Abstract

This article addresses the basic information regarding immunizations that all nurses who care for infants and children should know. It presents a brief overview of immunology and the history of immunization science. Immunization standards, techniques of administration, and the handling of immunobiologics are discussed along with current vaccines, toxoids, and immune sera. Public laws and governmental support resources relating to immunizations are presented as well as are special circumstances, such as foreign adoptions, breastfeeding infants, and those who are immunocompromised. Finally, the pediatric immunization schedule is presented and selected vaccine-preventable diseases are discussed.

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The Basics of Pediatric Immunizations

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A hundred years ago, infectious diseases were widely prevalent throughout North America and Europe. Indeed, in 1900, 4 of the 10 leading causes of death in the United States were attributed to them.¹ Immunization has greatly reduced deaths from infectious diseases and has resulted in the eradication of smallpox, the elimination of polio in most countries, and the widespread control of many other diseases, including measles, rubella, tetanus, and diphtheria.

Immunization administration is both a privilege and a responsibility for many nurses. It is almost always the nurse who screens for need, teaches parents and guardians about precautions and aftercare, and actually administers the immunizations. The art of immunization requires the provider to apply sound knowledge of vaccines and their administration with careful analysis of an individual's risk. This article addresses the basic information regarding administration of immunizations that all nurses who care for infants and children should know.

Overview of Communicable Disease, Immunity, and Immunizations

Communicable Diseases

In the 1880's and 1890's, Robert Koch established that a different microbe causes each infectious disease. Koch defined a process by which a specific causative organism could be identified by demonstrating that: 1) the suspected organism is present in every case of the disease; 2) the organism can be isolated and grown in the laboratory; 3) an animal will develop the disease when injected with the laboratory-grown culture; and 4) the organism can be isolated from the newly infected animal and the process repeated.²

Since Koch's time, scientists have recognized that communicable diseases do not occur in a vacuum, but are the result of the exposure of a susceptible individual (one who has not had the disease or who has not been immunized) to a disease-causing organism. This can be through direct person-to-person transmission by coughing, sneezing, kissing, or sex; through indirect transmission, which involves spread of the organism via inanimate objects such as contaminated food, water, money, or soiled tissues; or by animals (eg, rabies) or insects (eg, malaria). The communicability of an infectious agent causes the threat of ongoing disease, not just in an individual but also in whole populations.

Researchers and epidemiologists have determined that a chain of infection must exist for a disease to be communicable. The chain of infection requires

several links including 1) a pathogen of causation; 2) a reservoir, or place where the pathogen lives; 3) a method of transmission; and 4) a susceptible host.² Many public health advances through the years have successfully fought disease by countering the first three links of the chain of infection. Eliminating the causative organisms responsible for disease defeats the first link. This is frequently possible and is commonly accomplished by such means as cleaning, sterilizing, and using disinfectants. The second link can be targeted by the elimination or minimization of reservoirs or hosts that allow the organism to grow. An example of this is killing mosquitoes or removing their breeding areas to prevent malaria. Prevention of transmission, the third link, is accomplished in a variety of ways. Examples include use of surgical masks and gloves, quarantine of infected individuals, and control of vectors (eg, rats that carry plague). Immunization addresses the fourth link—host susceptibility.

Immunity and Immunization

Immunity to a communicable disease protects an individual from infection. There are several types of immunity. **Innate immunity** occurs if the individual is born resistant to a specific organism. **Acquired immunity** may be active or passive. **Active immunity** comes from actual exposure to an organism (natural immunity) or through obtaining the appropriate vaccine (artificially induced immunity). Active immunity requires a competent immune response to the antigen exposure and offers long-term immune protection. **Passive immunity** is a temporary immunity achieved through transmission of maternal antibodies to a fetus from its mother or by administration of immunoglobulins or antitoxins to a susceptible client.³

Immunization is the process of inducing an active immunity or providing immunity passively by administering an immunobiologic agent. Immunobiologic is a term that encompasses three categories of agents: vaccines, toxoids, and immune sera. Vaccines and toxoids are distinctly different agents and yet both induce active immunity. That is, the agents induce the body to respond to their presence with a natural immunologic response to an antigen. **Herd immunity** denotes an additional form of protection achieved through the active immunization of a significant proportion of the at risk population. By increasing the number of individuals who cannot contract and consequently cannot transmit a disease, a measure of protection is achieved for nonimmunized persons by default.

Vaccines are made from an infecting organism. Viral vaccines can be made from either killed viruses or live attenuated viruses, meaning that the organisms are altered in a way that enables them to multiply in the host but

leaves them unable to cause disease. Live attenuated vaccines induce a response in the host more similar to natural infection, and thus may confer lifelong immunity, as would a primary natural infection. This is not always the case, however. For example, measles vaccine, a live attenuated virus vaccine, requires a booster dose. Other live attenuated viral vaccines are Sabin polio (oral) vaccine, and mumps and rubella vaccines.

Killed virus vaccines may be whole viruses, split particles of a virus, or specific fragments (subunits) of a virus. Hepatitis B vaccine is an example of a viral subunit vaccine.⁴ Vaccines made from killed organisms always require additional doses at some time after the initial dose and may require additional boosting periodically.

Bacterial vaccines are usually made from whole killed bacteria or specific bacterial wall antigens. Examples of killed or inactivated bacterial vaccines are pertussis, plague, and anthrax. As with the killed viral vaccines, these vaccines do not confer lifelong immunity and must be boosted periodically to preserve effectiveness.

Toxoids are inactivated bacterial toxins. The toxin is modified in vaccine production and is often combined with agents that prolong its absorption and, thus, enhance its antigenicity. The toxoid retains the ability to stimulate antitoxin formation in the recipient and thereby confers active immunity.⁴ Toxoids, like the killed biologic vaccines, do not induce lifelong immunity and must be boosted periodically. Tetanus and diphtheria vaccines are examples of toxoids.

Immune sera are sterile solutions containing preformed antibodies derived from human (immune globulin) or equine (antitoxin) sources. Immune sera confer temporary passive immunity, that is, immunity that persists only for the lifetime of the antibodies given in the sera. In general, passive immunity lasts for 6 to 12 weeks.⁵ Examples of these sera include immune globulin (Ig), for use against a wide variety of diseases, and Hepatitis B Immune Globulin (HBIG), for therapy after known or suspected exposure specifically to hepatitis B.

Immune globulin is derived from the blood plasma of large donor pools (at least 1,000 per lot of sera) of populations known to have experienced specific diseases. The sera contain primary IgG and trace amounts of IgA and IgM and are treated to remove any infecting agents. **Antitoxins** are derived from horses that have been immunized with an antigen and allowed to form antibodies. The antibodies (antitoxins) are harvested and used to treat already infected subjects. **Monoclonal antibody** is sera prepared from a single lymphocyte clone that contains only antibody against a single microorganism. The monoclonal antibody has the lowest potential for allergic response because it is the least complex sera. Immune sera

are given when persons are immune deficient, have suffered exposure to a serious disease for which they have no protection, or are experiencing a disease for which an antibody may help avoid injury or complication.

In addition to the active components in immunobiologics, other active and inert ingredients may be present. These include suspending agents, preservatives, stabilizers, antibiotics, and aluminum salts. Vaccine recipients may experience an allergic response to any of these tangential components, as well as to the immunobiologic itself.⁴ The use of human immune sera or monoclonal antibody is always preferred if available, because the risk of allergic response is far less, though still considerable, compared with the equine sera.

Immunization of persons/populations is recommended when risk of infection exceeds risk from exposure to immunization material. Consideration should be given to 1) seriousness of the disease and its consequences, 2) likelihood of exposure to the causative organism, and 3) possible hazardous responses to a vaccine. In the case of active immunization, it is also important to assess the recipient's ability to respond to the antigenic challenge of the vaccine by forming appropriate humoral and/or cellular immunity.

Pediatric Immunizations

History of Pediatric Immunization

In the early 1950s there were four vaccines routinely used in the United States: diphtheria, tetanus, pertussis, and smallpox. Three of these vaccines (diphtheria, tetanus, and pertussis) were combined into a single shot (DTP). Children received five shots by the time they were 2 years old and not more than one shot at a single visit.³

By the mid 1980s, there were seven vaccines routinely given to children: DTP; measles, mumps, rubella (MMR); and polio (smallpox was discontinued in the early 1970s). DTP and MMR were given in two shots, and polio vaccine was given by mouth. Children still received five shots by the time they were two years of age and not more than one shot at a single visit.

Since the mid-1980s, several vaccines have been added to the schedule. *Haemophilus influenza B* vaccine (Hib) was added in the mid 1980s; Hib was originally given in a single dose to toddlers and then as a series at two, four and six months. In the 1990s, hepatitis B and varicella (chicken pox) vaccines were added, and the polio vaccine shot (IPV) replaced the oral polio vaccine. Then, in 2000, the pneumococcal conjugate vaccine (PCV) was added and hepatitis A was recommended to children in high-risk areas. Table 1 provides information about the vaccine-

preventable diseases, including type of organism, incidence for the year 2000, mode of transmission, symptoms, and complications.

As a result of the many additions and multiple doses required for most vaccines, the vaccine schedule has become very complicated. Now children may receive as many as 20 shots by two years of age and up to five shots in a single visit. By age two, children born today will have three doses of hepatitis B, four doses of DTP, four doses of Hib, three doses of polio, four doses of PCV, one dose of MMR, and one dose of chicken pox vaccine. At around four to six years they will be given booster doses of DTP and polio and second doses of MMR and chicken pox. This information is summarized in Table 2.

Vaccines are also recommended for teens. Depending on which immunizations they received when they were younger or other factors (such as contracting chicken pox as a child), they will need vaccinations for chicken pox, hepatitis B, MMR, and diphtheria-tetanus (pertussis is not recommended after age 7). Additionally, many colleges are recommending, and some even requiring, that college students receive vaccination against meningococcal diseases.

Informed Consent and Documentation

In many public health clinics or school systems, immunizations are given under standing orders of the chief public health officer of a given state or another designated medical professional. Immunizations given in private practice are administered as any medication, under the orders of a treating provider. The National Childhood Vaccine Injury Act of 1986,⁸ requires that "informed consent" be obtained from the legal representative of a child receiving any vaccine. Informed consent is very specifically stipulated to include the provision of standardized "Vaccine Information Sheets" (VIS) to parents or guardians. These VIS are available on the CDC's website⁹ or through a local public health office.

Documentation that is required includes: date the vaccine is given; vaccine manufacturer; vaccine lot number; name, address, and title of the person giving the vaccine; and the date of the edition of the vaccine information materials that were provided. A parent signature is not required by law, but is customary in the documentation of the immunization. This information must be maintained in permanent medical records. Official vaccine information cards have been established in each of the 50 States, US territories, and the District of Columbia. These cards are personal medical records that assist the client in providing documentation of immunization status for schools and

Table 1. Characteristics of Vaccine-Preventable Diseases

Disease	Type of Organism	Incidence (2000)	Mode of Transmission	Symptoms	Complications
Diphtheria	Gram-positive bacteria	1	Person-to-person direct contact or contact with airborne droplet usually affects children under 15 years.	Sore throat, fever. Characterized by formation of yellow-white membranes on tonsils and pharyngeal walls.	Potential respiratory distress.
<i>Haemophilus influenzae</i>	Gram-negative bacteria	1,398 (invasive disease)	Person-to-person contact or droplet.	Bacteria may cause otitis media, sinusitis, epiglottitis and upper respiratory infections.	Bacterial meningitis; most cases of invasive disease occur in children 3 months to 3 years of age.
Hepatitis B	Virus	8,036	Exposure to infected blood or body fluids. In children primarily prenatally spread.	General flu-like symptoms (may be asymptomatic). Liver may be enlarged, dark urine, light stool, jaundice. Symptoms last 4–6 weeks.	Chronic hepatitis; cirrhosis; liver cancer.
Measles	Virus	86	Person-to-person contact or droplet.	Flu-like symptoms, high fever (greater than 101), cough, and conjunctivitis. Rash usually starts on the face and spreads to the body. Koplik's spots in the mouth are bluish with very fine red spots.	Pneumonia and encephalitis. Persons allergic to eggs may have severe reactions to the vaccine.
Mumps	Virus	338	Person-to person contact or droplet. Communicable 6 days before to 9 days after swelling. Most often occurs in children.	Low-grade fever, headache, earache, pain and swelling of parotid glands (may be unilateral or bilateral). Swelling lasts about a week.	Infrequent complications are encephalitis and meningitis. Orchitis may occur in males who have reached puberty, but sterility is rare.
Pertussis	Gram-negative bacteria	7,867	Person-to person contact or droplet. Very contagious.	Characteristic cough is nonproductive with quick expiratory phase followed by inspiratory "whoop." Small scleral and conjunctival hemorrhages can occur because of severe coughing.	Infants younger than 1 year are severely affected. Pneumonia, seizures, and ear infections may occur.
Pneumococcus	Gram-positive bacteria	Not a reportable disease	Person-to-person, likely by droplet contact; in many persons are colonized in the upper respiratory tract.	Causes otitis media, sinusitis, and invasive bacterial infections.	Pneumonia meningitis.

Table 1. *Continued*

Disease	Type of Organism	Incidence (2000)	Mode of Transmission	Symptoms	Complications
Polio	Virus	0	Direct contact of virus with mouth.	Low-grade fever and sore throat (most cases are asymptomatic).	Muscle weakness progressing to paralysis in 0.1–2% of cases. May affect any muscle group including limbs and respiratory muscles. Adults may develop postpolio syndrome 30–40 years after the disease.
Rubella	Virus	176	Person-to-person contact or droplet. Communicable 4 days before to 4 days after rash appears. Highly contagious.	Mild in adults and young children; macular rash on scalp, trunk, and limbs lasting 1–3 days.	Severe complications in early fetal development—may result in congenital malformations and death. Vaccine is live so it must NOT be given to pregnant women.
Tetanus	Neurotoxin produced by an anaerobic, Gram-positive bacteria	35	Exposure of wound to the bacterium. Deep-puncture wounds are at greatest risk. Neonatal tetanus results from contamination of the umbilical stump.	Severe generalized muscle spasms.	
Varicella	Virus	27,382	Person-to-person contact or contact with airborne droplets. Very contagious. Communicable 2 days before to 6 days after vesicles appear. Primarily affects children.	Low-grade fever, listlessness. Lesions appear within 2–4 days. Rash has three phases: raised spots, fluid-filled vesicles, and scabs. Rash itches and is found over entire body.	Grandparents and older adults should avoid caring for children because they may develop herpes zoster (shingles).

Sources:^{5–7}

child-care centers and should be established for every newborn.

Storage and Handling of Immunobiologics

Vaccine manufacturers provide detailed recommendations for storage and handling of their products. Most vaccines require cold storage and some require freezing, while freezing damages many. All have a shelf life indi-

cated by an expiration date. Live attenuated virus vaccines (eg, MMR, Varicella, and Yellow Fever) are sensitive to increased temperature and all others are sensitive to freezing. Failure to meet storage and handling recommendations could reduce potency of a vaccine, resulting in an inadequate immune response on the part of the recipient.

Manufacturer's package inserts also describe the expected appearance of a vaccine. All vaccines should be inspected on receipt and again before administration, even

Table 2. Immunization Doses by Age for Infants and Small Children

Vaccine	Number of doses
Birth to 2 years	
Hepatitis B	3
Diphtheria/Tetanus/Pertussis (DTP)	4
Haemophilus influenza B (Hib)	4
Polio	3
Pneumococcal conjugate	4
Measles/Mumps/Rubella (MMR)	1
Varicella (chicken pox)	1
4 to 6 years	
DTP	1
Polio	1
MMR	1
Varicella	1
Hepatitis A (in high risk areas)	2

though it is not always possible to tell on visual inspection if a vaccine has been mishandled. Any vaccine dose that has been inadvertently given under questionable storage circumstances should not be counted as a true dose.¹⁰ Vaccines that require reconstitution should be reconstituted exactly according to manufacturer's instructions and given immediately after reconstitution. Vaccines that are distributed in multidose vials can be administered once opened, until their expiration date, given proper storage and the scrupulous use of sterile technique.

Scheduling of Vaccine Administration

Vaccine recommendations are based on risk of exposure and burden of disease, balanced against any possible untoward effects of a particular immunobiologic. The Advisory Committee on Immunizations (ACIP) of the Centers for Disease Control and Prevention (CDC) and the American Academy of Family Physicians (AAFP) devise immunization standards in the United States. Recommendations for immunization are made with respect to the nature of the immunobiologic, the immunocompetence of the recipient, the age-specific risk for the disease, disease complications, and the potential interference with an immune response by passively transferred maternal antibodies. Vaccines are recommended for the youngest age group at risk for the disease for which efficacy and safety have been demonstrated.¹⁰ The childhood immunization schedule approved by the ACIP and AAFP in 2003 can be viewed at <http://www.cdc.gov/nip/recs/child-schedule.pdf>.¹¹ This schedule is revised yearly and published every January.

Recommendations for administration and spacing of vaccines are devised to ensure optimal protection and efficacy and so should be followed carefully. There are times, however, modifications to the schedule are required. For example there may be a need to accelerate the schedule (eg, impending travel, being behind schedule), and a minimum interval between doses is provided in the immunization schedule. The recommendation allows for doses given within four days of the recommended minimum interval to be considered acceptable. Doses given in intervals more than four days shorter than recommended cannot be counted as valid doses to complete a series. Any repeat doses should be given four weeks after the invalid dose with consideration of the minimum age for the child. Certain vaccines, such as adult TD, pediatric DT, and tetanus toxoid can produce increased rates of local or systemic reactions if given too frequently.¹⁰

The safety and efficacy of simultaneously administered vaccines (ie, at the same visit) is well supported by research.^{12–14} Recommendations for nonsimultaneous administration of vaccines vary with the vaccines to be given. Inactivated vaccines do not interfere with other inactivated vaccines or with live vaccines. It is permissible to give inactivated vaccine before, with, or after any inactivated or live vaccine. It is thought, however, that the immune response to one live vaccine may be impaired if administered within 30 days of another live vaccine.¹⁰ The plan should be to give the needed live vaccines at the same time or at least 30 days apart for optimal response. In the case of lapsed vaccination status, an attempt should be made to bring the client "up to date" using the minimum spacing intervals. When there is no documentation of immunization status, the client should be started on an age-specific schedule and be brought up to date as soon as possible.

The American Academy of Pediatrics (AAP) recommends that preterm and low-birth-weight infants be immunized at the usual chronological age. Doses of vaccine should not be reduced despite the size of the infant. There is some indication that very-low-birth-weight infants have a reduced immune response. The AAP reports that there are some studies that indicate lower rates of seroconversion among infants less than 2 kg who have been immunized against hepatitis B at birth. The optimal time to initiate hepatitis B immunization for low-birth-weight infants has not yet been determined. However, preterm infants with birth weights less than 2 kg, who have HB-sAg-positive mothers, should be immunized within 12 hours of birth with HBIG.⁵

Internationally adopted children should be provided immunizations appropriate to US recommendations. Comparisons of immunization materials between countries should be made, as all vaccines of a type are not neces-

sarily interchangeable. That is, if an international immunization record lists a measles vaccine, for example, care should be taken to discover the specific product used and to compare it to the US product for equivalency.

Contraindications and Precautions

Contraindications and precautions are circumstances in which a vaccine should not be given. A contraindication is a condition in the client that increases the risk for a serious adverse reaction. A precaution is a condition in the client that *might* increase the risk for a serious adverse reaction or that *might* compromise the client's response to the vaccine. These circumstances are most often temporary and usually only result in delay of immunization. The CDC states that the only absolute contraindication for immunization is the known severe allergic reaction to a previous dose of a given vaccine or vaccine constituent. National standards for contraindications and precautions are updated yearly along with the immunization schedule.¹⁰ Providers should review these recommendations for precautions and contraindications periodically.

Vaccines for active immunization are administered to essentially well individuals. In many cases this can be a somewhat subjective decision. Minor illnesses such as colds are usually not a contraindication to vaccine administration. Children who are actively ill and significantly febrile should have immunization delayed if possible. This is due to concerns about an adequate immune response by the client, more than concern for potential vaccine injury.

Decisions to vaccinate immunocompromised children must be made individually. Severely immune-deficient persons should not receive live vaccines, as there is a true risk of disease. Persons with lesser degrees of immunodeficiency might benefit from killed vaccines and immune globulin. There is no increased risk of complications, though the benefit is unknown. In children with a secondary immune suppression, adequate immune response is usually reestablished within three months of cessation of immunosuppressive therapy.⁵ Vaccination can then be initiated or resumed at that time.

Breastfeeding is not considered a contraindication to vaccination in any situation. Neither inactivated nor live vaccine administered to a breastfeeding mother affect the safety of breast milk. Likewise, breastfeeding does not limit immune response on the part of the infant or toddler.^{15,16}

Administration of Vaccines

Administration of vaccines should employ infection control measures and sterile technique. Recommended routes of injection and needle length are always given by

the manufacturer and have been a part of the research on the vaccine. These recommendations should always be followed, as should precautions related to age. For infants, the anterolateral aspect of the thigh should be used for injection; for toddlers and older children, the deltoid may be used if muscle mass is adequate^{5,10} and if institutional policies permit. Jet injectors, needle-free devices that deliver a narrow stream of vaccine that penetrates the skin, can deposit vaccine into intradermal, subcutaneous, or intramuscular tissue. Jet injectors have been proven to be safe and effective delivery systems with comparable rates of immune response in recipients.¹⁷

Adverse Reactions and Safety Concerns

Adverse events to vaccines are common. Local reactions include pain, swelling, and redness at the injection site. Systemic reactions include fever, irritability, drowsiness, and rash.¹⁸ Allergic reactions and seizures are among the more serious undesired effects of immunizations. Pain and fever can be minimized with acetaminophen, but more serious side effects should be reported immediately to the health care provider administering the vaccine and treated accordingly.

Adverse reaction may occur after any immunization and may be related to the vaccine itself or a vaccine constituent. Adverse reactions may be mild, moderate, or severe and differ depending on the vaccine. Allergic reactions to egg-related antigens are common. For older children these may be anticipated and identified via screening; for infants, who probably have not had eggs, the risk appears to be low, but real. Neomycin and gelatin components of certain vaccines are sometimes implicated in adverse reactions. Other antibiotics are sometimes suspect, but proof of a causal relationship has not been made. For older children, scratch and intradermal testing is possible if there is true suspicion of potential harm.⁵

The AAP warns that "persons administering biologic products or serum should be prepared to recognize and to treat anaphylaxis. The necessary medication, equipment and staff competent to maintain the patency of an airway and to manage cardiovascular collapse must be immediately available." (p 51)⁵ In all instances of anaphylaxis, the drug of choice is epinephrine. Mild reactions, such as puritis, erythema, urticaria, and angioedema should be treated with epinephrine first, limiting response, and then may be followed by diphenhydramine or another antihistamine, depending on resolution of symptoms.

Reporting of Adverse Reactions

As the incidence of vaccine-preventable diseases declined, adverse effects became more visible and lead to a

demand by the public that risks to infants be defined and studied. Because of increasing litigation, several manufacturers threatened to stop production of vaccines. As a result, the National Vaccine Injury Act was passed in 1986,⁸ to compensate individuals who were injured by childhood vaccines; this released vaccine manufacturers of liability. The Vaccine Adverse Effects Reporting System (VAERS) was also created by this Act. VAERS is managed by the Food and Drug Administration and the CDC and is responsible for collecting, managing, and evaluating reports of vaccine reactions.^{19–21} Public and provider concern has increased in recent years because, in every year since the early 1990s, the number of reports of serious side effects has exceeded the reported incidence of all vaccine-preventable childhood diseases combined.²² Indeed, the number of problems reported by VAERS is approximately 11,000 per year,¹⁸ while there were approximately 10,000 cases of vaccine-preventable illnesses in children in 2000 (excluding varicella and hepatitis B, which is rare in children).

VAERS is a passive surveillance system for clinical events that occur following immunization. Manufacturers, health care professionals, state health coordinators, and parents of vaccinated children can submit VAERS reports. There are several limitations to VAERS, however. First, it receives only information regarding vaccinated individuals who have generally severe adverse events. Also, underreporting is a big problem and results from incomplete reports, lack of consistent diagnostic criteria, simultaneous administration of multiple vaccines, and reporting bias.²¹

Known adverse events to a specific vaccine can be found in the ACIP recommendations for that vaccine and the VIS, mentioned previously. Any potentially serious adverse event or side effect following administration of a vaccine should be reported. An isolated event alone may give little indication of causation without further research. Therefore, the report of any adverse event is important as a stimulus to studies attempting to prove causal relationships through epidemiologic research.

The VAERS system, despite its known weaknesses, has shown considerable success, as indicated by the adoption and then subsequent removal of the Rotavirus vaccine. The Rotavirus vaccine was licensed in August 1998 and recommended for the routine vaccination of healthy infants. In July 1999, use of the vaccine was suspended following reports to the VAERS of intussusception in several infants who had recently received the vaccine. Then, in October 1999, the ACIP withdrew its recommendation and the rotavirus vaccine was withdrawn from the market.²¹

The National Vaccine Injury Compensation Program is a no-fault system in which persons thought to have experienced an injury as the result of a vaccine may seek

compensation. Each matter involving a covered vaccine is adjudicated through the federal program before civil litigation may take place. This program is meant to protect clients, as well as to ensure a stable source of vaccine availability.

Concerns Related to Safety and Long-Term Health Problems

“To the modern parent and increasingly to health providers, the relative likelihood of having personal experience with an adverse event (real or coincidental) now exceeds that of having an experience with the disease.”²³ In recent years, a large number of providers and public health professionals have recognized that concerns related to the safety of vaccines are becoming increasingly common.^{24,25} Marshall and Gellin²⁶ conducted a survey of pediatricians and family physicians and reported that the overwhelming majority had families in their practice that refused one or more of the recommended vaccines out of concern for safety of the vaccine.

The public expects a high level of safety for vaccines because they are given to healthy persons to prevent disease. Thus, tolerance of adverse reactions resulting from products given to healthy infants and children is lower than that for products administered to persons who are ill.¹⁹ Furthermore, concerns regarding adverse events can lead to a loss of public confidence in immunization²¹ and the potential to refuse immunization. Some of the main safety concerns are summarized in Table 3.

Chronic illnesses recently linked with vaccinations include asthma, autism, diabetes, and multiple sclerosis. Known attributable risks include febrile seizures (DT, DTap, DTP, and MMR), hypotonic–hyporesponsive episodes (DT, DTap, and DTP), anaphylaxis (hepatitis B and MMR), and vaccine-associate paralysis (OPV).²⁸ Complications caused by vaccine components, including adjuvants, preservatives or contaminants, have also been described as problematic. Aluminum is added to some vaccines for diphtheria, tetanus, hepatitis A, and hepatitis B. Aluminum has been associated with macrophagic myofascitis, arthromyalgias, and chronic fatigue as well as demyelinating central nervous system disorders.²⁹

Thimerosal is a mercury-based preservative previously used in hepatitis B vaccines, some DTap, all DTP, and some Hib vaccines. Although it had been a vaccine component for decades, it was removed in 2000 due to concerns of mercury toxicity. Depending on the particular vaccine formulation and schedule, an infant might have received a cumulative mercury dose as high as 187.5 micrograms during the first six months of life; exceeding the maximum dose recommended by guidelines of methyl mercury intake.²⁹ It should be noted, however, according

Table 3. Examples of Safety Concerns Related to Immunization

Vaccine	Safety Concern
MMR	Autism
MMR	Inflammatory Bowel Disease
Hepatitis B	Autoimmune diseases, multiple sclerosis; rheumatoid arthritis
Hib	Diabetes
Multiple vaccines containing thimerosal	Autism
DTP/DTaP	SIDS
Pertussis	Acute encephalopathy
Simultaneous administration/combined vaccinations	Overwhelming the immune system
Rotavirus	Intussusception
Influenza	Guillain-Barré
Oral Polio	Paralysis

Sources:^{20,23,27}

to a recent report by the Institute of Medicine,¹⁴ no studies have established a causal link between vaccines and these diseases.

Conclusion

Vaccination is a powerful and dynamic tool. Vaccination programs and immunization schedules have undergone constant evaluation and significant changes in the past and will no doubt continue to do so in the future. Nurses and other health care providers who regularly administer vaccines should be knowledgeable about how to provide clients with the most effective, necessary, and safest vaccinations.

The CDC, through its publications and its website (www.cdc.gov), provides the latest recommendations, warnings, and news about vaccines and their use. The AAP periodically updates its publication, *The Red Book*, which is an outstanding resource for providers seeking specific information on immunizations and their administration. Finally, physiology and pharmacology textbooks can help renew basic knowledge of immunity and available immunization products. Keeping a fresh and dynamic attitude toward vaccine use will enable the nurse to make sound judgments and to provide excellent care.

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Continuing Education Questions

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Objectives: At the end of this article the reader will be able to: 1) Discuss the scientific basis for communicable diseases. 2) Describe the linkage between effective immunizations and decreased morbidity from infectious agents. 3) Analyze the role of the nurse in immunization administration and the impact on health outcomes. 4) Outline the recommended schedule for pediatric immunizations.

Article: The Basics of Pediatric Immunizations

1. The disease eradicated by the use of immunizations is
 - A. diphtheria
 - B. measles
 - C. polio
2. An example of indirect transmission of an infectious disease is
 - A. handling dollar bills
 - B. receiving a mosquito bite
 - C. sneezing on another person
3. A strategy for eliminating a pathogen causing an infectious disease is
 - A. quarantine of infected individuals
 - B. spraying for mosquitoes
 - C. using disinfectants on surfaces
4. Innate immunity occurs when an individual is
 - A. born with resistance to a microorganism
 - B. direct exposure to a microorganism
 - C. received maternal antibody during fetal life
5. Passive immunity occurs when an individual is
 - A. born with resistance to a microorganism
 - B. direct exposure to a microorganism
 - C. received maternal antibody during fetal life
6. Protecting non-immunized persons by vaccinating a significant number of the population is known as
 - A. acquired immunity
 - B. herd immunity
 - C. passive immunity
7. The type of vaccine that requires additional doses is
 - A. immune globulin
 - B. killed
 - C. live attenuated
8. An example of a vaccine made from viral fragments or subunits is the
 - A. hepatitis B vaccine
 - B. mumps vaccine
 - C. rubella vaccine
9. The type of vaccine that confers lifelong immunity is
 - A. attenuated live
 - B. killed virus
 - C. toxoid
10. The protection or immunity provided by immune globulin solutions lasts for
 - A. 0-6 weeks
 - B. 7-12 weeks
 - C. 13-18 weeks
11. Passive immunity that is produced from lymphocyte clones is
 - A. antitoxins
 - B. immune globulins
 - C. monoclonal antibodies
12. The type of antibody solution produced from horse serum is
 - A. antitoxin
 - B. immune globulin
 - C. monoclonal antibody
13. The total number of vaccines received by children at two years of age in the early 1950s is
 - A. 3
 - B. 4
 - C. 5
14. Routine use of the smallpox vaccine in children was discontinued in the
 - A. 1960s
 - B. 1970s
 - C. 1980s
15. The vaccine that should be avoided by individuals allergic to eggs is the
 - A. diphtheria
 - B. measles
 - C. pneumococcus

16. Older adults should avoid caring for infants recently vaccinated with
 - A. measles
 - B. rubella
 - C. varicella
17. The number of shots in a single visit received by children being vaccinated in 2003 is
 - A. 3
 - B. 4
 - C. 5
18. According to the National Childhood Vaccine Injury Act of 1986, informed consent is
 - A. not required
 - B. recommended
 - C. required
19. When documenting vaccination of a child, parent signature in the permanent medical record is
 - A. customary
 - B. not required
 - C. required
20. The type of vaccine that can be damaged by increased temperatures is
 - A. bacterial
 - B. killed virus
 - C. live attenuated
21. The United States vaccine schedule is revised every
 - A. 12 months
 - B. 18 months
 - C. 24 months
22. For a dose of a series vaccine to be considered valid, the dose must be given within how many days of the minimum recommended interval
 - A. 4 days
 - B. 1 week
 - C. 2 weeks
23. The immune response to a live virus vaccine can be impaired if a second live virus vaccine is given within
 - A. 15 days
 - B. 30 days
 - C. 45 days
24. The optimal time for initiating hepatitis B vaccination in low birth weight infants is
 - A. according to chronological age
 - B. corrected for gestation age
 - C. has not been determined
25. A scheduled vaccination should be delayed in the child who presents with a/an
 - A. cold
 - B. high fever
 - C. otitis media
26. The effect of breastfeeding on an infant's immune response to a vaccine is that it
 - A. decreases the response
 - B. enhances the response
 - C. has no effect on the response
27. The drug of choice in the treatment of severe allergic reaction to a vaccination is
 - A. antihistamine
 - B. dexamethasone
 - C. epinephrine
28. The vaccine that was removed from use by the Vaccine Adverse Effects Reporting System (VAERS) is
 - A. measles
 - B. pneumococcus
 - C. rotavirus
29. According to the National Vaccine Injury Compensation Program, the responsible party for a vaccine associated injury is
 - A. drug manufacturer
 - B. healthcare provider
 - C. no one or no fault
30. The preservative removed from infant vaccines in 2000 is
 - A. aluminum
 - B. lead
 - C. mercury