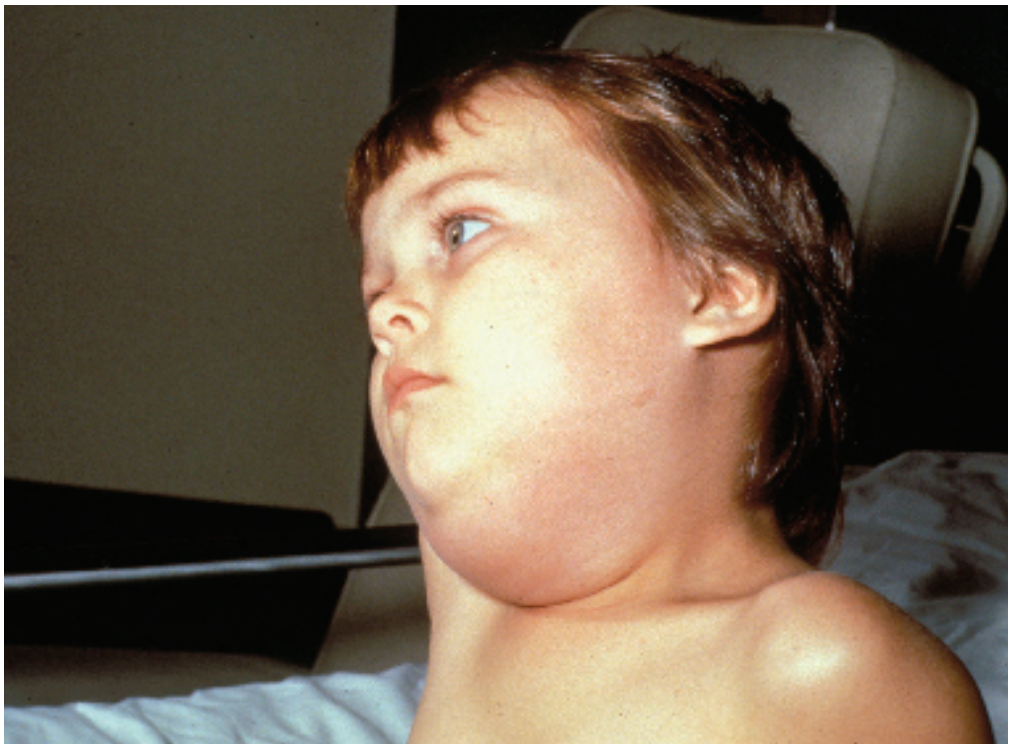

Childhood Immunizations

Robert Gamble, FNP

The development of effective vaccination programs against childhood infectious diseases has been one of the most significant advancements in public health over the last century. Smallpox has been eradicated worldwide, and wild poliovirus has been eliminated in the Western Hemisphere. The prevalence of diseases such as measles, diphtheria, and *Haemophilus influenzae* type b invasive disease, which used to cause substantial mortality in children, has been dramatically reduced with the advent and refinement of routine vaccine administration programs. The addition of new childhood vaccines against pneumococcal disease and refinements in the scheduling of existing vaccines has made the management and administration of vaccines for children a complicated process. This chapter will focus on the management of childhood vaccinations as laid out in the 2002 Recommended Childhood Immunization Schedule from the Advisory Committee on Immunization Practices (ACIP) of the CDC. Many of the diseases mentioned in this chapter, such as hepatitis B, measles, and pertussis, are discussed in more detail in previous chapters.

Mumps. This child has the swollen cheeks typical of mumps. This virus infects the parotid gland in children, as well as the testicles in teenage and adult males. Photo courtesy of the CDC

Special Considerations for Homeless Pediatric Populations

A major problem often encountered when working with homeless families is missing or inadequate documentation of children's vaccinations. Families often become homeless under traumatic circumstances, such as after a devastating fire or fleeing from frightening domestic violence, and are unable to bring the vaccination records of their children with them. Many homeless families have been relocated repeatedly, have received vaccinations at different health care facilities, and possess incomplete or conflicting documentation of vaccinations. Health care providers should try to obtain the most complete records possible. Only written and dated records are acceptable as evidence of vaccination, with the single exception of the pneumococcal polysaccharide vaccine (PPV). If records cannot be

obtained, the person must be considered susceptible and started on an age-appropriate schedule for the missing vaccines. Alternatively, serologic testing to confirm immunity for specific antigens (measles, mumps, rubella, varicella, tetanus, diphtheria, hepatitis A, hepatitis B, and poliovirus) can confirm immunity for children who, by history, have completed these vaccines.

Because homeless families live in close proximity in shelter settings, the determination of their immunization status is especially important, as unimmunized guests could precipitate an infectious disease outbreak in the shelter. An outbreak of varicella (chickenpox) could be extremely dangerous to other immunocompromised guests. A rubella outbreak could cause severe birth defects among pregnant mothers living at the shelter. In addition, health care providers and shelter staff should have documented immunity to varicella, rubella, and hepatitis B when working with homeless families.

Because it is often difficult for homeless families to obtain consistent routine health care for the children, the opportunity should be taken at every clinic visit to review a child's vaccination records. Any required or missing vaccine doses should be administered at that time, particularly if the provider feels that it will be difficult for the patient to make a return visit to receive further vaccines. Because of the complexity of the immunization schedule, this means that at certain age intervals a child could be facing up to five vaccinations at one visit. Extensive clinical evidence shows that simultaneous administration of vaccines during the same clinic visit greatly increases the probability that children will be immunized by the appropriate age. For homeless children, who can so easily slide through gaps in the health care system, this is particularly important. ACIP now states that all combinations of the live and inactivated vaccines in the Routine Childhood Immunization Schedule can be given safely and effectively at the same visit, with no decrease in the rate of seroconversion and no increase in adverse effects from the vaccines. The only exception is that the live vaccines (MMR and varicella) should be given at least 4 weeks apart. The MMR vaccine will also affect the sensitivity of PPD testing for tuberculosis; PPD may be planted at the same time as an MMR is given, but for 3 months after MMR vaccination, the PPD may be falsely negative.

When children are on a "catch-up" schedule of multidose vaccines, it may be necessary to immunize them at shorter than recommended intervals between doses, particularly if up-to-date immunizations are required for entry into school or daycare programs. ACIP has developed guidelines for the minimum ages and intervals between vaccine doses, which are outlined in Table 1. Table 2 shows the overall "catch-up" schedule.

Pediatric Vaccines

This section will discuss particular considerations for each of the vaccines that appear in the ACIP Recommended Childhood Immunization Schedule (Table 1). Some vaccines immunize against individual diseases, while others (e.g. DTaP and MMR) are vaccines that combine several antigens in a single vaccine dose. Many of the diseases covered by this vaccine schedule are discussed in detail in other chapters. The more "uncommon" vaccine-preventable diseases will be described briefly here.

Hepatitis B

The disease process of hepatitis B is discussed in detail in a previous chapter.

The first Hep B vaccine dose is usually administered shortly after birth, before the infant and mother are discharged from the hospital. Infants born to hepatitis B surface antigen positive mothers should also receive a 0.5 ml dose of Hep B immunoglobulin (HBIG) within 12 hours of birth.

An infant's first postpartum clinic visit is a good teaching opportunity to discuss the importance of regularly scheduled vaccines with the infant's caregivers and to ensure that they have begun to fill out the infant's immunization record. Parents should be instructed to bring this record to all subsequent clinic appointments.

The Hep B vaccine is an inactivated vaccine. Hep B vaccines produced by different manufacturers may be used interchangeably to complete a three-dose Hep B series.

DTaP

DTaP is a combination vaccine, conferring immunity for diphtheria, tetanus, and pertussis. Diphtheria, one of the "uncommon" vaccine-preventable diseases, is a bacterial infection that usually affects the upper respiratory airways. Before the advent of universal vaccination measures, diphtheria was a common and frequently fatal disease. In 1920, almost 150,000 cases of diphtheria were reported in the USA, with over 13,000 fatalities. In contrast, from 1980 to 1989, only 24 cases of respiratory diphtheria were reported nationwide, resulting in 2 deaths.

Table 1: Routine Childhood Immunization Schedule

Recommended Age	Vaccine
At birth	HBV-1
2 months of age	DTaP-1 IPV-1 Hib-1 HBV-2 (HBV-1, if no documentation of birth dose) PCV7-1
4 months of age	DTaP-2 IPV-2 Hib-2 HBV-3 (if dose 2 at 2 months) PCV7-2
6 months of age	DtaP-3 IPV-3 (can be given between 6-8 months) Hib-3 HBV-3 (can be given between 6-18 months) PCV7-3
12 months of age	MMR-1 (can be given between 12-15 months, but after first birthday) Varivax (can be given between 12-18 months, but after first birthday) Hib-4 PCV7-4 (can be given between 12-15 months) DtaP-4 (can be given between 15-18 months)
4-6 years old	DTaP-5 IPV-4 MMR-2
11-12 years old	HBV series Td MMR-2 (if no history of 2nd dose) Varivax (if no history of chicken pox)
13-18 years old	Td MMR Varivax (will require two doses, if no documented history of disease or vaccination)

The disease process for tetanus is discussed elsewhere in this chapter, and pertussis is covered in a previous chapter. Pertussis, also known as whooping cough, is a common cause of chronic cough in adults but can be a fatal respiratory disease for children.

The DTaP vaccine is routinely given at 2, 4, 6, and 15 months of age, with a fifth booster dose given before entering kindergarten or elementary school. Unlike other vaccine series, the DTaP series has been demonstrated to have greater efficacy if the same brand of vaccine is given for all doses of the vaccination series, and children should be given the same brand when possible.

At age 11-12 years, a tetanus-diptheria combination (Td) booster should be given, with subsequent Td boosters every 10 years.

The pertussis component of the original DTP vaccine has been associated with rare instances of acute encephalopathy and prolonged convulsions in children. In 1998, most companies changed to an acellular form of the pertussis component of the vaccine, forming the DTaP vaccine (aP = acellular pertussis). Since the recommended vaccine schedule has been changed to use the acellular form of pertussis, no cases of encephalopathy have been reported. However, further vaccination with DTaP is still contraindicated for any child who developed encephalopathy within 7 days of a previous DTaP vaccination and had no other identifiable cause for the reaction. ACIP has also issued precautions for further vaccination with DTaP if a child had any of the following events after a previous DTaP vaccination:

- temperature greater than or equal to 40.5°C (105°F) within 48 hours of vaccination;
- collapse or shock-like state within 48 hours of previous vaccination;
- persistent, inconsolable crying for more than 3 hours, occurring within 48 hours of previous vaccination; and
- convulsions with or without fevers within 3 days of previous vaccination.

In these instances, a later schedule of pertussis vaccine can be considered after the child has completed a thorough neurological evaluation and the providers and parents have evaluated risks

Table 2: The Catch-up Schedule

Visit	Under 7 years old	7 years and older
First visit	HBV (2nd if birth dose documented) DtaP IPV MMR (if >12 months old*) Varicella (*) Hib (if no previous doses, or if one dose before 12 months old, recommend 2 doses) PCV-7 (without previous doses; 12-23 months, 2 doses 8 weeks apart; 24-59 months, 1 dose; 2 doses for "high risk")	HBV Td IPV MMR Varicella (if no history of disease)
Second visit	HBV (4 weeks between dose 1 and 2) DtaP (4 weeks) IPV (4 weeks) HiB (4 weeks) PCV7 (4 weeks)	HBV (8 weeks, dose 2 and 3; note: 16 weeks between dose 1 and 3) Td (4 weeks) IPV (4 weeks) MMR (4 weeks) Varicella (if >13 years old, 2 doses required)
Third visit	HBV (4 weeks between dose 1 and 2) DtaP (4 weeks) IPV (4 weeks)	HBV Td (6 months) IPV (4 weeks)
Fourth visit (now <11 years old)	DtaP (6 months) IPV (4 weeks) Hib (8 weeks) PCV7 (8 weeks)	Td booster at minimal interval of: **(a) 6 months** if 1st dose at <12 months old and now <11 years old **(b) 5 years** if 1st dose at >12 months old, 3rd dose at < 7 years old and patient is now 11 years old or older **(c) 10 years** if 3rd dose given at age > 7 years old IPV Booster (with minimal intervals)

(*) indicates minimal intervals required.

and benefits of continuing a pertussis-containing vaccine series.

The DTaP vaccine is *not* contraindicated in the following circumstances: low-grade fever; current antimicrobial therapy; infant prematurity; or a family history of convulsions, sudden infant death syndrome (SIDS), or an adverse event following a DTP vaccination.

Hib

The disease process of meningitis from *Haemophilus influenzae* type b (Hib) is discussed in detail in a previous chapter.

Before the advent of an effective Hib vaccine, 1 in 200 children under the age of 5 in the USA developed invasive Hib, making it the leading pediatric invasive disease. 60% of these children developed meningitis; 3-5% of them died, while another 20-30% were left with permanent damage including hearing loss and mental retardation.

The Hib vaccine is routinely given at 2, 4, 6, and 12-15 months of age. Hib vaccines produced by different manufacturers may be used interchangeably to complete a four-dose Hib series. Children who have had invasive Hib disease and are less than 24 months old should be given a vaccine series, as they likely will not develop immunity from their invasive infection. For older healthy children who have not been previously immunized, a single Hib vaccine dose after 15 months of age will provide sufficient coverage. Vaccination is not needed if a child is over 7 years of age.

IPV

Polio was a serious childhood infectious disease until the advent of the polio vaccine. Polio is caused by a highly contagious enterovirus. The disease is generally either asymptomatic or a mild nonspecific febrile illness. In 1% of cases, the illness progresses to aseptic meningitis or paralytic disease. Since

Table 2: (cont.) Haemophilus Influenza Type B Vacine Catch-up Schedule

Age of Child	Vaccine History	Recommendations
7-11 months	0 doses	3 doses: dose number 2 one month after dose 1; dose 3 two months after dose 2 at 12-15 months old
	1 dose	1-2 doses at 7-11 months with booster at least two months later at 12-15 months
	2 doses	1 dose, then booster 2 months later at 12-15 months
12-14 months	0 doses	2 doses with 2 months minimum interval
	1 dose before 12 months	2 doses with 2 month interval
	2 doses before 12 months	1 dose
15-59 months	Any incomplete schedule	1 dose
60 months or older	Any incomplete schedule	1 or 2 doses if "high risk"

PCV7 Vaccine Catch-up Schedule

Age of Child	Vaccine History	Recommendations
7-11 months	0 doses	2 doses, 4 week interval with booster 8 weeks later at 12-15 months old
	1 dose	1 dose with booster 8 weeks later at 12-15 months
	2 doses	1 dose, then booster 8 weeks later at 12-15 months
12-23 months	0 doses	2 doses at 8 week intervals
	1 dose before 12 months	2 doses at 8 week intervals
	2 doses before 12 months	1 dose>8 weeks after most recent dose
24-59 months	Any incomplete schedule	1 dose
Children with underlying medical conditions (e.g. sickle cell disease, asplenia, HIV infection, AIDS, other immuno-suppressive conditions and treatments)	Any incomplete schedule	2 doses at 8 week intervals

polio vaccines were first introduced in the 1950s, wild poliovirus has been completely eradicated in the Western Hemisphere, with the last case detected in Peru in 1991.

There are two types of polio vaccine in use: inactivated polio vaccine (IPV) and oral polio vaccine (OPV), which is a live vaccine. Over the past five years ACIP has shifted from recommending a sequential IPV/OPV schedule to using an all-IPV series for polio immunization. The shift to IPV was made to reduce the risk for vaccine-associated paralytic poliomyelitis, a rare but serious consequence to vaccination with OPV (one case per 2.4 million OPV doses distributed). OPV is more effective against wild virus and is now reserved for use in regions in Africa and Asia where polio is still endemic, as well as for places where injectable polio vaccines are logistically difficult to provide.

IPV is routinely given at 2, 4, and 6 months, and then at 4-6 years of age. Children who began the polio vaccine series with OPV can complete their scheduled series with IPV.

MMR

MMR is a combination vaccine, conferring immunity for measles, mumps, and rubella. The disease process for measles is covered in a previous chapter. Measles remains a significant public health

Marsha Adderly has worked in BHCHP's respite program since 1987. She is pictured here with several children from the nearby Neighborhood School, who volunteer to share in holiday festivities with the guests and patients. Photo by James O'Connell MD

issue, with occasional outbreaks in the USA. In 1991, 100 children died from measles because of inadequate immunization.

Mumps is a viral infection, causing painful swelling of the salivary glands, giving a typical "chipmunk" appearance. Fever, headache, and stiff neck are usually present. Mumps generally has an incubation period of 2-3 weeks, followed by an acute phase which usually resolves within 7 days. Complications occur more frequently with older patients and can include encephalitis, meningitis, and inflammation of the testicles. A single attack of mumps will confer lifelong immunity from the disease.

The incidence of mumps dropped dramatically in the USA as a result of routine immunization against the disease, declining from 152,209 reported cases in 1968 to 1537 cases in 1994.

Rubella (German measles) is another viral infection, causing rash, fever, and lymphadenopathy. This cluster of symptoms is similar to measles and other viral exanthems. For most people, rubella is usually a mild and self-limiting disease. However, a mother who becomes infected during pregnancy can pass the rubella virus on to the fetus, causing severe fetal malformations known as congenital rubella syndrome. This syndrome can include defects in the eyes, ears, heart, brain, and bones.

The incidence of rubella has also been well controlled by routine immunization programs against the disease. Only 227 cases of rubella and 7 cases of congenital rubella syndrome were reported in the United States in 1994.

The first MMR dose is routinely given at 12-15 months, with a second dose given at 4-6 years, before a child enters school. MMR is a live virus that is given subcutaneously and needs to be administered within 8 hours of being reconstituted. MMR should not be administered within 4 weeks of a varicella vaccination, another live virus vaccine, for risk of interference in developing immunity to both live virus vaccines.

Varicella

The disease process of varicella is discussed in a previous chapter.

Varicella vaccine is routinely given once after 12 months of age. Varicella vaccination or serologic evidence of immunity is now required for children before entry into elementary school or child care facilities in all states. Children age 13 or older with no previous evidence of immunity should be given 2 vaccinations at least 4 weeks apart. Varicella is a live virus, given subcutaneously, and needs to be administered within one hour of reconstitution. Varicella vaccine is contraindicated for children with blood dyscrasias, leukemia, lymphoma, or other lymph and bone marrow cancers. Under certain guidelines, some HIV-infected children might be candidates for varicella vaccine and a specialist should be consulted. Varicella should not be administered within 4 weeks of vaccination with MMR.

PCV

The most recent addition to the Recommended Immunization Schedule is the pneumococcal conjugate vaccine (PCV), which provides immunity against *Streptococcus pneumoniae* bacteria, or pneumococcus. Pneumococcus is a leading cause of invasive bacterial disease in children, responsible for the majority of cases of pneumonia, bacteremia, and meningitis. Each year, pneumococcus causes approximately 700 cases of meningitis in children under the age of 5 in the USA, resulting in 200 deaths. Pneumococcus also causes the majority of cases of sinusitis and acute otitis media in children. The extensive use of antibiotics to treat these infections has been a major factor in the emergence of antimicrobial resistance among pneumococcal strains, increasing the risk for more virulent invasive pneumococcal disease.

ACIP now recommends all children under 23 months of age should receive a PCV vaccine series. The routine immunization schedule is 2, 4, 6, and 12-15 months of age. Immunization is also recommended for children age 2-6 who are in certain high-risk groups: (1) sickle cell disease, sickle hemoglobinopathies, or asplenia; (2) HIV infection; (3) renal failure; (4) immunodeficiency from immunospressive therapy, organ transplant, or malignant neoplasms; (5) chronic cardiac or pulmonary disease; or (6) diabetes mellitus. In addition, ACIP notes that a PCV series should be considered for children age 2-6 who attend group day care centers, as well as for children of African-American, Native Alaskan, or American Indian descent.

Influenza (for selected pediatric populations)

The disease process for influenza is discussed in a previous chapter.

ACIP recommends annual influenza vaccines for children over 6 months of age who have certain risk factors, including: asthma, cardiac disease, sickle-cell disease, HIV, and diabetes. These children should receive an age-adjusted dose: 0.25 ml for age 6-35 months, and 0.5 ml for age 3 and up. ■

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