MEASURING NONRESPONSE BIAS IN PRAMS, 2019

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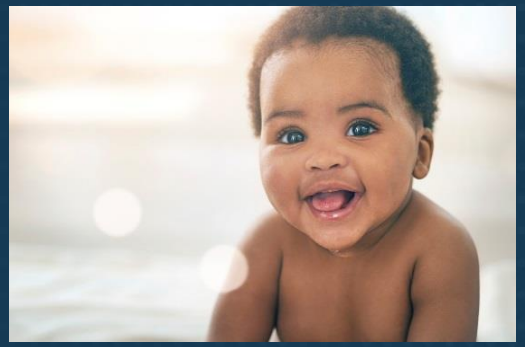
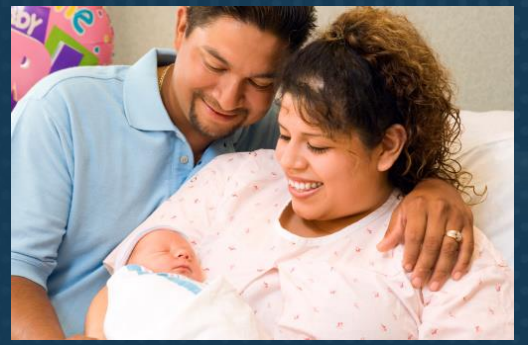


Centers for Disease Control and Prevention

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Division of Reproductive Health

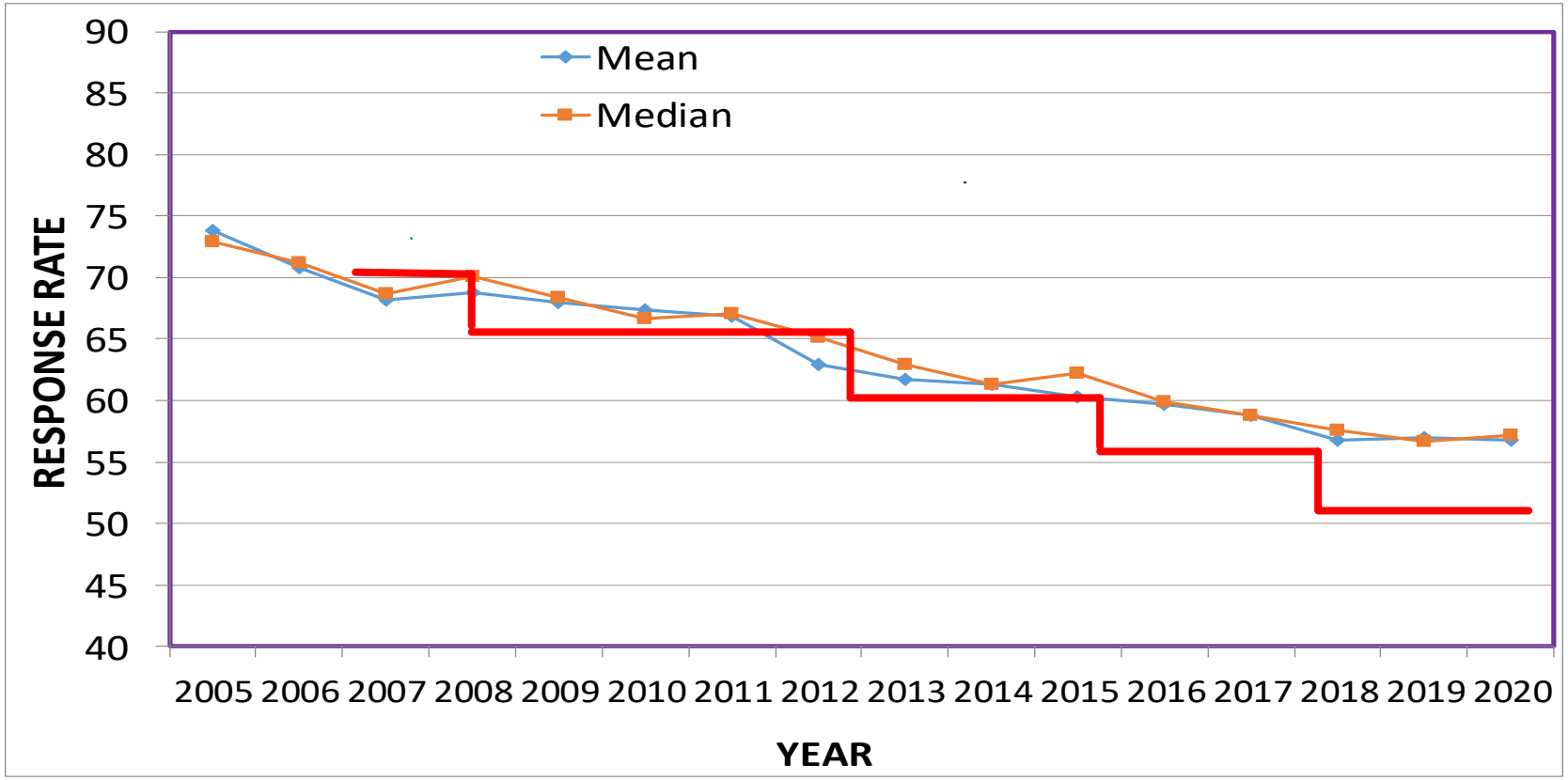
OVERVIEW

- Background
- Justification for Conducting Ongoing Nonresponse Bias (NRB) Analyses
- Previous PRAMS NRB Analyses
- NRB Analyses
  - True Bias
  - Level of Effort and Incremental Bias
  - Model-based Approaches
- Discussion and Next Steps

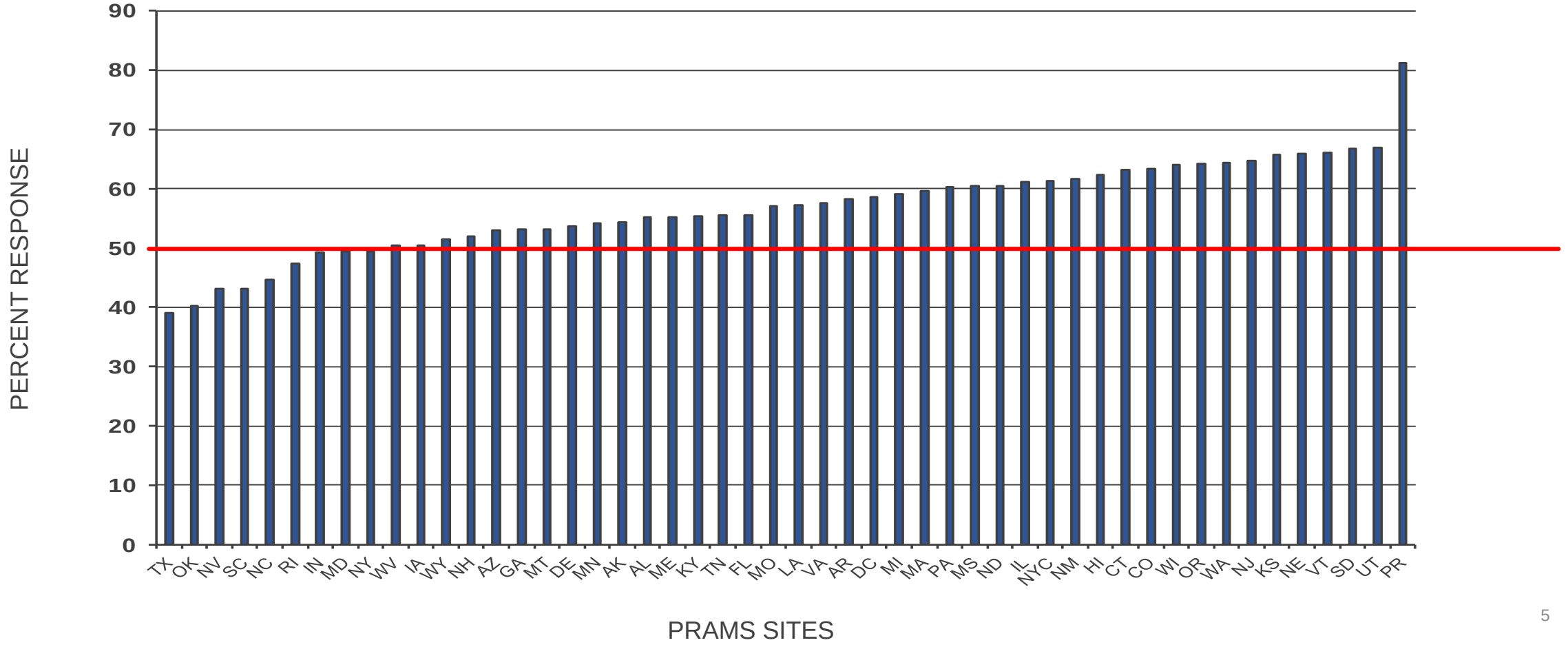
BACKGROUND: RESPONSE RATE THRESHOLDS FOR DATA RELEASE

- PRAMS currently implements response rate thresholds based on what could reasonably be achieved within survey climate using PRAMS protocol
- Data released and included in CDC reports if jurisdiction reaches or exceeds threshold:
  - Before 2007 – 70%
  - 2007 to 2011 – 65%
  - 2012 to 2014 – 60%
  - 2015 to 2017 – 55%
  - 2018 to 2020 – 50%

PRAMS MEAN AND MEDIAN WEIGHTED RESPONSE RATES BY YEAR, 2005 – 2020



PRAMS WEIGHTED RESPONSE RATES BY JURISDICTION, 2020



PURPOSE OF NONRESPONSE BIAS ANALYSES

- Survey response rates steadily falling, with more rapid declines as of late
  - Higher response rate *less likely* to have NRB
  - Lower response rate *not always* indicative of NRB

- 2006 Office of Management and Budget (OMB) Directive
  - Mandated NRB assessment for federal surveys with <80% response rate

- Continually lowering PRAMS response rate threshold unsustainable

- *Systematic Review of Nonresponse Bias Studies in Federally Sponsored Surveys.* FCSM 20-02. Federal Committee on Statistical Methodology. March 2020.
- *Standards and Guidelines for Statistical Surveys.* OMB. 2006

PREVIOUS NONRESPONSE BIAS ANALYSES

Research Questions

- What differences arise in prevalence estimates subject to different response rates?
- Are early respondents different from more difficult-to-reach respondents?

Data Examined

- 2002 data from IL (83% response rate), OK (84% response rate) and VT (86% response rate)
- 8 survey indicators

APPROACH

- Identify states with high response rates
- Based on time of survey completion, order respondents from earliest to latest by batch
- Create response rate groupings of 50%, 60%, 70%, and 80+%
- Weight each response group separately
- Compute and compare weighted estimates for each response group
- Compare demographic distributions of response groups to overall population distributions

RESULTS

- Not much evidence of bias, even at lowest response rate examined at 50% response rate
- From 70% threshold perspective, comparing 70% group to 60% group yielded minimal differences in estimates
- Results varied by site and within site by indicators – not generalizable to other sites or other years
- In other analyses using all sites, we estimated about a 1 percentage point change in estimates per 10% decline in response rates

NEW NON-RESPONSE BIAS EFFORTS IN PRAMS

1. *True bias analysis*: comparing weighted estimates with actual population values for selected birth certificate indicators

2. *Level of effort analysis*: simulating response groupings and examining incremental bias for different response levels

3. *Model-based analysis*: estimating worst-case bias under different missing data assumptions

Each analysis examines bias through a different lens, but collectively may provide actionable results to inform PRAMS data release policies

TRUE BIAS ANALYSIS - RESEARCH QUESTION

- What is the NRB found for indicators available on the birth certificate, when calculating estimates based on PRAMS survey respondents as compared with the population (i.e., true values)?

- Examine NRB by indicator type (sensitivity) and by response rate of site

APPROACH

- Jurisdiction vital records birth file serves as sampling frame and source of population information
- Linked birth file with PRAMS sample for 47 PRAMS sites (3 sites did not grant permission for access to their full birth file) to compute:
  - Population values
  - Estimates of the population values from the full PRAMS sample (using sampling weights only)
  - Estimates of the population values from PRAMS respondents (using analysis weights)

BIRTH CERTIFICATE VARIABLES EXAMINED

Health Behaviors	Medical	Demographic/Socio-Economic Status (SES)
Adequate prenatal care (PNC)	Gestational diabetes	Medicaid as payment source for delivery
Smoking before pregnancy	Gestational high blood pressure (hypertension)	WIC participant
Smoking during pregnancy	C-Section delivery	Previous live birth (LB)
Breastfed in hospital	Infertility treatment	
	Pre-pregnancy Body Mass Index (BMI) - Normal	

Note: WIC is the Special Supplemental Nutrition Program for Women, Infants, and Children

COMPARISON OF RESPONDENT ESTIMATES TO POPULATION VALUES

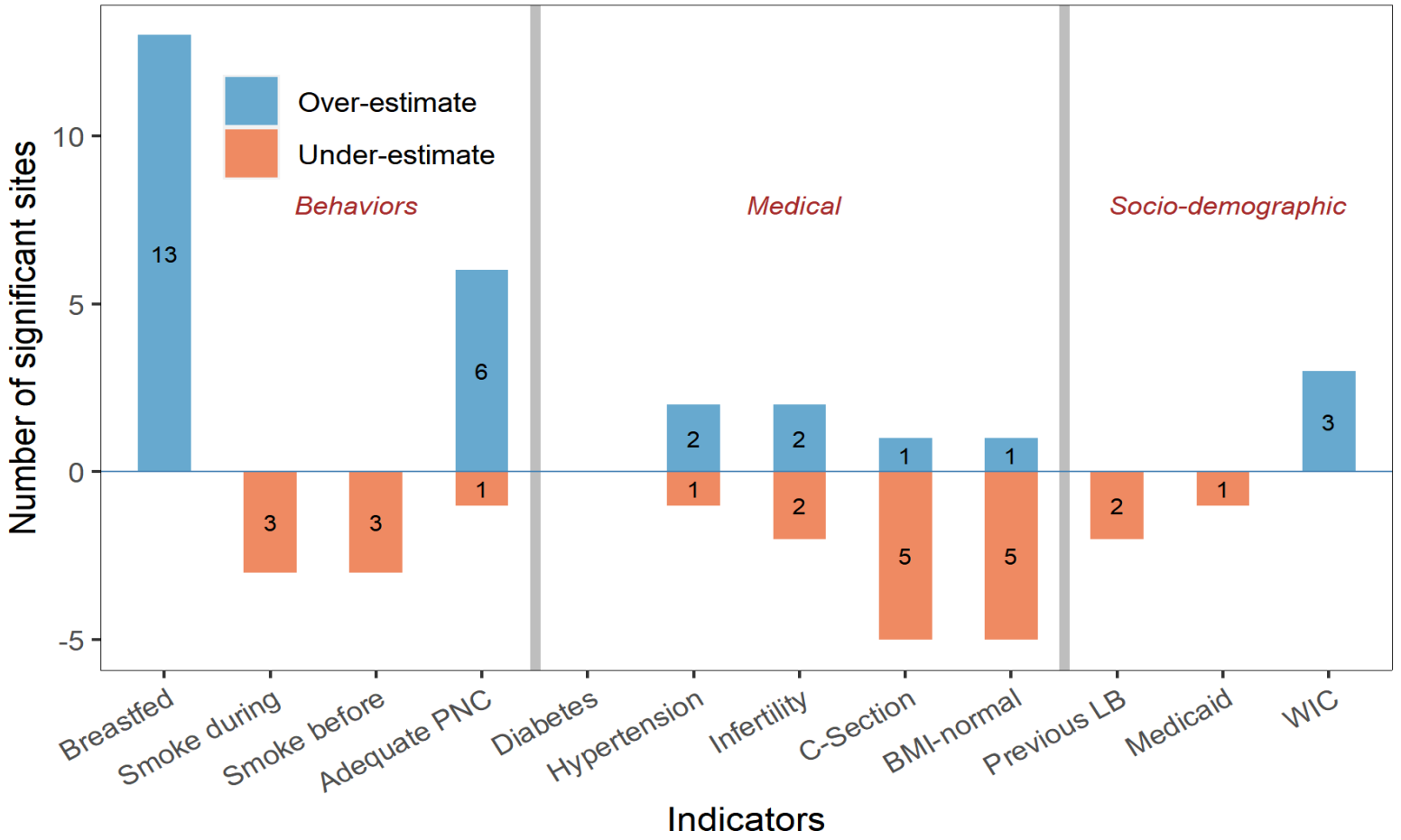
- Produce 95% confidence interval (CI) for estimates of each indicator from PRAMS respondents in each jurisdiction
- Identify instances where 95% CI excludes true population value
- Compute bias and absolute relative bias

$$Bias_{NR}(\overline{Y}_r) = \overline{Y}_r - \overline{Y}_f$$

$$Absolute\ Relative\ Bias_{NR}(\overline{Y}_r) = \left| \frac{100\% * (\overline{Y}_r - \overline{Y}_f)}{\overline{Y}_f} \right|$$

where $\overline{Y}_f$ is the frame value and $\overline{Y}_r$ is the respondent weighted estimate

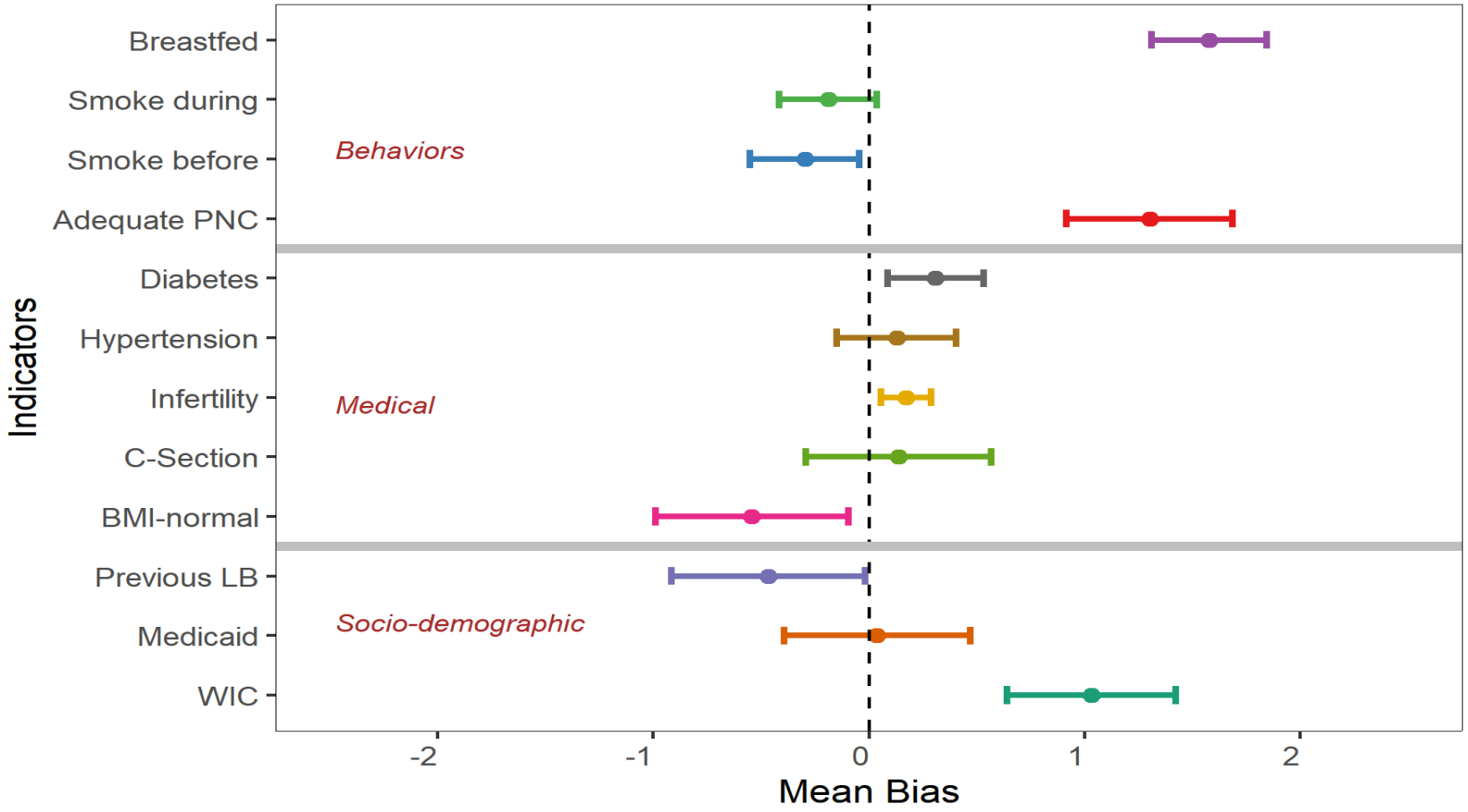
COMPARISON OF RESPONDENT ESTIMATES TO POPULATION VALUES - NUMBER OF SIGNIFICANT DIFFERENCES (47 SITES)



MEAN BIAS BY INDICATOR

- Averaged bias over all 47 sites to produce the mean bias for each indicator
- For each indicator, conducted a fixed-effects meta-analysis with each site treated as a study to account for different sample sizes across sites
  - Effect size measure for the meta-analysis was the (logged) risk ratio, comparing "risk" (prevalence) of reporting in the weighted PRAMS sample to prevalence in the population at each site
  - Allows us to estimate a confidence interval around the mean bias

MEAN BIAS ACROSS SITES BY INDICATOR



IMPACT OF RESPONSE RATES ON BIAS

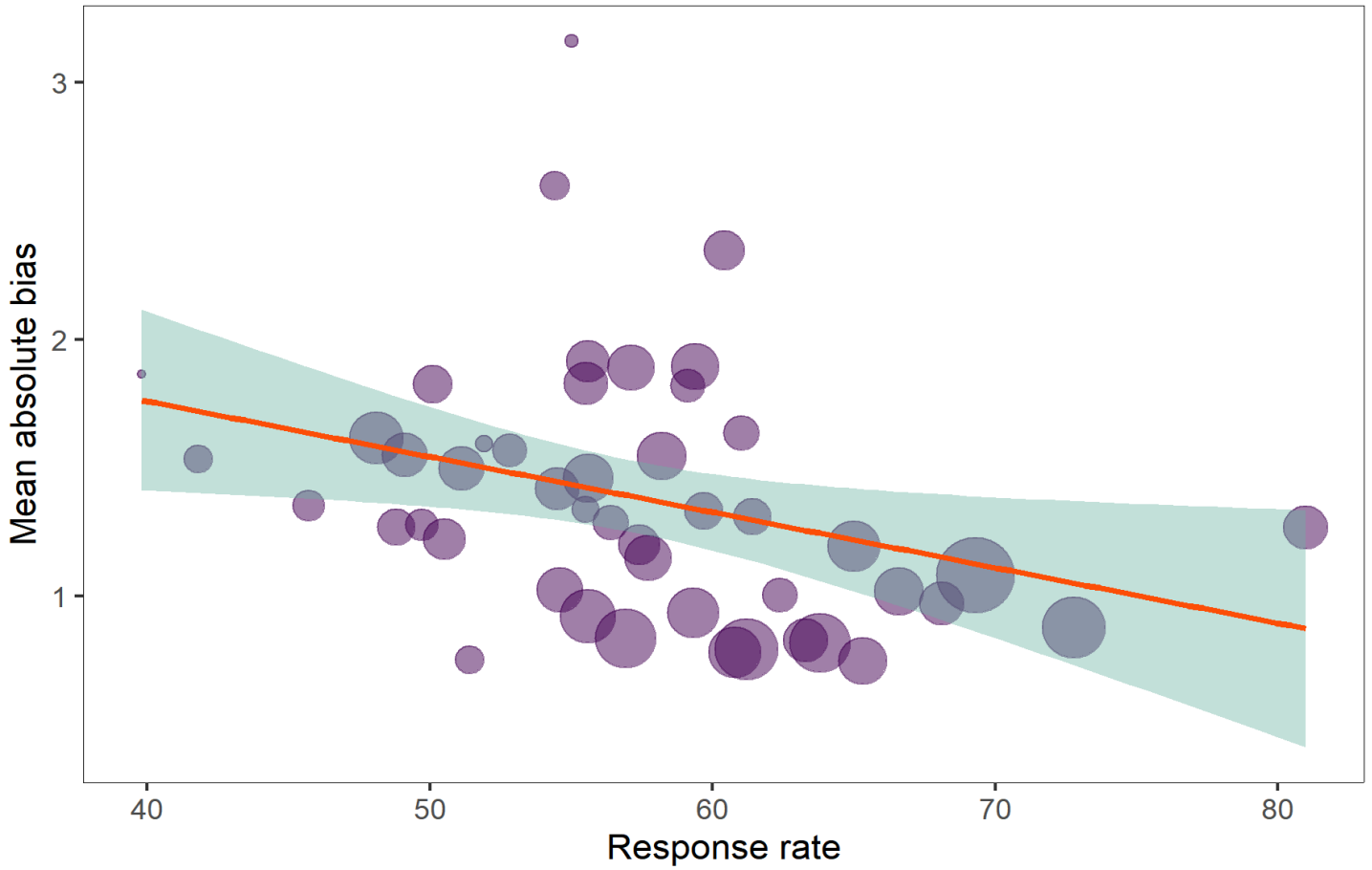
- Calculate mean absolute bias (MAB) across all 12 indicators for each site

$$Mean\ Absolute\ Bias_{NR}(\overline{Y}_r) = \sum_{i=1}^{12} |\overline{Y}_{ri} - \overline{Y}_{fi}| \ /\ 12$$

where $\overline{Y}_{f\,\mathrm{i}}$ is the frame value for indicator i and $\overline{Y}_{r\,i}$ is the respondent weighted estimate for indicator i

- Compute least squares regression line for MAB as predicted by response rate

RELATIONSHIP BETWEEN MEAN ABSOLUTE BIAS AND RESPONSE RATES



Least Squares Regression Line (b = -0.021, SE = 0.009, t = =2.35, p = .023)

Correlation between response rate and bias = -0.33

COMPARISON OF RESPONDENT ESTIMATES, FULL SAMPLE ESTIMATES, AND POPULATION VALUES

- Calculate bias and absolute bias for both the full sample estimates (i.e., 100% response) and respondent estimates for three indicators: breastfed in hospital, gestational diabetes, and WIC participant
- Compute mean bias and mean absolute bias over all 47 jurisdictions

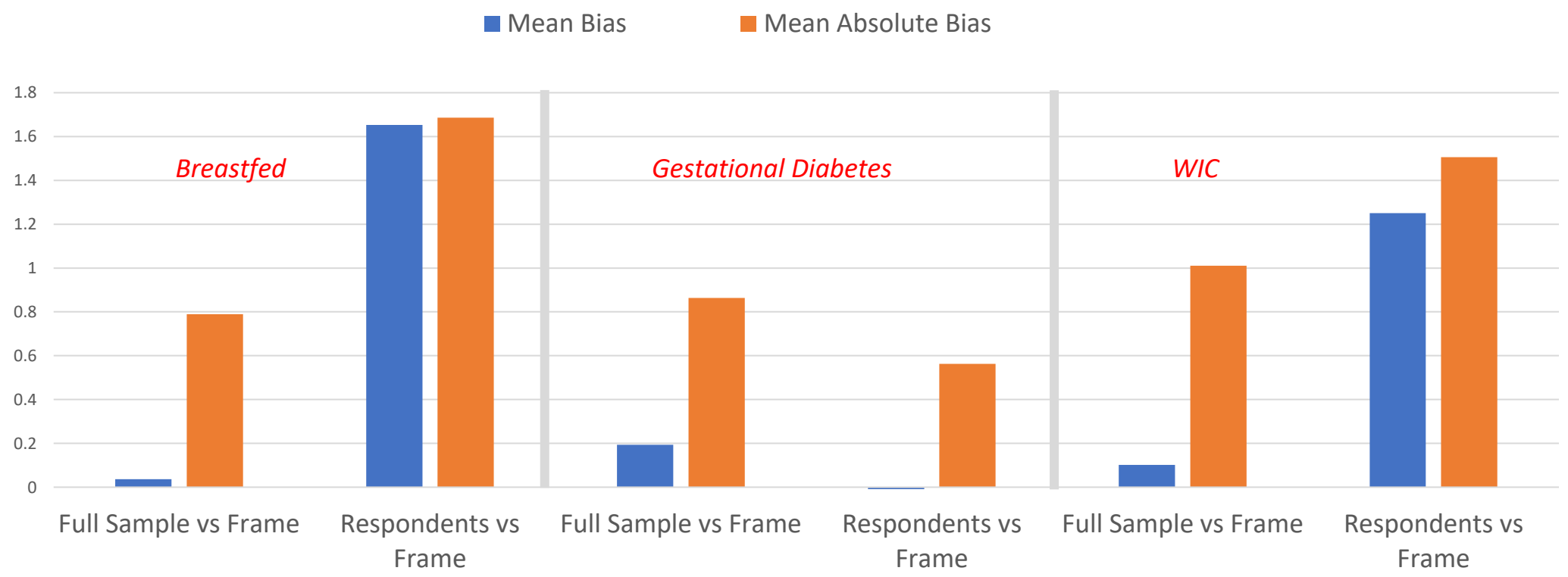
$$Mean\ Bias_{NR}(\overline{Y}_{fs}) = \sum_{i=1}^{47}(\overline{Y}_{fsi} - \overline{Y}_{fi}) \,/\, 47$$

$$Mean\ Absolute\ Bias_{NR}(\overline{Y}_{fs}) = \sum_{i=1}^{47} |\overline{Y}_{fsi} - \overline{Y}_{fi}| \,/\, 47$$

where $\overline{Y}_{f\mathrm{i}}$ is the frame value for indicator i and $\overline{Y}_{fsi}$ is the full sample weighted estimate for indicator i

- Similar computation for respondent sample weighted estimate

MEAN BIAS AND MEAN ABSOLUTE BIAS FOR FULL SAMPLE AND RESPONDENT ESTIMATES (47 SITES)



RESULTS

- Actual bias observed in PRAMS was relatively small
  - Highest mean absolute bias was 1.68 percentage points for breastfeeding
  - 9 of the 12 indicators examined had mean absolute bias less than 1 percentage point
- Behavioral indicators had highest levels of bias; demographic/socio-economic indicators had the lowest
- Positive behaviors were over-estimated; risky behaviors were under-estimated
- Weak correlation (-0.33) between response rate and bias
- Mean bias of full sample estimates was very small, as would be expected from a series of independent random samples

CONCLUSIONS

- Observed levels of bias should be acceptable for most uses of PRAMS data
- Behavioral indicators might be more susceptible to bias – private behaviors may be subject to unobserved individual- and group-level influences not amenable to weighting adjustments
- Bias varies across indicators (even within categories); must be examined at the indicator level

STRENGTHS AND LIMITATIONS

Strengths

- Access to complete, population-level data for a broad range of indicators
- Standard methodology across sites allows for analysis of impact of response rate on bias while controlling for other factors associated with bias
- Overlap of variables on birth certificate (medical and behavioral) with survey topics

Limitations

- Limited set of indicators collected on birth certificates
- Results cannot be generalized beyond study population (people recently delivering a live-born infant)

LEVEL-OF-EFFORT APPROACH TO ASSESSING INCREMENTAL NONRESPONSE BIAS IN PRAMS

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BACKGROUND

- **Decreasing survey response rates are driving new interest in non-response (NR) bias research**
  - **The level-of-effort (LOE) approach simulates low response rates (RR) in higher RR surveys**
  - **Later respondents are treated as non-respondents**

- **Research Question: *Do survey estimates from earlier versus later respondents exhibit differential bias?***
  - **Assumption: Respondents requiring greater effort are more similar to nonrespondents**
  - **Can be tested since PRAMS samples from birth certificates with information (i.e., demographics, medical) on respondents and nonrespondents**

METHODS

- **Selected 20 sites from PRAMS (2019)**
- **Criteria:**
  - **Response rate**
  - **Sample size**
  - **Urbanicity (*FiveThirtyEight index*)**
  - **Diversity (*WalletHub index*)**
  - **Geographical area**

		Urbanicity % of population in locale		
Diversity	Response rate (RR)	Rural	Mix	Urban
Homogeneous	Low RR	WV, NH	IN	
	Medium RR	ND	MO	PA
	High RR	MS, SD*	OR*	PR
Diverse	Low RR	OK*	SC	AZ*, FL*
	Medium RR	AK*	VA	IL
	High RR		KS	NYC*, MA

Note:
* Special subpopulation: [AK – Alaska Native; AZ – Hispanic (Mexican); FL – Hispanic (Cuban); NYC – Chinese and other races; OK – Hispanic and Native American; OR – Asian; SD – Native American]

RR:	Low: 0-55% (n=7)	Medium: 55-60% (n=6)	High: 60+% (n=7)
Sample size:	<1000 (n=6)	1000-1265 (n=8)	1266+ (n=6)

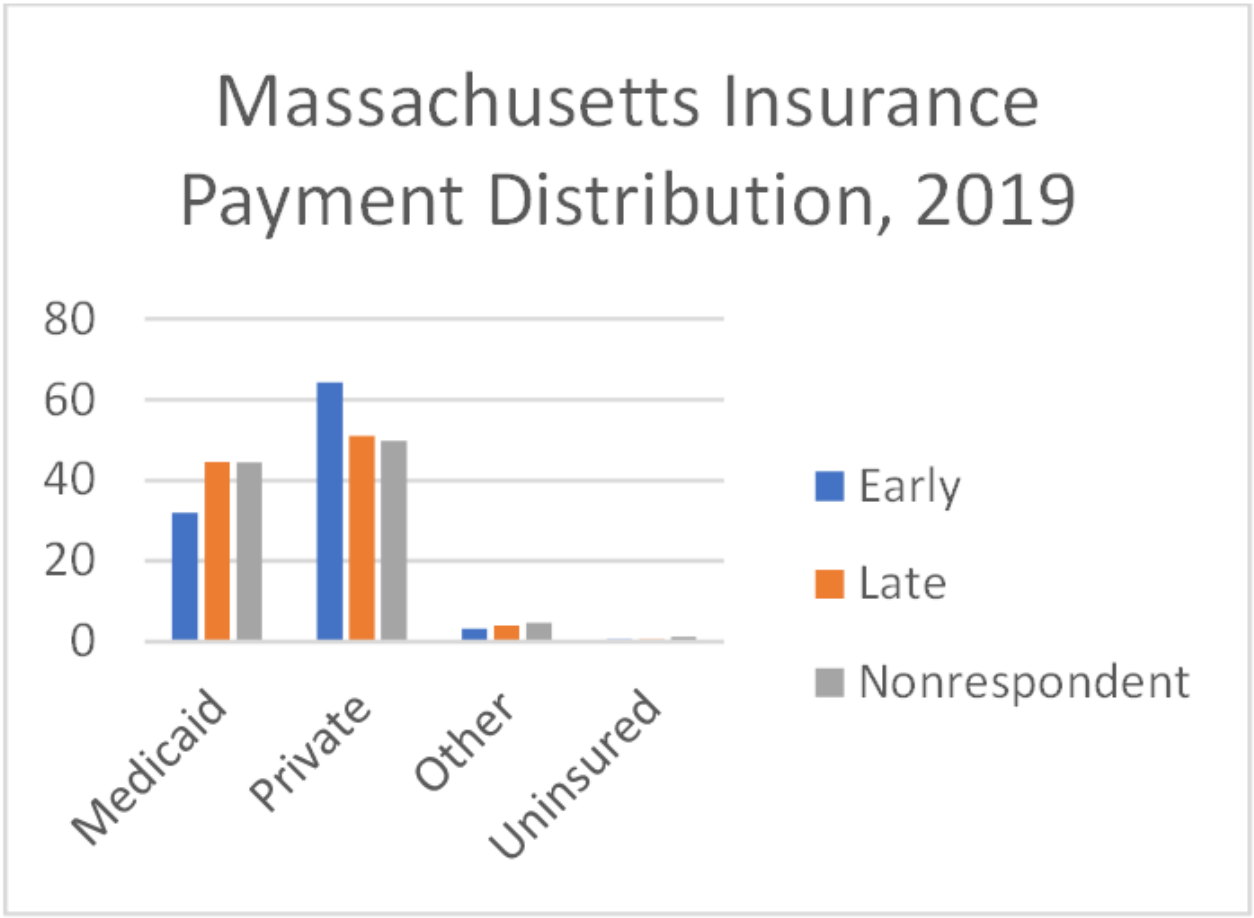
METHODS

- **Examples of 21 core PRAMS variables selected for analysis**

Contraception related	Medical conditions /health services	Other behavioral indicators	Demographic/SES
Intended pregnancy	Gestational diabetes	Physical abuse before pregnancy	Less than 100% of federal poverty level (FPL)
Postpartum birth control (BC) use	Flu shot	Smoking before pregnancy	
Moderate/Most effective postpartum BC method	Teeth cleaned during pregnancy	Smoking during pregnancy	
Discuss BC at postpartum visit (PPV)	Maternal postpartum visit	Still breastfeeding	

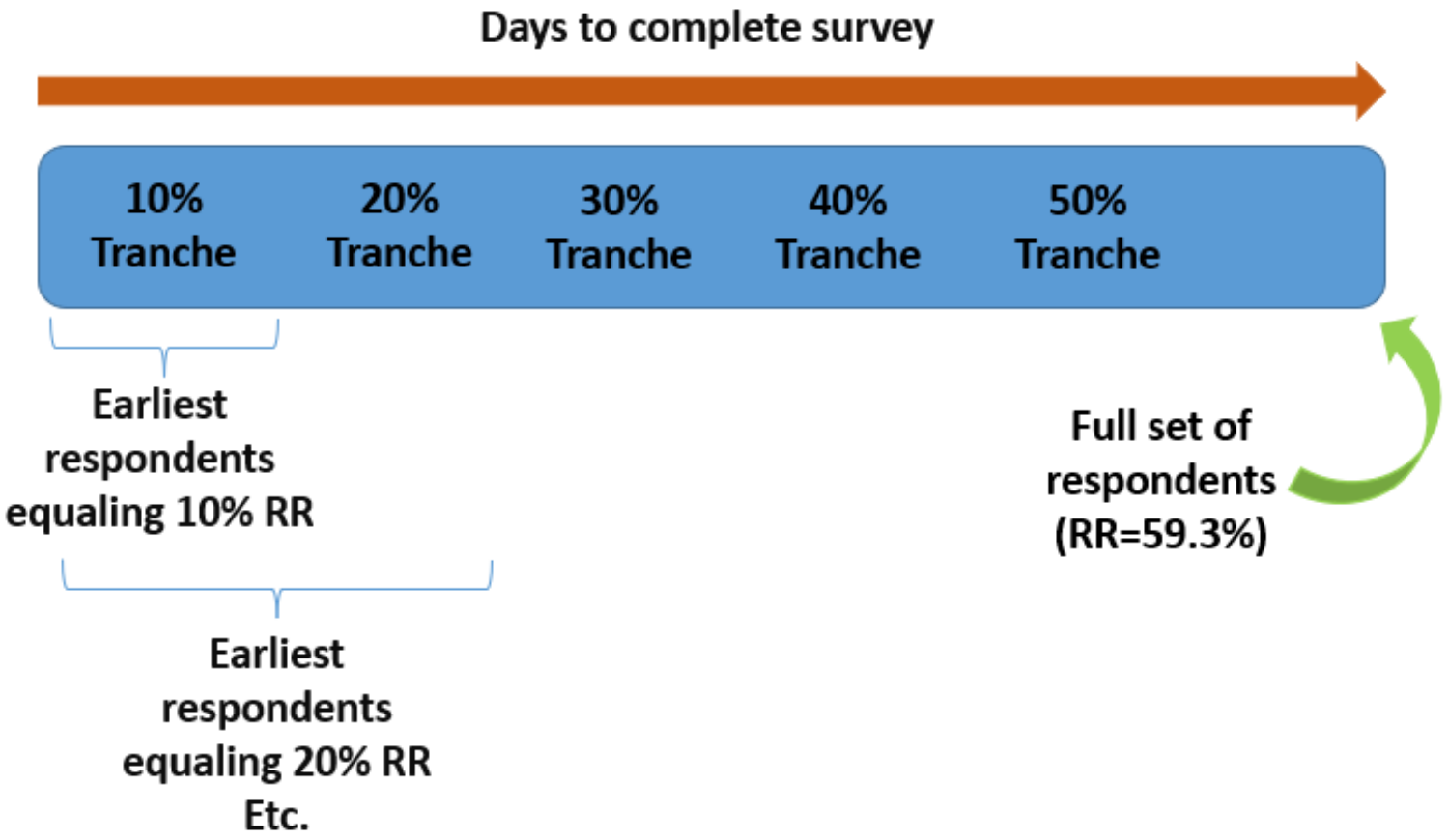
METHODS

- **Assumption: late-respondents are more similar to non-respondents**
- **Tested using 11 birth certificate variables**
  - **E.g., maternal race/ethnicity, maternal education, insurance for birth**
- **Early-respondents: completed survey before or during the first week of phone interview**



METHODS

- Created ‘tranches’ simulating lower RRs
- Earliest respondents comprised lowest RR tranches
  - Ranged from 5% to the full set of respondents
- Tranche data re-weighted with new non-response adjustment
- Example: Illinois 2019



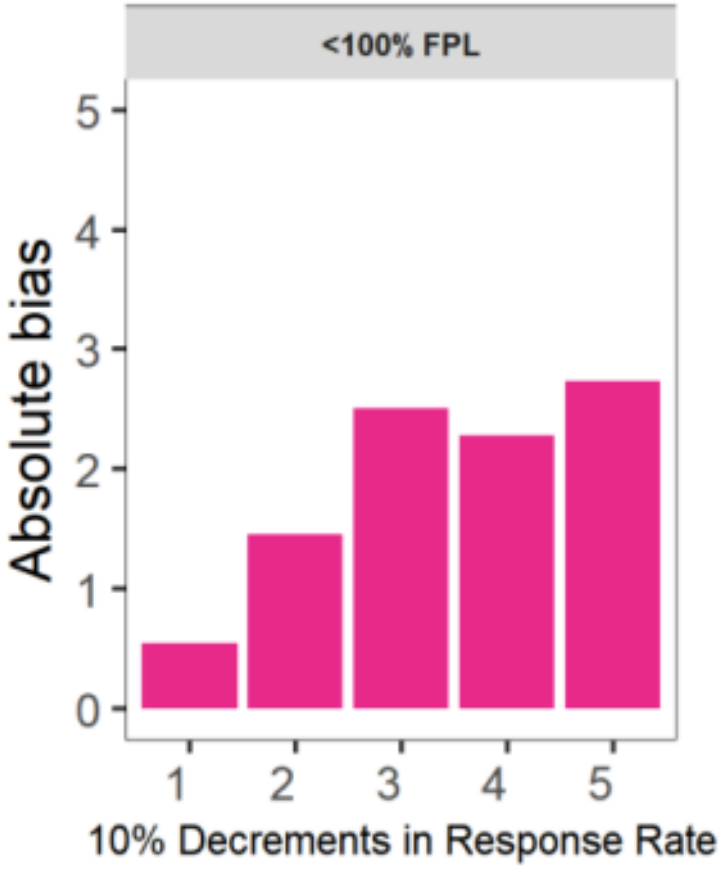
METHODS

- **Statistics calculated:**
  - **Absolute bias: Difference in weighted estimates between each response tranche and the full set of respondents**
  - **Relative bias: Percentage of the weighted estimate; a standard scale when examining multiple survey measures**
  - **Instances where estimated value from a response tranche fell outside the 95% CI of the full response estimate identified**
  - **Incremental bias: Mean absolute difference in estimates across sites as response rates drop in each tranche**

- **Multilevel regression model**
  - **Modeling bias as a function of response rate**
  - **Response rate tranche (level-1) nested within PRAMS site (level-2)**

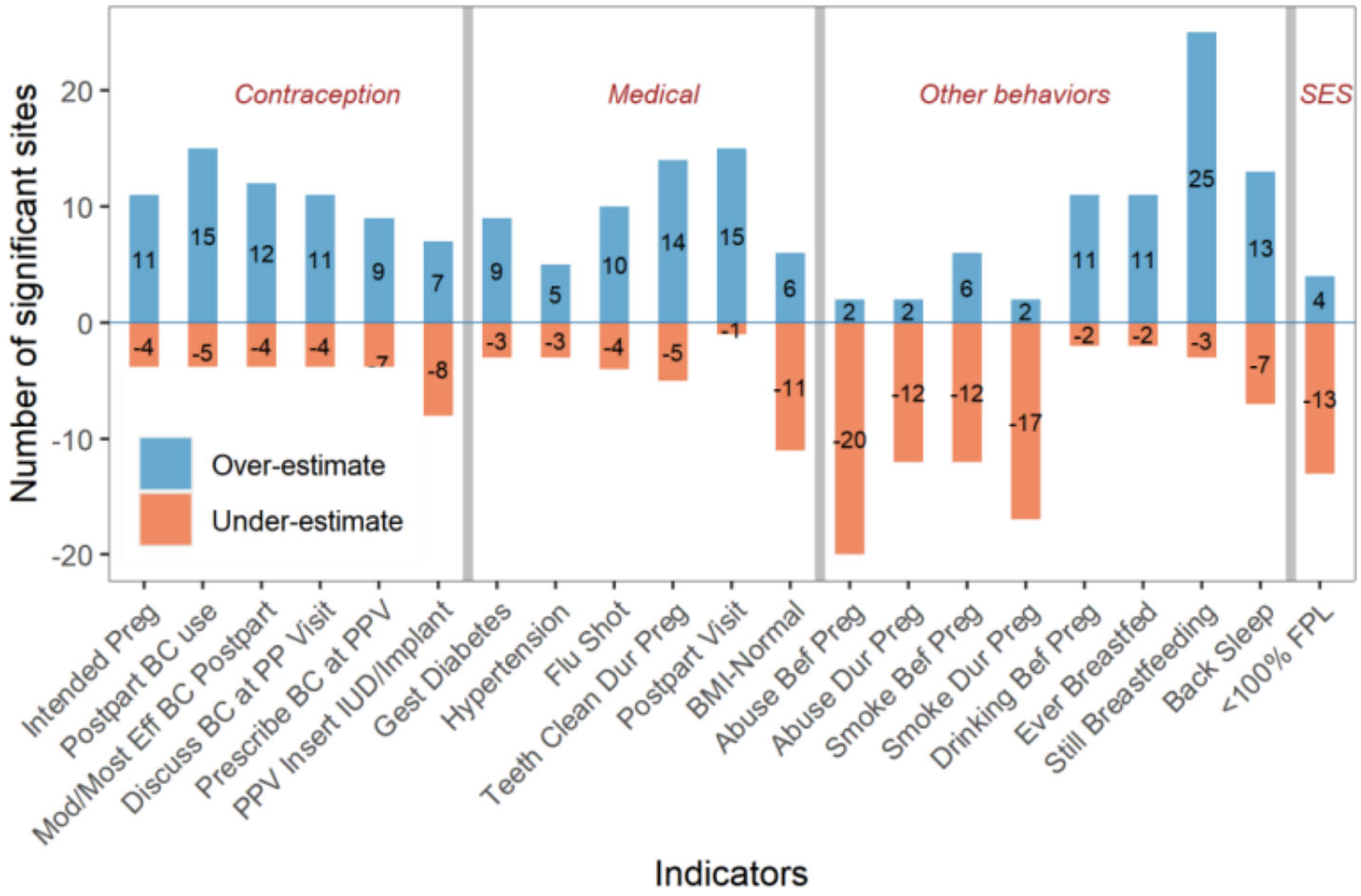
PREVIEW: KEY FINDINGS

- **On average, for every 10% decline in RR, we observed ~0.5% bias in estimation**
- **Bias tends to be in a predictable direction:**
  - **Indicators representing desirable outcomes or positive behaviors tended to be overestimated**
  - **Indicators of adverse outcomes/behaviors (e.g., physical abuse, smoking) tended to be underestimated**



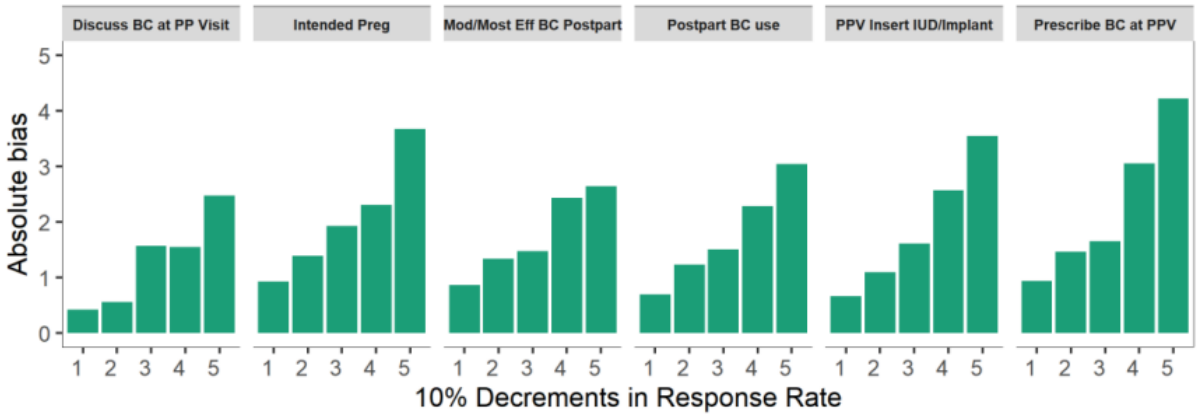
RESULTS

- **Number of significant differences across tranches for 20 sites**
  - **Positive behaviors overestimated when response rates dropped**
  - **Indicators representing less desirable/risky behaviors likely to be underestimated**

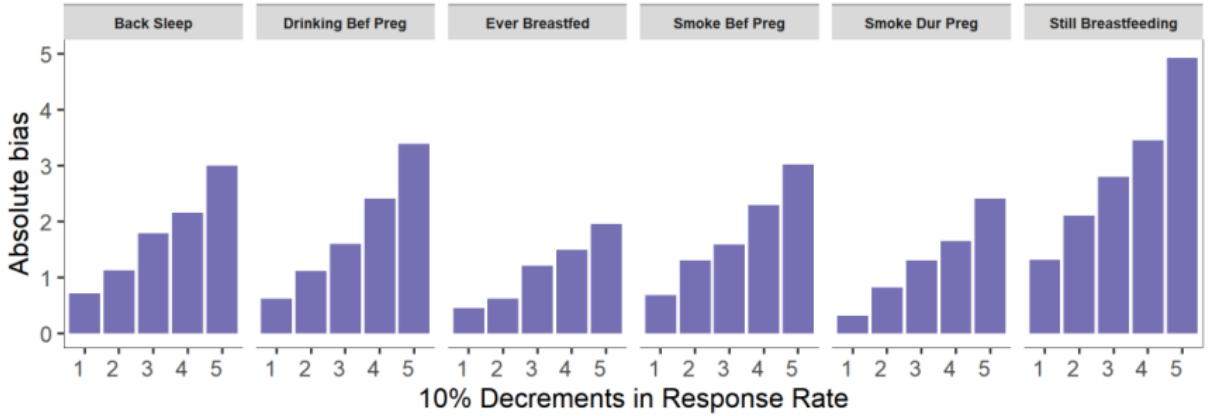


RESULTS

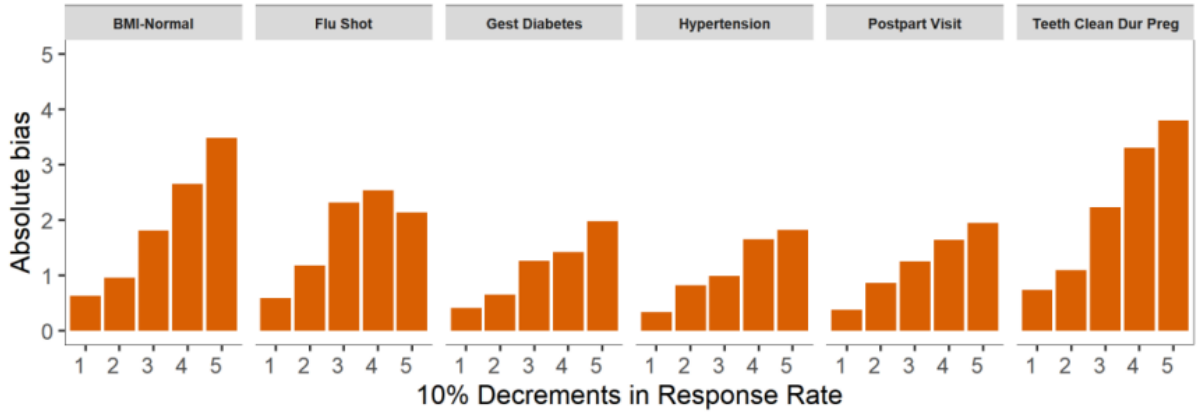
Contraception-Related Indicators



Other Behavioral Indicators

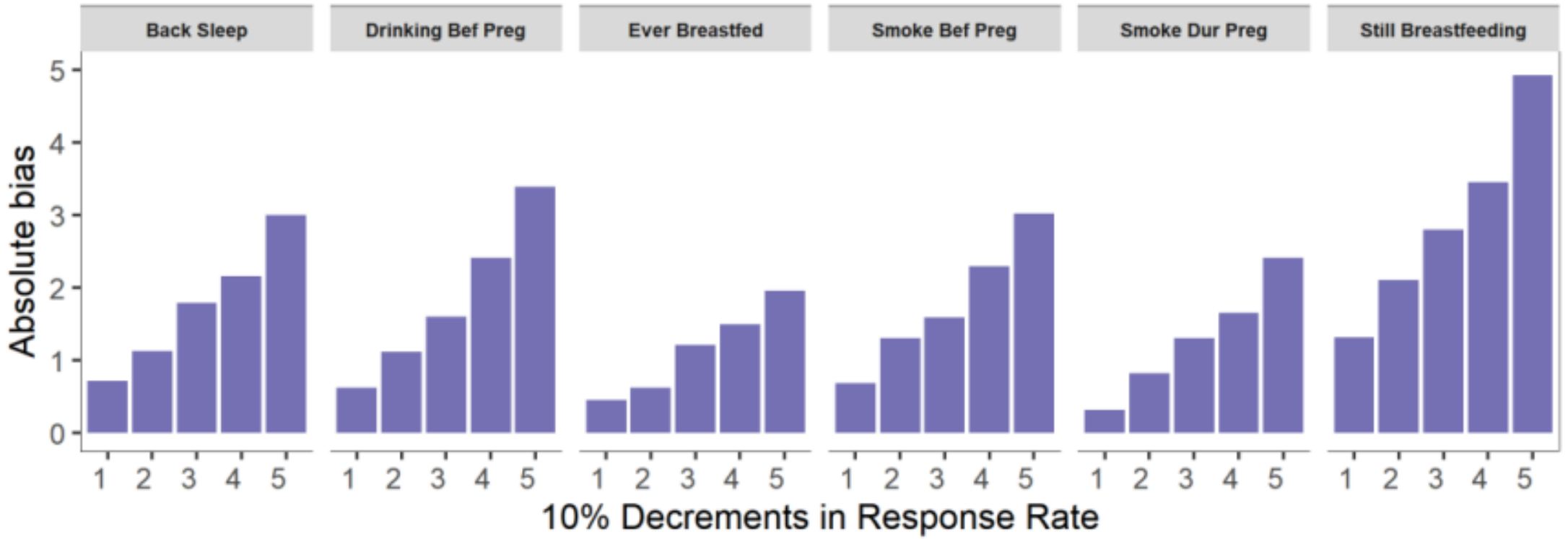


Medical Conditions/Health Indicators



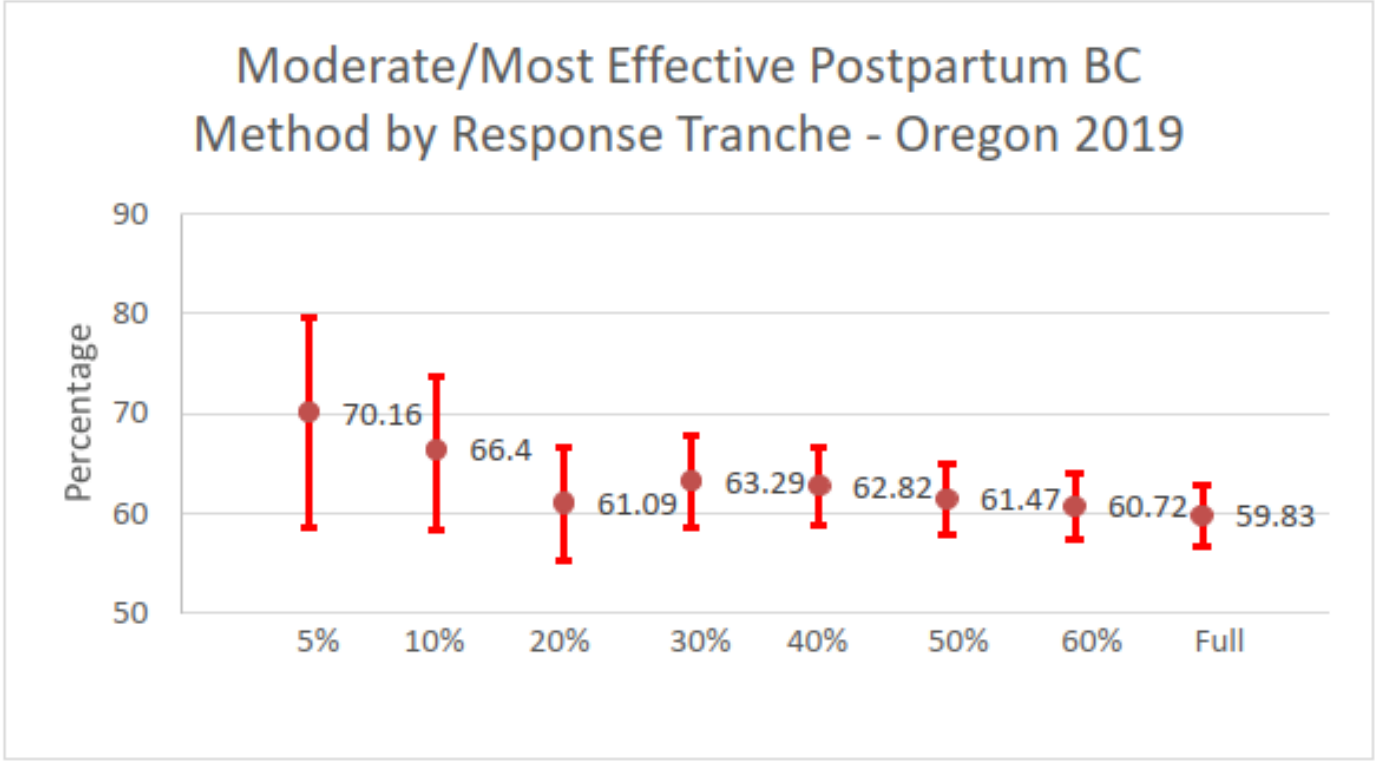
RESULTS

Other Behavioral Indicators



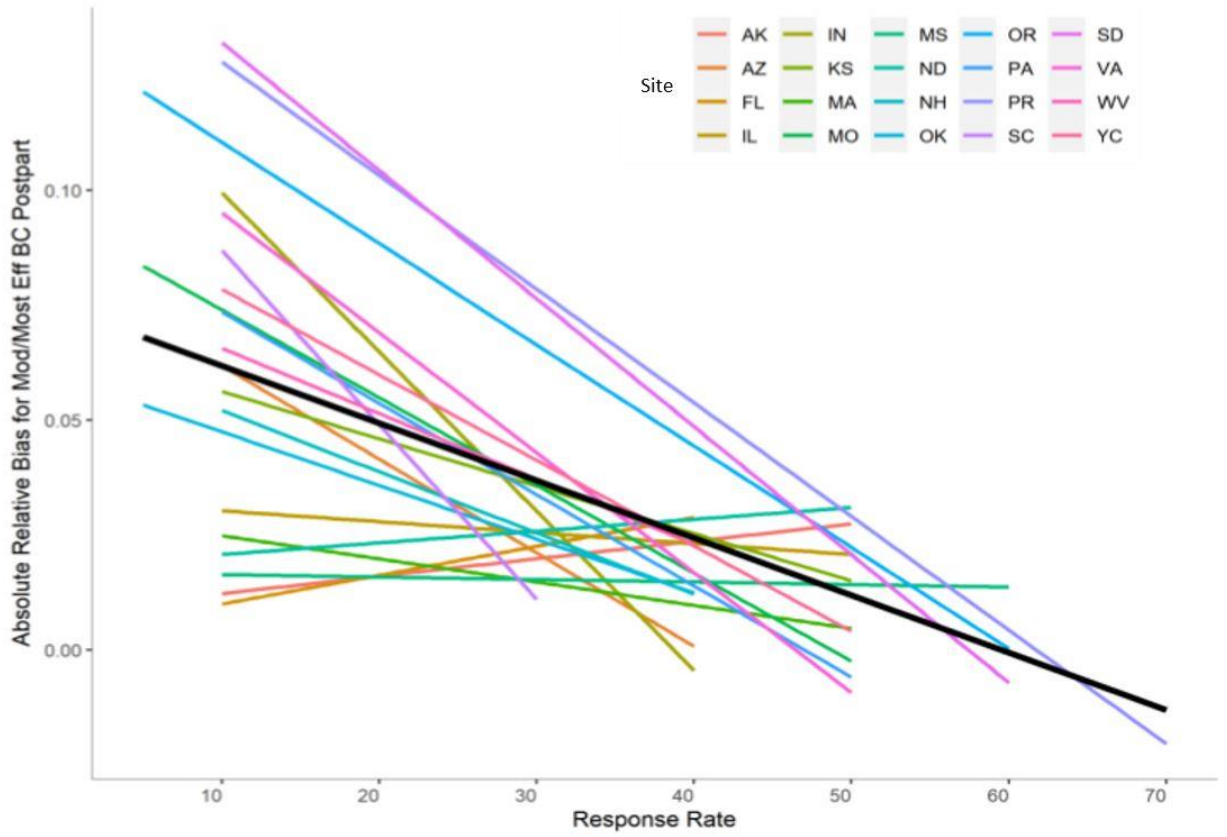
RESULTS

- **Mod/most effective birth control (BC) in Oregon: all tranches overestimate the full estimate**
  - **Estimates from the 5%, 10%, and 30% tranches are outside of the 95% CI around the full estimate**



RESULTS

- **Multilevel regression models: Absolute relative bias for mod/most effective postpartum BC**
  - ***Absolute relative bias*** **decreased by an average of 1.25% for each 10% increase in response rate. (Range = 0.42 – 6.26% across indictors.)**



WRAP-UP

- ***Findings***
  - ***On average, we saw ~0.5% absolute bias per 10% decrease in RR***
  - ***Some indicators were differentially prone to over-/under-estimation at lower RR***

- ***Implications:*** **LOE approach allows us to explore nonresponse bias across a range of decreasing response rates**

- ***Limitations:*** **Full response estimates from the lower response rate sites may already have inherent bias**
  - **e.g., estimates from full response estimates in a site with 30% response rate might be different from estimates from the 30% tranche in a site with 70% response rate.**

NONRESPONSE BIAS SENSITIVITY ANALYSIS FOR THE PRAMS SURVEY, 2019

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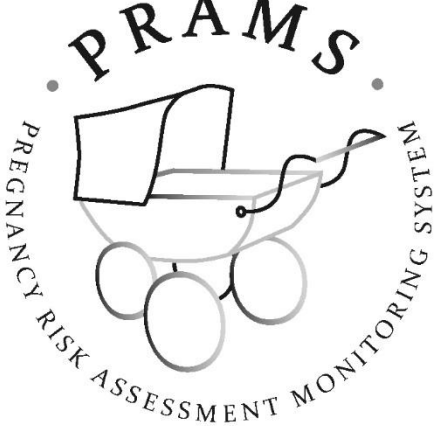
CHALLENGE OF NON-RESPONSE BIAS ANALYSIS

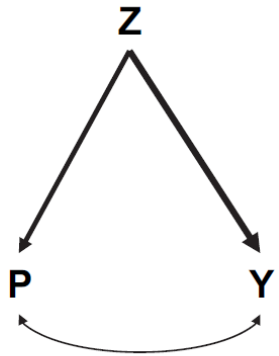
- **Estimating non-response bias is always imperfect; we cannot really know what non-responders 'would have answered'…**

- **<u>Research Question</u>: Despite this, can we find a plausible upper limit of nonresponse bias (i.e., the 'worst case scenario')?**



MISSINGNESS SCENARIOS

- **Missing-at-random (MAR)**
  - **Subgroups of the population can *systematically differ* in their propensity to respond (P)**
  - **Yet we can still produce unbiased estimates (of Y) conditioned on auxiliary variables (Z; e.g., demographics, geography…)**



- **Missing-not-at-random (MNAR; aka *non-ignorable nonresponse*):**
  - **Response probability is driven by the survey topic itself**
  - **Adjustments based on auxiliary variables would not produce unbiased estimates**
  - **Example Topics: Poverty, depression, substance abuse, …**

From Groves (2006) Nonresponse rates and nonresponse bias in household surveys.

NEW ADVANCES IN STUDY OF BIAS

- **Proxy Pattern-Mixture Analysis (PPMA; Andridge and Little, 2020*)**
- **PPMA is a *sensitivity analysis* method: "Given the observed data, how do changes to our assumptions about nonresponse impact estimates of bias?"**
- **New: PPMA can now simulate *binary outcomes* under varying missingness assumptions**
  - **Missing-at-random (best case) → missing-not-at-random (worst case)**
- **PRAMS data contains rich auxiliary data for the full sample (respondents + non-respondents)**
  - **Ideal for PPMA analyses**

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METHODS (DATA): PRAMS, 2019

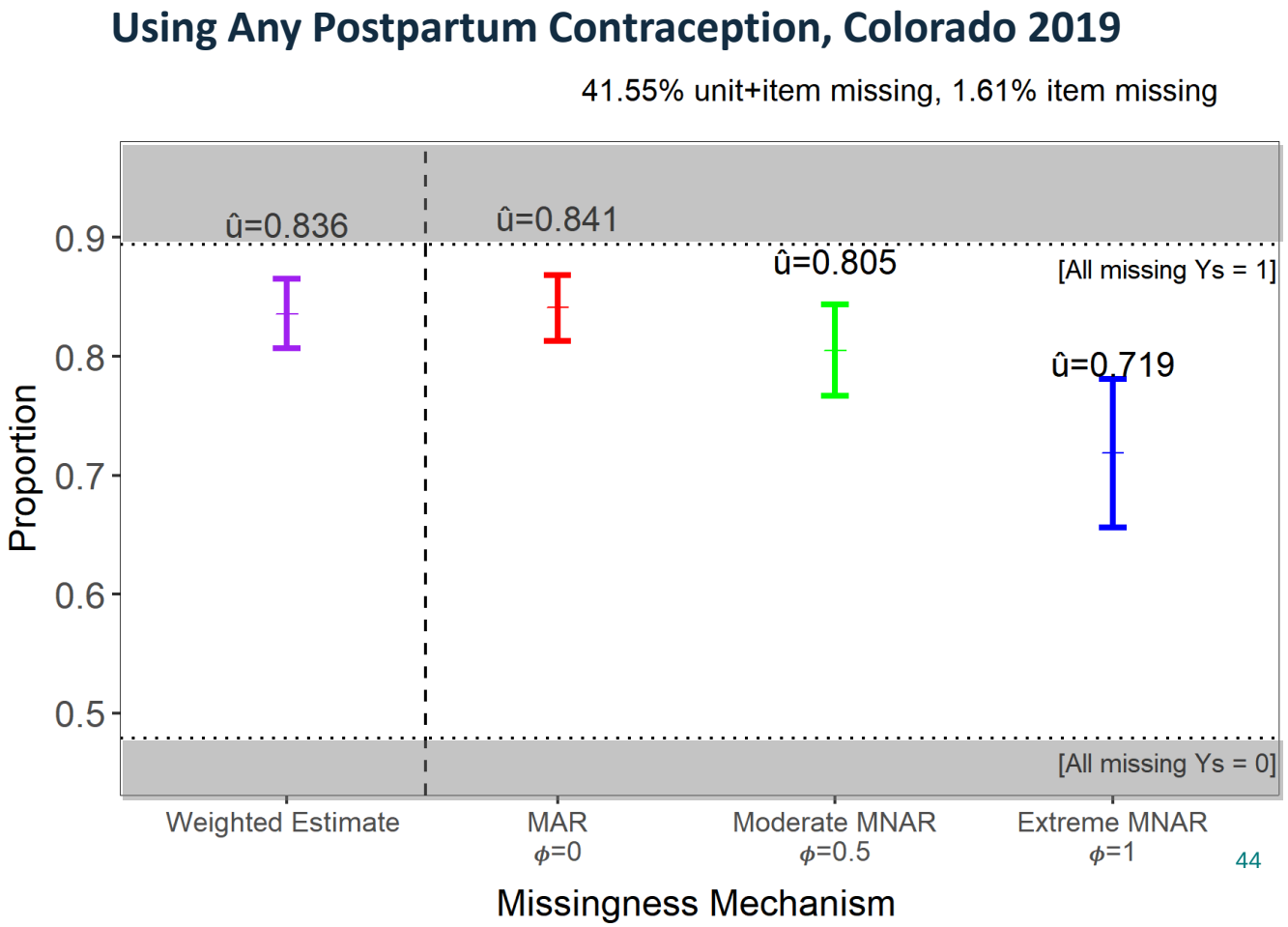
- **Analyzed 13 survey indicators: contraceptive and other behaviors, medical conditions, poverty**
- **Grouped 45 PRAMS sites into 5 response rate groupings:**
  - **Low (39.8% -- 50.1% RR; 8 sites)**
  - **Med-Low (50.5% -- 55.0% RR; 8 sites)**
  - **Med (55.5% -- 59.7% RR; 15 sites)**
  - **Med-High (60.4% -- 65.0% RR; 8 sites)**
  - **High (65.3% -- 81.0% RR; 6 sites)**

- **Unique benefit of PRAMS:**
  - **Multi-site survey with same protocol & questions; lends confidence to findings across 45 sites**
  - **Fully "known" population**

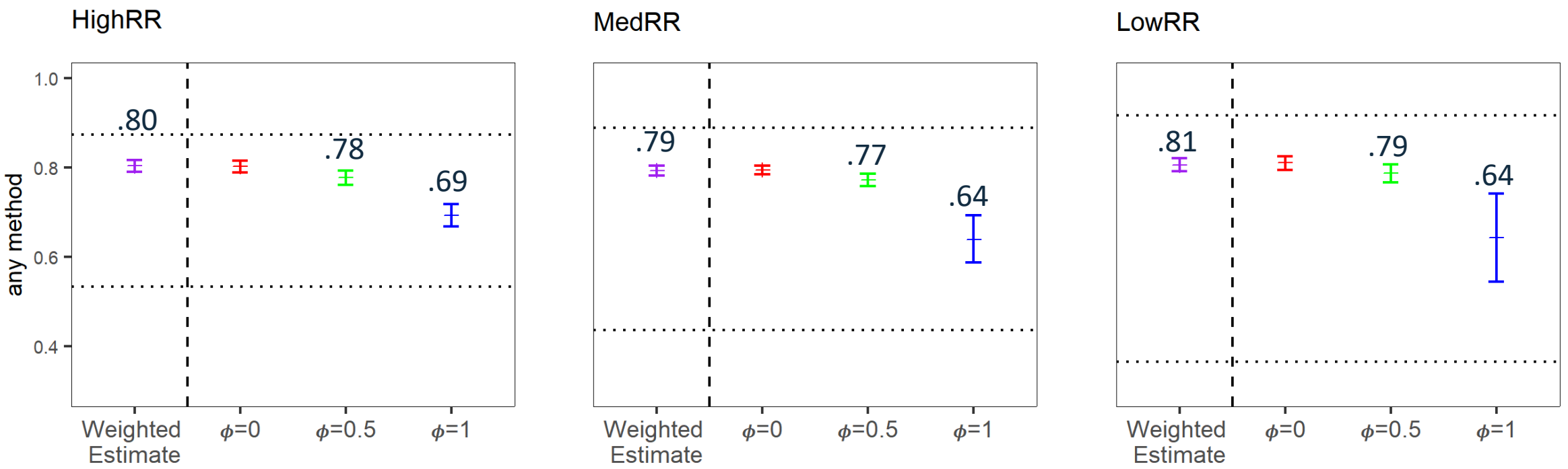
PRAMS Auxiliary Variables	
Education	Race
Age	Ethnicity
Marital Status	Previous Live Birth
Medicaid Birth Coverage	Prenatal Care
Women, Infants and Children Program Status	Top 20% Hospital & County ranked by # births

FINDINGS: EXAMPLE GRAPH

- **PRAMS weighted estimate**
- **Manski bounds (horizontal dotted lines)**
  - **Nonresponders set to "all yes" or "all no"**
  - **Impossible boundary**
  - **Upper=0.89; Lower=0.48**
- **3 missingness simulations**
  - **MAR (ϕ = 0.0, best case)**
  - **Moderate MNAR (ϕ = 0.5)**
  - **Extreme MNAR (ϕ = 1.0, worst case)**

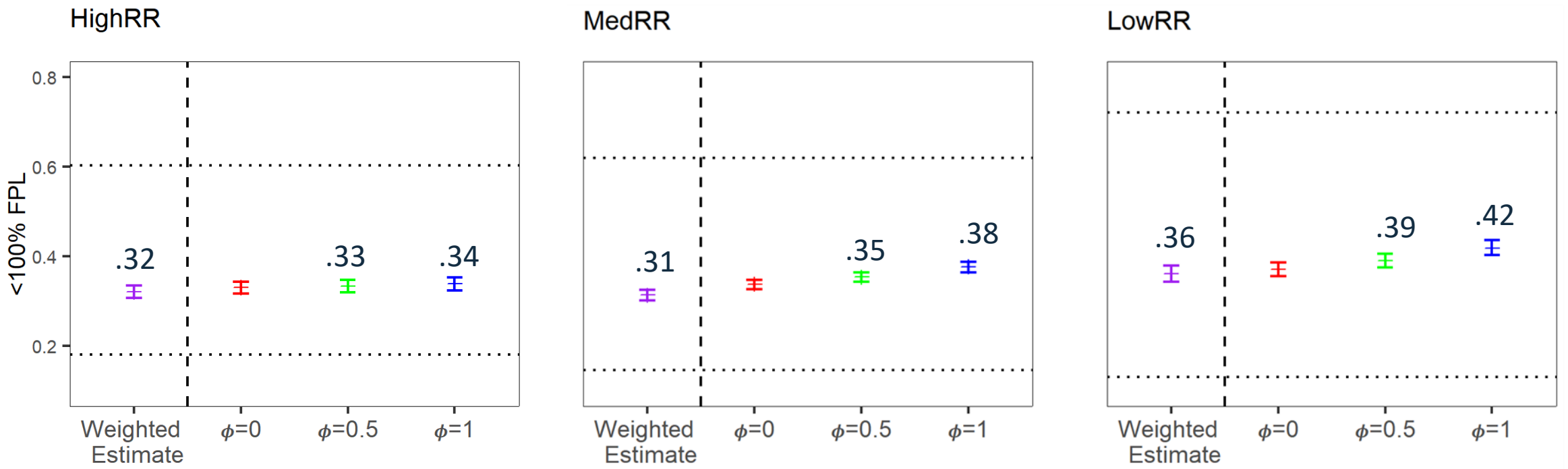


FINDINGS: ANY POSTPARTUM CONTRACEPTION



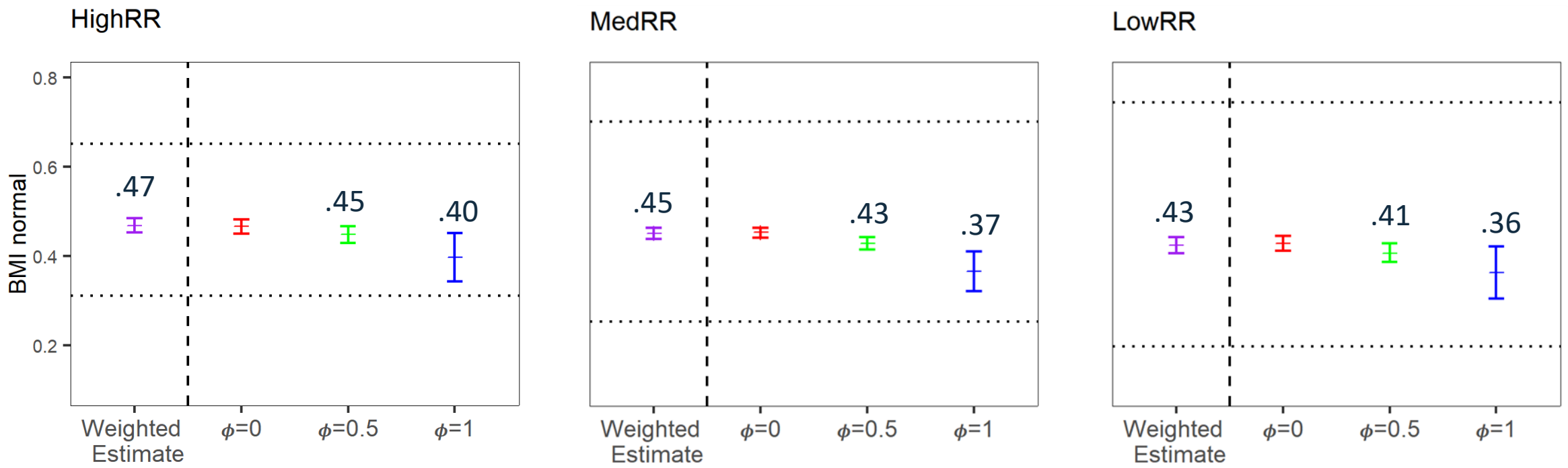
- **As MNAR worsens, PRAMS over-estimates proportion of women using postpartum contraception.**
- **Patterns are similar as you go from high to low RR sites; yet confidence worsens as RR decreases.**
- **Median bias across 45 sites: Moderate MNAR = +1.5%; Extreme MNAR = +6.25%.**

FINDINGS: POVERTY



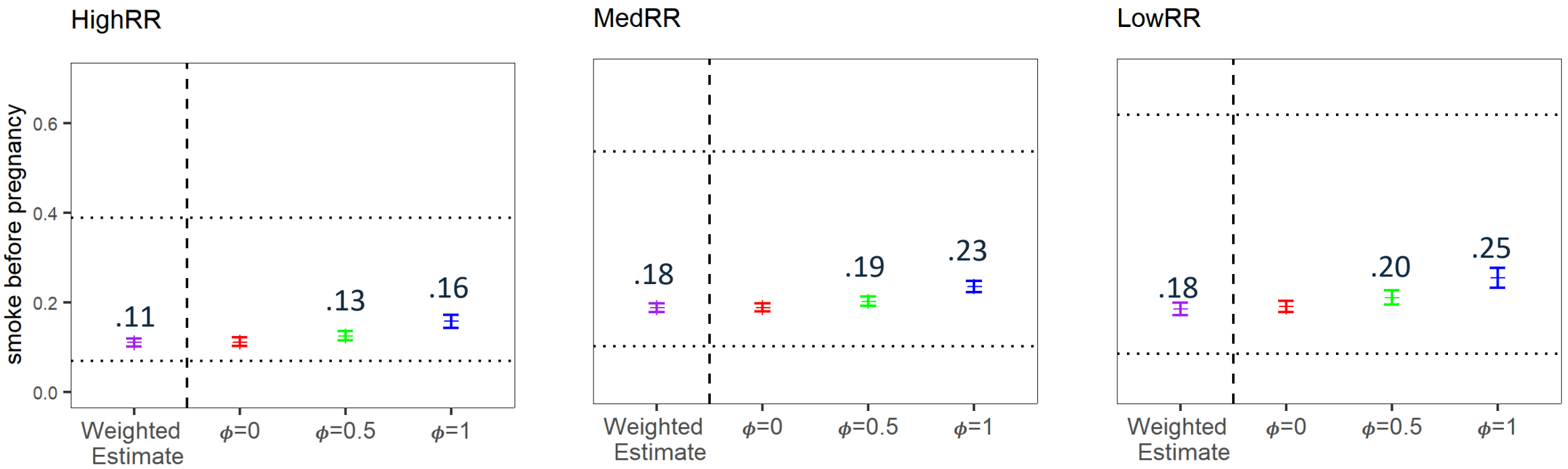
- **As MNAR worsens, PRAMS tends to *under-estimate* proportion of women below poverty line.**
- **Under-estimation is more pronounced with lower response rates.**
- **Median bias across 45 sites: Moderate MNAR = -3.15%; Extreme MNAR = -5.25%.**

FINDINGS: NORMAL BMI (BODY MASS INDEX)



- **As MNAR worsens, PRAMS slightly over-estimates proportion of women with normal BMI.**
- **Median bias across 45 sites: Moderate MNAR = 0.85%; Extreme MNAR = 3.15%.**

FINDINGS: SMOKING BEFORE PREGNANCY



- **As MNAR worsens, PRAMS under-estimates proportion of women smoking before pregnancy.**
- **Median bias across 45 sites: Moderate MNAR = -1.25%; Extreme MNAR = -3.10%.**

KEY TAKEAWAYS

- **As we increased MNAR, weighted survey:**
  - **Tended to overestimate "healthy/positive" indicators**
    - **E.g., postpartum contraception, normal BMI**
  - **Tended to underestimate "risky/negative" indicators**
    - **E.g., smoking before pregnancy, poverty**

- **Lower response rates were associated with *increased* bias -- regardless of missingness assumption**

- **Moderate MNAR scenarios showed relatively "acceptable" biases**
  - **Median bias estimates (45 sites) usually within 0-3 percentage points of PRAMS weighted estimate**

- **Extreme MNAR (among the *most biased* indicators) showed *median* bias (45 sites) within 6-8 percentage points of the PRAMS weighted estimate**

IMPLICATIONS

- **Estimates of bias and uncertainty can be reasonably quantified (topic-by-topic)**
  - **Bias estimates are driven by:**
    - **Proxy differences between responders & nonresponders**
    - **Missingness assumptions (MAR → MNAR)**
  - **Uncertainty around bias is reduced by:**
    - **Higher proxy correlation with topic**
    - **Higher response rates**

- **Sensitivity methods can identify the limit of *plausible* bias -- extreme MNAR as the "worst case"**
  - **More precise than Manski boundaries (i.e., *impossible* bias)**
  - **Offers more interpretibility than 'MAR' assumption**
  - **Imputation is relatively efficient (and programmable)**

LIMITATIONS

- **Weaker proxy association with indicator (e.g., contraception) yields less precise bias estimates**
- **Good auxiliary data is the key to identify (as well as adjust for) potential bias**
- **Model performance becomes less stable with smaller sample sizes (n<1000)**
- **Generalizability:**
  - **PRAMS population is only among postpartum women**
  - **PRAMS, unlike many surveys, has 'luxury' of auxiliary variables at the record level**

DISCUSSION

- Results from all 3 NRB analyses yielded similar results:
  - Weak association between response rates and bias
  - Sensitive/behavioral survey indicators more susceptible to bias than medical and factual indicators
  - Magnitude of bias was small
- Practical implications
  - On average for every 20% decline in response rates, expect about 1 percentage point increase in bias
  - Current NRB analyses found bias levels to be half of what was estimated from 2002 NRB analysis
  - Most survey indicators examined have little evidence of bias

RESPONSE RATE THRESHOLD ADVANTAGES AND DISADVANTAGES

Pros

- Strong incentive for jurisdictions to maintain data collection efforts
- Concerns that response rates would drop if threshold abolished

Cons

- Little evidence to support continued use of threshold policy
- Difficult to justify withholding critical maternal and child health (MCH) data
  - PRAMS response rates higher than many federal health surveys
  - Many sites below threshold have high levels of maternal and infant morbidity and mortality
  - Major data collection and processing effort unused

IMPLICATIONS FOR PRAMS DATA RELEASE

Possible data release approaches to consider:

- Retain threshold
- Abolish threshold and publish results of bias analyses (overall and site-specific) so data users know risks of bias
- Abolish threshold and add warnings or qualifiers to published reports using PRAMS data for sites with low response rates

NEXT STEPS

- NRB analyses are underway for the 2020 PRAMS data
- After the 2020 NRB analyses are completed, CDC will use the results of the 2019 and 2020 analyses to re-evaluate the response rate threshold policy
- Going forward, conduct annual, comprehensive NRB analyses to quantify the risk of bias

THANK YOU!

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