RESPONSE ERRORS ASSOCIATED WITH HOUSEHOLD REPORTS OF IMMUNIZATIONS ANALYSIS OF SUBGROUP DIFFERENCES

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Key Words: response bias, relative bias

1. Introduction

Current vaccination coverage levels in the U.S. are the highest ever reported (CDC, 1996). However, not all children receive all the recommended doses of vaccines which allows the buildup of susceptible populations. With the reintroduction of a disease, outbreaks or epidemics can then occur. State and local areas know where subgroups of susceptible children are located, but how do we best monitor vaccination coverage levels in these subgroups?

One goal of the Childhood Immunization Initiative is to develop better tools for monitoring vaccination coverage levels. The National Health Interview Survey (NHIS) is used to monitor national vaccination coverage levels. To better monitor children at risk for undervaccination, understanding the response errors associated with reported vaccination levels in different subgroups of children is important. The purpose of this paper is to evaluate response errors in the vaccination coverage level estimates from the NHIS. Net and gross difference rates, and the net and relative bias by subgroups including age and race/ethnicity of the child; parents' highest level of education; household income, area of residence, and telephone status of the household are presented.

2. Methods

The National Immunization Provider Record Check Study (NIPRCS) was begun in 1994 as a substudy of the National Health Interview Survey's Immunization Supplement. The objective of the study is to collect provider data on vaccinations for all children 19 to 35 months of age included in the National Health Interview Survey (NHIS) for whom the receipt of one or more doses of any vaccine was reported. Provider reports combined with reports obtained from household respondents' provide a more accurate estimate of vaccination coverage levels. Vaccination status is collected for five vaccines: diphtheria and tetanus toxoids and pertussis vaccine (DTP) or diphtheria and tetanus toxoids (DT), poliovirus vaccine, measles-mumps-rubella (MMR) or measles vaccine, *Haemophilus influenzae* type b vaccine (Hib), and hepatitis B vaccine. Household respondents either refer to a shot card or rely on their recall to report the child's vaccination history.

The design of the National Immunization Provider Record Check Study has previously been discussed by Peak and Cadell (1996) and Ezzati-Rice *et al.* (1996). For simplicity, the analysis in this paper focuses on 4:3:1:3 series. This is the series of vaccinations that all children should have received by 19 months of age and includes at least four doses of DTP/DT, at least three doses of poliovirus vaccine, one dose of MMR vaccine, and at least three doses of Hib vaccine.

Information is presented for all children, for children whose household report was based on a shot card, and for those children whose household report was based on recall. Since the vaccination schedule is very complicated, the most reliable household-based information is obtained from a shot card.

A child's age is defined in months as of the date of the interview. Age groups studied are children 19 to 25 months and 26 to 35 months. Race/ethnicity of the child is defined as Hispanic, non-hispanic black, or non-hispanic other. Parents' highest level of education is categorized as less than 12 years, high school education (12 years), or more than 12 years of education. Household income is defined as at or above the poverty level or below the poverty level. We compare the area of residence by metropolitan statistical area (MSA) central city, MSA non-central city, and non-MSA. We also compare households with and without a telephone.

Vaccination coverage level estimates based on the household interview exclude children for whom the respondent reported "unknown" or "missing" for either receipt of the vaccine or the number of doses received. However, the vaccination coverage levels based on provider reports include the children where the respondent reported "unknown" or "missing" as illustrated in the weighting class adjustment method in Ezzati-Rice *et al.* (1996).

Data available from the 1994 NHIS and NIPRCS that includes all four quarters are used. Since "best" values as discussed by Ezzati-Rice *et al.* were not available for all quarters of the 1994 NIPRCS, provider data on vaccination coverage are considered as the "gold standard" or "truth". All analyses use the weighted NHIS data set which includes a nonresponse adjustment.

Table 1. Up-to-date (UTD) status of a child receiving the complete vaccination series according to the household and the provider response

Provider	Household		Total
	UTD	Not UTD	
UTD	a	b	a+b
Not UTD	c	d	c+d
Total	a+c	b+d	n=a+b+c+d

The net and gross difference rates are used to determine the measurement error in the household-based report of vaccination coverage levels. The net difference rate estimates the net response bias in the household-based estimate of vaccination coverage levels. Referring to the designated cells in Table 1, the net difference rate is calculated by

$$\frac{(c-b)}{n} \times 100.$$

Incorrect household-based information can be of two types: understating the number of vaccinations (b) and overstating the number of vaccinations (c).

The gross difference rate is the percentage of incorrect household reports when the provider value is accepted as truth. The gross difference rate can be thought of as the total amount of measurement error in the estimate. The gross difference rate is calculated by

$$\frac{(b+c)}{n} \times 100.$$

The net and gross difference rates exclude those children for whom the respondent reported "unknown" or "missing" for either receipt of a vaccine or the number of doses received.

The net bias is the difference in the two vaccination coverage estimates (e.g., household-based vaccination coverage level estimate minus provider-based vaccination coverage level estimate). The relative bias is the net bias divided by the provider-based vaccination coverage level estimate times 100 percent. It measures the proportionate error in the estimate of vaccination coverage levels (Lessler and Kalsbeek, 1992, Ch. 10).

3. Results

The 1994 NHIS included 2,651 children 19 to 35 months of age. The Immunization Supplement was completed on 2,439 (92%) of the children and a provider response was received on 1,370 (56%) of the children (Table 2). Household vaccination histories were reported from a shot card for 1,202 (49%) of the children. Provider data were received from 776 (65%) children whose household respondent referred to a shot card, and from only 594 (48%) of those whose household respondent relied on recall. Among subgroups, shot card use ranged from a high of 55% among Hispanics respondents to 35% among non-hispanic black respondents. Some subgroups are based on small sample sizes. For example, those households without a telephone are based on only 278 children. More provider reports were always received for respondents using a shot card than those relying on recall.

For all children and all subgroups, the household-based estimates of vaccination coverage (4:3:1:3) levels were lower than the provider-based estimates (Table 3). Those children living in a household with no telephone were the least well vaccinated by both estimates of vaccination coverage. The net difference rate ranged from an initial under-reporting of the vaccination coverage level of 18 percentage points for those living in a non-MSA area to a six percentage point under-reporting of the vaccination coverage level for those with only a high school degree. The gross difference rate ranged from 24 percent in those households with no telephone to a high of 38 percent for non-hispanic blacks.

For children for whom the respondent relied on a shot card for the reporting of the vaccination history, the household-based estimate of vaccination coverage (4:3:1:3) levels was lower than the provider-based estimate in all subgroups (Table 3). The net difference rate ranged from an under-reporting of the vaccination coverage level of 23 percentage points for non-hispanic blacks to seven percentage points for Hispanics. The gross difference rate was smallest, 24 percent, for those with no telephone. The largest gross difference rate, 35 percent, was observed for non-hispanic blacks.

For children for whom the respondent relied on recall for the report of vaccination histories, the household-based estimate of vaccination coverage (4:3:1:3) levels was lower than the provider-based estimate in all but three subgroups (non-hispanic black, high school graduate, and those living below poverty) (Table 3). For subgroups in which the household-based estimate was lower than the provider-based estimate, under-reporting was as much as 24 percentage points for those residing in a non-MSA area. For those groups in which the household-based estimate were higher than the provider-based estimate, the household-based estimates over reported the provider-based estimates by three to five percentage points. The gross difference rate ranged from 23 percent for those in nontelephone households to

41 percent for those living in an MSA non-central city area.

For all estimates of vaccination coverage, the relative improvement in the household-based estimate with the inclusion of the provider data needs to be noted. Table 4 presents the net bias and the relative bias for all children and by the source of information used in reporting vaccination coverage by subgroup. The net bias is similar to the net difference rate. The net bias indicates that for all children and for shot card children the household-based estimate under estimates the vaccination coverage levels. For recall children, the net bias indicates that for non-hispanic blacks, parents' highest education 12 years, and those living below poverty, the household-based estimate of vaccination coverage over estimates the vaccination coverage levels. For the remaining subgroups of recall children, the net bias indicates that the household-based vaccination coverage estimate is an under estimate.

For all children the relative bias, or the proportionate change in the estimate, ranges from an under estimate of four percent for high school graduates to 29 percent in those households where the education of the parent was less than 12 years. For shot card children, the relative bias shows an under estimate of 11 percent in the vaccination coverage estimate for Hispanics. However, for non-hispanic blacks a 32 percent under estimate occurred. For recall children, the relative bias shows an over estimate in the vaccination coverage level of 12 percent for high school graduates. There was a 34 percent under estimate for those children who's parents education was less than 12 years.

4. Summary

In the NHIS, the net and gross difference rates show that household reports of vaccination coverage levels are subject to high degree of response error. The net difference rate shows a difference between the household-based estimate and the provider-based estimate. Reporting from a shot card has been considered to provide the most reliable vaccination history. Based on the net difference rates, the shot card reports tend to under estimate the vaccination coverage levels more often than those relying on recall. Overall, for all children, the relative bias demonstrates a 16 percent increase in the estimate. The increase in the estimate varies greatly by subgroup.

Based on the provider reports as the "gold standard" for vaccination coverage, the household respondent's knowledge about the vaccination status of their children is generally poor. This can be attributed to the large number of different vaccines necessary and to the complexity of the vaccination schedule which requires multiple visits to a provider within the first 18 months of life. The gross difference rate exceeds 20 percent for all children and for all subgroups. These relatively large differences tend to confirm that household-based reports have a high degree of unreliability. Among household shot card reports, the gross difference rate is lower in all but two subgroups than among reports relying on recall. The two exceptions are households where the education of the parent in less than 12 years and for children living in nontelephone households. Those respondents that rely on a shot card for reporting of the vaccination history rarely indicate additional vaccinations not documented on the shot card. This tends to a bias of under-reporting of the true vaccination status among the shot card children.

A larger proportion of provider information is available for shot card children than recall children. One reason for this might be that the shot card contains complete identification information on the provider making it easier to locate the provider and include the provider in the study.

5. Recommendations

Inclusion of provider information in vaccination coverage surveys to reduce respondent error is critical. In addition, assessing the potential biases when conducting these surveys is also very important. Knowing information about the population being surveyed will help in developing appropriate methods for survey implementation and estimation of vaccination coverage.

References

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Table 2. Sample Sizes for All Children and by Method of Reporting Vaccination History for the National Health Interview Survey (N) and for the National Immunization Provider Record Check Study (Prov N)

	All Children		Shot Card Children		Recall Children	
	N	Prov N (%*)	N	Prov N (%)	N	Prov N (%)
Total	2439	1370 (57)	1202	776 (65)	1237	594 (48)
Age						
≤ 25 months	975	546 (56)	490	300 (65)	485	185 (48)
> 25 months	1464	824 (57)	730	476 (66)	734	348 (48)
Race/Ethnicity						
Hispanic	373	170 (46)	206	107 (52)	167	63 (38)
Non-Hispanic Black	406	202 (50)	142	78 (57)	264	124 (46)
Non-Hispanic Other	1660	998 (61)	854	591 (70)	806	407 (51)
Education of Parent						
< 12 years	331	161 (50)	164	91 (58)	167	70 (42)
High School Graduate	836	477 (57)	274	244 (64)	562	233 (52)
> 12 years	1272	732 (58)	656	441 (68)	616	291 (47)
Household Income						
Below Poverty	561	305 (56)	274	167 (63)	287	138 (49)
At or above Poverty	1684	994 (59)	859	575 (67)	825	419 (51)
Area of Residence						
MSA Central City	819	409 (50)	365	209 (58)	454	200 (44)
MSA Non-central City	1107	626 (57)	544	362 (68)	563	264 (48)
Non-MSA	513	335 (65)	293	205 (70)	220	130 (59)
Telephone Status						
Telephone	2161	1223 (57)	1087	710 (66)	1074	513 (48)
No Telephone	278	147 (53)	115	66 (59)	163	81 (48)

* Percent based on weighted survey data.

Table 3. Vaccination Coverage (4:3:1:3) Levels for All Children and by Method of Reporting Vaccination History for the National Health Interview Survey (Household) and for the National Immunization Provider Record Check Study (Provider) with Net and Gross Difference Rates by Subgroup

Subgroup	All Children				Shot Card Children				Recall Children			
	Vaccination Coverage		Difference Rate		Vaccination Coverage		Difference Rate		Vaccination Coverage		Difference Rate	
	Household	Provider	Net	Gross	Household	Provider	Net	Gross	Household	Provider	Net	Gross
Total	59.8	71.3	-13.1	30.4	59.1	75.7	-16.9	25.9	60.8	67.0	-7.2	37.6
Age												
≤ 25 months	54.9	62.7	-10.0	29.7	54.8	69.3	-14.9	25.0	55.0	56.7	-2.6	36.7
> 25 months	63.3	77.4	-15.5	31.1	62.1	80.2	-18.4	26.7	65.4	74.6	-10.8	38.4
Race/Ethnicity												
Hispanic	59.4	67.7	-7.5	24.3	58.0	64.9	-6.6	22.1	63.0	71.1	-9.9	29.6
Non-Hispanic Black	50.9	59.5	-8.9	38.1	43.3	64.0	-22.7	34.9	57.7	57.0	3.5	40.9
Non-Hispanic Other	61.6	74.3	-14.5	30.2	61.7	79.5	-17.8	25.4	61.3	68.9	-9.0	38.0
Education of Parent												
< 12 years	48.1	67.7	-17.4	30.0	50.2	69.2	-18.5	31.6	43.5	66.2	-15.1	26.4
High School Graduate	61.8	64.6	-6.4	30.5	58.8	71.4	-13.6	23.8	65.9	59.0	3.4	39.7
> 12 years	61.1	76.5	-16.2	30.5	61.4	79.4	-18.1	25.8	60.5	73.6	-13.0	38.1
Household Income												
Below Poverty	53.3	61.4	-7.2	31.0	51.7	65.2	-14.2	26.5	61.4	57.8	4.7	38.8
At or above Poverty	61.6	74.5	-15.1	30.3	61.7	79.5	-18.1	25.5	61.3	69.5	-10.3	38.1
Area of Residence												
MSA Central City	54.9	62.6	-9.4	32.1	51.6	65.9	-13.9	29.1	59.4	60.0	-3.2	36.3
MSA Non-central City	61.3	72.4	-12.3	32.1	60.3	78.3	-18.7	26.0	62.7	66.8	-2.8	41.2
Non-MSA	63.4	79.4	-18.1	24.8	65.9	81.3	-15.5	21.8	58.1	77.0	-23.5	31.2
Telephone Status												
Telephone	61.6	73.2	-12.8	31.1	60.6	77.3	-17.2	26.1	63.4	69.1	-5.7	39.1
No Telephone	42.6	53.0	-12.9	23.6	44.5	57.5	-12.1	24.0	40.1	49.8	-14.1	23.1

Table 4. Vaccination Coverage (4:3:1:3) Levels for All Children and by Method of Reporting Vaccination History for the National Health Interview Survey (Household) and for the National Immunization Provider Record Check Study (Provider) with Net Bias and Relative Bias

	All Children				Shot Card Children				Recall Children			
	Vaccination Coverage		Bias		Vaccination Coverage		Bias		Vaccination Coverage		Bias	
	Household	Provider	Net	Relative	Household	Provider	Net	Relative	Household	Provider	Net	Relative
Total	59.8	71.3	-11.5	-16.1	59.1	75.7	-16.6	-21.9	60.8	67	-6.2	-9.3
Age												
≤ 25 months	54.9	62.7	-7.8	-12.4	54.8	69.3	-14.5	-20.9	55	56.7	-1.7	-3.0
> 25 months	63.3	77.4	-14.1	-18.2	62.1	80.2	-18.1	-22.6	65.4	74.6	-9.2	-12.3
Race/Ethnicity												
Hispanic	59.4	67.7	-8.3	-12.3	58	64.9	-6.9	-10.6	63	71.1	-8.1	-11.4
Non-Hispanic Black	50.9	59.5	-8.6	-14.5	43.3	64	-20.7	-32.3	57.7	57	0.7	1.2
Non-Hispanic Other	61.6	74.3	-12.7	-17.1	61.7	79.5	-17.8	-22.4	61.3	68.9	-7.6	-11.0
Education of Parent												
< 12 years	48.1	67.7	-19.6	-29.0	50.2	69.2	-19.0	-27.5	43.5	66.2	-22.7	-34.3
High School Graduate	61.8	64.6	-2.8	-4.3	58.8	71.4	-12.6	-17.6	65.9	59	6.9	11.7
> 12 years	61.1	76.5	-15.4	-20.1	61.4	79.4	-18.0	-22.7	60.5	73.6	-13.1	-17.8
Household Income												
Below Poverty	53.3	61.4	-8.1	-13.2	51.7	65.2	-13.5	-20.7	61.4	57.8	3.6	6.2
At or above Poverty	61.6	74.5	-12.9	-17.3	61.7	79.5	-17.8	-22.4	61.3	69.5	-8.2	-11.8
Area of Residence												
MSA Central City	54.9	62.6	-7.7	-12.3	51.6	65.9	-14.3	-21.7	59.4	60	-0.6	-1.0
MSA Non-central City	61.3	72.4	-11.1	-15.3	60.3	78.3	-18.0	-23.0	62.7	66.8	-4.1	-6.1
Non-MSA	63.4	79.4	-16.0	-20.2	65.9	81.3	-15.4	-18.9	58.1	77	-18.9	-24.5
Telephone Status												
Telephone	61.6	73.2	-11.6	-15.8	60.6	77.3	-16.7	-21.6	63.4	69.1	-5.7	-8.2
No Telephone	42.6	53	-10.4	-19.6	44.5	57.5	-13.0	-22.6	40.1	49.8	-9.7	-19.5