American College of Preventive Medicine Practice Policy Statement

Childhood Immunizations

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Overview: Vaccine-preventable diseases were a major cause of mortality and morbidity in the United States in the 20th century. With the advent of immunizations, there have been dramatic rates of decline in these diseases. Clinical studies have shown vaccines to be efficacious and cost effective. Despite the simplification of the immunization schedule, vaccination rates are still suboptimal because of missed opportunities. Although several controversies have arisen about the safety of childhood immunizations, they are yet to be validated. There have been recent concerns about the stability of the infrastructure that supports the U.S. immunization program. Research has established strong evidence that certain interventions can increase vaccination coverage rates. The American College of Preventive Medicine outlines recommendations for childhood immunizations.
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Burden of Suffering

Vaccine-preventable diseases were a major cause of morbidity and mortality in children prior to the institution of routine immunizations. The annual incidences of measles and pertussis in the United States, for instance, was greater than 800,000 and 70,000, respectively, in the 1940s, with high associated rates of pneumonia, encephalitis, and death.[1,2] Paralytic poliomyelitis occurred in epidemic waves, crippling thousands of children in its wake, while *Haemophilus influenzae* type b (Hib) affected 1 in 200 U.S. children with severe systemic disease.[3,4] Rubella was responsible for causing devastating congenital defects in thousands of children born to infected mothers.[3] Tetanus, mumps, and diphtheria were likewise significant causes of childhood morbidity and mortality in prevaccination years.[3] Hepatitis B, infecting approximately 200,000 individuals annually in the United States, may cause complications such as fulminant liver failure, cirrhosis, and hepatocellular carcinoma.[5] The highly prevalent varicella infection is generally mild in healthy children, but results in lost school and workdays as well as leading occasionally to serious medical complications and 100 deaths per year in the United States.[6] Each year in the United States, an estimated 100 persons die as a result of acute liver failure due to hepatitis A.[7] Finally, *Streptococcus pneumoniae* infection remains a leading cause of serious illnesses such as pneumonia, bacteremia, and meningitis in young children.[8]

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Description of Preventive Measures

Childhood immunizations consist of a series of intramuscular or subcutaneous injections of inactivated bacteria, toxoids, live attenuated viruses, or inactive viral antigens. Currently it is recommended that all children receive immunization against 11 diseases: diphtheria, tetanus, pertussis, measles, mumps, rubella, polio, *H. influenza* b (Hib), hepatitis B, varicella, and *S. pneumoniae*. Most of the immunizations are given as combined vaccines during routine well-child checks in the first 2 years of life. A new unified schedule for immunizations recommended by the American Academy of Pediatrics (AAP), the American Academy of Family Physicians (AAFP), and the Centers for Disease Control and Prevention's (CDC) Advisory Committee on Immunization Practices (ACIP) is reviewed regularly, and an updated national schedule is issued annually in January to incorporate new vaccines and revised recommendations. The January 2003 schedule simplified the dosing intervals and included the newly licensed pneumococcal conjugate vaccine (PCV7), as well as new recommendations for polio vaccine (see Figure 1). While pre-event smallpox vaccination is not recommended in children,[9] the influenza vaccine is recommended for children aged >6 months with certain risk factors and encouraged in healthy children aged 6 to 23 months.[10] Additionally, hepatitis A vaccine

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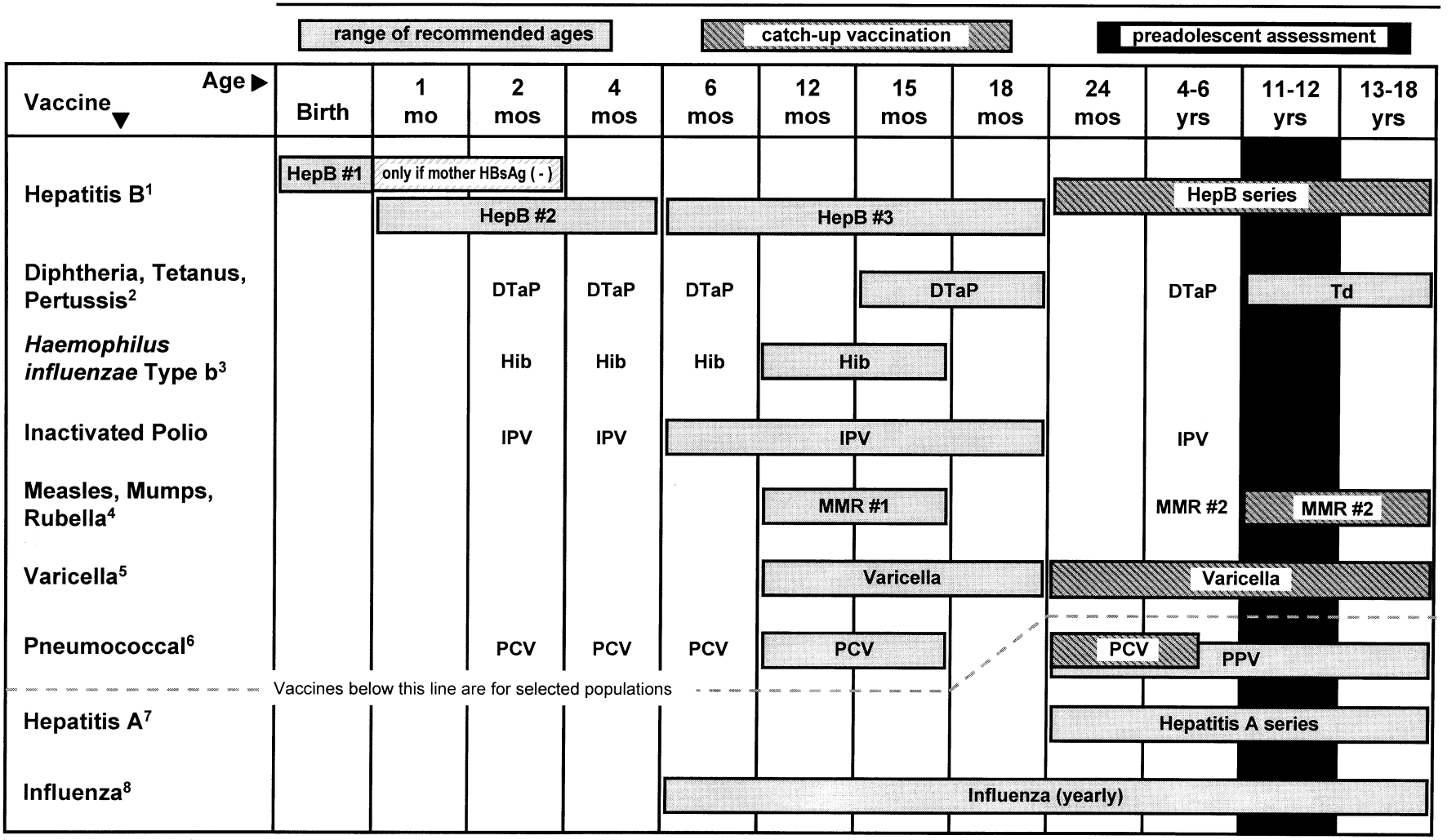
Recommended Childhood and Adolescent Immunization Schedule—United States, 2003



This schedule indicates the recommended ages for routine administration of currently licensed childhood vaccines, as of December 1, 2002, for children through age 18 years. Any dose not given at the recommended age should be given at any subsequent visit when indicated and feasible. ▨ Indicates age groups that warrant special effort to administer those vaccines not previously given. Additional vaccines may be licensed and recommended during the year. Licensed combination vaccines may be used whenever any components of the combination are indicated and the vaccine's other components are not contraindicated. Providers should consult the manufacturers' package inserts for detailed recommendations.

A

Figure 1. American College of Preventive Medicine recommended childhood and adolescent immunization schedule—United States, 2003.

Footnotes

Recommended Childhood and Adolescent Immunization Schedule—United States, 2003

1. Hepatitis B vaccine (HepB). All infants should receive the first dose of hepatitis B vaccine soon after birth and before hospital discharge; the first dose may also be given by age 2 months if the infant's mother is HBsAg-negative. Only monovalent HepB can be used for the birth dose. Monovalent or combination vaccine containing HepB may be used to complete the series. Four doses of vaccine may be administered when a birth dose is given. The second dose should be given at least 4 weeks after the first dose, except for combination vaccines which cannot be administered before age 6 weeks. The third dose should be given at least 16 weeks after the first dose and at least 8 weeks after the second dose. The last dose in the vaccination series (third or fourth dose) should not be administered before age 6 months.

Infants born to HBsAg-positive mothers should receive HepB and 0.5 mL Hepatitis B Immune Globulin (HBIG) within 12 hours of birth at separate sites. The second dose is recommended at age 1-2 months. The last dose in the vaccination series should not be administered before age 6 months. These infants should be tested for HBsAg and anti-HBs at 9-15 months of age.

Infants born to mothers whose HBsAg status is unknown should receive the first dose of the HepB series within 12 hours of birth. Maternal blood should be drawn as soon as possible to determine the mother's HBsAg status; if the HBsAg test is positive, the infant should receive HBIG as soon as possible (no later than age 1 week). The second dose is recommended at age 1-2 months. The last dose in the vaccination series should not be administered before age 6 months.

2. Diphtheria and tetanus toxoids and acellular pertussis vaccine (DTaP). The fourth dose of DTaP may be administered as early as age 12 months, provided 6 months have elapsed since the third dose and the child is unlikely to return at age 15-18 months. **Tetanus and diphtheria toxoids (Td)** is recommended at age 11-12 years if at least 5 years have elapsed since the last dose of tetanus and diphtheria toxoid-containing vaccine. Subsequent routine Td boosters are recommended every 10 years.

3. *Haemophilus influenzae* type b (Hib) conjugate vaccine. Three Hib conjugate vaccines are licensed for infant use. If PRP-OMP (PedvaxHIB® or ComVax® [Merck]) is administered at ages 2 and 4 months, a dose at age 6 months is not required. DTaP/Hib combination products should not be used for primary immunization in infants at ages 2, 4 or 6 months, but can be used as boosters following any Hib vaccine.

4. Measles, mumps, and rubella vaccine (MMR). The second dose of MMR is recommended routinely at age 4-6 years but may be administered during any visit, provided at least 4 weeks have elapsed since the first dose and that both doses are administered beginning at or after age 12 months. Those who have not previously received the second dose should complete the schedule by the 11-12 year old visit.

5. Varicella vaccine. Varicella vaccine is recommended at any visit at or after age 12 months for susceptible children, i.e. those who lack a reliable history of chickenpox. Susceptible persons aged ≥13 years should receive two doses, given at least 4 weeks apart.

6. Pneumococcal vaccine. The heptavalent **pneumococcal conjugate vaccine (PCV)** is recommended for all children age 2-23 months. It is also recommended for certain children age 24-59 months. **Pneumococcal polysaccharide vaccine (PPV)** is recommended in addition to PCV for certain high-risk groups. See *MMWR* 2000;49(RR-9);1-38.

7. Hepatitis A vaccine. Hepatitis A vaccine is recommended for children and adolescents in selected states and regions, and for certain high-risk groups; consult your local public health authority. Children and adolescents in these states, regions, and high risk groups who have not been immunized against hepatitis A can begin the hepatitis A vaccination series during any visit. The two doses in the series should be administered at least 6 months apart. See *MMWR* 1999;48(RR-12);1-37.

8. Influenza vaccine. Influenza vaccine is recommended annually for children age ≥6 months with certain risk factors (including but not limited to asthma, cardiac disease, sickle cell disease, HIV, diabetes, and household members of persons in groups at high risk; see *MMWR* 2002;51(RR-3);1-31), and can be administered to all others wishing to obtain immunity. In addition, healthy children age 6-23 months are encouraged to receive influenza vaccine if feasible because children in this age group are at substantially increased risk for influenza-related hospitalizations. Children aged ≤12 years should receive vaccine in a dosage appropriate for their age (0.25 mL if age 6-35 months or 0.5 mL if aged ≥3 years). Children aged ≤8 years who are receiving influenza vaccine for the first time should receive two doses separated by at least 4 weeks.

For additional information about vaccines, including precautions and contraindications for immunization and vaccine shortages, please visit the National Immunization Program Website at www.cdc.gov/nip or call the National Immunization Information Hotline at 800-232-2522 (English) or 800-232-0233 (Spanish).

Approved by the Advisory Committee on Immunization Practices (www.cdc.gov/nip/acip), the American Academy of Pediatrics (www.aap.org), and the American Academy of Family Physicians (www.aafp.org).

B

Figure 1. Continued.

Table 1. Baseline 20th-century annual morbidity and 2001 provisional morbidity from nine diseases with vaccines recommended before 1990 for universal use in children in United States[23–26]

Disease	20th-century annual morbidity	2001 provisional morbidity	% decrease
Congenital rubella	823	2	99.8
Diphtheria	175,885	2	100.0
Hib	20,000[a]	183	99.1
Measles	503,282	108	100.0
Mumps	152,209	231	99.8
Pertussis	147,271	5,396	96.3
Polio (paralytic)	16,316	0	100.0
Rubella	47,745	19	100.0
Smallpox	48,164	0	100.0
Tetanus	1,314	27	97.9

[a]Estimated number of cases from population-based surveillance studies before vaccine licensure in 1985.

is recommended for all children in selected geographic areas and in certain high-risk groups.[11]

Evidence of Effectiveness

Clinical studies of vaccines have shown them to be 85% to 100% effective after appropriate dosing, with the exception of pertussis, which is 62% to 92% effective.[12–17] The clinical effectiveness of immunizations, however, is best substantiated by observing the dramatic decline in incidence of disease since their institution. Poliomyelitis has been eradicated from the western hemisphere and many other parts of the world (<20 countries now have circulating wild polioviruses).[18,19] Measles, which once infected essentially every child born in the United States, is no longer an endemic disease.[20] During the first 6 years after licensure of an effective vaccine, the incidence of invasive *H. influenzae* disease, for example, declined by 95% among children aged <5 years.[21] This rapid decline occurred in spite of a vaccination rate of only 36% in 12- to 23-month-old children in 1992.[21] In 1997, coverage for three doses of Hib by age 24 months reached 93%, and the number of reported Hib invasive disease cases among children aged <5 years declined 99%.[22] Similar dramatic rates of decline of reported cases are seen with many of the other vaccine-preventable diseases[23–26] (see Table 1). Since hepatitis B affects chiefly adolescents and adults, the benefits of its vaccine will likely not be appreciated for another 10 to 20 years. Long-term studies of hepatitis B vaccine indicate that immune memory remains intact for ≥12 years and protects against chronic hepatitis B infection, even though antibody concentrations are low or undetectable.[3] No postlicensure data are yet available for the effect of the recently licensed pneumococcal conjugate vaccine; however, clinical trials suggest >90% efficacy in the prevention of invasive disease.[8]

Most of the adverse effects of immunizations, such as fever, local tenderness at the site of administration, and irritability, are mild and self-limited. Of the more serious side effects, the whole cell pertussis vaccine (DTwP) is most likely to cause adverse events with incidence of seizures or hypotonic-hyporesponsive episodes in 1 per 1750 doses.[3] The rates of similar adverse events following immunization with acellular pertussis vaccine have not yet been determined, but because the diphtheria, tetanus, and acellular pertussis (DTaP) vaccine causes high fever less frequently than DTwP, seizures are anticipated to be much less likely following receipt of DTaP.[3] The measles, mumps, and rubella (MMR) vaccine is rarely associated with encephalopathy (1 in 1 million doses).[3] Although the risk of vaccine-associated paralytic polio (VAPP) is low (1 in 2.4 million doses of oral polio vaccine [OPV]), an inactivated polio vaccine (IPV)-only schedule for all doses has been adopted in order to eliminate VAPP.[3,27] The significant public health benefits of these vaccines far outweigh their infrequent harm. Eliciting a brief history prior to administration can minimize other risks such as transmission of disease with live-virus vaccines to immunocompromised individuals or the risk of anaphylaxis in egg-allergic individuals (e.g., MMR). The full list of adverse effects from immunizations is listed in the AAP's *Red Book Report of the Committee on Infectious Diseases.*[3]

Public Policy Considerations

Funding for vaccines comes from federal Section 317 grants and state revenues, state Child Health Insurance plans, the Vaccines for Children program, and private insurance. Recent fluctuations in healthcare programs and reductions in federal Section 317 grants have resulted in instability in the public health infrastructure that supports the U.S. immunization program.[28] The cost effectiveness of routine childhood immunizations has been well documented, with one estimate suggesting that for each dollar spent now on immunization, $10 to $14 will be saved by preventing diseases in the future.[29]

Despite the incontrovertible evidence that vaccines are an efficient and cost-effective means of reducing morbidity and mortality, immunization coverage remains suboptimal in preschool children. In 2000, only 76% of 19- to 35-month-old children were fully immunized.[30] Coverage levels in areas of poverty and many metropolitan areas with large populations of low-income residents remain below national levels. In 1996 and 1999, there was a 13.6% and 10% difference, respectively, in vaccination coverage between children living in severe poverty and those living above poverty.[31] Although series-complete vaccination rates are suboptimal among U.S. children, individual vaccine coverage rates exceed 90% for three or more of DTP,

one or more doses of a measles-containing vaccine, three or more doses of hepatitis B vaccine, and three or more doses of Hib vaccine. Coverage rates are lower for three or more doses of OPV, four or more doses of DTP vaccine, and one dose of varicella vaccine.[30]

Part of the problem lies with healthcare providers who misinterpret contraindications or miss opportunities, such as sick visits, emergency room visits, or visits during which a sibling or parent is being seen, to administer needed vaccines. During the 1989–1991 measles outbreak, 53% of preschool children in Dallas and New York who developed measles had been eligible to receive the vaccine at the time of a healthcare visit.[32] In addition, parents frequently face many obstacles, both logistic and financial, in seeking immunizations for their children. Inconvenient office hours, long waiting times, and the often-unnecessary prerequisite for a full "well-child" check impede the efficient delivery of vaccines. Currently, all states have immunization mandates for school and daycare facilities.[33]

In addition to the direct protection of individuals who are vaccinated, vaccines also protect the community by decreasing the spread of infectious agents. For diseases spread through person-to-person contact, a high level of immunization in a community may disrupt the transmission of disease, thus protecting those who have not been immunized or who did not respond to the immunization. This indirect protection is called "herd immunity." Exact levels of community immunization needed for herd immunity are not known.[34]

In order to address these issues, the National Vaccine Advisory Committee (NVAC) developed the Standards for Child and Adolescent Immunization Practices, which includes 17 standards that constitute essential vaccine policies[35,36] (see Table 2). In addition, vaccination registries, follow-up and reminder systems, incentives, and performance measures such as the Health Plan Employer Data and Information Set 3.0 (HEDIS) can enhance compliance, especially for preschool children.[37,38]

Although vaccines undergo extensive safety and efficacy evaluations prior to licensure, postlicensure evaluation is critical because of the risk of rare reactions. Providers should help ensure vaccine safety by supporting ongoing surveillance and monitoring systems. Reporting suspected side effects to the Vaccine Adverse Events Reporting System (VAERS), good record keeping, adequate spacing of vaccines, and adherence to storage and administration recommendations are essential. In 1986, the U.S. Congress passed the National Childhood Vaccination Act, resulting in the creation of the Vaccine Injury Compensation Program (VICP), which compensates individuals for health concerns arising after vaccination. This program provides liability protection for manufacturers and pediatricians in order to ensure their continued participation in the vaccination program.

Table 2. National Vaccine Advisory Committee's Standards for Child and Adolescent Immunization Practices

1. Vaccination services are readily available.
2. Vaccinations are coordinated with other health/care services and provided in a medical home when possible.
3. Barriers to receiving vaccines are identified and minimized.
4. Patient costs are minimized.
5. Healthcare professionals review the vaccination and health status of patients at every encounter to determine which vaccines are indicated.
6. Healthcare professionals assess for and follow only medically accepted contraindications.
7. Parents/guardians and patients are educated about the benefits and risks of vaccination in a culturally appropriate manner and in easy-to-understand language.
8. Healthcare professionals follow appropriate procedures for vaccine storage and handling.
9. Up-to-date written vaccination protocols are accessible at all locations where vaccines are administered.
10. Persons who administer vaccines and staff who manage or support vaccine administration are knowledgeable and receive ongoing education.
11. Healthcare professionals simultaneously administer as many indicated vaccine doses as possible.
12. Vaccination records for patients are accurate, complete, and easily accessible.
13. Healthcare professionals report adverse events following vaccination promptly and accurately to the Vaccine Adverse Event Reporting System (VAERS) and are aware of a separate program, the National Vaccine Injury Compensation Program (VCIP).
14. All personnel who have contact with patients are appropriately vaccinated.
15. Systems are used to remind parents/guardians, patients, and healthcare professionals when vaccinations are due and to recall those who are overdue.
16. Office or clinic-based patient record reviews and vaccination coverage assessments are performed annually.
17. Healthcare professionals practice community based approaches.

Recommendations of Other Groups

Two major groups, the AAP's Committee on Infectious Diseases and ACIP, have traditionally developed vaccine guidelines since the 1960s. Because of the potential for confusion over their slightly differing immunization schedules, however, these two groups joined with the AAFP in 1995 to produce a unified schedule for childhood immunizations. These recommendations appear regularly in the CDC's *Morbidity and Mortality Weekly Report* and the AAP's *Red Book*. The joint group also included representatives from the National Institutes of Health and the Food and Drug Administration, and received input from state immunization programs, the Maternal and Child Health Bureau of the Health Resources and Services Administration, and vaccine manufacturers.

In its *Guide to Clinical Preventive Services*, the U.S. Preventive Services Task Force recommendations for

childhood immunizations echo those of the joint group. The Task Force on Community Preventive Services, which accepts these recommendations for childhood immunizations, conducted a systematic review of the literature to address interventions to improve vaccine coverage. The Task Force concluded that strong evidence exists that client reminder recall; multicomponent interventions (including education, reducing out-of-pocket costs, and expanding access in medical or public health clinical settings as part of a multicomponent intervention); provider reminder/recall interventions; assessment and feedback of vaccination coverage information to providers; as well as standing orders in adults are effective in improving vaccination coverage.[39,40] They also found that there is sufficient evidence that vaccination requirements for childcare, school, and college attendance, interventions in Women, Infant, and Child (WIC) settings, and home visit interventions are effective in improving vaccination coverage.[39,40] These findings are recommended and are contained in one of the first completed chapters in its upcoming *Guide to Community Preventive Services*. The current child and adolescent immunization schedule is designed to facilitate early administration of vaccines while providing flexibility for individual circumstances.

Rationale Statement

All the vaccines licensed for routine use in children and recommended by the joint committee have been efficacious in studies. Most of them—including measles, mumps, rubella, polio, diphtheria, pertussis, tetanus, hepatitis B, varicella, hepatitis A, and Hib—have also been proven effective and safe during their many years of use. Whether the newer pneumococcal conjugate vaccine will result in similar public health benefits is uncertain, although studies do suggest that it is safe and cost effective.[8]

Several controversies in the area of childhood immunizations have recently arisen. In response to recent studies showing acellular pertussis vaccine to be equally efficacious to the whole cell vaccine with fewer side effects, it is now the preferred option.[41] Preliminary postlicensure studies suggested an increased risk of intussusception following vaccination with the recently licensed rotavirus vaccine. Although the incidence of intussusception was low (125 per 100,000 infant years), the concern led to a suspension of the recommendation for rotavirus vaccination.[42] Case–control studies conducted subsequently resulted in the withdrawal of rotavirus vaccine.[43] Also recent concerns about mercury-based preservatives in vaccines have led to the development of Thimerosal-free vaccines.[44] Although there has been growing public concern about possible links of the MMR vaccine to autism and inflammatory bowel disease, several studies have shown a lack of causal association.[45–48] Similar concerns between hepatitis B vaccine and multiple sclerosis have not been validated.[49] The Institute of Medicine Immunization Safety Review Committee recently found no epidemiologic evidence supporting a causal relationship between multiple immunizations and an increase in the incidence of infections by other pathogens.[50]

Recommendations of the American College of Preventive Medicine

All children without established contraindications should receive DTaP, MMR, Hib, hepatitis B, varicella, IPV, and pneumococcal conjugate vaccinations as outlined in the Unified Schedule of Childhood Immunizations and as detailed in the ACIP's General Recommendations on Immunization. Children in selected areas with high rates of hepatitis A should receive hepatitis A vaccination.[9] Children with special risk factors, such as compromised immune systems, may require additional immunizations.[3]

All healthcare providers should adopt the Standards for Child and Adolescent Immunization Practices developed by the National Vaccine Advisory Committee outlined in Table 2, and promote the *Healthy People 2010*[51] goal of 90% vaccination rate of 2-year-olds in their communities.

Research priorities should include:

- Development of new vaccines for diseaseImprovement of immunogenicity and minimizing of the adverse effects of existing vaccines
- Development of new combinations of vaccines and needleless vaccine delivery systems, which will help to minimize the emotional and physical trauma and inefficiency of multiple injections in children while promoting compliance
- Ensuring uninterrupted supplies of vaccines, including increased funds for vaccine supplies, strengthening the VICP to include all active and inactive vaccine ingredients in the definition of the vaccine, and streamlining and strengthening the regulatory process for vaccine production
- Definition of optimum systems-level interventions for childhood immunizations, including investigation of the role of managed care entities in immunization delivery, the impact of local, state, and national immunization registries, and exploration of other community-wide programs and projects aimed at enhanced immunization (e.g., the role of schools)
- Investigation of the effectiveness, applicability, economic impact, and barriers to recommended interventions for improving vaccine coverage rates[39,40]
- Adoption of strategies that would increase funding to strengthen the infrastructure of immunization pro-

grams, reorganize Section 317 grants to improve infrastructure stability, introduce state match requirements for increased funding, and develop consistent measures for monitoring the status of children enrolled in public and private health plans[24]

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