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Estimating Vaccination Coverage Using Parental Recall, Vaccination Cards, and Medical Records

S Y N O P S I S

Objective. To compare estimates based on vaccination cards, parental recall, and medical records of the percentages of children up-to-date on vaccinations for diphtheria, tetanus, and pertussis; polio; and measles, mumps, and rubella.

Method. The authors analyzed parent interview and medical records data from the Baltimore Immunization Study for 525 2-year-olds born from August 1988 through March 1989 to mothers living in low-income Census tracts of the city of Baltimore.

Results. Only one-third of children had vaccination cards; based on medical records, these children had higher up-to-date coverage at 24 months of age than did children without cards. For individual vaccines, only two-thirds of parents could provide information to calculate coverage rates; however, almost all provided enough information to estimate coverage for the primary series. For each vaccine and the series, parental recall estimates were at least 17 percentage points higher than estimates from medical records. For children without vaccination cards whose parents could not provide coverage information, up-to-date rates based on medical records were consistently lower than for children with cards or with parents who provided coverage information.

Conclusions. Population-based vaccine coverage surveys that rely on vaccination cards or parental recall or both may overestimate vaccination coverage.

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Until 1985, national estimates of vaccination coverage were based solely on parental recall.¹ However, since 1991, concern over the accuracy of recall has led to more frequent use of both parent-held vaccination cards and audits of medical records. The National Health Interview Survey (NHIS), conducted annually by the Centers for Disease Control and Prevention, now uses vaccination cards when available; only if a child does not have a card is the parent asked to recall vaccinations. Even then, the vaccination coverage of some children is doubled-checked against their medical records to improve the accuracy of the data.^{2,3}

Despite concerns, little has been published on whether recall is less accurate than vaccination cards and medical record audits. Studies from the United Kingdom suggest that before a national effort was put in place to improve vaccination coverage medical records were less accurate than recall⁴ or only slightly more accurate than recall and cards combined.⁵

Our objective was to look at agreement among vaccination cards, parental recall, and medical records for children at age two years. How well do these data sources agree in measuring the coverage of individual children and populations? We studied an inner-city population using data from each source to create separate coverage estimates for diphtheria vaccine, tetanus toxoid, and pertussis vaccine (DTP); oral polio vaccine (OPV); measles, mumps and rubella vaccine (MMR); and the 4:3:1 series of four doses of DTP, three doses of OPV, and one dose of MMR. This was the primary series recommended by the American Academy of Pediatrics for the study's birth cohort.⁶

METHODS

Data for this analysis come from the Baltimore Immunization Study (BIS) conducted by Guyer et al. in 1991–1992.^{7–15} Children eligible for this community-based study were born from August 1, 1988, through March 31, 1989, to women residing in the 57 Census tracts of Baltimore in which at least 50% of the resident births in 1987 were to mothers eligible for Medicaid.

From the eligible children, the BIS first excluded children who weighed less than 500 grams at birth, children who had died, and children who had been adopted prior to the survey. From the remaining 2489 eligible children, 1100 were then randomly selected. By the survey termination date, the primary caregiver (henceforth referred to as the parent) of 735 children had been located and 557 had been interviewed. The study found

no significant differences in maternal age, "race," and marital status between children whose parents were interviewed and those whose parents were located but not interviewed.⁷

Trained interviewers conducted in-home interviews between November 1991 and April 1992. Prior to the home interview, parents were asked to locate their child's vaccination card(s). If the card was available, the interviewer made note of the dates and types of vaccinations. If the card was unavailable, parents were asked to recall each vaccination the child had received by age 2 years. Consistent with NHIS methodology, the parent could state the number of doses for each vaccine received or report "Do not know the number but know the child is up-to-date" or "Do not know the number or whether the child is up-to-date." For the 4:3:1 series, parents were asked if the child was up-to-date for baby shots by 24 months of age. Parents could respond yes, no, or "do not know."

Finally, each parent was asked to name all outpatient providers used by the child since birth. Written informed consent to review their children's medical records was granted for 546 (98%) of the children. Trained auditors collected data for 525 of the 546 children.

Data analysis. For the present study, we calculated vaccine coverage for DTP, OPV, MMR, and the 4:3:1 series for the following groups of children:

1. *Vaccination card subset*: children for whom cards were available at interview.
2. *No vaccination card subset*: children for whom cards were not available, further divided for each type of vaccine into:
 - a. *Parental recall subset*: children in the "no vaccination card" subset whose parents stated the number of doses received of a given vaccine or said they were up-to-date for the vaccine.
 - b. *Do not know subset*: children in the "no vaccination card" subset whose parents could not remember the number of doses or whether the child was up-to-date.

For this analysis, we defined up-to-date by age 2 years for DTP as having received four doses, for OPV as having received three doses, and for MMR as having received one dose—regardless of the intervals between doses. We considered children who had received four doses of DTP, three doses of OPV, and one dose of MMR by age 2 years as up-to-date for the 4:3:1 series, regardless of the intervals between doses.

“The current methodology, by permitting parents to declare their child up-to-date and excluding the ‘do not knows,’ may exacerbate response error.”

Population coverage. For DTP, OPV, MMR, and the 4:3:1 series, we compared coverage estimates derived from parental recall and medical records using the parental recall subset and compared coverage estimates derived from vaccination cards and medical records using the vaccination card subset. To identify bias resulting from excluding children in the “do not know” subset, we compared coverage estimates derived from medical records for children in the parental recall subset and those in the “do not know” subset.

Individual children's vaccination status. For each vaccine and the 4:3:1 series, we looked at agreement between parental recall and medical records for children in the parental recall subset and agreement between vaccination cards and medical records for children in the vaccination card subset. If both sources indicated the child was up-to-date or if both sources indicated the child was not up-to-date, there was agreement.

We calculated simple unweighted *kappa* scores for each comparison; these scores indicate the extent of agreement beyond chance. We rated scores using the terminology of Landis and Koch: zero or negative scores indicate no agreement; 0.01–0.20, slight agreement; 0.21–0.40, fair agreement; 0.41–0.60, moderate agreement; 0.61–0.80, substantial agreement; and 0.81–1.00, almost perfect to perfect agreement.¹⁶

We also studied the pattern of disagreement between the data sources for each vaccine and the 4:3:1 series. For children in the parental recall subset, we compared children whose parents said they were up-to-date but whose medical records indicated they were not with children whose medical records showed they were up-to-date but whose parents reported them as not up-to-date. This comparison was repeated for vaccination cards versus medical records for children in the vaccination card subset. We assumed a binomial distribution with an equal likelihood of the parental recall or vaccination cards estimating higher or lower coverage than the medical records as the null hypothesis. *Alpha* was set at less than or equal to 0.05.

RESULTS

Vaccination cards were available at interview for 175 (33.3%) of the 525 children studied. The remaining 350 children constituted the no vaccination card subset.

The parental recall subset for a given vaccine consisted of children whose parents either reported the number of doses received or said that they did not know how many had been received but knew whether their children were up-to-date. All but two of the 350 parents in the parental recall subset reported knowing whether their children were up-to-date at 24 months for the 4:3:1 series. For the individual vaccines, however, approximately one-third (range 111–118) of the parents did not know the number of doses or whether their children were up-to-date. Of the remaining two-thirds (range 232–239) of parents, 22% to 23% reported the number of doses received; the remaining 77% to 78% did not know how many doses had been received but knew whether the children were up-to-date.

Agreement between data sources on population coverage. According to vaccination cards, parental recall, and medical records, the highest coverage was for MMR, followed by OPV, then DTP (Tables 1–3). Card-based estimates were lower than medical records estimates for the 4:3:1 series and DTP, but the two types of estimates were similar for OPV and MMR (Table 1). For children in the parental recall subset (Table 2), each coverage estimate based on parental recall was at least 17 percentage points higher than the coverage estimate based on medical records. Children whose parents provided no vaccination card and did not know if their children were up-to-date had lower coverage, based on medical records, than children from the other two subsets (Tables 1 and 3).

Agreement between data sources on individual children's vaccination status. Table 4 shows the agreement between medical records and parental

Table 1. Percentage of children up-to-date at age 2 years, by type of vaccination, according to vaccination cards and medical records (vaccination card subset; n = 175)

Vaccine	Vaccination cards	Medical records
DTP.....	63.4	74.3
OPV.....	72.0	76.6
MMR.....	85.7	88.0
4:3:1 series.....	56.6	73.7

DTP = diphtheria vaccine, tetanus toxoid, and pertussis vaccine or diphtheria vaccine and tetanus toxoid (DT)
 OPV = oral polio vaccine or inactivated polio vaccine (IPV)
 MMR = measles, mumps, and rubella vaccine
 4:3:1 series = four doses of DTP, three doses of OPV, and one dose of MMR

Table 2. Percentage of children up-to-date at age 2 years, by type of vaccination, according to parental recall and medical records (parental recall subset)

Vaccine	n	Parental recall	Medical records
DTP.....	235	82.1	64.7
OPV.....	239	89.5	71.1
MMR.....	232	97.4	79.7
4:3:1 series...	348	82.2	40.5

DTP = diphtheria vaccine, tetanus toxoid, and pertussis vaccine or diphtheria vaccine and tetanus toxoid (DT)
 OPV = oral polio vaccine or inactivated polio vaccine (IPV)
 MMR = measles, mumps, and rubella vaccine
 4:3:1 series = four doses of DTP, three doses of OPV, and one dose of MMR

recall and between medical records and vaccination cards for individual children. Parental recall and medical records showed only slight agreement beyond chance, except for the 4:3:1 series, for which *kappa* was equal to 0.33.

Parents were more likely than medical records to classify children as up-to-date for each vaccine, with a strong tendency to classify children as up-to-date for the 4:3:1 series when medical records suggested they were not (Table 4). Vaccination cards were significantly less likely than medical records to show a child as up-to-date for DTP and the 4:3:1 series (Table 4). For OPV and MMR, vaccination cards also underestimated the number of children revealed as up-to-date according to medical records, although in each case the difference was not statistically significant.

DISCUSSION

Poor agreement between parental recall and medical records and better agreement between vaccination cards and medical records suggests that vaccination cards are better information sources than parental recall for individual vaccines.

However, when parents were asked if the child was up-to-date for all vaccines, agreement between medical records and parental recall (*kappa* = 0.33) approached that between cards and medical records (*kappa* = 0.46). Goldstein et al. found greater agreement between vaccination cards and medical records than between parental recall and medical records and also noted that simply asking if a child is up-to-date gave a more accurate picture of vaccine coverage than asking the number and timing of

Table 3. Percentage of children up-to-date at age 2 years according to medical records, by type of vaccination, parental recall subset versus "do not know" subset

Vaccine	n	Parental recall subset		n	"Do not know" subset	
			Percent up-to-date			Percent up-to-date
DTP.....	235		64.7	115		40.9
OPV.....	239		71.1	111		47.7
MMR.....	232		79.7	118		66.9

DTP = diphtheria vaccine, tetanus toxoid, and pertussis vaccine or diphtheria vaccine and tetanus toxoid (DT)
 OPV = oral polio vaccine or inactivated polio vaccine (IPV)
 MMR = measles, mumps, and rubella vaccine

Table 4. Agreement on individual children's up-to-date vaccination status: parental recall versus medical records and vaccination cards versus medical records

Vaccine	n	Parental recall vs medical record (parental recall subset)			Kappa	Vaccination card vs medical record (vaccination card subset) n = 175			Kappa
		Parental recall and medical records agree	Parent UTD; medical record not UTD	Parent not UTD; medical record UTD		Card and medical records agree	Card UTD; medical record not UTD	Card not UTD; medical record UTD	
DTP	235	144	66 ^a	25 ^a	0.05	142	7 ^a	26 ^a	0.57
OPV	239	165	59 ^a	15 ^a	0.07	143	12	20	0.52
MMR	232	189	42 ^a	1 ^a	0.15	159	6	10	0.60
4:3:1 series	348	238	104 ^a	6 ^a	0.33	131	7 ^a	37 ^a	0.46

^aP < 0.05, indicating that when up-to-date estimates derived from parental recall (or vaccination cards) did not agree with estimates from medical records, parental recall (or vaccination cards) estimates were either more likely or less likely, but not equally likely, to produce estimates higher or lower than estimates from medical records. For instance, when parental recall and medical records estimates did not agree, parents were significantly more likely to report up-to-date estimates higher than medical records estimates than to report estimates lower than medical records estimates.

UTD = up-to-date; for example, parent UTD means parent reported the child was up-to-date

DTP = diphtheria vaccine, tetanus toxoid, and pertussis vaccine or diphtheria vaccine and tetanus toxoid (DT)

OPV = oral polio vaccine or inactivated polio vaccine (IPV)

MMR = measles, mumps, and rubella vaccine

4:3:1 series = four doses of DTP, three doses of OPV, and one dose of MMR

individual vaccinations.¹⁷ This suggests that while respondents do not always know the details of vaccinations, they may be reasonably well informed of the "big picture" of whether the child has had all required vaccinations. Wood et al. found that inner-city Los Angeles parents relied on providers to ensure that children were up-to-date.¹⁸ The same effect may have been operating among parents in inner-city Baltimore in our study.

At the same time, allowing parents to declare the child as up-to-date enables those who do not know the recommended number of doses to give the socially acceptable response. Our findings support this: parents showed a strong tendency to declare their child up-to-date when records suggested otherwise. Of the 110 children for whom parental recall did not agree with medical records, 104 (94.6%) had parents reporting their children were up-to-date for the series when their medical records indicated they were not up-to-date. The marked improvement in NHIS national coverage figures between 1991 and 1992 (from 68.8% to 83% for DTP, and from 53.2% to 72.4% for OPV²) may be due to the fact that 1992 was the first year parents could declare the child was up-to-

date even if they could not remember the number of doses received.²

Both in the NHIS and our own study, children whose parents did not know the number of doses received or whether the child was up-to-date are assigned to the "do not know" category, and in the NHIS they are excluded from the sample. Using medical records, we found that these children had lower coverage than children whose parents did know or thought they knew their children's status. For individual vaccines, we also found a higher proportion of these children (32% to 38%) than were found in the 1994 NHIS (12% to 16%).³ The NHIS might have used greater efforts to obtain an estimate than we did: we used no prompts after the respondent was unable to make an estimate. In addition, the percentage of children falling into the "do not know" category may vary widely and may be higher in the inner cities. Whatever the case, our study suggests that excluding children whose parents do not know their vaccination status may be a significant bias toward higher coverage estimates.

Our results suggest that parental recall is not a valid data source for assessing the immunization status of popu-

lations or individuals. Since its reintroduction in 1991, the NHIS has tried to minimize dependence on parental recall data by using vaccination cards where available. However, because each year approximately half the children in the national survey do not have cards, the survey continues to rely heavily on recall. Since 1994, the NHIS has audited provider records of some children to adjust for response error.² Yet the current methodology, by permitting parents to declare their child up-to-date and excluding the "do not knows," may exacerbate response error.

A comparison of medical records data in Tables 1 and 2 shows that keeping a vaccination card is associated with higher coverage in this population for each vaccine and for the 4:3:1 series. Perhaps the ability to produce a card reflects greater commitment to vaccination or better parental organization. Failure to produce a card may be a predictor of underimmunization on the basis of which providers can target children for greater vigilance. However, because those with cards have higher coverage than those without, and a significant part of the population does not keep cards, cards alone cannot accurately estimate population coverage.

A limitation of the study is the reliance on parents to provide a list of all providers seen by the children since

birth. It is possible that not all providers were listed, resulting in an underestimate of coverage derived from medical records. Given, however, that vaccination card estimates were consistently lower than medical records estimates, it is unlikely that medical records estimates greatly underestimated true coverage rates.

These data were collected in the early 1990s. We are unaware of significant initiatives or trends that suggest these findings are not still applicable. Our sample represents a poor, inner-city population; similar studies are needed in other populations. Yet this group represents an important segment of the general population, since the inner cities have had the lowest vaccination rates¹⁹ and had the highest measles attack rates during the 1989–1991 outbreaks. Any action to improve coverage and measurement must be successful in the inner cities if it is to be successful for the general population.

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