A Comparison of Conventional Weighted Estimates of Vaccination Coverage with Estimates from Imputed Data Using Available Software

Taylor Lewis and Meena Khare[1]
National Center for Health Statistics,
Centers for Disease Control and Prevention

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[1]The findings and conclusions in this paper are those of the authors and do not necessarily represent the views of the National Center for Health Statistics, Centers for Disease Control and Prevention

National Immunization Survey (NIS)

- Began in 1994, sponsored by CDC
- Collects vaccination data on children 19 – 35 months old for coverage estimates
- NIS 2008, 67 estimation areas (strata) covering all 50 states and DC
- Two-stages of data collection:
  1. RDD telephone survey to screen and interview households with age-eligible children
  2. After initial telephone interview (and consent), nominated providers are sent immunization history questionnaire

Missing Data Details

- Ultimately, vaccination data unascertained for about 30% of children identified from the household interview:
  - Parent/guardian explicitly refuses to supply provider contact information
  - Parent/guardian does not know provider contact information
  - Providers do not provide adequate vaccination data

Overall Missing Data Pattern

	RDD Stage Data				Provider Stage Data			
Child	State	Age (mos.)	Sex	…	DTP	Polio	MCV	…
1	VA	19	M	…	4	3	1	…
2	MD	24	M	…				
3	DC	25	F	…	4	4	2	…
4	MA	21	M	…				
.	.	.	.	.	.	.	.	…
.	.	.	.	.	.	.	.	…
.	.	.	.	…	.	.	.	…

Missing Data Details (2)

- Brick and Kalton (1996) refer to this scenario as “partial nonresponse”
  - Unit nonresponse? → Weight
  - Item nonresponse? → Impute
  - Partial nonresponse? → Weight or Impute??

Missing Data Details (3)

- Public-use file contains data for 25,948 children and two sets of weights:
  1. RDDWT – weights the RDD stage household-level responses to the population
  2. PROVWT – adjusts RDDWT to account for 7,433 cases with missing provider data (7,433/25,948 = 28.6% item missing rate)

- Thus, current compensation methods involve multi-step weighting process, but would imputation provide substantively different results?

Key Outcome Variable

- Focus is a composite indicator of five specific vaccinations:
  - 4+ doses of diphtheria and tetanus toxoids and acellular pertussis (DTaP)
  - 3+ doses of poliovirus vaccine (polio)
  - 1+ doses of measles-containing vaccine (MCV)
  - 3+ doses of *Haemophilus Influenza* type b (Hib)
  - 3+ doses of hepatitis B (HepB)

- Referred to as the 4:3:1:3:3 series – being up-to-date (UTD) means meeting all five dose criteria

- NOTE: in the 2008 data, all five 4:3:1:3:3 doses are either all known or all unknown

Provider Missing Data Pattern

Child	Vaccination - Number of Doses					Composite
	DTP	Polio	MCV	Hib	HepB	4:3:1:3:3 UTD?
1	4	3	1	3	2	N
2						?
3	4	4	2	3	3	Y
4						?
.	.	.	.	.	.	.
.	.	.	.	.	.	.
.	.	.	.	.	.	.
25,948	4	3	2	4	3	Y

Key Predictor Variables

- Available covariates which best described the missingness and 4:3:1:3:3 UTD pattern:
  - Age of the child
  - Mother's age
  - Race/ethnicity of the child
  - Indicator of first born
  - Total number of children in the household
  - Indicator of a shot card
  - Sex of the child
  - Mother's education level
  - Mother's marital status
  - Indicator of household poverty status
  - Region indicators – geographically collapsed strata into 10 regions

- Some degree of missingness in these covariates, which were singly imputed (generally < 3%); this uncertainty not accounted for in present analysis

Imputation Methods

1. Single imputation hot-deck (SOLAS) (*M* = 1)

2. UMich Survey Research Center's IVEware (*M* = 5)
   - model the outcome via logistic regression
   - separate model for each region

3. Propensity Score Method (SOLAS) (*M* = 5)
   - model missingness indicator and group into 5 propensity classes
   - one model (e.g., region maintained as an independent variable)

4. Propensity Score Method (programmed in SAS) with a modified approximate Bayesian Bootstrap (ABB) (*M* = 5)
   - first stage of ABB routine (Rubin and Schenker, 1986) maintained as normal
   - second stage modification: sample donors PPS with RDDWT as the measure of size

NOTE: Taylor series linearization was used for approximating variances

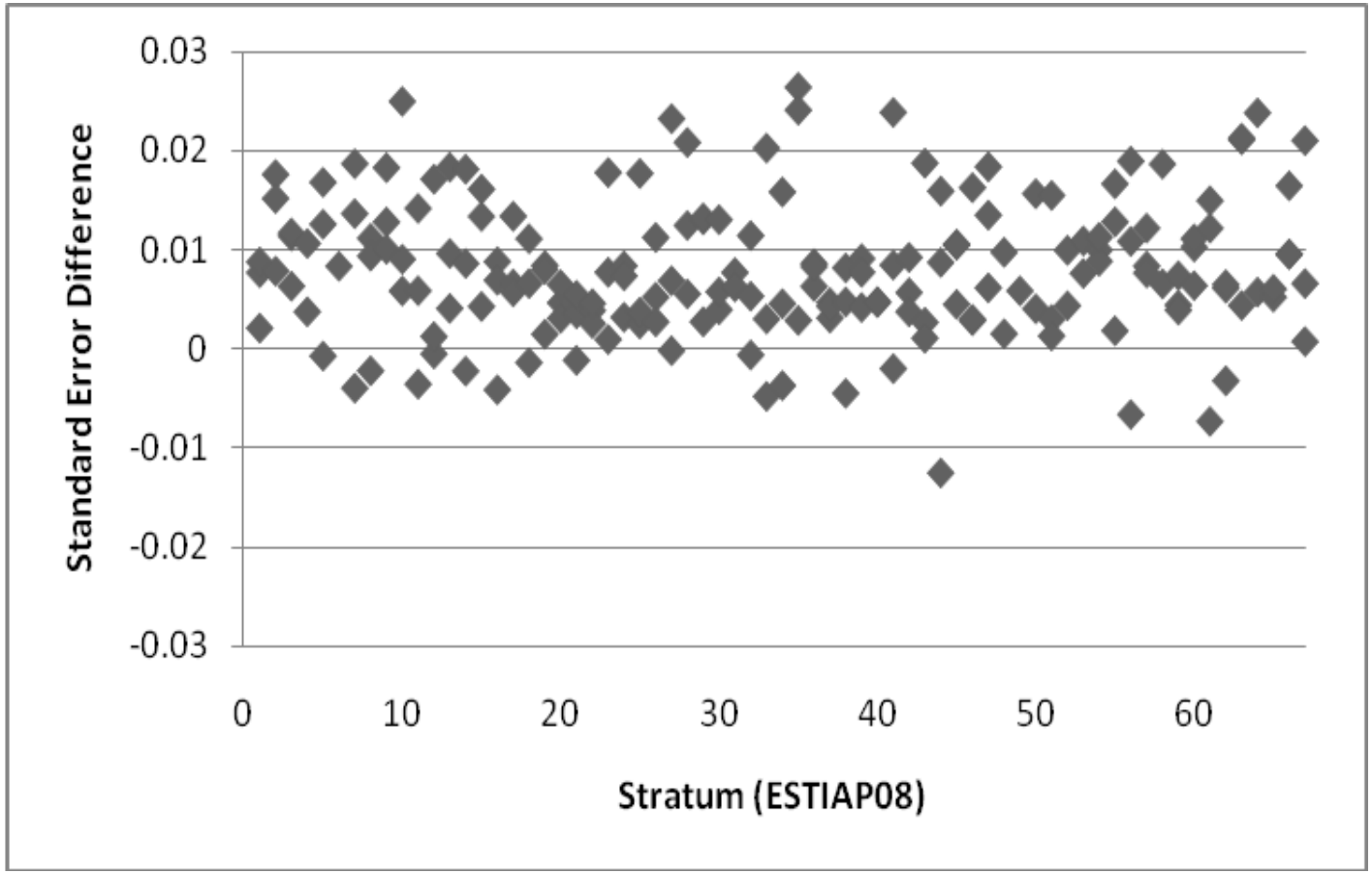
Results

Table 1. Unweighted Proportions of Observed and Imputed Up-to Date 4:3:1:3:3 Status

Imputation Method	Observed	Imputed
M1. Hot-Deck	0.785	0.771
M2: IVEware	0.785	0.763
M3: Propensity	0.785	0.766
M4: Propensity with PPS ABB	0.785	0.769

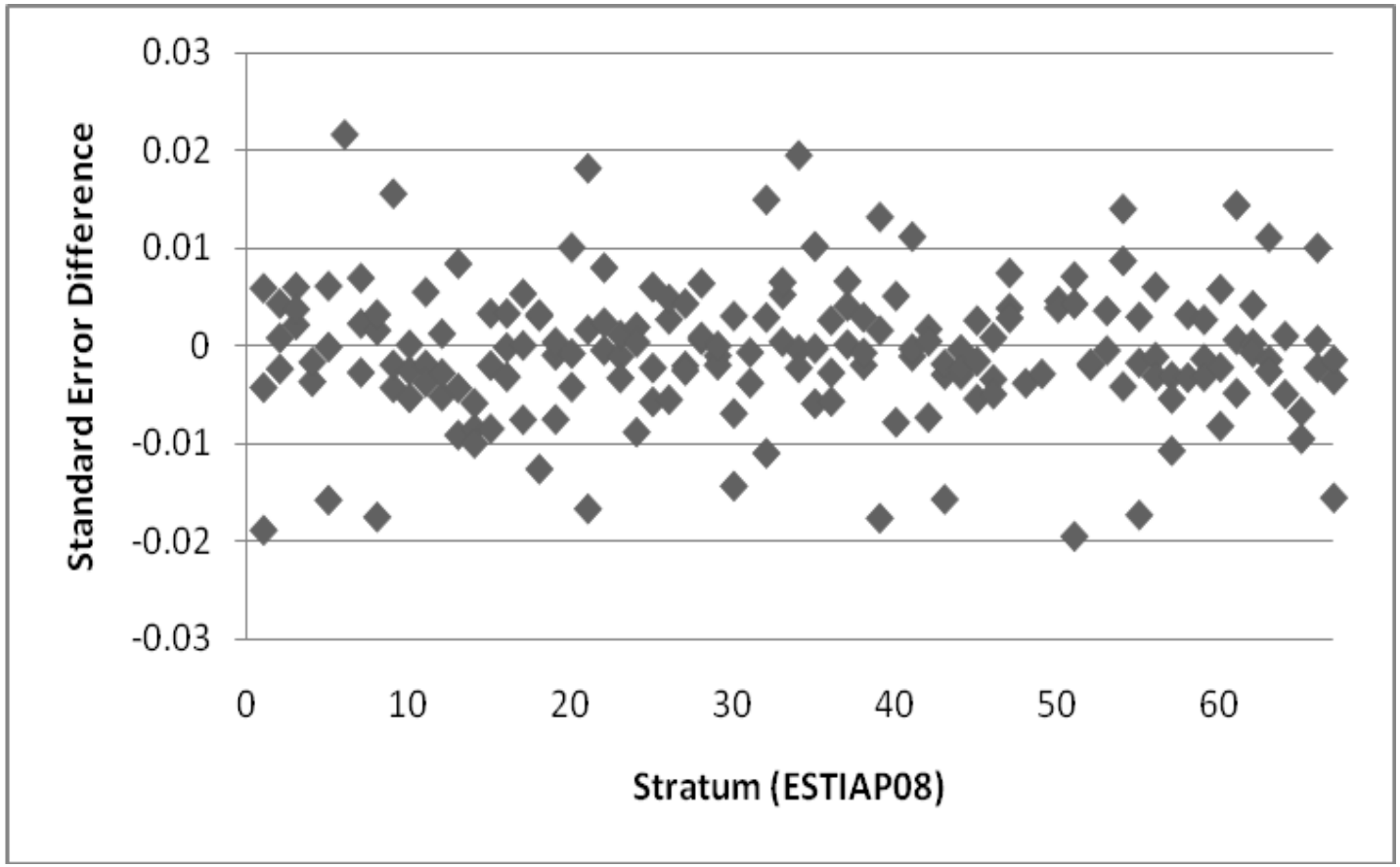
Results (2)

Figure 1a. Stratum-Level Standard Error Differences between NIS Weighted and Method 1 for 4:3:1:3:3 Status within Income/Poverty Status Domains.



Results (3)

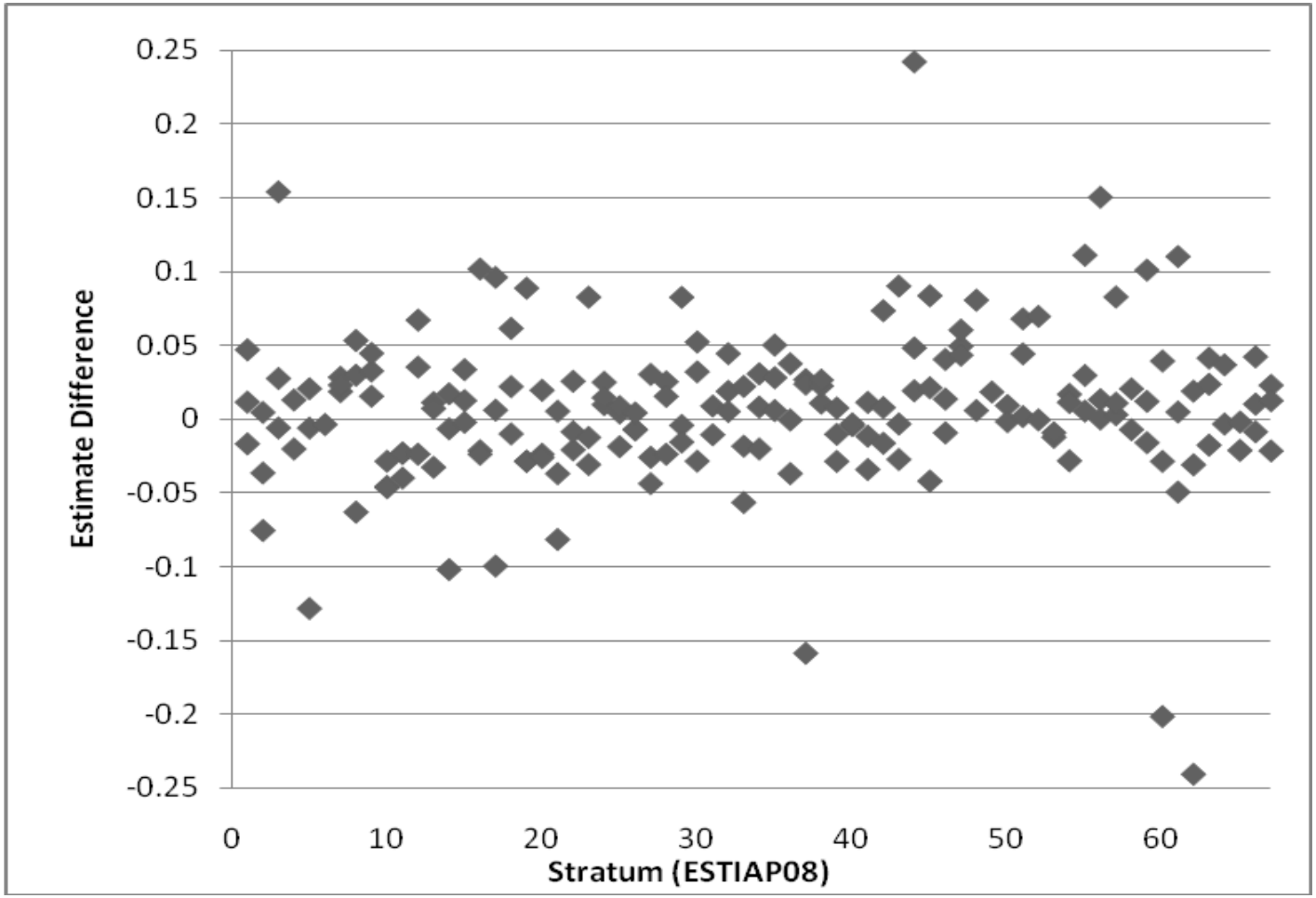
Figure 1b. Stratum-Level Standard Error Differences between Method 2 and Method 3 for 4:3:1:3:3 Status within Income/Poverty Status Domains.



*Though not shown, the plot of standard error differences between weighted estimates and any multiply imputed estimate looks the same.

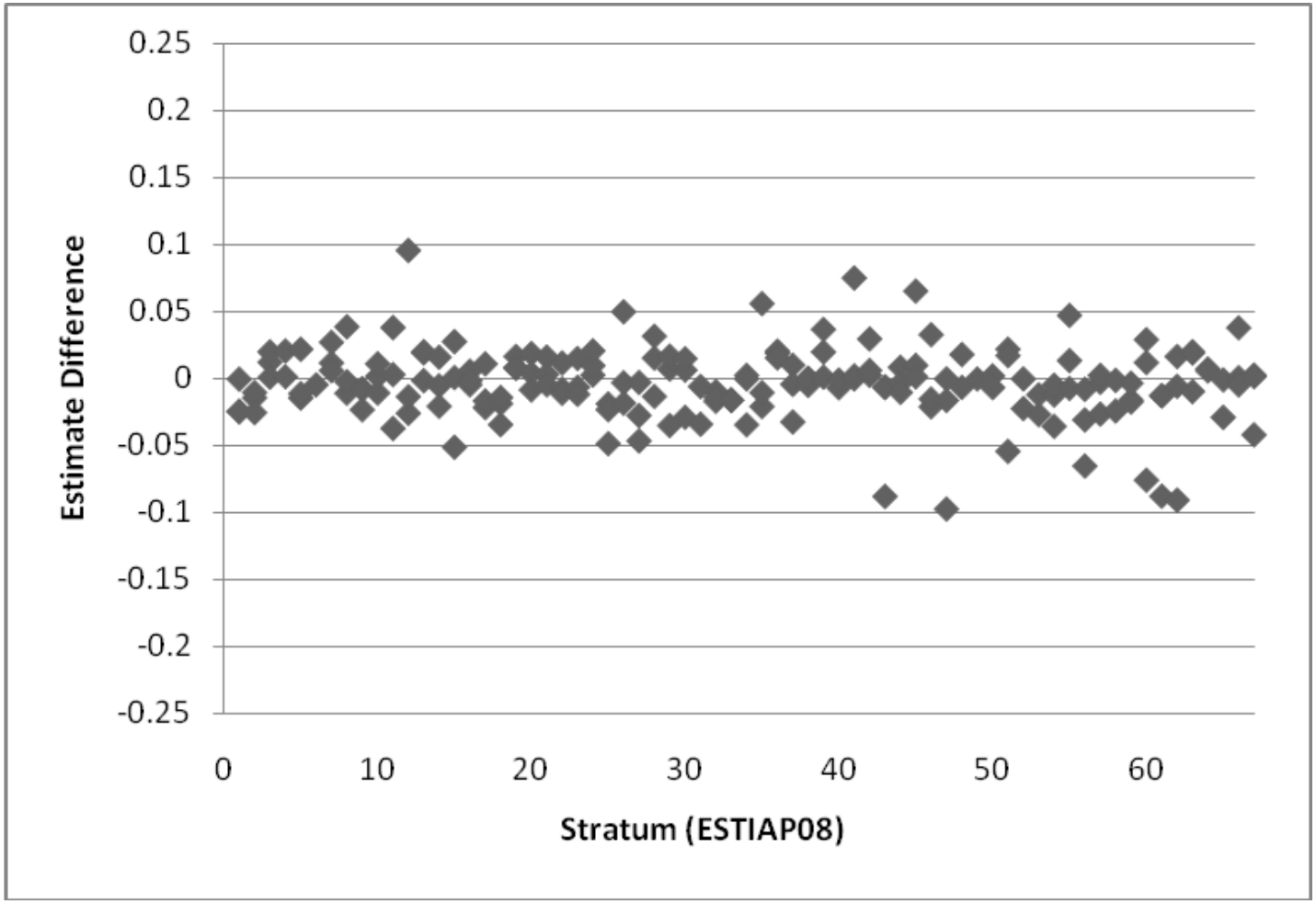
Results (4)

Figure 2a. Stratum-Level 4:3:1:3:3 Status Estimate Differences between Method 2 and Method 3 for Child Race/Ethnicity Domains.



Results (5)

Figure 2b. Stratum-Level 4:3:1:3:3 Status Estimate Differences between Method 3 and Method 4 for Child Race/Ethnicity Domains.



Summary of Findings

- Given the available covariates, we examined four distinct imputation methods to fill in missing 4:3:1:3:3 UTD status and found:
  - Single imputation leads to the smallest standard errors
  - All imputation methods tend to yield a slightly smaller point estimate (agrees with previous findings from Khare and Yucel, 2003)
  - The current weighting method yields comparable standard errors against all three *multiple* imputation methods
  - Modification of incorporating RDDWT into the ABB did very little → recent work by Andridge and Little (2009, 2010) suggest proper way to incorporate the weights in a hot-deck would be to use them during cell construction ONLY
  - All things considered, the multiple imputation methods do not appear to offer any advantages

Limitations

- Treat weights as known
- Estimates are highly correlated: about 70% of the (observed) data are the same for each imputation method → correlation needs to be accounted for in assessing significance (Schenker and Gentleman, 2001)
- Only have access to variables on PUF
- Differences attributable to method or covariates?

Possible Future Research

- Re-evaluate methods if there is evidence response patterns change or new auxiliary variable become available → few variables in current analysis demonstrate strong relationship with missingness indicator or outcome

- Paradata?

- State immunization registries?

Thanks!

name: Taylor Lewis
email: Taylor.Lewis@cdc.hhs.gov