Hepatitis B Vaccination Among Children in Inner-City Public Housing, 1991-1997

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Context  In 1991, the Advisory Committee on Immunization Practices recommended universal vaccination of infants against hepatitis B virus (HBV), with series initiation within days of birth.

Objective  To determine HBV vaccine coverage in a low-income urban population and to examine whether HBV immunization within the first month of life affects subsequent vaccine receipt.

Design  Cohort study based on immunization records collected in the Pediatric Immunization Program.

Setting  Large public housing development in Chicago, Ill.

Participants  All 1143 children who were born between 1991 and 1997 and enrolled between 1993 and mid-1998, with follow-up to age 35 months.

Main Outcome Measures  On-time vaccine receipt of HBV vaccine doses, diphtheria-tetanus-pertussis vaccine (DTP) dose 1, and the 4:3:1 series (4 doses of DTP vaccine, 3 doses of poliomyelitis vaccine, and 1 dose of measles-containing vaccine), analyzed by year.

Results  On-time HBV vaccination increased quickly following new guidelines and reached a plateau of about 50% coverage for those born in or after 1995. Since 1994, more children (64%) received the first HBV vaccine dose on time than any other vaccine. Children who received a dose of HBV vaccine during their first month of life were more likely to receive the first DTP vaccine dose on time (60.1%) than those who did not get an HBV vaccine dose during the first month (36.4%; $\chi^2 = 53.7; P<.001$). Children who received the first HBV vaccine dose during their first month were more likely than those receiving it at age 1 to 2 months to complete 3 HBV doses by 19 months (70.6% vs 51.1%; $\chi^2 = 11.6; P = .001$) and to complete the 4:3:1 series by age 19 months (49.8% vs 37.9%; $\chi^2 = 4.0; P = .05$).

Conclusions  In this inner-city population, HBV vaccine has been received at rates similar to those of other vaccines within 3 years of issuance of new recommendations. Of note, immunization with HBV vaccine at birth was associated with timely receipt of other vaccines and, therefore, may have the potential to increase vaccination among groups less likely to be up-to-date on early childhood vaccines.

See also pp 1763 and Patient Page.

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partment of Public Health found that among children aged 19 to 35 months, the citywide coverage rate for 4 doses of diphtheria-tetanus-pertussis (DTP) vaccine, 3 doses of a poliomyelitis vaccine (PV) and 1 dose of a measles-containing vaccine (MCV), the so-called 4:3:1 series, was 47%. Among children in public housing it was just 23%.6

These coverage rates are much lower than national immunization rates for children aged 19 to 35 months reported by the National Immunization Survey (NIS). The 1997 NIS, which included children born from February 1994 through May 1996, found only modest differences in vaccination rates for children living below vs above the poverty threshold.7 For non-Hispanic blacks living below the poverty threshold, 72% of children were complete for the 4:3:1 series. Individual series completion rates were higher, and HBV vaccine coverage was similar to other series: 90% of children had received 3 doses of a PV and 82% had received 3 doses of HBV vaccine.

Several programs have targeted improving vaccination rates in Chicago, particularly among low income families. For example, the Chicago Department of Public Health has deployed a mobile van with free vaccines to 5 public housing developments since 1991, and the Special Supplemental Nutrition Program for Women, Infants, and Children began a voucher incentive program in 1996 in 14 of 47 available program sites.6,8 Another such initiative, the Pediatric Immunization Program (PIP), begun in 1993, monitors childhood immunization status in the largest public housing development in Chicago, the Robert Taylor Housing Development, and seeks to improve immunization coverage by providing in-person reminders of immunizations due.

We used immunization records collected by PIP to determine the level of HBV vaccination coverage for children born from 1991 through 1997 who were resident in the Robert Taylor Housing Development. We determined whether HBV vaccination has been incorporated into well-child care, whether the recommendation to begin immunization at birth has been followed, and whether the timing of the first dose affected subsequent vaccine receipt.

**METHODS**

The Robert Taylor Housing Development originally consisted of twenty-eight 16-story apartment buildings with 10 apartments per floor. The Chicago Housing Authority estimated in 1998 that 11,000 people resided there and described it as the most densely populated public housing in the country. Seventy percent of the residents are under age 21, 99.9% are African American, and about 84% earn less than $10,000 a year.9

PIP has been previously described.10 Briefly, its purpose is to determine the immunization status of children from birth through age 72 months who are resident in the Robert Taylor Housing Development, explain the immunization status to the caregiver, and provide reminder-recall in person. Community-based PIP outreach workers receive training in the recommended schedule for well-child care visits and in AAP/ACIP recommended immunization schedules. To enroll a child in the program, the PIP outreach worker records the parent or legal guardian's name, address, and telephone number, and the child's date of birth. The caregiver is asked to identify the child's primary health care provider(s). If the caregiver cannot identify a provider, PIP workers distribute a list of neighborhood health care facilities. The PIP worker also asks for the parental opinion of the child's immunization status at the time of enrollment and whether there are immunization records in the home. If available, these are used to assess the child's immunization status on the spot. Unverified parental recall of administered immunizations is not used for assessment purposes, although the information is noted. If there are no records in the home and the caretaker believes that the child has received some immunizations, the PIP worker obtains a signed release form to request the immunization record(s) from the designated clinic(s). If the records are not received within 2 weeks, PIP workers telephone the clinic or physician's office. Efforts to obtain records continue for 6 months, at which time the PIP worker assumes that the immunization records are unavailable and that the child has received no immunizations.

When a child's immunization status is assessed for PIP, the date of each immunization is recorded. The PIP outreach worker explains the child's immunization status to the caregiver and leaves a written summary of immunizations that are due. PIP outreach workers revisit families when immunizations are due and record immunizations that have been administered since the last visit, always based on written immunization records in the home or from the designated clinic. Thus, there is a complete record of immunizations for each enrolled child current up to the date of the last PIP visit. Children are maintained as active enrollees from age at enrollment through age 72 months, when they “age out” of the program.

When PIP began in 1993, it was hoped that a Chicago Housing Authority roster could be used to identify the apartments in which children lived; however, the roster was not sufficiently accurate. Therefore, PIP workers knock on each door in a building to identify eligible children and pregnant women. When contact is not successful, the PIP outreach worker does not know whether the apartment is vacant or, if occupied, whether there are age-eligible children present. PIP outreach workers canvassed their first building in 1993 and gradually expanded coverage from 1993 to 1997 to include all of the buildings in the development. Five of the buildings were demolished in 1997. The population is highly mobile, with families moving both within buildings as well as into and out of the development. Buildings are recanvassed approximately every year to identify additional age-eligible children who were not previously enrolled, who recently moved into the buildings, or who were born in the interim. Without a continuously
updated roster of the housing development, PIP outreach workers do not know what proportion of eligible children are identified through the canvasses. When a child is identified through the door-to-door canvass, the caregiver rarely refuses to enroll. However, less infrequently, the caregiver will ask the outreach worker to return for another visit to complete the enrollment process, and the outreach worker will be unsuccessful in making contact again. More than three quarters of identified families are eventually enrolled; however, PIP has not systematically entered information about refusals and incomplete enrollments into its database, and a precise figure for the history of the program is not available.

PIP has enrolled children born in 1988 (who were 5 when PIP was initiated in 1993) through 1999. The data in this report include all 1143 children born in 1991 through 1997 and enrolled between 1993 and midyear 1998 (Table). The mean age at enrollment was 26 months. Both because of the mobility of the population and the gradual increase in building coverage, PIP outreach workers identify new families, and not just newborn infants, in each year of the program. The distribution of ages at enrollment varied little by year of enrollment. Children born before 1991 are not included since they were aged 1 year and older at the time the HBV vaccine guidelines were issued. The last observation date for each child is the date of the last PIP visit. The outreach workers were not able to maintain contact with some families, usually because the family moved from the housing development. About 11% of children were lost to follow-up before age 19 months, and another 3% had not yet reached that age by the date when the data were extracted for analysis.

Our analysis addressed 4 questions. First, what proportion of children in this population were immunized against HBV on schedule? To do this, we calculated the proportion of children by birth year who received the first HBV vaccine dose by age 3 months, dose 2 by age 5 months, and dose 3 by age 19 months. Because of the incomplete observations, due either to loss to follow-up or age younger than 19 months at study termination, we calculated proportions immunized on time using Kaplan-Meier product limit functions.

Second, have the recommendations for HBV vaccination been incorporated into routine well-child care? We identified cohorts by birth year of children who were complete for the 4:3:1 series by age 35 months and determined what proportion of them also received the 3 HBV vaccine doses.

Third, has the immunization-at-birth recommendation been followed? We identified which infants received the first dose of HBV vaccine before age 1 month (month 0); for most, this probably represented receipt in the hospital. Immunization records include the date, but not the place, of immunization, and PIP does not collect data about the age of the infant at hospital discharge. Eighty-seven percent of infants in PIP who received the first dose of HBV vaccine in month 0 received it within 5 days of birth, and 93% by 14 days.

Finally, has the timing of the first dose affected subsequent vaccine receipt? To determine this, we first divided the entire cohort into children who did and did not receive an HBV vaccine dose in month 0, and we compared the proportions in each group who received the first DTP vaccine dose by age 3 months with a $\chi^2$ test. Second, we performed a subset analysis that focused on the infants who received the first HBV vaccine dose on schedule, that is, in months 0, 1, or 2. We divided that subset into infants who received the dose in month 0 and those who received it later, in months 1 or 2. We tested whether the proportions receiving the third HBV vaccine dose by age 19 months varied by month of the first HBV dose receipt. Third, we similarly tested whether the proportion of children complete for the 4:3:1 series by age 19 months varied by month of the first HBV vaccine dose receipt. For these last 2 comparisons, we excluded children lost to follow-up before age 19 months unless they were already complete for the relevant series (HBV or 4:3:1) at the time of their last assessment.

For personal safety, the outreach workers do not use computerized equipment on site. Data from handwritten forms were entered into EpiInfo Version 6.0 (Centers for Disease Control and Prevention, Atlanta, Ga) initially. These data were later transferred to, and new data entered into, Excel (Microsoft Inc, Redmond, Wash). Stata 6 (Stata Corp, College Station, Tex) was used for the analysis.

## RESULTS

There was a marked increase in the proportion of children immunized on time for HBV by birth year from “negligible receipt” for birth year 1991 to 0.54 receiving dose 3 on time for birth year 1995 (Figure 1). There is no trend after birth year 1995, with the proportion receiving dose 3 on time at 0.45 for birth year 1996 and 0.60 for birth year 1997. For every birth year, the proportion of children receiving the second and third doses on time is somewhat lower.

<table>
<thead>
<tr>
<th>Birth Year</th>
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</tr>
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</tr>
<tr>
<td>1992</td>
<td>253</td>
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</tr>
<tr>
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<td>79</td>
</tr>
<tr>
<td>1997</td>
<td>47</td>
</tr>
<tr>
<td>Total</td>
<td>1143</td>
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![Figure 1](image-url)

**Table. Number of Children Enrolled in the Pediatric Immunization Program by Birth Year**
than the proportion receiving the first dose on time. Thus, on-time HBV immunization rates rose quickly following the issuance of new guidelines and reached a plateau of about 50% coverage in 4 years. Since birth year 1994, more children in this population received the first dose of the HBV series on time than any other single vaccine dose: 64% received HBV dose 1 on time, 47% received the first DTP vaccine dose on time, 42% received the first PV dose on time, and 33% received the first MCV dose on time.

The proportion of 4:3:1 series recipients that were also in receipt of 3 HBV vaccine doses by 35 months increased each year, from 0.01 in 1991 to 0.36% of infants (297/817) who did not receive the vaccine at month 0 received the first DTP vaccine dose on time (χ² = 53.7; P<.001). In the first subset analysis, 70.6% of infants (204/289) who received the first dose at month 0 received the third HBV vaccine dose on schedule, while 51.1% of infants (46/90) who received the first dose in month 1 or 2 completed the series on time (χ² = 11.6; P = .001). Only 10.6% of children who received the first HBV vaccine dose at age 3 months or later (but did receive it) went on to receive the third dose by age 19 months. In the second subset analysis, 49.8% of infants (134/269) immunized at month 0 received the 4:3:1 series by age 19 months, while 37.9% of infants (36/95) immunized at age 1 or 2 months received the 4:3:1 series by age 19 months (χ² = 4.0; P = .05).

**COMMENT**

We found low rates of on-time immunization for children residing in a large public housing development in Chicago. The percentage of children fully immunized against HBV on time increased quickly following issuance of new guidelines in November 1991, but plateaued at about 50% coverage within 4 years. Further gains associated with increased acceptance of the recommendations are unlikely for 2 reasons. First, this rate was similar to the rate of on-time receipt for other recommended vaccine series in the population (44% of children with the same birth year received the third PV dose on time), and second, HBV vaccine appeared to be well integrated into vaccination schedules, as evidenced by the high proportion of children “up-to-date” for other vaccines (4:3:1) who also had received 3 HBV vaccine doses.

We found much lower rates of HBV vaccine coverage than the NIS report of 82% for 3 HBV vaccine doses among non-Hispanic black children age 19 through 35 months living below the poverty threshold. The comparable rate for the Robert Taylor Housing Development, in which children born from February 1994 through May 1996 were similarly assessed, is 48% at age 19 months and 55% at age 35 months. One possible explanation for the difference may be that about 60% of the residents in the Robert Taylor Housing Development do not provide functioning telephone numbers. Such families are excluded from the sampling frame for the NIS, which is a telephone survey. This low rate of telephone service is one marker of a socioeconomic condition inadequately described by the poverty threshold alone.

The low rate of HBV vaccination coverage is a special concern in this population. Children at the Robert Taylor Housing Development are likely to be at increased risk of HBV infection throughout their lives if they are not immunized. The seroprevalence of HBV infection among the adolescents and adults in the Robert Taylor Housing Development is unknown. However, HBV infection is more prevalent among African Americans than whites overall in the United States. Major risk factors for HBV infection include parenteral drug use and multiple sex partners. Drug traffic is a serious problem in the Robert Taylor Housing Development, and rates of syphilis and gonorrhea are 3 to 4 times higher than in the city as a whole. Thus, these children are at increased risk of HBV infection, and a special effort to increase HBV vaccine coverage would seem to be warranted.

The consequences of delayed or inadequate HBV vaccine coverage for children differ from the consequences of delayed or inadequate coverage for other vaccine-preventable diseases, such as measles. Even with delayed measles immunization for some children, the entire population, a majority of whom are adults and school-age children, may still reach the 90% to 95% immunity sufficient to achieve herd immunity. By contrast, the immunization of other children does not greatly decrease the risk of HBV infection for an unimmunized child both because the overall population immunization rate is not as high and because infection, rather than
The first dose of HBV vaccine is the most likely of all recommended childhood vaccines to be received on time in this population. A majority of infants receiving the first dose of HBV vaccine on time receive it in month 0 rather than in month 1 or 2. We were surprised to realize that initiating the HBV vaccine series before age 1 month, presumably while in the hospital, is associated with on-time receipt of the first DTP vaccine dose. Further, HBV immunization at month 0 is associated with increased likelihood of HBV vaccine series completion and 4:3:1 series receipt by age 19 months, even relative to infants who received the first dose of HBV vaccine on schedule but during months 1 or 2.

Given the low level of immunization in this population despite several public health programs directed at improving rates of coverage, the apparent beneficial effect of initiating the HBV vaccine series at birth is noteworthy. Previous studies have found that on-time receipt of the first DTP vaccine dose is a strong indicator of up-to-date immunization status at 2 years of age. That observation most likely reflects a self-selection of parents whose children begin their vaccine series on time, i.e., parents who demonstrate they will be attentive to their child’s well-child care requirements early. Our data extend that finding by showing that receipt of HBV vaccine at month 0 is associated with increased receipt of the first DTP vaccine on time. Immunization at birth primarily reflects the hospital’s policy and not the parent’s initiative, although a parent would need to give consent for the vaccine to be given. While PIP has not ascertained whether any enrolled caregivers refused to give consent for immunization in the hospital, at the University of Chicago Children’s Hospital, one of the hospitals that serve this population, consent is refused for no more than 1% of children in the newborn nursery (birth weight, ≥2000 g) (Marguerite Herschel, MD, Medical Director, General Care Nursery, University of Chicago Children’s Hospital, oral communication, August 23, 1999). The primary reasons for refusal are unwillingness to receive any vaccines and desire to receive all vaccines from a private physician.

Receiving an immunization at birth might affect subsequent vaccine receipt if the days following birth represent a time when parents are especially open to educational intervention. Perhaps the explanation of the HBV vaccine recommendation or vaccines in general, or the knowledge that a 3-dose series has been started and should be completed, or the provision of a vaccine record card affects subsequent parental behavior. Alternatively, giving birth in a hospital that provides HBV immunization for newborns may be a marker of a family able to access adequate medical care. Finally, some infants for whom we have no record of a dose in month 0 may have received one, but neither the parents nor the primary care provider were aware of it. The combination of hospital, primary care, and parental characteristics associated with that communication failure may also be associated with inadequate subsequent vaccine receipt.

The limitations of this study fall into 2 categories: data issues and generalizability. Immunization rates may be understated because we insisted on written documentation. We did this because we have previously found parental report to be inaccurate. The second data issue is that we only know the date, and not the location, of the first HBV vaccine dose. Ninety percent of immunizations received in month 0 were received within 10 days of birth. Most of these were probably given in the hospital, but a small proportion of immunizations we categorized as “at-birth” may have occurred during a postnatal visit in a clinic. Several factors could potentially limit generalizability of our findings about immunization at birth to other inner-city populations. First, these data reflect the immunization experience of children in a single, large housing development in Chicago, and there may be conditions unique to this setting. Although all the families live in the same housing development, the range of medical care providers is surprisingly diverse: the 1447 children enrolled in PIP report over 80 different primary care providers. A second limitation is that all of the children were enrolled in PIP. It is unlikely that the reminder-recall intervention affected HBV immunization rates because most of the children were enrolled in PIP after their HBV series should have been completed. The mean age at enrollment was 26 months, and so data on immunizations at birth to age 18 months primarily were collected retrospectively. A third potential limitation is the number of immunization-related programs available to families in public housing in Chicago. The relative availability of health-related programs to public housing residents in other cities, or geographic variation in hospital immunization policies, could affect generalizability to other inner-city populations. The question of whether these findings can be generalized to populations with higher immunization rates is also unknown. If these findings are replicated in other populations, they suggest a new factor to be considered in articulating HBV vaccine guidelines: the impact of beginning a vaccine series at birth on subsequent vaccine receipt. Our data suggest that introducing the immunization process at birth may be one way to improve immunization rates in populations with persistently low coverage.

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REFERENCES

In all circumstances of his life, the writer can recapture the feelings of a living community that will justify him. But only if he accepts as completely possible the two trusts that constitute the nobility of his calling: the service of truth and the service of freedom.
—Albert Camus (1913-1960)