Immunization of Young Children

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Vaccination is the most important medical intervention to prevent disease. Not only are immunized individuals themselves protected from developing a potentially serious illness, but also, if enough of the population is immunized, transmission of the disease in a community may be interrupted. This indirect, so-called herd immunity, provides protection even to those who are not themselves immunized. Vaccines have been developed, and more are currently being developed, to protect children and adults from a number of potentially serious diseases. Failure to achieve adequate and timely rates of immunization among young children with available vaccines risks outbreaks of serious diseases with a resulting increase in unnecessary death and disability. Because certain vaccine-preventable diseases (especially measles, pertussis, and Haemophilus influenzae type b infection) can have devastating effects on young children, this Child Indicators article focuses on the immunization status of children 19 to 35 months old (classified as two-year-olds for reporting purposes).

In essence, a vaccine provides a controlled exposure to a disease as a way of priming the body’s natural defense against infection. Traditionally, vaccines have consisted of components of disease-causing organisms which have been treated to reduce their virulence.

Frequently, multiple doses of a vaccine are necessary to gradually build up the body’s defenses against future infection while minimizing the possibility of adverse effects from the vaccine itself. Also, as immunity may wane with the passage of time, so-called booster doses of the vaccine may be necessary to sustain protection.

To date, vaccines have been developed to protect young children from a number of infectious diseases including, but not limited to, diphtheria, tetanus, and pertussis or whooping cough (DTP vaccine); measles, mumps, and rubella or German measles (MMR vaccine); polio (OPV); hepatitis B (HBV vaccine); and Haemophilus influenzae type b (Hib vaccine). Recommendations for use of a vaccine depend on balancing the benefits and risks of vaccination with the risks of disease. Recommendations must be reassessed periodically. For example, children are no longer vaccinated against smallpox because smallpox was eradicated by the late 1970s.

Recommended Immunizations

Recommendations regarding the routine immunization of
healthy infants and children have traditionally been developed and promulgated by the Committee on Infectious Diseases (CID) of the American Academy of Pediatrics (AAP) and by the Advisory Committee on Immunization Practices (ACIP) of the U.S. Centers for Disease Control (CDC) and Prevention. Although effort is expended to ensure that recommendations from these two bodies are not discrepant, their recommendations do not always agree. Recommendations for immunization for children through 5 years of age as of January 1994 are summarized in Figure 1.

Unfortunately, immunization recommendations are complex and can be confusing to health professionals and parents alike. In part, problems arise because multiple doses of disease-specific vaccines and thus multiple interactions with providers are required to achieve adequate levels of immunity. Also, vaccines are not all given on the same schedule, and recommendations change primarily because of the availability of new vaccines and new criteria for vaccination.

There are also alternative recommendations for children at high risk for specific diseases such as those who are HIV positive or immunocompromised, for children beginning immunization at or after 15 months but before 7 years of age, and for those beginning immunization after 7 years of age (primarily new immigrants).

There have been several recent important changes in the childhood immunization schedule. In response to measles outbreaks among older children in the mid-1980s, it is now recommended that children be reimmunized against measles either at school entry (age 5 to 6 years) or at entry into middle or junior high school (age 11 to 12 years). Because of the continuing occurrence of hepatitis B among adults despite the availability since 1982 of an effective and safe vaccine, universal childhood immunizations against hepatitis B with HBV vaccine are now recommended. There are however, two alternative schedules recommended for HBV vaccinations: (1) at birth, 1 to 2 months, and 6 to 18 months; or (2) at 1 to 2 months, 4 months, and 6 to 18 months.

In early October 1993, the ACIP revised its recommended childhood immunization schedule for OPV and MMR vaccinations. The committee recommended that the third dose of OPV be administered at 6 months rather than 15 months of age. This change simplifies the immunization schedule because OPV can now be given to infants on the same schedule as DTP and Hib vaccines (see Figure 1). In addition, the recommendation regarding the first dose of MMR was liberalized to 12 to 15 months of age from 15 months to allow more “flexibility” in timing the delivery of this vaccine.

The situation with regard to immunization for Haemophilus influenzae type b disease, an important cause of meningitis in young children, is complex. Four Hib vaccines and a combination

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**Recommendations for use of a vaccine depend on balancing the benefits and risks of vaccination with the risks of disease.**

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# Summary of Recommendations for Immunizations as of January 1994

<table>
<thead>
<tr>
<th>Immunization</th>
<th>Dosage Timetable</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Birth 1 mo. 2 mos. 4 mos. 6 mos. 12 mos. 15 mos. 18 mos. School Entry Booster</td>
</tr>
<tr>
<td><strong>DTP</strong>&lt;sup&gt;a&lt;/sup&gt; Diphtheria, tetanus, pertussis (whooping cough) vaccine</td>
<td>between</td>
</tr>
<tr>
<td><strong>Hib</strong>&lt;sup&gt;b&lt;/sup&gt; Haemophilus influenzae type b vaccine</td>
<td>between</td>
</tr>
<tr>
<td><strong>HBV</strong> Hepatitis B virus vaccine option 1</td>
<td>between between</td>
</tr>
<tr>
<td><strong>HBV</strong> Hepatitis B virus vaccine option 2</td>
<td>between between</td>
</tr>
<tr>
<td><strong>MMR</strong>&lt;sup&gt;c&lt;/sup&gt; Measles, mumps, rubella (German measles) vaccine</td>
<td>between between</td>
</tr>
<tr>
<td><strong>OPV</strong>&lt;sup&gt;d&lt;/sup&gt; Oral polio vaccine</td>
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<sup>a</sup> A tetanus booster is recommended at the age of 14 to 16 years.

<sup>b</sup> Certain Hib vaccines do not require a dose at 6 months of age.

<sup>c</sup> CDC recommends the MMR booster at school entry; AAP recommends the booster at entry to middle or junior high school.

<sup>d</sup> AAP recommends third dose of OPV at 6 to 18 months of age.

According to committees of the U.S. Centers for Disease Control (CDC) and Prevention and the American Academy of Pediatrics (AAP), children should have received a total of 14 or 15 immunizations for childhood diseases by the age of two plus DTP, MMR, and OPV boosters at school age. Multiple doses of most vaccines are required to achieve adequate and sustained levels of immunity. Immunization schedules that require multiple visits to health care providers are inconvenient and increase the probability that children will not be fully immunized. Scheduling multiple vaccinations to occur at the same visit where possible and combining vaccines for several diseases into a single vaccine (such as the DTP or MMR immunizations) makes vaccination easier and less uncomfortable and increases the likelihood that children will be fully immunized.

- Further progress in this dimension was made in 1993 when Tetramune, a new combined DTP and Hib vaccine, was approved for sale in the United States. Use of the combined vaccine would reduce from eight to four the number of injections necessary to protect young children against these four diseases.

- In October 1993, the childhood immunization schedule was revised so that administration of the third dose of OPV is now recommended for 6 months of age instead of 15 months and the first dose of MMR is now recommended for 12 to 15 months of age. These changes are intended to simplify the immunization schedule and thereby to increase coverage with these vaccines.

munization rates, but it may be a while before it is possible to evaluate the utility of this new vaccine.

Because recommendations with regard to immunization of young children for Haemophilus influenzae type b and hepatitis B virus infections are very recent, the adequacy of the vaccination status of preschool-age children has historically been measured by the rate at which these children have been adequately immunized for diphtheria, tetanus, pertussis (whooping cough), polio, measles, mumps, and rubella (German measles).

These are the measures of vaccination status highlighted in this article. Attention to this so-called basic subset of vaccines should, however, not be interpreted as suggesting that immunization of young children for Haemophilus influenzae type b and hepatitis B virus infections is not important.

**Data**

Assessing the immunization coverage of young children in the United States is quite difficult. Some countries with national health systems maintain computerized immunization registers that can be used both to monitor the immunization status of the population and to track children who are not meeting recommended schedules for vaccination. The closest arrangement to such a data system in the United States is the disease surveillance system which, by monitoring the incidence of vaccine-preventable diseases, can identify gaps in immunization coverage after they occur and help characterize high-risk populations.

In addition, because children are required to provide proof of immunization status at time of entry into school in all states, data collected at school entry can provide retrospective estimates of the immunization status of young children, although the information will be three to four years out of date and perhaps subject to substantial error.

The United States has relied, intermittently, on national survey data to provide timely estimates of the immunization status of young children. Through 1985, information on immunization status was collected in the United States Immunoepidemiology Service (USIS). This survey was a section of the annual Current Population Survey conducted by the Bureau of the Census.

The USIS was suspended after 1985, but following large outbreaks of measles in the late 1980s, national immunization surveillance was reinstated by adding questions on immunization status to the National Health Interview Survey (NHIS) in 1991. The NHIS is administered annually to approximately 50,000 households. Data from the NHIS immunization sample are presented in this article and are based on information about the immunization status of only one child aged 0 to 5 years per survey household. Information was obtained from a written immunization record if the record was available.

Written immunization records may have been supplemented by adult oral recall information, and if written records could not be produced, the information on immunizations was based completely on adult recall. Information on DTP/DT, polio, MMR/measles, and Hib vaccines are included in the 1991 survey. The NHIS immunization survey component was also conducted in 1992.

The NHIS immunization survey is useful for monitoring national trends but of limited value in implementing remedial programs. The survey is not designed to provide reliable estimates at the state and local level or to give reliable estimates for narrow age groups. There also is a time delay of more than a year between the time survey data are initially collected and the time they become generally available.

Beginning in 1994, as discussed below, new modalities of data collection will be implemented to measure immunization coverage at various levels, from national down to individual clinics. Some data will be reported quarterly.

**Immunization Status**

Because there are different vaccines with different dosage schedules, there are many possible ways of assessing the immunization status of young children. Objectives are frequently stated in terms of the proportion of children of a specified age who are fully immunized at a point in time.

The United States had established for 1990 an objective that at least 90% of all children should have fully completed their basic immunization series (four doses of DTP, three doses of OPV, and one dose of MMR) by age two. This objective, however, was not met.

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**For two-year-olds, disease-specific immunization levels were 52% for OPV, 67% for DTP (at least three doses), and 80% for MMR in 1991.**
Because certain vaccine-preventable diseases (especially measles, pertussis, and Haemophilus influenzae type b infections) can have devastating effects on very young children, current national objectives focus particularly on the immunization status of two-year-olds (defined as children 19 to 35 months old). Immunization rates have been tracked by national surveys, the United States Immunization Survey in years prior to 1986 and the National Health Interview Survey in 1991 and 1992. Fluctuations in reported vaccine coverage rates may reflect actual changes in the immunization status of children from one year to the next or changes in data collection and reporting.

- Immunization rates for measles increased substantially between 1985 and 1991, apparently in response to an extensive national campaign that followed a large outbreak of the disease between 1989 and 1991. Coverage for measles, however, remains below 90% of preschool-age children.

- Immunization coverage against diphtheria, tetanus, pertussis (whooping cough), and polio had declined between 1970 and 1985 and were basically unchanged between 1985 and 1991. Reported rates of DTP and OPV immunization increased substantially between 1991 and 1992 because of increased efforts to immunize children and because of a change in the methodology for measuring immunization status based on parent recall information. Whether the large reported increments in DTP and OPV vaccination coverage between 1991 and 1992 reflect an important increase in the immunization status of two-year-olds or at primarily statistical artifacts has not yet been determined.

that children with at least three doses by age two are counted as immunized. Under these less stringent criteria, 49% of two-year-olds were adequately immunized in 1991. Using a comprehensive criterion for measuring immunization status yields lower measures of immunization than are recorded for disease-specific immunization levels. For two-year-olds, disease-specific immunization levels were 52% for OPV, 67% for DTP (at least three doses), and 80% for MMR in 1991.

In contrast to the relatively low levels of full immunization recorded for young children, recently released data suggest that about 97% of children in the United States are adequately immunized before or shortly after starting school.9,11

Figure 2 presents data on disease-specific immunization rates for two-year-olds for 1985, 1991, and 1992. The immunization rates presented are not strictly comparable over time because the data from 1985 are from the USIS and data for 1991 and 1992 are from the NHIS. There have been changes over time in the way refusals, unknowns, and “don’t know” responses were handled. In addition, between 1991 and 1992, there was a change in how responses based on parental recall were handled.

In 1991, parents were required to specify the exact ages at which vaccinations were administered for the full number of doses to be credited. Beginning in 1992, a parental response that a child had received all doses of a particular vaccine was accepted even if the time of immunization was not specified. The CDC expects this change in methodology to enhance the accuracy of the data. It also has the effect of increasing reported vaccination levels, perhaps substantially.12

Immunization levels for measles increased considerably between 1985 and 1991, apparently in response to an intensive national inoculation campaign that followed a large outbreak of the disease between 1989 and 1991.13 As a result, in part, of increased levels of vaccination, only 175 cases of the disease were reported in the first half of 1993, down from nearly 14,000 cases reported for the same period in 1990, the height of the epidemic. In contrast, the percentage of two-year-olds immunized against polio, diphtheria, tetanus, and pertussis (whooping cough) was essentially unchanged between 1985 and 1991. Rates of immunization for these diseases registered substantial increases between 1991 and 1992, but it is too soon to tell whether these increases reflect intensified efforts to immunize preschool children or changes in the way immunization status is measured.

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Preschool-age white children are more likely to be fully immunized than black children of the same age.14 As illustrated in Figure 4, the primary difference in the immunization status of white and black children, particularly with regard to DTP and OPV, is that white children are more likely to be fully immunized by age two while a larger proportion of black children are only partly immunized by age two. Yet, because there are many more white children than black children in the general population, almost 75% of all undervaccinated two-year-olds are white. Note also that, because almost 90% of children are at least partly immunized at age two, most children will require only an abbreviated series of inoculations to be fully immunized at school entry. This may account, in part, for the high level of immunization verification.
Figure 3

**Immunization Status of Two-Year-Olds**

- **Source of Information, 1991**

![Bar chart](chart)

- **Percent**
- **Columns:**
  - DTP
  - OPV
  - MMR
  - Hib

- **Legend:**
  - Light blue: All respondents
  - Dark blue: Respondents with shot records

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2. Two-year-olds = children aged 19 to 35 months; DTP = diphtheria, tetanus, pertussis (whooping cough) vaccine; Hib = Haemophilus influenzae type b vaccine; MMR = measles, mumps, rubella (German measles) vaccine; OPV = oral polio vaccine.

Written immunization (“shot”) records can serve an important function in helping parents navigate the complex maze of recommended childhood immunizations. These records also supply information to providers on the immunization status of children so that remedial action can be taken to vaccinate children who are off schedule.

In national surveys, children whose parents consult written shot records are more likely to be reported as fully immunized than children whose status is based on unaided recall. Because immunization status for about 50% of children in national surveys is based on parental recall, it is possible that immunization status is underestimated if parents who rely on recall systematically underreport the number of doses of vaccine their children receive. It appears probable, however, that children whose parents use shot records are more likely to be adequately immunized than children whose parents do not use written shot records to track immunizations. The net effect on national immunization coverage rates of relying in almost equal proportions on shot record and unaided parental recall data has not been determined.

At age two, white children are more likely to be fully immunized for diphtheria, tetanus, pertussis (whooping cough) and polio than black children; however, approximately 75% of underimmunized two-year-olds are white.

Approximately 90% of all children have been at least partly immunized for these diseases. As a result, most children only require an abbreviated series of vaccine doses to be fully immunized at school entry. That most children only have to catch up to meet school entry immunization requirements may help explain why more than 95% of school-aged children in the United States are fully immunized. Children who are not fully immunized until they enter school, however, are at risk for potentially serious, preventable diseases during their preschool years.

Source: 1991 National Health Interview Survey, calculation by authors.
coverage among children at school entry.

Why Are Immunization Rates So Low?

The increase in the immunization rate for measles among preschool children between 1985 and 1991 suggests that it is possible to raise immunization rates among young children to more satisfactory levels than currently exist in the United States. Yet, the fact that rates remain below the 1990 objective of at least 90% coverage of children under age two with the basic immunization series suggests that the United States still faces many obstacles to effectively protecting young children from preventable illnesses.

Many reasons have been cited for the low level of immunizations among preschool children in the United States. Costs may prove a serious impediment for many families, especially those with low or moderate incomes, without health insurance, or with insurance policies that do not cover immunizations. Vaccines to fully immunize a child cost more than $230 in the private sector and more than $160 in the public sector in 1992—a tenfold increase in the past decade. Several factors account for this increase, including the costs of new vaccines (Hib and HBV), general inflation, and a federal excise tax to provide compensation for vaccine-related injuries.

Rising out-of-pocket costs of vaccines appear to have led to an increase in the number of families that seek immunizations at public health clinics. Many of these facilities are overburdened and have curtailed services in response to budget cuts. Barriers associated with accessing these facilities—including long queues, inconvenient hours and locations, and prerequisites for service such as a comprehensive physical exam or an appointment for an inoculation—all contribute to low vaccination rates.

Providers and parents also contribute to the problem. Providers’ failure to take advantage of every medical opportunity to check a child’s immunization status and overly conservative behavior about giving vaccines to children with minor respiratory infections have been cited as important failings in this regard. The recently released Standards for Pediatric Immunization Practices, developed by a 35-member expert workgroup and endorsed by the U.S. Public Health Service, the AAP, and a number of other professional organizations, presents 18 provider-related standards to eliminate health care delivery system barriers and obstacles to the efficient and effective delivery of vaccinations.

Some experts believe that the failure of some parents to appreciate the seriousness of vaccine-preventable diseases and the value of immunization presents another barrier to achieving high levels of immunization among young children. In part, this complacent attitude may reflect the success of the vaccines themselves. Because the incidence of vaccine-preventable diseases is very low by historic standards, the complicated immunization process may frequently be regarded as an inconvenient procedure to prevent diseases hardly anyone has actually experienced rather than as a miracle of modern medicine.

In addition, some parents may resist vaccinations because of exaggerated fears of side effects. Community education and outreach programs may be necessary to counteract parental complacency and ignorance.

Conclusion

In response to unacceptably low levels of immunization among very young children, the federal government announced the President’s Childhood Immunization Initiative in December of 1993. Designed to make immunization of preschool children one of the nation’s highest priorities, the initiative attempts to marshal resources in the private sector and at all levels of the public sector to achieve 90% immunization coverage of preschool children by 1996. Previously, when the United States failed to achieve 90% immunization coverage of preschool children by 1990, this level of coverage was carried over as an objective for the year 2000. This new program attempts to accelerate that timetable.

One aspect of this initiative, simplifying the immunization schedule to improve compliance, has already been discussed. Other important components include the following:

- National vaccine coverage goals are now provided for individual vaccines over several years (see Table 1). This is a change from a national objective which included 90% coverage with all vaccines by the year 2000. It is hoped that looking at coverage with individual vaccines one year at a time will allow programs to focus their efforts on the specific immunization practices.
Table 1

<table>
<thead>
<tr>
<th>Vaccine</th>
<th>Number of Doses</th>
<th>Percentage Reported Adequately Covered</th>
<th>Annual Goals: Percentage Adequately Covered</th>
</tr>
</thead>
<tbody>
<tr>
<td>DTP</td>
<td>3 plus</td>
<td>83</td>
<td>80</td>
</tr>
<tr>
<td>Hib</td>
<td>3 plus</td>
<td>59</td>
<td>75</td>
</tr>
<tr>
<td>HBV</td>
<td>3</td>
<td>NM</td>
<td>30</td>
</tr>
<tr>
<td>MMR</td>
<td>1</td>
<td>83</td>
<td>85</td>
</tr>
<tr>
<td>OPV</td>
<td>3</td>
<td>72</td>
<td>75</td>
</tr>
</tbody>
</table>

a 1991 data; DTP = diphtheria, tetanus, pertussis (whooping cough) vaccine; Hib = Haemophilus influenzae type b vaccine; HBV = Hepatitis B virus vaccine; MMR = measles, mumps, rubella (German measles) vaccine; OPV = oral polio virus vaccine.

In a departure from previously stated goals that considered only full coverage with all vaccines, the U.S. Centers for Disease Control (CDC) and Prevention established annual individual vaccine coverage goals for the President’s Childhood Immunization Initiative. The goals specify the percentage of two-year-olds to be vaccinated with one dose of MMR, three doses of OPV, at least three doses of DTP, at least three doses of Hib, and three doses of HBV vaccines. For HBV, 90% coverage is the goal for 1998. The actual coverage rates as reported in the 1992 NHIS indicates approximately how far the initiative has to go to reach specified targets. (The rate of immunization coverage with Hib and HBV was not reported for 1992.)

- Although four full doses of DTP are recommended for adequate coverage, the first three doses, which offer the greatest biologic advantage, will be used to assess the DTP goal of 90% coverage.

- In part, because of a change in survey methodology, reported vaccine coverage rates for DTP and OPV increased substantially between 1991 and 1992. Reported rates for the “basic” set of vaccines (DTP, OPV, and MMR) for 1992 are almost equal to 1994 targets.

its 1993 budget. However, relatively costless policy changes, such as revising the immunization schedule or disaggregating vaccine coverage goals, may be important factors in whether the program is ultimately judged a success.

Already, changing the methodology for recording parental recall information in the NHIS may have contributed substantially to reaching the objective of 90% coverage by 1996. In fact, data in Table 1 suggest that 1994 objectives had almost been reached in 1992, more than a year before the initiative was launched. Efforts to adjust future survey data for possible underreporting associated with relying on parental recall may boost reported coverage levels further toward the 90% objective.

The considerable changes in the methodology by which immunization status is measured, in vaccine coverage goals, and in the immunization schedule pose dilemmas for those concerned about children’s health and health policy. If the process of moving toward national vaccination coverage goals relies too heavily on changing the way vaccination status is assessed, the new initiative may do little to actually improve the health status of children although the statistics may improve. If the new procedures result in an overestimate of the true immunization coverage rate among young children, then a large group of children may remain inadequately immunized and at risk for serious disease even if the initiative appears to reach its objectives.

If, however, immunization coverage rates had been underestimated in previous data, it may be difficult to assess the real impact of the program and resources may be wasted attempting to reach children who are already adequately immunized. In any event, it will be important to assess honestly the extent to which programmatic activities lead to substantial increases in immunization coverage and improvements in children’s health and the extent to which the achievements result from changes in the way the score is kept.

The helpful comments and information provided by Steven Sepe and Martha Mayfield are gratefully acknowledged, as are the comments of Richard Behrman, Howard Bauchner, Carol Larson, Linda Quinn, and Pat Shiono. Cheri Gaither helped with manuscript preparation. The usual cautions apply.

2. Peter, G. Childhood immunizations. New England Journal of Medicine (December 17, 1992) 327:1794-800. Vaccines for a number of other diseases, such as tuberculosis (BCG vaccine) and varicella (chicken pox), have been developed but are not recommended for general use in the United States.
3. Although smallpox was eradicated by the late 1970s, attempts to eradicate measles and rubella from the United States have not been successful.
8. For statistical purposes, two-year-olds are children aged 19 to 35 months.
10. Calculations by the authors from 1991 NHIS public use tapes.
11. Nearly complete immunization coverage of children at school entry is desirable but should not lead to complacency. The large gap between the immunization coverage of two-year-olds and school-age children suggests that many young children remain inappropriately at risk for potentially serious diseases for several years.
