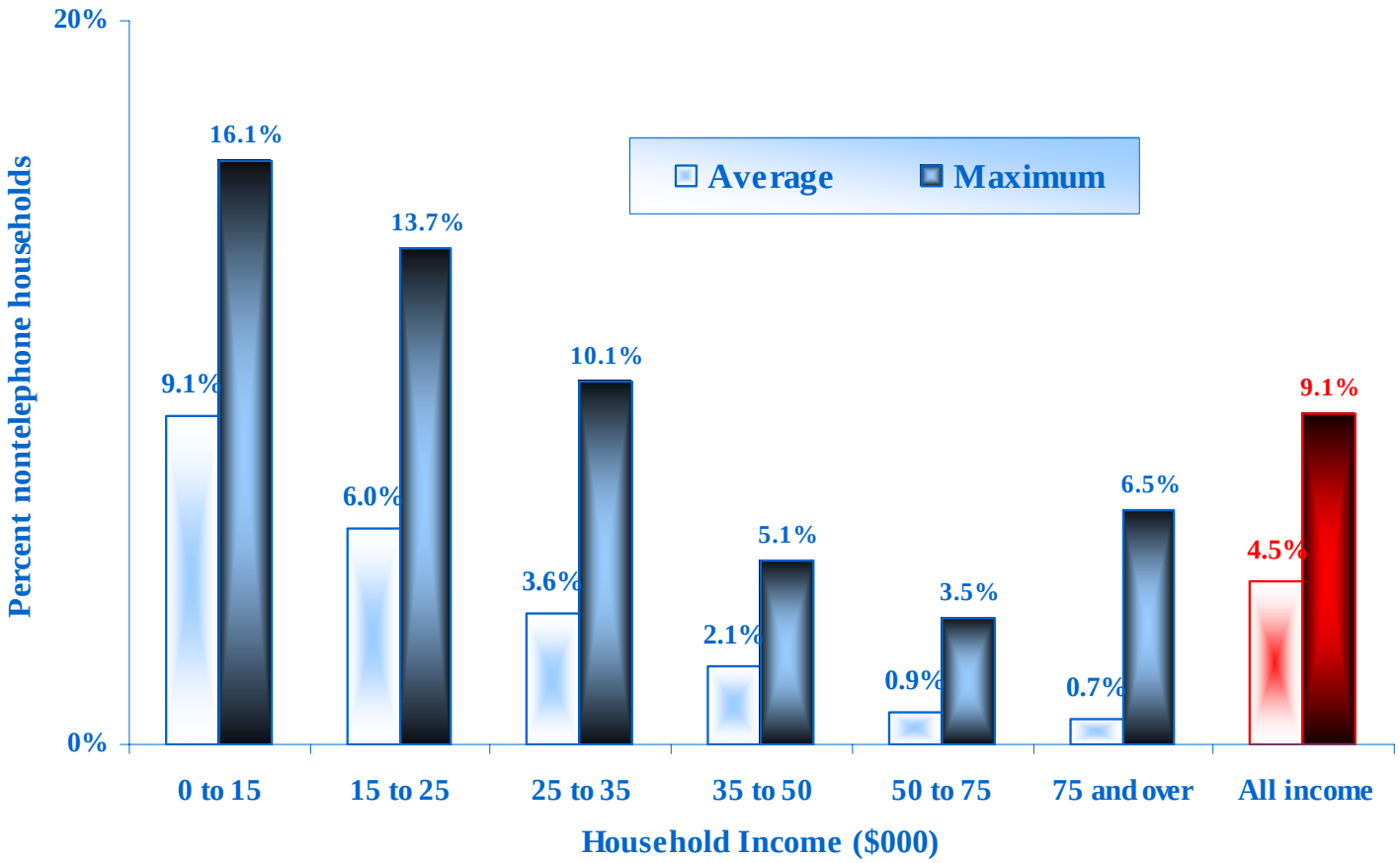


Additional Weighting Enhancements

- RDD surveys miss nontelephone households:
  - The current weighting method does very little to remedy this problem
  - The proposed raking methodology does a better job eliminating some of the noncoverage bias
- Can use interruption in telephone service as a surrogate for having no telephone:
  - Consider nontelephone households as “nonrespondents”
  - Let households with service interruption “speak” for nontelephone households
- Interrupted Telephone Service Adjustment (*ITSA*)

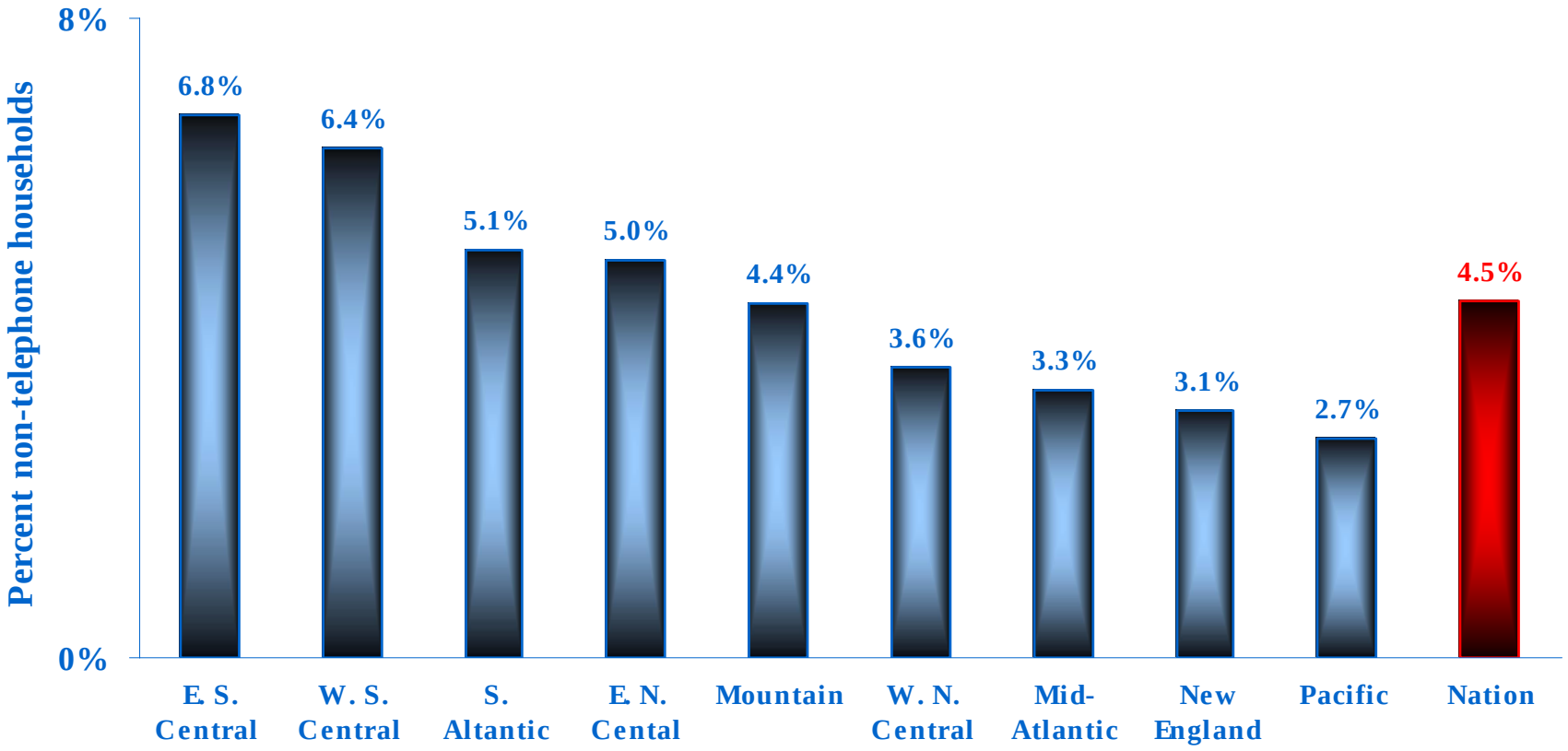
Nature of the Problem

Average and Maximum Percent Nontelephone Households by Household Income (CPS 2002)



Nature of the Problem

Percent Nontelephone Households by the Census Division (CPS 2002)



ITSA Notation

w_{ijk}^{B} **Base weight for the *k*th respondent in the *i*th state and *j*th household income category**

w_{ijk}^{P} **Post-stratified weight for the *k*th respondent in the *ij*th cell based on the 2003 methodology**

n_{ij} **Number of respondents in the *ij*th cell**

I_{ij} **Subset of respondents in the *ij*th cell with telephone service interruptions**

N_{ij}^{T} **Number of adults in telephone households in the *ij*th cell**

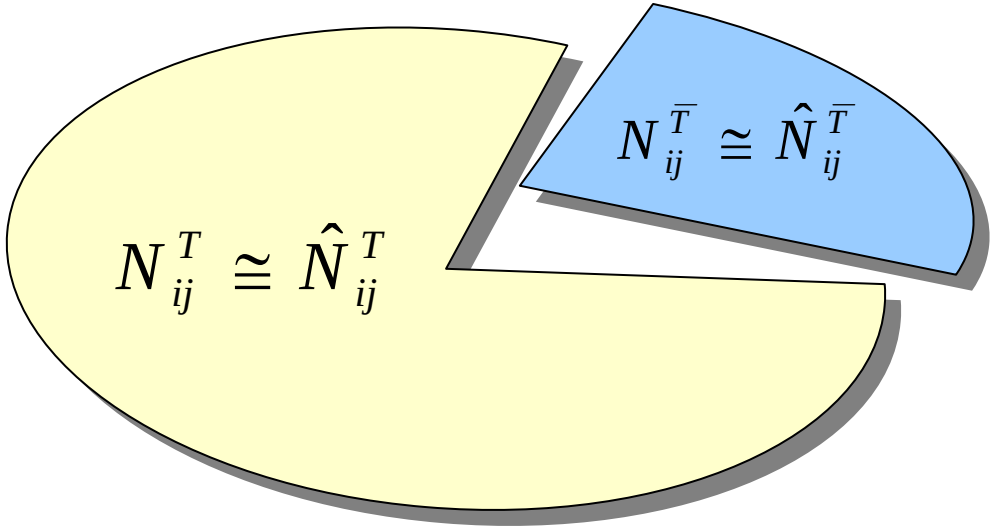
$N_{ij}^{\bar{T}}$ **Number of adults in non-telephone households in the *ij*th cell**

N_{ij}^{I} **Number of adults in households with telephone service interruptions in the *ij*th cell**

$N_{ij}^{\bar{I}}$ **Number of adults in households with no telephone service interruptions in the *ij*th cell**

ITSA Weighting Adjustment Ingredients

- Two of the needed population totals can be estimated from the CPS:

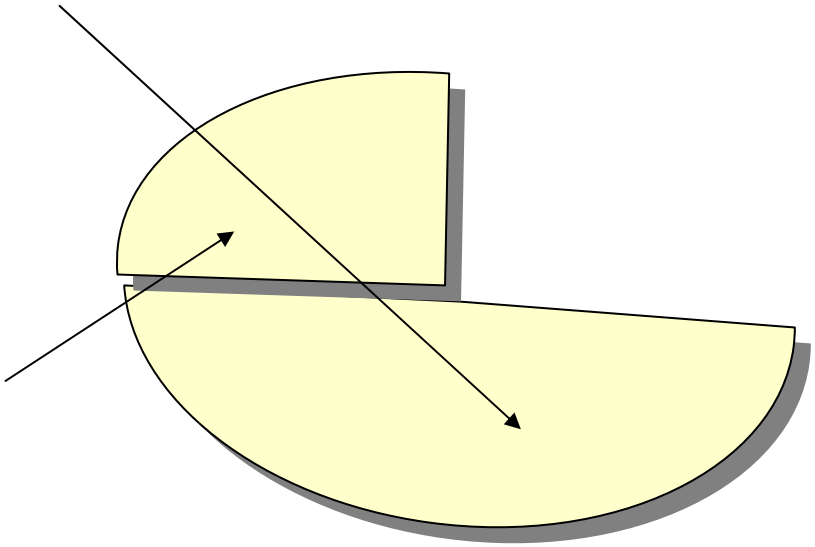


ITSA Weighting Adjustment Ingredients

- The latter two can be estimated from the survey data:

$$N_{ij}^{\bar{I}} \cong \hat{N}_{ij}^{\bar{I}} = \hat{N}_{ij}^{T}\left(1-\frac{\sum_{k\in I_{ij}} w_{ijk}^{P}}{\sum_{k=1}^{n_{ij}} w_{ijk}^{P}}\right) = \hat{N}_{ij}^{T} \times \frac{\sum_{k\notin I_{ij}} w_{ijk}^{P}}{\sum_{k=1}^{n_{ij}} w_{ijk}^{P}}$$

$$N_{ij}^{I} \cong \hat{N}_{ij}^{I} = \hat{N}_{ij}^{T}\left(\frac{\sum_{k\in I_{ij}} w_{ijk}^{P}}{\sum_{k=1}^{n_{ij}} w_{ijk}^{P}}\right) = \hat{N}_{ij}^{T} - \hat{N}_{ij}^{\bar{I}}$$



ITSA Methodology

- Increase the design weights of households with telephone service interruption to account for nontelephone households
- Decrease the design weights of households without telephone service interruption to account for over-representation of telephone households

$$w_{ijk}^{A} = \begin{cases} w_{ijk}^{B} \times \dfrac{\hat{N}_{ij}^{I} + \hat{N}_{ij}^{\bar{T}}}{\sum\limits_{k \in I_{ij}} w_{ijk}^{B}}, \forall k \in I_{ij} \\ w_{ijk}^{B} \times \dfrac{\hat{N}_{ij}^{\bar{I}}}{\sum\limits_{k \notin I_{ij}} w_{ijk}^{B}}, \forall k \notin I_{ij} \end{cases}$$

- The resulting weights are pos-stratified to CPS counts

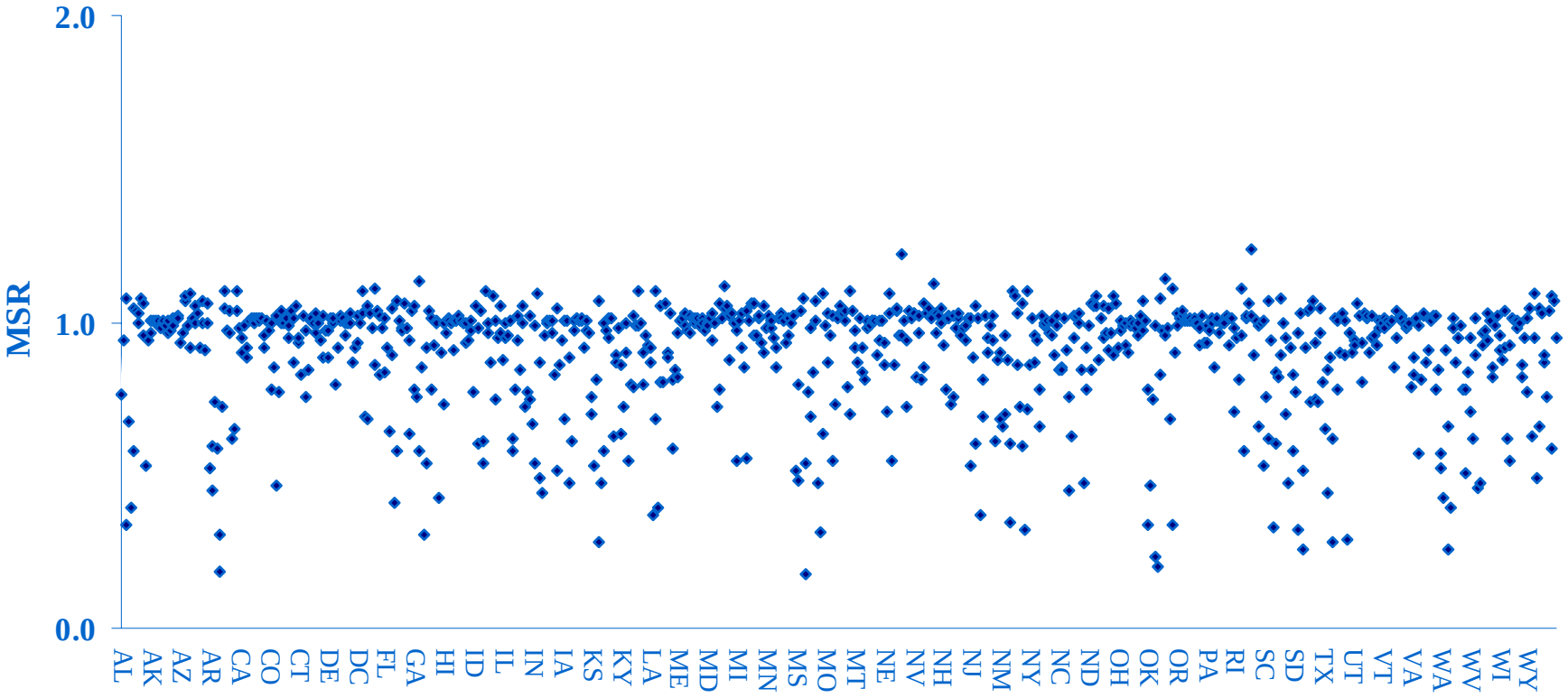
Evaluation of *ITSA*

(Key Outcome Measures)

BRFSS Outcome Measure	Variable Name
General health status	GOODHLTH
Any kind of health care coverage	HLTHCOV
Cost prevented dr. Visit, past 12 months	COSTPREV
Any exercise, past month	EXERCISE
Diagnosed diabetes, excluding pregnancy	EVERDIAB
Diagnosed high blood pressure, excluding pregnancy	EVERBP
Diagnosed high blood pressure and currently taking medicine	CURBPMED
Ever had blood cholesterol checked	BP
Currently trying to lose weight	CURLOSEW
Currently have asthma, Dr. Diagnosed	CURASTH
Had flu shot, past 12 months	FLU
Ever had pneumonia shot, people 65+	PNEUM
Current smoking status	CURSMK
Obesity	OBESE
Binge drinking	BINGE
Ever tested for HIV, excluding tested when donating blood, people 18-64	HIVTEST
Any activities limited due to physical, mental, or emotional problems	LIMACT

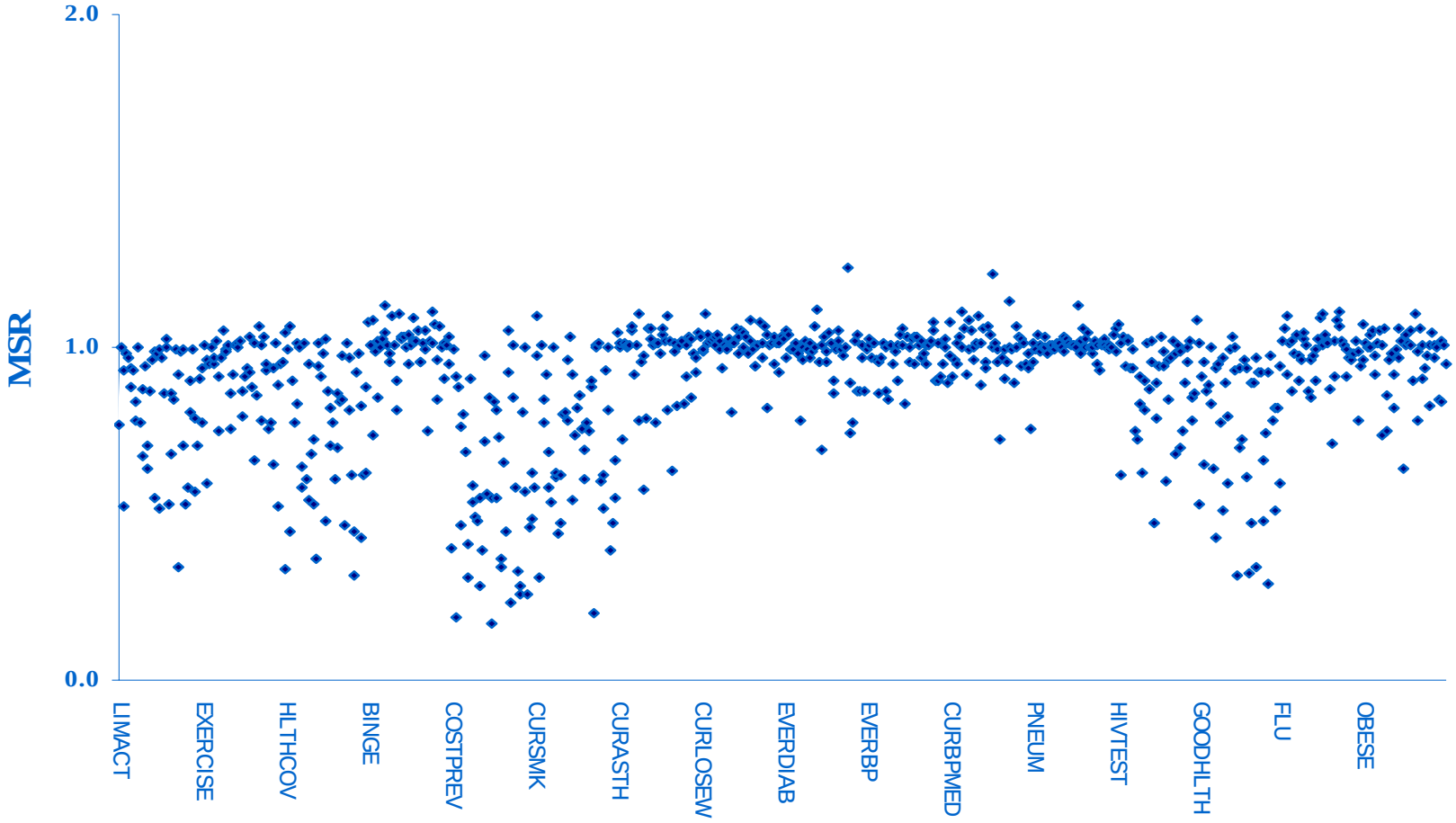
Evaluation of *ITSA*

Mean Square Ratio of Key Outcome Measures by State



Evaluation of *ITSA*

Mean Square Ratio by Key Outcome Measure Across States



Summary
Benefits of the Proposed Raking Method

- Matches target population characteristics more comprehensively:
  - Use more detailed classification of weighting variables such as race/ethnicity and age
  - Includes socioeconomic control variables such as employment status, education, and marital status
- Applies uniformly across all states
- Eliminates manual intervention by removing the need for cell collapsing to avoid small weighting cells
- Reduces bias with virtually no cost due variance inflation

Further Considerations

- Impute missing data to allow more comprehensive weighting
- Add further controls for reporting domains such as:
  - Region
  - County
- Investigate the potential benefits of adding other weighting variables such as:
  - Veteran status
  - Lifestyle indicators
- Investigate the pros and cons of:
  - Trimming extreme weights
  - Use of RTI's proprietary weighting software GEM