On-Time Immunization Rates Among Children Who Enter Chicago Public Schools

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ABSTRACT. Objective. A primary objective of the Healthy People 2010 initiatives is to increase on-time immunization rates during the first 2 years of life and to decrease racial disparities in coverage. The objective of this study was to determine on-time immunization coverage rates among infants and toddlers stratified by race/ethnicity in a large metropolitan center.

Methods. A retrospective cohort study that was based on immunization records in the Chicago Public Schools computerized database was conducted using all 67376 children who completed kindergarten in 2001 and 2002.

Results. On-time immunization rates in Chicago public school children are low (31% at 7 months, 32% at 19 months, 59% at 36 months). At 19 months of age and thereafter, Hispanic children had the highest rate of on-time immunization coverage. Among children <48 months old, black children had the lowest rates of up-to-date immunization status. At 48 months of age, the up-to-date rate for black children improved to a rate similar to white children (58%) and by school entry surpassed the up-to-date rate for white children (71%). Compared with the recommended 2, 4, 6, and 15 to 18 months schedule, black children received 4 doses of diphtheria/tetanus/acellular pertussis at a mean age of 10.9, 14.6, 20.4, and 34.5 months of age. In contrast, Hispanic children received the same doses at a mean of 4.5, 7.4, 11.0, and 25.1 month of age. In addition, 28% of black children received the majority of their vaccinations >12 months later than the recommended time intervals.

Conclusions. Striking immunization delay still exists during the infant and toddler years. Targeted efforts are needed to increase on-time immunization rates and to decrease racial disparity in immunization coverage. Pediatrics 2004;114:e741–e747. URL: www.pediatrics.org/cgi/doi/10.1542/peds.2004-1053; immunization rates, children, Chicago, school, racial disparity.

ABBREVIATIONS. NIS, National Immunization Survey; DTP, diphtheria/tetanus/pertussis; DTaP, diphtheria/tetanus/acellular pertussis; IPV, inactivated polio vaccine; MCV, measles-containing vaccine; Hib, Haemophilus influenzae type b; hePB, hepatitis B; HBV, hepatitis B vaccine; AAP, American Academy of Pediatrics; ACIP, Advisory Committee on Immunization Practices.

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who enter the Chicago Public Schools. Approximately 90% of the data recorded are transcribed from school physical forms accompanied by the signature of a physician or a nurse. The remainder come from immunization cards presented by the parent or the guardian. Data obtained from parental recall were not used. Included in the database are the date of birth (month and year), school attended, residence zip code, race (defined by self-report or observationally and recorded as white, black, Native American, Asian, or Hispanic), and month and year of receipt of the following vaccine doses: ≤5 DTaP, ≤4 polio-containing vaccines, ≤3 hepatitis B vaccines (HBV), and ≥2 MCVs. The recorded data regarding Hib vaccination were more complex. An entry coded as “yes” meant that 3 to 4 doses of Hib vaccine were given before 12 months of age and an additional (booster) dose was given at 12 months of age or thereafter. An entry of “no” meant that <3 Hib vaccine doses were given before 15 months of age and no dose was given at 15 months of age or thereafter. A dated entry was made when a dose of a Hib vaccine was given at ≥15 months of age, irrespective of the number of doses given before 15 months of age. Data regarding varicella vaccine and the pneumococcal conjugate vaccine Prevnar were not available, and these vaccinations were not required for school entry during those years. Illinois law requires that at entry into kindergarten, children must show proof of immunity or evidence of receipt of 4 doses of DTP/DTaP, 3 doses of polio, 2 doses of an MCV, 1 dose of mumps, 1 dose of rubella, and 3 doses of HBV.

Recommendations of the American Academy of Pediatrics (AAP) and the Advisory Committee on Immunization Practices (ACIP) were used to define age-appropriate criteria for immunization receipt. Only 31% of children had received all recommended immunizations at 7 months of age (Fig 1). In the interval between 7 and 13 months of age, no additional immunizations are recommended; thus, at 13 months of age, the percentage of children who were “up to date” increased to 64%. In the interval between 13 and 19 months of age, additional immunizations were needed to maintain up-to-date status; thus, at 19 months of age, only 32% of children had received all recommended immunizations (4:3:1:3:3; “on time” receipt for DTaP dose 1 (DTaP1) was defined as receipt of this dose by 3 months of age, DTaP2 by 5 months of age, etc. Race and/or ethnicity was recorded according to the designation assigned by the Chicago Public Schools (white, black, Hispanic, Native American, or Asian).

The database had information regarding 67,376 children who completed kindergarten. Children were excluded when they were >7 years or <5 years old on the first day of kindergarten. After this adjustment, 66,556 cases (98.79% of the original cohort) remained. Children were also excluded when the recorded date of an immunization was before the date of birth. The number of children excluded by this criterion varied by immunization and ranged from 13 for MCV1 (99.98% included) to 48 for HBV1 (99.93% included).

Statistics were calculated using SPSS 10.0. Survival analysis life tables were generated to determine the percentage of children who had received individual immunizations at a given age. Mean age of vaccine receipt was calculated only for children whose records indicated receipt of immunization; censored data were excluded from this analysis. Statistical significance of pairwise differences among group means was calculated using a Tarone-Ware statistic. This statistic was used because it does not assume that the association between immunization coverage and race/ethnicity is constant over time. Group mean differences were considered significant at \( P < .05 \). Because of the large sample size, even very small differences in immunization rates were generally highly significant (\( P < .0001 \)).

**RESULTS**

Only 31% of children had received all recommended immunizations at 7 months of age (Fig 1). In the interval between 7 and 13 months of age, no additional immunizations are recommended; thus, at 13 months of age, the percentage of children who were “up to date” increased to 64%. In the interval between 13 and 19 months of age, additional immunizations were needed to maintain up-to-date status; thus, at 19 months of age, only 32% of children had received all recommended immunizations (4:3:1:3:3;
Fig 1). After 19 months of age, the percentage of children who were up to date gradually increased with age (Fig 1).

The percentage of children who were up to date at school entry (mean age: 70.7 ± 3.8 months) varied according to the definition. A total of 76.6% of children had completed the 4:3:1:3:3 series. In contrast, 84.3% had received the immunizations required for school entry by Illinois law. If the Illinois law requirements were changed from 2 MCV vaccines to 1 (the number recommended by ACIP/AAP in children <6 years old), then percentage up to date at school entry would have been 87.0%.

When children were stratified by race/ethnicity, at 7 and 13 months of age, Asian children had the highest up-to-date rate (42.7% and 70.8%), followed by Hispanic and white children, whose rate of coverage was roughly equal (Fig 2). At 19 months of age and at each time point thereafter, Hispanic children had the highest rate of 4:3:1:3:3 immunization coverage. The percentage of Hispanic children who were up to date at 19 months of age (38.6%) exceeded the percentage for white and black children by 8.1 and 12.9 percentage points, respectively. Similarly, at 36 months of age, 65.5% of Hispanic children were up to date, 8.2 and 12.8 percentage points greater than white and black children, respectively. At school entry, 80.2% of Hispanic children were up to date, 8.8 and 5.8 percentage points greater than white and black children, respectively.

Among children who were <48 months old, at every time point surveyed, black children had the lowest rates of up-to-date immunization status. At 48 months of age, however, the up-to-date rate for black children had improved to 58%, a rate similar to that found among white children (Fig 2). This trend continued, and at school entry, black children (74%) had surpassed the up-to-date rate for white children (71%). Asian children had a slightly higher rate than white children throughout the time points surveyed. Because of the small number of Native American children (n = 127) in the database, these data were omitted from Fig 2.

Among children who were <48 months old, the DTaP series consistently had the lowest up-to-date percentage. This was reflective of the greatest number of vaccine doses needed to achieve up-to-date status for this series. The percentages of children who were up to date for the DTaP series at 7, 13, and 19 months of age and school entry were 37.4%, 74.2%, 41.3%, and 93%, respectively. In children who were >2 years old, the MCV and polio vaccine series had the highest percentage up to date. At school entry, MCV had the highest percentage up to date at 97%, probably reflective of only 1 dose being required to achieve up-to-date status.

The mean age of receipt of individual immunizations, stratified by race/ethnicity, is shown in Table 1. For the DTaP series, white children received the first vaccine dose at a mean age of 5.3 months. DTaP doses 2 to 4 were received at an average age of 8.4, 12.3, and 26.9 months, respectively. This delay in the average age of receipt of DTaP vaccine doses was even more pronounced in black children. In contrast to the recommended 2, 4, 6, and 15 to 18 months schedule for DTaP receipt, black children received the 4 doses of DTaP at mean ages of 10.0, 14.6, 20.4, and 34.5 months of age. For all individual immuni-
zations, black children received each dose at a later mean age than children of any other race/ethnicity group. Black children received MCV1 a mean 4.8 months later, completed their hepB series a mean 5.2 months later, and completed their polio series a mean 7.3 months later than white children (Table 1). In contrast, Hispanic children received all immunizations a mean 1 to 2 months earlier than all other race/ethnicity groups (Table 1).

The percentage of children who were >2, 6, and 12 months late for individual DTaP immunizations and MCV1 stratified by race is shown in Fig 3. For the 4 doses of DTaP, 16.4%, 24.3%, 37.5%, and 48.3% of black children received their vaccination >6 months late and 13.6%, 18.6%, 28.3%, and 39.8% received their vaccination >1 year after the recommended time interval. Similarly, 25.4% of black children received MCV1 >1 year after the recommended time interval. Black children received each dose at a later mean age than children of any other race/ethnicity group. Black children received MCV1 a mean 4.8 months later, completed their hepB series a mean 5.2 months later, and completed their polio series a mean 7.3 months later than white children (Table 1). In contrast, Hispanic children received all immunizations a mean 1 to 2 months earlier than all other race/ethnicity groups (Table 1).

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In contrast, 3.6%, 5.0%, 9.1%, and 19.5% of Hispanic children received the 4 doses of DTaP and 12.4% received MCV1 >1 year after the recommended time interval. Similar trends were observed for the polio and hepatitis vaccinations series (data not shown).

**DISCUSSION**

Our results demonstrate that up-to-date rates for immunizations at the time points that we surveyed in Chicago are low. The incidence of vaccine-preventable disease in the United States is also low, but the immunization rates that we found are still of concern. The measles outbreaks in Chicago and other US metropolitan areas during the early 1990s were fueled by a large cohort of children who did not receive the measles vaccine at the recommended age. Moreover, despite the current low incidence of Hib disease, cases still occur among infants who have not completed the primary series. Achieving the goal of elimination of Hib disease from United States will require improved age-appropriate vaccination. Moreover, the incidence of pertussis is increasing in infants who are at highest risk for complications, and outbreaks of pertussis have been reported. Also, immunization coverage has been shown to be a marker for receipt of other preventive health care services in children, raising the question of access and use of recommended well-child care visits for children in this population.

An environment in which most children are behind in receipt of on-time immunization poses an additional problem. We recently demonstrated that physicians are not adept at designing appropriate catchup regimens for such children. Because the majority of children whom we studied are in need of a catchup regimen, the problem that we identified with designing such regimens likely increases the occurrence of missed opportunities based on provider error and amplifies the problem of children who may leave a clinic visit having failed to receive all possible immunizations.

Our results also demonstrate that marked racial disparity exists in immunization coverage among infants and toddlers who enroll in Chicago Public School kindergarten. Black children <48 months old had the lowest up-to-date coverage rates. Moreover, the mean age of receipt for all immunizations among black children was significantly older, and a greater number of black children were >1 year late in receipt for every immunization dose than for all other race/ethnicity groups. In sharp contrast, Hispanic children consistently had the highest immunization rates.

Racial disparities in immunization rates in Chicago were documented a decade ago in a smaller study by Kenyon et al., who used a door-to-door, household cluster survey to demonstrate that 19- to 35-month-old black children had significantly lower immunization rates than white and Hispanic children; the lowest rates were among black children who resided in public housing developments. We have now evaluated a more comprehensive cross-section of children in Chicago and documented that these disparities still exist. If these snapshots of Chicago immunization rates can be compared, then it seems that little progress has been made in decreasing low rates among black children despite considerable effort.

Despite the lowest rates of on-time coverage in children who are <4 years old, the on-time immunization compliance rate among black children subsequently increased and actually exceeded that measured among white children at school entry. This increase most likely reflects perceived pressure from school entry laws that require up-to-date immunization status among parents in the black community. A targeted intervention that communicates the importance of being up to date during the infant and toddler years is needed in the black community.

In sharp contrast, Hispanic children consistently had the highest immunization rates. This finding is consistent with a previous observation in Chicago but contrasts with other reports in which rates among Hispanic children are low. Our finding is of interest because the Hispanic and black communities in Chicago both are believed to have substantial representation from individuals with low socioeconomic status and suggests that it is not low socioeconomic status per se that is associated with low immunization rates.

The high rates found in the Chicago Hispanic community were consistent with other documented equal or better health outcomes among Hispanics. One possible explanation is that the occurrence of vaccine-preventable diseases in their country of origin may motivate on-time receipt of immunizations aimed at protecting against these diseases, a hypothesis that may also explain the higher rates that we found in Asian children as well. Immunization-seeking behavior to avoid disease has been shown to occur; a measles epidemic in Chicago motivated a sharp increase in measles vaccination rates. We do not know whether the high rate of on-time compliance among Hispanic children would be found among other US, urban, Hispanic populations.

Our data highlight the importance of clearly defining what is meant by “up to date” in assessing rates of immunization coverage. At school entry, the percentage of children who were up to date according to Illinois law requirements was significantly higher than the percentage who had completed the 4:3:1:3:3 series. The primary difference between these 2 standards reflects that Hib vaccines are not included in the up-to-date assessment according to Illinois school entry requirements.

Our analysis did not include children who attend parochial and private schools. Chicago has the largest Catholic school system in the nation, with ~25% of children attending parochial schools. Unfortunately, a centralized, computerized database of immunization records for these children is not available, and so a similar analysis in this population of children was not feasible.

A limitation of our study is its assumption that the school-based immunization record is accurate. The Chicago Public School database does not rely on
parental recall. The vast majority of records are obtained from school physical forms with immunization records verified by a physician or a nurse. Researchers in Rochester, NY, compared school-based records with medical chart review and found error rates of ~15%. The errors occurred in both the school-based and the medical chart review with roughly equal frequency and therefore were considered unbiased.21

Discrepancies between school-based and provider records were also compared in Dallas County, TX, and Minnesota.22 In Minnesota, age-appropriate immunization coverage as determined by school records was within 2% of the actual coverage assessed among provider records. In Dallas, school records underestimated actual coverage by ~21% compared with provider records. Additional analysis of the data from Dallas suggested an explanation. In Dallas, less stringent state immunization laws mandated only 3 DTP and 3 polio vaccines (compared with 5 and 4, respectively, in Minnesota). Some school immunization record forms provided space only for recording these required immunizations. Murphy et al22 estimated that as much as 10% of the difference between school and provider records may have been attributable to selective recording only of the immunizations required by law. The Chicago school-based data are similar to Minnesota in that all immunizations required for being up to date by AAP/ACIP recommendations are also required by Illinois state law. The sole exception was Hib immunization data, which could not be included in our analysis until 19 months of age.

Another source of inaccuracy in the Chicago school entry database could be physicians’ or parents’ failure to keep track of early immunizations, necessitating unnecessary repeat immunizations at time of preschool or school entry. Were this the case, however, then one would expect to find heaping or clustering of immunization receipt at ~36 months of age (time of entry into preschool/Head Start programs) and at the time of school entry, but this phenomenon was not observed.

Several other limitations of our database would serve to overestimate the percentage of children who were up to date. Because of the coding of Hib vaccination, we were not able to analyze on-time receipt of Hib vaccines before 15 months of age. Therefore, we could not include Hib in our analysis before that age. Furthermore, because our data only contained month and year of birth and vaccine receipt, we were unable to exclude vaccine doses that were given too early or with an inappropriate interval between doses. This restriction forced us to use lenient definitions of acceptable time intervals to be considered up to date.

Racial disparity in receipt of on-time immunization coverage has received considerable study but with conflicting results. Race was not a factor that affected immunization rates in Ohio in the mid-1970s.23 Among children 19 to 35 months of age, in 1999, NIS documented a 76% national coverage rate for the 4:3:1:3:3 series for whites, but lower rates were documented among blacks and Hispanics, although any racial/ethnicity disparity for children in Chicago could not be determined.4 More recently, NIS reported that race was not a significant determinant affecting national immunization coverage rates.24 In contrast, Szilagyi et al15 found that Hispanic and black children in Rochester had significantly lower immunization rates than did white children, and similar disparity was found among Minnesota school children.16

Our on-time coverage data are lower than those reported by NIS. NIS data for completion of the 4:3:1:3:3 series in Chicago in 1999–2002 indicated that 60.7% and 69.1% of children were up to date in 2000 and 2002, respectively.3,4,25,26 Excluding hepb vaccine from the analysis (4:3:1:3 series), NIS vaccination rates for Chicago children at 36 months of age in 1995–1998 (the time frame encompassing our cohort of children) ranged from 66% to 74%.27–29 The rates that we observed at 36 months for the 4:3:1:3:3 and 4:3:1:3 series were somewhat lower. The reason for the discrepancies is not clear but probably reflects differing methods. NIS is a random telephone survey with a follow-up mail survey to vaccination providers that uses an adjustment to account for households without access to telephones; a substantial proportion of families in inner-city Chicago live in households that are unable to provide a working telephone number.30,31 Also, our data included all children in the public school system and were based solely on immunization records (immunization cards or letters from vaccination providers). We used no data obtained from parental recall.

Our data reveal sizable immunization rate disparities in Chicago. This is of importance because immunization receipt in children is a key marker for primary care in children.12 Our data add to other research efforts demonstrating health disparities in minority children.32–41 Indeed, the primary goal of the Healthy People 2010 initiative is to eliminate disparity in infant mortality, cancer screening and management, cardiovascular disease, diabetes, human immunodeficiency virus/acquired immune deficiency syndrome, and immunizations.1 Considerable effort will be required to accomplish this goal.

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REFERENCES

4. Luman ET, Barker LE, Simpson DM, Rodewald LE, Szilagyi PG, Zhao A. National, state, and urban-area vaccination-coverage levels among

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