

The Infection Control Forum

Current Infection Control Insights from The Richmond Institute

Volume VI, Issue II
\$10

Abstract

In 2008 there has been an alarming increase in confirmed cases of measles in the USA. Although a safe and effective vaccine can prevent measles, many individuals do not receive recommended vaccinations. This issue of the Forum will discuss vaccines, vaccine-preventable diseases and the importance of compliance with current vaccine recommendations.

Learning Objectives

- Become familiar with diseases that are vaccine-preventable.
- Understand what would happen if vaccination was discontinued.
- Learn the different kinds of vaccines and how they work.
- Know which vaccines are recommended for HCWs.

Editor

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Vaccines & Vaccinations

A Review for Dental Practitioners

By Louis G. DePaola, DDS, MS

The impact of infectious disease has been dramatically reduced in modern society by the development of effective antimicrobial drugs and safe and efficacious vaccines. Prior to these medical breakthroughs, millions died from tuberculosis, syphilis, pneumonia and diphtheria. The dawn of the “Age of Antibiotics” began in 1928 with the discovery of penicillin. This remarkable new drug, followed by the production of subsequent antibiotics, afforded clinicians the ability to treat bacterial infections such as *Staphylococcus*

and *Streptococcus* that had been widely fatal. Other important prevention practices were also being developed such as improvements in sanitation, housing, and nutrition. The most effective strategy to prevent a disease would be to make a population immune to that disease. It was observed that infection and recovery from some diseases conferred immunity of the individual for a long period of time. While beneficial in the long run, this natural, active immunity had serious drawbacks including the possibility of death from the infecting agent. Perhaps immunity could be triggered by the introduction of an agent that closely mimics a naturally occurring infectious organism. Vaccines are designed to do exactly that.¹⁻⁴

Upon administration, an effective vaccine produces an immune response (immunologic memory) similar to that produced by the natural infection. Because the vaccine is non-infectious this artificial, active immunity is stimulated without development of the disease and potential adverse sequelae.¹⁻⁴ Over time, the morbidity and mortality rates of smallpox, polio, measles, diphtheria, meningitis, tetanus, hepatitis A & B and many other diseases for which effective vaccines have been developed have decreased.¹⁻⁴ This issue of the Forum will discuss vaccines, vaccine-preventable diseases and the importance of compliance with current vaccine recommendations.

Vaccine-Preventable Diseases

Vaccines have the remarkable power to prevent and even to eradicate disease. The list of vaccine-preventable diseases is presented in Table 1 and includes hepatitis A, hepatitis B, diphtheria, tetanus, pertussis, *Haemophilus influenzae* type B (Hib), polio, measles, mumps, rubella, meningococcal disease, pneumococcal disease, influenza, rotavirus, human papillomavirus, varicella, and herpes zoster.¹⁻⁵ In the United States, seventeen vaccines are recommended by the Centers for Disease Control and Prevention (CDC) in collaboration with numerous public health organizations.

However, despite the availability of safe and efficacious vaccines, many in the U.S. will not or cannot receive one or more of them.¹⁻⁵ There are multiple reasons for this lack of compliance. Some do not have access to and/or financial resources for preventive healthcare. Others have fears of receiving an injection or potential side effects, which are often grossly exaggerated. Still others simply do not feel that they are at risk for developing a disease. Consequently, 42,000 adults and 308 children die each year in the U.S. from vaccine-preventable diseases and/or their complications.⁵

In addition to their potential to save lives, vaccines are extraordinarily cost-effective. The CDC evaluated seven

vaccines routinely given to children: DTaP (diphtheria, tetanus, acellular pertussis), Td (Tetanus, diphtheria), Hib, polio, MMR (measles, mumps, rubella), hepatitis B, and varicella (chickenpox).⁵ The data suggested that childhood administration of these seven vaccines has prevented over 33,500 deaths and 14 million cases of disease over the lifetime of children born each year.⁵ The economic impact of these seven vaccines was staggering; the annual cost savings was \$10 billion in direct medical costs and over \$40 billion in indirect societal costs.⁵

On a global scale, access to medical care is very often difficult or non-existent. The World Health Organization (WHO) along with other groups has instituted a global immunization program with the goal of providing routine vaccination in all developing countries against measles, polio, diphtheria, tetanus, pertussis, and tuberculosis.⁶ Immunization against hepatitis B and Hib are recommended and yellow fever vaccine is offered in about two-thirds of nations at risk for outbreaks.⁶ The WHO estimates that in 2002, over 2 million lives were saved worldwide as a result of vaccination.⁶ However, that same year an estimated 2.1 million people died from vaccine-preventable diseases, including 1.4 million children under the age of five.⁵ Over 500,000 of these children died from measles, ~400,000 from Hib, ~300,000 from pertussis and ~180,000 from neonatal tetanus.⁶ Prevention of these diseases is much easier and cheaper than the treatment of them. Vaccination has proven very successful in preventing disease and therefore a very cost-effective means of improving global healthcare.

What Would Happen If We Stopped Vaccinations?

There are people who strongly oppose vaccinations for numerous reasons. Suppose they got their way. If vaccinations were stopped in the U.S., what would happen? At the present time, vaccine-preventable diseases are at very low levels and some have been eliminated. However, natural, infective agents remain endemic in many areas. If a sufficient number of people became susceptible because vaccine-induced immunity was curtailed, the morbidity and mortality rates of these diseases, could return to pre-vaccination levels. For example, polio has been virtually eliminated in the U.S. but if vaccination were to stop, people would once again be susceptible. Annual polio epidemics could return and infect thousands. Cases may reach or exceed pre-vaccine levels of 3,000 to 20,000 cases of paralytic polio each year. There almost certainly would be a resurgence of measles, which almost everyone in the U.S. got between 1953 and 1963. Up to 20 percent of those infected in this decade were hospitalized and there was an average of 450 deaths each year.⁷ Complications such as ear infections, pneumonia and diarrhea were frequent and severe. As many as three out of every 1,000 persons with measles died. Since the introduction of the measles vaccination there has been a greater than 99% reduction in cases of measles.⁷ Prior to the availability of immunization, there were between 150,000 and 260,000 cases of pertussis reported each year resulting in over 9,000 deaths.⁷ While usually mild in children and adults, rubella has devastating effects on the developing fetus and as many as 90% of infants born to mothers infected during their first trimester will develop congenital rubella syndrome (CRS).⁷ During the 1964-1965 epidemic of rubella, prior to rubella vaccination, almost 20,000 infants were

born with CRS—11,000 with deafness, 3,580 with blindness and 1,800 with mental retardation. An additional 2,100 neonatal deaths and 11,250 miscarriages also resulted.⁷ Diphtheria, fatal in 5-10% of cases, killed 15,520 people in 1921.⁷ When a vaccine was introduced in 1923, new cases fell dramatically and in 2001 only two cases were reported in the entire country.⁷ The organism that causes tetanus, *Clostridium tetani*, is widespread in the environment, and can only be prevented by immunization. If vaccination against tetanus were stopped, people of all ages would be susceptible.⁷ These are just a few examples of the importance of vaccines to the physical and economic health of our society.

How Do Vaccines Work?

The immune system is a complex network of cells and organs. When a substance or molecule or a microorganism, known as an antigen, is recognized as foreign, the immune system responds through various specialized cells by developing an immunoglobulin, known as an antibody, which attaches to and destroys or inactivates that antigen.^{2,4,7-8} Immunity to a disease is achieved through the presence of specific antibodies to that disease.

Immunity may be induced actively or passively. Active immunity results naturally when exposure to a disease organism triggers the immune system to produce antibodies to that disease. It may also be induced by the exposure of the immune system to a killed or weakened form of the disease organism through vaccination (vaccine-induced immunity).^{2,4,7-9} Both result in the recognition of the disease, production of antibodies that will prevent infection, and immunity, which is sometimes life-long. Passive immunity results when a person is given antibodies to a disease rather than production of them through his or her own immune system. A common example of passive immunity is when a newborn baby acquires antibodies from its mother through the placenta. However, unlike active immunity, passive immunity lasts only for only a short time, usually a few weeks or months.^{2,4,7-9}

Types of Vaccines

There are currently several different types of vaccines which induce immunity by different mechanisms. Table 2 is a list of the types of vaccines and the diseases that they prevent.²⁻⁶ Live vaccines contain a version of the living organism that has been weakened in the lab by a process called attenuation.²⁻⁶ These vaccines closely mimic the natural infection and elicit strong immune system response, often conferring lifelong immunity with only one or two doses. The downside to live, attenuated vaccines is that under certain conditions the attenuated microorganism could revert to a virulent form and cause disease.²⁻⁶ Therefore, these vaccines are generally not recommended in immunocompromised patients and pregnant women. Because they contain living organisms, attenuated vaccines usually need to be refrigerated to remain viable which limits their shelf and transportation life.²⁻⁶

Inactivated or “killed” vaccines are produced by killing the infectious organisms with chemicals, heat or radiation which eliminates the problem of infectivity.²⁻⁶ In addition to being safer, they are also much more stable, do not require refrigeration, and

can be easily transported long distances without losing their potency. However, they are much less effective in producing a sustained immune response and require booster doses, sometimes multiple, to maintain immunity.²⁻⁶

When dealing with certain bacteria that produce toxins, toxoid vaccines are utilized.²⁻⁶ The toxins are inactivated by treatment with formalin creating toxoids, or “detoxified toxins.” These vaccines cause the immune system to produce antibodies that lock on to and block the toxin, neutralizing the effect of the infection.²⁻⁶

A subunit vaccine uses just a portion of the organism— (the antigen(s)) that best stimulates the immune response.²⁻⁶ Because subunit vaccines contain only the essential antigens and not all the other molecules that make up the microbe, the chances of adverse reactions to the vaccine are lower.²⁻⁶

Some organisms produce an outer coating of polysaccharide which effectively disguises a bacterium’s antigens so that the immature immune systems of infants and younger children cannot recognize or respond to them.²⁻⁶ Conjugate vaccines link antigens or toxoids from a microbe to the polysaccharide so an immature immune system will react to polysaccharide coatings and defend against the disease-causing bacterium.

As technology advances new techniques for developing vaccines are being sought.²⁻⁶ Examples include DNA vaccines, which use genes from an organism to create an immune system response, and recombinant vector vaccines, which utilize an attenuated virus or bacterium to introduce microbial DNA into cells of the body. Inserting this genetic material may cause an organism to display the antigens of other microbes on its surface, provoking an immune response.²⁻⁶ With the threats of emerging diseases such as avian influenza and bioterrorism, the quest for better, safer and easier-to-produce vaccines has never been so important.

Vaccine-Preventable Adult Diseases

The CDC has published the Recommended Adult Immunization Schedules-United States, for October 2007-September 2008, which can be downloaded in its entirety at <http://www.cdc.gov/mmwr/pdf/wk/mm5641-Immunization.pdf>. Links to child and adolescent vaccination schedules can also be found at that site. Everyone should be familiar with the CDC vaccine recommendations. Review the document thoroughly and see if you are at risk for any of the vaccine preventable diseases and are in need of vaccination and/or a booster of previous vaccination. The CDC recommends adult immunizations for the following: tetanus, diphtheria, and acellular pertussis (Td/Tdap); human papillomavirus (HPV); measles, mumps, rubella (MMR); varicella; influenza; pneumococcal polysaccharide; hepatitis A; hepatitis B; meningococcal; herpes zoster.¹⁻²

Some vaccines are age specific or have other limitations. For example pneumococcal polysaccharide is indicated for adults 65 and older and HPV vaccination, at this time, is approved only for women. The 2008 recommendations stress the importance of five vaccinations for Health Care Workers (HCWs): influenza, hepatitis B, MMR, Td/Tdap, and varicella.¹⁻²

As a dental HCW, review the recommendations for vaccination of HCWs and make certain you are adequately protected. The delivery of dental care compels the clinician to come in very close contact to patients who may be infectious for many diseases, but adequate immunization can take away the worry of being close. **The decision for an individual to receive a vaccination should be determined by the current recommended guidelines in conjunction with evaluation and/or consultation with a licensed physician.**

Safety of Vaccines

Vaccines have achieved a remarkable safety record, yet many people still question the evidence. Information regarding vaccine safety published by the CDC can be downloaded at <http://www.cdc.gov/Features/VaccineSafety/>. Clinicians should rely on the overwhelming evidence regarding vaccine safety and depend on organizations such as the CDC, FDA and WHO for accurate reporting of the facts. As always, individuals should consult with their physician if they have any questions about the safety of a vaccine or a medical condition that may contraindicate receiving a vaccination.

Conclusions

1. Vaccines are one of the greatest success stories in public health.
2. Vaccines have a remarkable record of safety and efficacy.
3. All HCWs should review the list of recommended vaccinations and correct any immunization deficiencies.
4. Consult your physician if you have any questions regarding vaccine safety or medical condition(s) that may contraindicate receiving a vaccine.

Table 1

Vaccine-Preventable Diseases²⁻³

<ul style="list-style-type: none"> • Anthrax • Cervical Cancer • Diphtheria • Hepatitis A • Hepatitis B • <i>Haemophiles influenzae</i> type b (Hib) • Human Papillomavirus (HPV) • Influenza • Japanese Encephalitis (JE) • Lyme Disease* • Measles • Meningococcal disease • Monkeypox 	<ul style="list-style-type: none"> • Mumps • Pertussis (Whooping Cough) • Pneumococcal disease • Poliomyelitis (Polio) • Rotavirus • Rubella (German Measles) • Herpes Zoster (Shingles) • Smallpox • Tetanus (Lockjaw) • Tuberculosis** • Typhoid Fever • Varicella (Chickenpox) • Yellow Fever
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* Withdrawn from market ** BCG-not recommended in USA

Table 2**Vaccine Types and Diseases They Protect Against[†]**

VACCINE TYPE	DISEASE	ADVANTAGES	DISADVANTAGES
Live, attenuated	Measles, mumps, rubella, polio (Sabin vaccine), yellow fever	<ul style="list-style-type: none"> • Produce a strong immune response • Often give lifelong immunity with one or two doses 	<ul style="list-style-type: none"> • Remote possibility that the live microbe could mutate back to a virulent form • Must be refrigerated to stay potent
Inactivated or “Killed”	Cholera, influenza, hepatitis A, Japanese encephalitis, polio (Salk vaccine), rabies	<ul style="list-style-type: none"> • Safer and more stable than live vaccines • Don’t require refrigeration • More easily stored, transported 	<ul style="list-style-type: none"> • Produce a weaker immune response than live vaccines • Usually require additional doses
Toxoid	Tetanus, diphtheria	<ul style="list-style-type: none"> • Teaches the immune system to fight off bacterial toxins 	
Subunit	Hepatitis B, pertussis, pneumonia caused by <i>S. pneumoniae</i>	<ul style="list-style-type: none"> • Targeted to very specific parts of the microbe • Fewer antigens, so lower chance of adverse reactions 	<ul style="list-style-type: none"> • When developing a new vaccine, identifying the best antigens can be difficult and time consuming
Conjugate	<i>H.influenzae</i> type B, pneumonia caused by <i>S. pneumoniae</i>	<ul style="list-style-type: none"> • Allow infant immune systems to recognize certain bacteria 	
DNA	In clinical testing	<ul style="list-style-type: none"> • Produce a strong antibody and cellular immune response • Relatively easy and inexpensive to produce 	<ul style="list-style-type: none"> • Still in experimental stages
Recombinant vector	In clinical testing	<ul style="list-style-type: none"> • Closely mimic a natural infection, stimulating a strong immune response 	<ul style="list-style-type: none"> • Still in experimental stages

* The decision to receive a vaccination should be determined by the current recommended guidelines in conjunction with evaluation and/or consultation with a licensed physician.

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CE Questions

Vaccines & Vaccinations

A Review for Dental Practitioners

Test Instructions- Please fill in the bubble corresponding to the answer you believe to be correct for each question. Mail or fax completed tests to the Richmond Institute to receive CE Credit.

- Which of the following is not a vaccine preventable disease?
 - Hepatitis A
 - Hepatitis B
 - Measles
 - HIV/AIDS
 - Rubella
- Failure to receive recommended vaccinations results in the death of how many Americans each year from vaccine preventable diseases?
 - > 42,000
 - > 10,000
 - 100 - 500
 - 1.2 million
 - There are no deaths from vaccine preventable diseases in the USA
- If vaccination against vaccine preventable diseases was to be discontinued which of the following might happen?
 - Measles would probably increase
 - More people would develop tetanus
 - Cases of diphtheria would increase
 - All of the above
 - None of the above
- Active natural immunity is preferable to vaccine-induced immunity?
 - True
 - False
- Which of the following occurs when a person is given antibodies to a disease rather than producing them through his or her own immune system?
 - Passive immunity
 - Active natural immunity
 - Vaccine-induced immunity
 - All of the above
 - None of the above
- Which of the following vaccines is most likely to confer long term immunity without booster shots?
 - Subunit
 - Toxoid
 - Inactivated or "killed"
 - Live, attenuated
 - None of the above
- Which of the following are benefits of inactivated (killed) vaccines?
 - No risk of infection
 - More stable
 - Do not need refrigeration
 - Easily transported
 - All of the above
- Which of the following diseases would be prevented with a toxoid vaccine?
 - Hepatitis B
 - Rubella
 - Polio
 - Tetanus
 - Rabies
- Which of the following diseases would be prevented with a subunit vaccine?
 - Hepatitis B
 - Rubella
 - Polio
 - Tetanus
 - Rabies
- The 2008 recommendations stress the importance of which vaccinations in HCWS?
 - Influenza
 - Hepatitis B
 - Measles, mumps, rubella (MMR)
 - Tetanus, diphtheria, acellular pertussis (Td/Tdap)
 - All of the above

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Vaccines & Vaccination By Louis G. DePaola, DDS, MS

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