Alternative Methods to Compensate for Provider Nonresponse in the National Immunization Survey

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1. BACKGROUND

Data is collected in the National Immunization Survey (NIS) in two phases. In the first phase, households with 19-35 month-old children are identified using a list-assisted RDD survey and data on children's socio-demographic characteristics are collected. At the end of the random digit dialing (RDD) interview, consent is requested to contact children's vaccination providers to obtain provider-reported vaccination histories. When consent is obtained, a mail survey questionnaire is sent to vaccination providers who were listed by the NIS RDD respondent to obtain the child's provider-reported vaccination history. Those histories are used to obtain official estimates of vaccination coverage. More detailed description of the sampling design and methods used by the NIS are described by Smith et al[1,2,3]. The NIS has been reviewed and approved by an institutional review board at the Centers for Disease Control and Prevention every year between 1994 and 2006.

Provider-reported vaccination histories can be missing because either (i) the household did not give consent to contact the sampled child's vaccination providers, or (ii) the household gave consent to contact the providers but the providers did not respond to the mail survey or responded but provided a vaccination history that was inadequate to evaluate the child's vaccination up-to-date (UTD) status. In this paper, we refer to the problem of not obtaining adequate provider data for either reason (i) or (ii) as the problem of "provider nonresponse." Currently, NIS survey weights are adjusted for provider nonresponse using a weighting-class method based on response propensities. This paper explores an alternative method for accounting for provider nonresponse that accounts for the two different ways in which provider-reported vaccination histories can be missing, and compares estimates of vaccination coverage obtained from the method currently used by the NIS and alternative method.

2. METHODS

2.1 The NIS RDD sampling weights. Sampled children whose parent completes the NIS RDD interview are assigned an "RDD sampling weight" that may be interpreted as the number of children in the target population that the sampled child represents. In the NIS, RDD sampling weights are adjusted for the probability of sampling the landline telephone number from a sampling frame of landline telephone numbers, the number of residential non-business telephone numbers in the sampled child's household, and household nonresponse, with a further adjustment made to account for households without a landline telephone; and are poststratified according to published or derived statistics on the level of educational attainment of the mother, the race/ethnicity of the mother, and the age of the child at the time of the NIS RDD interview.

2.2 Reasons for provider nonresponse in the 2005 NIS. In 2005, a completed RDD interview was obtained for 27,627 age-eligible children. Among those, adequate provider data required to evaluate UTD status was obtained from 17,448 children, and 115 children had received no vaccine doses. However, among the 27,627 children sampled in 2005, adequate provider data were not obtained for ~37% of the children: ~21% of the children because consent was not granted; ~2% because consent was granted but inadequate contact information was obtained for the providers; ~7% of the children because consent was granted and provider contact information obtained but no vaccination histories were returned from childrens' vaccination providers; and ~7% of the children because vaccination histories were returned but these histories were inadequate to evaluate the vaccination UTD status.

In this paper we refer to a sampled child who has a complete NIS RDD interview and an adequate provider-reported vaccination history as a "complete" responder, and a sampled child who has a complete RDD interview but inadequate or missing provider-reported vaccination history as a "partial" responder.

2.3 The NIS adjustment for provider nonresponse. To reduce potential bias in vaccination coverage estimates that could be incurred by failing to account for provider nonresponse in the sampling weights, the NIS uses a statistical method known as a weighting-class adjustment[4] within each stratum of the NIS sampling design. The NIS

implementation of the weighting-class adjustment involves three steps. In the first step, sampled children are classified according to the similarity of their estimated propensities to have adequate provider data. Those propensities are estimated from a logistic model where the dependent variable is a binary indicator denoting whether a child has adequate provider data and the independent variables are socio-economic variables collected in the NIS RDD interview that are selected for the propensity model by a forward-selection process. Table 1 lists the socio-demographic variables used as candidates for predictors in the response propensity model and the order in which selected variables entered in the forward variable-selection process. Within a stratum, sampled children are grouped into 1 of 5 weighting classes that depend on the quintiles of the distribution of estimated response propensities within the stratum.

In the second step of the NIS weighting-class adjustment, within each weighting class, the NIS adjustment redistributes the RDD sample weights of the partial responders proportionally among the complete responders. In the third step of the NIS weight class adjustment, complete responders' adjusted RDD sampling weights are then "raked" so that the marginal sum of the weighted distribution of specified socio-economic variables match published totals for those variables. Literature that describes the NIS adjustment for provider nonresponse is given elsewhere.[1,2,3]

2.4 The alternative adjustment to account for provider nonresponse. The alternative method consists of two separate weighing-class adjustments. In the first weighing-class adjustment, the propensity of giving consent is modeled using the same forward selection procedure as in the NIS adjustment. Table 1 lists the sociodemographic variables selected by that procedure and the order in which the selected variables entered the "consent propensity" model. Next, within each stratum of the NIS sampling design, each sampled child is grouped into 1 of 5 weighting classes that are defined by the quintiles of the estimated consent propensities; and then the RDD weights of sampled children for whom consent was not obtained are distributed proportionally among children who had consent. Finally, adjusted weights are raked to yield an intermediate "consent" sampling weight.

In the second adjustment, among children for whom consent was obtained, the propensity of having adequate provider data is modeled using the same forward selection procedure as in the NIS adjustment. Table 1 lists the sociodemographic variables selected by that procedure and the order in which the selected variables entered the propensity model. Next, within each stratum of the NIS sampling design each sampled child is grouped into 1 of 5 weighting classes that are defined by the quintiles of the estimated propensity of having adequate provider data; and then the RDD weights of sampled children for whom adequate provider data was not obtained are distributed proportionally among children who had adequate provider data. Finally, adjusted weights are raked to yield the sampling weight of the "alternative" method.

2.5 Comparison of the NIS and alternative method of adjusting for provider nonresponse. Since 1995, the Advisory Committee on Immunization Practices has recommended that children should be administered 4 doses of the diphtheria, tetanus toxoids, and (acellular) pertussis vaccine (DTaP/DTP), 3 doses of the polio vaccine, 1 dose of the measles-mumps-rubella vaccine (MMR), 3+ doses of the *Haemophilus influenzae* type b (Hib), and 3 doses of the hepatitis B vaccine (Hep B).[5] In this paper we refer to a child as being UTD if they receive 4+ doses of DTaP/DTP, 3+ doses of polio, 1+ doses of MMR, 3+ doses of Hib, and 3+ doses of Heb B.

To compare the NIS method of adjustment for provider nonresponse to the alternative method, we compare state-level estimates of the UTD rates and their estimated standard errors (SEs) for the 2 methods using data from the 2005 NIS.

3. RESULTS

3.1 Similarity of factors selected by the three propensity models. Table 1 lists the socioeconomic predictors that were offered to the forward model selection processes for the three propensity models. A blank cell in the table associated with a predictor indicate that the predictor was not selected by a propensity model. Of the 11 predictors that were selected by at least one of the 3 model selection processes, the NIS method selected 9 of those variables, the consent model selected 8 of those variables, and the final alternative model selected 9 of those predictors. Furthermore, the first 4 or 5 variables selected in the forward selection processes were nearly the same for all three models.

3.2 Similarity of estimated UTD rates across the 50 states and the District of Columbia. Using data from the 2005 NIS, Figure 1 shows a plot of the estimated UTD coverage rates obtained from NIS methodology versus estimated UTD coverage rates obtained from the alternative methodology for each of the 50 states and the District of Columbia. This plot shows that each plotted point is nearly identical to the dashed 45° line, confirming that there is little difference in the UTD estimates.

Figure 2 shows a boxplot of the difference in estimated UTD coverage rates (NIS methodology estimate minus alternative methodology estimate). This plot shows that the interquartile range in the difference is well within ±0.5 percentage points, illustrating that 50% of the differences are negligible in practical terms. The maximum absolute difference in the estimated coverage rates between the methods is 1.9 percentage points.

3.3 Similarity of estimated SEs of estimated UTD rates across the 50 states and the District of Columbia. Figure 3 is a plot of estimated SEs of the estimated UTD coverage rate obtained from NIS methodology versus that of the alternative methodology. Again, this plot shows that each plotted point is nearly identical to the dashed 45° line, confirming that there is little difference in the estimated SEs of UTD estimates, regardless of which of the two adjustment methodologies is used. The maximum absolute difference in the estimated SE of estimated UTD coverage rates between the methods is 0.3 and is negligible in practical terms. Figure 4 is a boxplot of ratio of estimated SEs of estimated UTD coverage rates (NIS methodology SE divided by alternative SE), again showing no practical differences in the SEs of any consequence.

4. CONCLUSIONS

This paper shows that using data from the 2005 NIS, there were minimal differences in the estimated UTD rates and their estimated SEs that could be attributed to differences between the NIS and alternative adjustments for provider nonresponse.

Why are the results so similar? Examination of Table 1 shows that the leading terms (i,e., sociodemographic variables selected in the forward selection procedures) in each of the three propensity models used in the 2 adjustments are essentially the same. Because the leading predictors are essentially the same, children within a stratum will either be "funneled" into essentially the same weighting class regardless of what method is used, or be assigned to a neighboring weighting-class where the nonresponse adjustment is similar. That is, sampled children within a stratum that belong to any of the five weighting classes in the NIS method are essentially the same children in both weighting classes formed using the alternative method. Consequently, within any weighting class the children will be adjusted essentially the same amount, regardless of the method used. Also, the raking that is used in the last step of both the NIS and alternative method will have the effect of smoothing differences between the two methods. Because of the similarities of the NIS and alternative method, it is difficult to argue that the additional complexity required by the alternative method yields more refined estimates, or appreciable benefits in terms that matter with respect to the surveillance of state-level vaccination coverage rates.

Figure 1: Plot of estimated UTD coverage rate obtained from NIS methodology versus estimated UTD coverage rate obtained from alternative methodology. 2005 NIS.

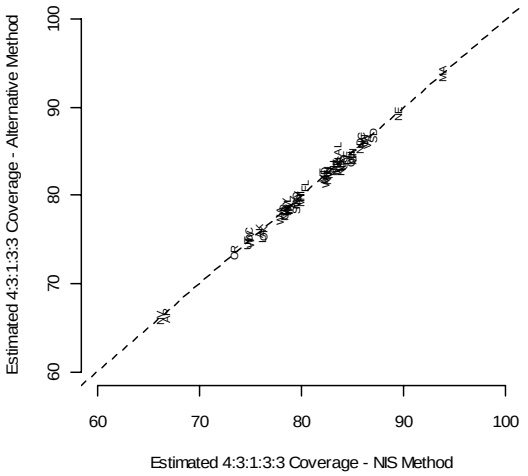

Figure 2: Boxplot of difference in estimated UTD coverage rates (NIS methodology estimate minus alternative estimate). 2005 NIS.

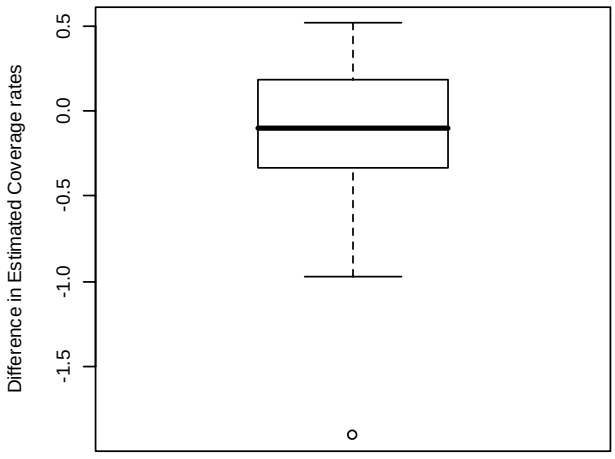

Figure 3: Plot of estimated standard error (SE) of the estimated UTD coverage rate obtained from NIS methodology versus that of the alternative methodology. 2005 NIS.

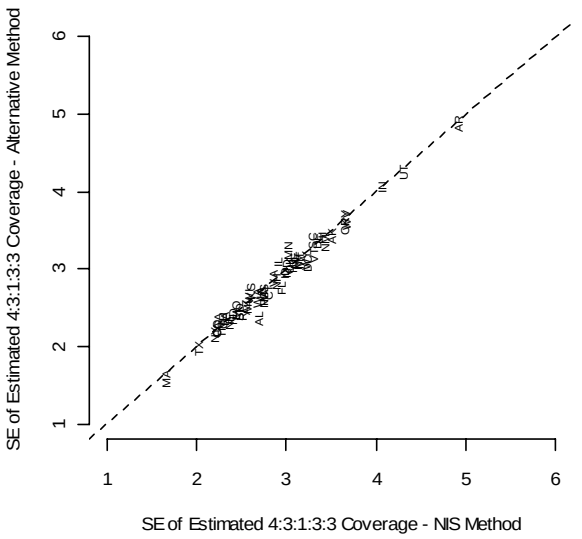

Figure 4: Boxplot of ratio of estimated SEs of estimated UTD coverage rates (NIS methodology SE divided by alternative SE). 2005 NIS.

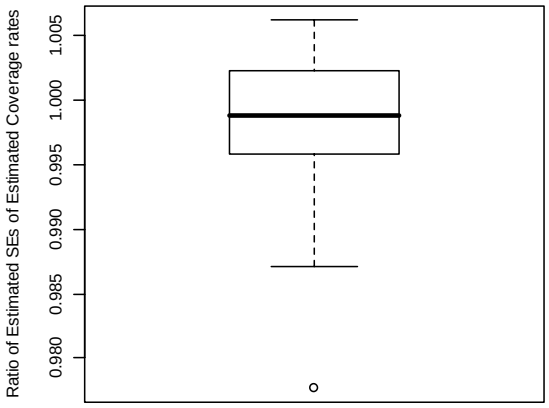

Table 1: Predictors offered and selected by the NIS and alternative model selection procedures. Numeric values in the table indicate the order in which the variable selection methods chose the candidate predictors. 2005 NIS.

CANDIDATE PREDICTORS OFFERED TO THE STATISTICAL MODELS	Predictors Included In The Model As A Result Of The Model Selection Procedure		
	NIS method	Alternative method	
		Consent Model	Missing Data Model
Child's Characteristics			
Race/ethnicity	4	5	2
Age group	8		8
Gender			9
First-born status	7	7	
Maternal Characteristics			
Marital Status			
Age Group	9	8	
Educational level		4	4
Has a written record of the child's	1	1	1
Household Characteristics			
Relation of the NIS RDD respondent to	3	3	5
Number of children in the household ≤18 yrs			
Annual income level	2	2	6
Moved across state lines since child's	5		3
Metropolitan statistical area designation	6	6	7

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