Measles Immunization Coverage Determined by Serology and Immunization Record from Children in Two Chicago Communities

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SYNOPSIS

Objectives. We compared the prevalence of measles immunization determined by serology with the prevalence of measles immunization determined by immunization records, and identified factors predictive of measles immunization among a sample of children from two Chicago communities.

Methods. We collected demographic information and blood specimens from a sample of children aged 12–71 months in two Chicago communities at risk for low measles immunization coverage levels. We collected immunization information from provider records, parent-held records, and the statewide immunization registry. We compared evidence of immunization determined by serology with evidence of immunization from these three sources of immunization records.

Results. The sample of children from the two communities had serologic measles immunity levels of 85% and 90%. Significantly fewer children had evidence of immunization by record in both communities (45% and 63%, respectively).

Conclusions. Immunization coverage levels determined using immunization records were significantly lower than immunization coverage determined using serology. A fully populated immunization registry used by all immunization providers could prevent the problems of record loss and scatter.

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National childhood immunization coverage levels have reached all-time highs.[1] However, childhood immunization coverage levels in large metropolitan areas, in certain racial and ethnic groups, and among children living in poverty are trailing national levels.[2–4] According to the National Immunization Survey (NIS), which provides annual estimates of immunization coverage using information from household and provider records, immunization coverage levels among Chicago's preschool population are lower than national coverage levels.[5] In 2003, the national coverage level for series completion of 4 doses of diphtheria and tetanus toxoids and pertussis (DTP) vaccine, 3 doses of poliovirus vaccine (IPV), 1 dose of measles containing vaccine (MCV), and 3 doses of Haemophilus influenza type b (Hib) vaccine—4:3:1:3—was 81.3% ±0.9, while the coverage level among Chicago children was 76.8% ±7.2. When compared to coverage levels among non-Hispanic white (83.1% ±10.0) and Hispanic (86.0% ±6.7) children in Chicago, non-Hispanic black children in Chicago had the lowest 4:3:1:3 coverage at 62.8% ±15.8 (Centers for Disease Control and Prevention [CDC], unpublished data; 2004).

Chicago has a population of 2.9 million persons and covers 228.5 square miles. It is divided into 77 distinct communities, many of which are racially, ethnically, and socioeconomically segregated. Determining where underimmunized children reside has been difficult because data on community-level coverage levels are not available. To identify communities with underimmunized children and to determine where immunization resources should be focused, the Chicago Department of Public Health (CDPH) has conducted cluster surveys in poor, primarily non-Hispanic black communities that had high incidence rates of measles during the 1989–1990 measles epidemic and low coverage levels based on school retrospective data (CDPH, unpublished data; 1999). Results of a door-to-door cluster survey conducted in 2000 in a predominantly non-Hispanic black community found that measles vaccination coverage (74%, 95% confidence interval [CI] 68.9, 79.1) was 12 percentage points lower than the NIS estimate for Chicago (86% ±5.1) and 18 percentage points lower than the NIS estimate for the United States (92% ±0.6), based on immunization records.[6]

Estimating immunization coverage levels using parent-held or provider records can be problematic. Scattered immunization records are a common problem, with 22% of children estimated to receive their early preschool immunizations from more than one health care professional.[7] Health care providers might over-immunize children without immunization records or miss opportunities to immunize these children.[8,9] Assessments of practice-level coverage levels might underestimate true coverage because of record loss or scatter. Surveys to determine coverage levels based on parent recall or parent-held records also have been shown to be inaccurate, as parents frequently overestimate their child's immunization status, and children with parent-held records might be more likely to be fully immunized than those without parent-held records.[10–14]

Fully populated immunization registries can reduce record scatter by consolidating immunization records from multiple sources, improve the accurate determination of up-to-date status in children, and with increased use can be used to accurately determine community and clinic coverage levels.[15–19] In 2002, the Illinois statewide immunization registry, Tracking Our Toddlers Shots (TOTS), was populated with records from the Illinois Department of Public Aid billing system, Illinois Department of Human Services case management, and Women, Infants and Children (WIC) databases, the Cook County Department of Public Health and CDPH billing systems, and records from approximately 250 public and private providers. Additionally in 2002, approximately 70% of children 4 months to 6 years of age in Illinois had at least two immunizations included in TOTS and 56% of 19- to 35-month-olds included in the registry had completed or were missing one dose of the 4:3:1:3:3 (4:3:1:3 series plus 3 doses of the hepatitis B vaccine) series. Since TOTS was not fully populated nor fully utilized by all providers in Illinois, it was not used to determine community and clinic coverage levels. It did, however, consolidate the immunization records of many children and served as a useful source for locating immunization records.

The neighborhoods of Humboldt Park and West Garfield Park are both located on the west side of Chicago and have high rates of poverty and unemployment. The racial and ethnic compositions of the two communities, however, are somewhat different. According to the 2000 U.S. census, Humboldt Park has nearly equal populations of Hispanic (47%) and non-Hispanic black (48%) residents, while West Garfield Park's population is >97% non-Hispanic black. Information on socioeconomic status from the 2000 census revealed that Humboldt Park had an 18% unemployment rate and a childhood poverty rate of 41%. West Garfield Park had 22% unemployment and a 42% rate of childhood poverty.

The demographic and socioeconomic characteristics of these communities place them at risk for a high prevalence of underimmunized children. The purpose

of this study was to compare evidence of measles immunization determined by serology to evidence of measles immunization determined by immunization record among a sample of children aged 12–71 months in these two communities. We also evaluated predictors of serologic evidence of immunization, immunization record evidence of immunization, and availability of immunization records.

METHODS

Targeted screening

High Intensity Targeted Screening (HITS) is a survey method used by the CDC and local public health agencies to estimate the prevalence of children with elevated blood lead levels in specific locales. HITS consists of the administration of demographic and risk factor questionnaires to a parent or legal guardian and the collection of blood specimens from children residing in the household. HITS has been used previously to determine blood lead levels among children aged 12–71 months residing in selected inner-city neighborhoods of Chicago and to identify risk factors for lead poisoning among these children.[20] In the Humboldt Park and West Garfield Park surveys, CDPH staff also abstracted immunization records from three different sources: hand-held records from the parent, immunization records from the most recent provider, and the TOTS registry. In addition to determining blood lead levels, blood specimens were also collected to test for evidence of measles immunization. Institutional review board approval was obtained for this study.

Sampling

The HITS protocol divided the community areas of Humboldt Park and West Garfield Park into clusters corresponding to individual city blocks, as defined by the City of Chicago's Department of Business Information Systems (DBIS). Each cluster had a pre-existing, sequential number assigned by the DBIS. For each cluster, a sampling value was determined based on the sum of the following three characteristics: (*1*) total number of children reported with elevated blood lead levels (from the CDPH Lead Program database); (*2*) total number of housing units, excluding non-residential structures (from the City of Chicago, DBIS); and (*3*) total number of children aged ≤5 years residing in the corresponding census tract (from the U.S. Census Bureau). To ensure that each sample contained an adequate number of children aged 12–71 months, only clusters with a resulting sampling value >100 for each community area were selected. From among the clusters with a sampling value of >100, 30 clusters in each community were then randomly selected using a random number generator.

All housing structures within each of the selected clusters were then sequentially numbered. The address to begin sampling was randomly selected, again by using a random number generator. Households were then visited sequentially until the target sample of six households with eligible children per cluster was reached. Eligibility criteria included age 12–71 months and residency in Chicago for ≥30 days. Sampling within each cluster was considered complete when data from at least six eligible households had been successfully collected. Three attempts were made to visit all missed households, and if an attempt was ultimately successful, these households were included in the sample, regardless of whether the desired sample size had been reached for this cluster. As a result, certain clusters have more than six eligible households represented.

Data collection

Between June 14 and July 1, 2002, after informed consent was obtained, CDPH staff conducted interviews, administered a demographic and risk factor questionnaire to the parent or legal guardian of children between 12–71 months of age, and collected blood specimens from children. Demographic characteristics were based on the report of the parent or legal guardian. During the interview, the member of the household most knowledgeable about immunization status was asked for any immunization records of children aged 12–71 months residing in the household and immunization dates were abstracted. Because previous studies have demonstrated inaccurate parental recall of a child's immunization history, verbal reports of immunization status were not accepted without immunization record verification.[11,12] CDPH staff members also recorded the name and contact information, or if precise information was not available, the description of the clinic location of the most recent primary care provider last seen by the child. As blood specimens were collected to determine lead exposure, additional blood was obtained to test for evidence of measles immunization.

Lab methods

Laboratory determination of the presence of measles antibodies was performed at the Illinois Department of Public Health laboratory using measles IgG indirect fluorescent antibody (IFA) testing (Hemagen Diagnostics, Inc. Columbia, MD).[21] The CDC measles laboratory subsequently verified all specimens in which measles antibodies were not present by using a measles indirect IgG assay.[22]

Post survey immunization record collection

CDPH Immunization Program staff members contacted the most recent primary care provider whose contact information was available and valid. In situations where landmarks were used to identify provider's clinics, CDPH staff members familiar with the area reviewed the descriptions to identify providers. CDPH staff members then went to each clinic and abstracted any available immunization records from the patients' medical records. CDPH staff members also searched the TOTS registry for any immunization records of survey participants whose parents gave consent for CDPH to do so.

Data analysis

The data were analyzed using STATA Version 8.0 and CASA version 2.5.[23,24] We calculated measles immunization coverage levels determined by serology and by immunization record for all children sampled from West Garfield Park and Humboldt Park. We calculated the frequency of immunization record availability for each source of immunization record (parent-held immunization record, provider record, and immunization registry record) and from all three sources combined. We used McNemar's test to compare serologic evidence of measles immunization to evidence of measles immunization as determined from immunization records.

Children without retrievable records were presumed to be unimmunized and susceptible to measles infection. This assumption is consistent with the Advisory Committee on Immunization Practices (ACIP) and American Academy of Family Physicians (AAFP) General Recommendations on Immunization, which recommend that persons whose records cannot be located should be considered susceptible and started on the age-appropriate vaccination schedule.[25]

For the sample of children in Humboldt Park, multivariate logistic regression analysis was conducted with race/ethnicity (self-reported), age and sex of the child, and parent education level as predictor variables. Outcome variables were presence of parent-held immunization record, presence of provider record, presence of immunization registry record, serologic evidence of measles immunization, and evidence of measles immunization determined by immunization record. To control for repeat sampling within a household, we used the Generalized Estimating Equation (GEE).[26] Since the population of West Garfield Park is predominantly non-Hispanic black, multivariate analysis was limited to the sample of children from Humboldt Park in order to examine racial/ethnic differences in the outcome variables.

RESULTS

A total of 359 children were enrolled in our study. In West Garfield Park, 144 children from 92 households were enrolled, and in Humboldt Park, 215 children from 156 households were enrolled. Blood specimens were collected from 300 of the 359 children. Laboratory determinations of serologic evidence of measles immunization were available for 277 (92%) of these. Of the 23 specimens without laboratory determinations available, 14 were from children aged >6 years, five were unaccounted for, and four had results that were unable to be interpreted. These were excluded from analysis.

Of the 277 children in our sample, 113 (41%) were from West Garfield Park and 164 (59%) were from Humboldt Park; 91% were born in the United States. Eight (4%) of the children born outside the United States were living in Humboldt Park, 100% of whom reported being born in Mexico or Puerto Rico. Of the 164 from Humboldt Park, 156 (97%) reported a race/ethnicity: 79 (51%) being non-Hispanic black and 77 (49%) being Hispanic; 84 (51%) were male. The median age was 3 years. In West Garfield Park, 108 (96%) reported a race/ethnicity, with 97 (90%) being non-Hispanic black, and five (5%) being Hispanic; 57 (50%) being male. The median age of enrollees was 4 years.

Of the 113 from West Garfield Park, 96 (85%) had serologic evidence of measles immunization, whereas only 51 (45%) had evidence of immunization by parent-held immunization records, provider records, or immunization registry records. In Humboldt Park, 148 (90%) children had serologic evidence of measles immunization, but only 103 (63%) had evidence of immunization by any retrievable records. In both communities, the difference between the proportion of children in the sample with serologic evidence of measles immunization and the proportion with evidence of immunity by any available record was statistically significant (Table 1).

Very few children in both samples had immunization records available at home, in provider offices, or in the statewide immunization registry. Although more children in Humboldt Park than West Garfield Park had a parent-held immunization record with at least one immunization documented, <50% in either community had a record at home (Table 2).

Analysis of the sample of children from Humboldt Park indicated that Hispanic children were more likely than non-Hispanic black children to have available parent-held records (OR=3.1, 95% CI 1.4, 6.5) and provider records (OR=3.8; 95% CI 1.5, 9.6), but race

Table 1. Comparison of evidence of measles immunization determined by serology and consolidated immunization record,[a] by community area, Chicago, Illinois, June 2002

Evidence of immunization	*West Garfield Park* n=*113* *(percent)*	*Humboldt Park* n=*164* *(percent)*
Serologic	85[b]	90[b]
Immunization record	45	63

[a]Documentation of measles-containing vaccine in parent-held, provider, or registry record

[b]p=<0.01, using McNemar's test. Difference between the proportion of children in the sample with serologic evidence of measles immunization and the proportion with evidence of immunity by any available record was statistically significant.

and ethnicity did not influence the availability of registry records (Table 3).

In Humboldt Park, Hispanic children were more likely to have serologic evidence of measles immunization than non-Hispanic black children. Among non-Hispanic black children, 68 (86%) demonstrated serologic evidence of measles immunization, while 74 (96%) Hispanic children demonstrated serologic evidence of measles immunization, a significant difference (OR=4.4, 95% CI 1.1, 17.0). Among non-Hispanic black children, 45 (57%) had a record of having received a measles immunization, whereas 53 (69%) Hispanic children had a record of having received a measles immunization; this difference was not statistically significant (Table 4). Older age of the child was associated with serologic evidence of measles immunization, but the association did not reach statistical significance (p=0.07).

CONCLUSION

This report documents a significant discrepancy between the prevalence of serologic evidence of measles immunization and the prevalence of documented measles immunizations among a sample of children from two Chicago communities. The findings also demonstrate a significant difference in serologic evidence of measles immunization between Hispanic and non-Hispanic black children in our sample.

The levels of serologic evidence of measles immunization in our sample appear to be sufficient to prevent epidemic transmission of measles, despite the persistence of racial and ethnic disparities.[27,28] These disparities have been described in previous studies, which have demonstrated immunization levels of preschool-aged children from lower-income areas of Chicago to be lower than national levels, with non-Hispanic black children at higher risk.[29] Race was also predictive of availability of immunization records within our sample, as Hispanic children were more likely than non-Hispanic black children to have parent-held or provider records available.

We determined levels of measles immunity in our sample by serologic testing; these levels would have been underestimated by using traditional means of assessing immunization coverage levels. Record scatter, frequent changes in health care providers, and inconsistent use of existing immunization registries all complicate accurate assessment. This discrepancy between serologic evidence of immunization and evidence of measles immunization by record was not likely caused by immunity acquired by measles infection, since nearly all of the children (91%) in the sample were born in the United States and after the last measles outbreak reported in Chicago (1989–1990), and no cases were reported from Humboldt

Table 2. Immunization record availability in West Garfield Park and Humboldt Park, Chicago, Illinois, June 2002

Records[a]	*West Garfield Park* n=*113* n *(percent) available*	*Humboldt Park* n=*164* n *(percent) available*	p-*value*[b]
Parent-held	25 (22)	77 (47)	<0.01[c]
Provider	13 (12)	38 (23)	0.01[d]
Registry	55 (49)	70 (43)	0.33
Any record	71 (63)	121 (74)	0.05

[a]At least one immunization given, not necessarily measles-containing vaccine.

[b]p-values were determined using Pearson chi-square test.

[c]Significantly more children in Humboldt Park than in West Garfield Park had a parent-held immunization record with at least one immunization documented.

[d]Significantly more children in Humboldt Park than in West Garfield Park had a provider immunization record with at least one immunization documented.

Table 3. Immunization record availability among a sample of children residing in Humboldt Park, by race, Chicago, Illinois, June 2002

	Non-Hispanic black (n=79)	*Hispanic (n=77)*	*Adjusted OR[b] (95% CI)*
Records[a]	*n* (percent) available	*n* (percent) available	
Parent-held	26 (33)	51 (66)	3.1 (1.4, 6.5)
Provider	11 (14)	25 (32)	3.8 (1.5, 9.6)
Registry	38 (48)	26 (34)	0.6 (0.3, 1.3)
Any record	53 (67)	62 (81)	2.3 (0.9, 5.3)

[a]Dependent variable

[b]Predictive variables in the multivariate logistic regression models were race/ethnicity, child age, child sex, and parental education level.

OR = odds ratio

CI = confidence interval

Park or West Garfield Park during 1994–2004.[30] Additionally, serologic immunity to measles is unlikely a reflection of immunity acquired from infection outside the United States since all of the foreign-born Humboldt Park children were born in Mexico or Puerto Rico. From 1997–2002, Puerto Rico did not report any confirmed cases of measles and Mexico reported 33 confirmed cases of measles, all of which were associated with importations from other countries.[31,32] This finding highlights the potential value of universally utilized immunization registries as a way to increase the availability of childhood immunization information.

Readily accessible consolidated immunization records will reduce the potential for under- and over-immunization of children. Additionally, registries can be used to generate patient reminders, recalls, or evaluations of practice or community-wide immunization coverage levels.[33]

Healthy People 2010 has called for the increase in the proportion of children aged <6 years who participate in fully operational population-based immunization registries to 95% by 2010.[34] In our sample, only 45% of children had immunizations included in TOTS. The low levels of participation might be attributed to different factors, e.g., TOTS is not a web-based system, parental consent is required for immunization records to be included, provider participation is voluntary, and dedicated resources are scarce. Accurate immunization registry data could provide information needed to help determine both immediate individual immunization needs and community immunization coverage levels.

Parental possession of an immunization record has

Table 4. Independent predictors of measles immunization status determined by serology or immunization record among a sample of children residing in Humboldt Park, Chicago, Illinois, June 2002

	Evidence of immunization			
	Serologic		*Immunization record*	
Predictor	n *(percent)*	*Adjusted OR (95% CI)*	n *(percent)*	*Adjusted OR[a] (95% CI)*
Race/ethnicity				
Black[a] (*n*=79)	68 (86)	1.0	45 (57)	1.0
Hispanic (*n*=77)	74 (96)	4.4 (1.1, 17.0)	53 (69)	1.9 (0.9, 3.9)
Age				
≤2 years[a] (*n*=59)	50 (85)	1.0	40 (68)	1.0
>2 years (*n*=97)	92 (95)	3.2 (0.9,10.8)	58 (60)	0.8 (0.4, 1.6)
Education				
≤High school[a] (*n*=111)	101 (90)	1.0	49 (63)	1.0
>High school (*n*=29)	26 (90)	1.5 (0.3, 6.4)	20 (69)	1.4 (0.5, 3.6)
Sex				
Male[a] (*n*=78)	69 (88)	1.0	49 (63)	1.0
Female (*n*=78)	73 (94)	1.9 (0.5, 6.4)	49 (63)	0.8 (0.4, 1.6)

[a]Reference group

OR = odds ratio

CI = confidence interval

been identified as a predictor of up-to-date immunization status in young children.[35] Hispanic children in this study were significantly more likely than non-Hispanic black children to have an immunization record at home and to have serologic evidence of measles immunization. Parental possession of an immunization record might reduce missed opportunities for providers to administer needed immunizations.[36] Parental possession of an immunization record might also reflect a greater understanding of the importance of immunizations and immunization record-keeping, which might be associated with an increased likelihood of obtaining immunizations. Parental education about the importance of keeping an up-to-date record of their children's immunization status might improve immunization coverage and the accuracy of immunization surveys.

The children in our sample are from two socioeconomically disadvantaged areas of Chicago and might not be typical of children in other areas. This might help explain the low level of record availability but could limit the generalizability of findings based on this population. Additionally, our findings describe only the children in our sample, and are not necessarily generalizable to their respective communities in the form of community coverage levels. For this sample, immunization record retrieval included parental records, immunization registry records, and the records from only the most recent immunization provider seen. By limiting the retrieval process to the most recent immunization provider seen, immunizations administered in previous provider offices may not have been included in our estimates of immunization coverage based on immunization records. Although we included immunization registry records to minimize the effect of record scattering, immunization coverage levels based on records may have been underestimated.

In disadvantaged Hispanic and non-Hispanic black communities, immunization record scatter and loss might lead to overimmunization or missed opportunities for immunization and to underestimates of community immunization coverage levels. Fully operational population-based immunization registries could eliminate these problems. As of 2002, however, only four states had >95% of children aged 6 years with two or more immunizations included in their state registries, and only seven states had more than 75% of their private providers participating in the registry.[37] Continued federal, state, and local financial support is required to develop, maintain, and improve immunization registries. Additional federal, state, and local efforts are needed to encourage provider participation in registries.

Until more registries become fully populated and more providers participate in the immunization registries, parental immunization records will continue to play a vital role in ensuring that young children are appropriately immunized. Particularly in disadvantaged Hispanic and non-Hispanic black communities, parents should be educated about the importance of keeping copies of their children's immunization records and bringing their records to all visits with health care providers.

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