

Immunizations Update — 2008

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Goals

1. To provide the pharmacist with new information regarding vaccines for prevention of tetanus, diphtheria and pertussis [Tdap/DTaP]
2. To provide the pharmacist with an overview of use, safety and efficacy of three recently marketed vaccines for adolescents and adults, specifically, meningococcal, HPV and herpes zoster vaccines

Learning Objectives

Pharmacists and Pharmacy Technicians:

After completing the article, the pharmacist should be able to:

1. Describe the actions and side-effects of each vaccine
2. List the disease targeted for prevention for each vaccine
3. Discuss the recommended dosing regimens and administration guidelines for each vaccine
4. Describe the contraindications and precautions of each vaccine
5. Discuss the Center for Disease Control's [CDC] Advisory Committee for Immunization Practice [ACIP] recommendations for each vaccine

Introduction

Why do we immunize? Many viral and bacterial diseases can be prevented by immunization at an early age. They prevent personal disease as well as protect others, such as the unborn and immune

compromised individuals. Immunizations in the 20th century have greatly reduced the incidence and/or completely eradicated many diseases, such as smallpox and rubella, by mass immunization programs.

Table 1
Impact of Vaccines in the 20th Century

| Disease | 20 th Century Annual | Year Vaccine Introduced | 2006 Case Total | % Decrease |
|----------------------------------------|---------------------------------|----------------------------------------|-----------------|------------|
| Smallpox | 29,005 | 1798 | 0 | 100 |
| Pertussis | 200,752 | 1914-1941-whole cell 1991-acellular | 15,632 | 92.2 |
| Diphtheria | 21,053 | 1923-1943 | 0 | 100 |
| Tetanus | 580 | 1933-1949 | 41 | 92.9 |
| Mumps | 162,344 | 1940s, 1967 | 6584 | 95.9 |
| Poliomyelitis, acute | 19,794 | 1955 1961-1963 1987 | 0 | 100 |
| Poliomyelitis, paralytic | 16,316 | 1955 1961-1963 1987 | 0 | 100 |
| Measles | 503,217 | 1963 | 55 | 99.9 |
| Rubella | 47,745 | 1969 | 11 | 99.9 |
| Congenital rubella | 152 | 1969 | 1 | 99.3 |
| Hepatitis B, acute | 66,232 | 1981, 1986 | 4713 | 80.1 |
| Haemophilus influenza, type b invasive | 20,000 | 1985, 1987, 1990 | 208 | 99.8 |
| Varicella | 4,085,120 | 1995 | 612,768 | 85 |
| Hepatitis A | 117,333 | 1995 | 3579 | 87 |
| Pneumococcal, invasive | 63,067 | 2000 | 41,550 | 34.1 |

There are many different types of vaccines. Live attenuated vaccines derived from the “wild” virus or bacteria work by mimicking the natural infection without causing serious disease. These vaccines are usually effective with a single dose. Inactivated vaccines require multiple doses to stimulate an immune response to the antigenic components of the virus or bacteria.

In the 1950s, there were only vaccines for diphtheria, tetanus, pertussis, polio and smallpox. Many factors have influenced the routine schedule since then. These changes include discovery of new vaccines, changes in disease epidemiology, such as the resurgence of measles in the late 1980s, and concerns about vaccine safety as with the oral polio

vaccine, where the incidence of vaccine-related paralysis became more common than naturally occurring disease as the incidence of polio decreased.

Even in the 21st century, and as recently as the last decade, several new vaccines have been approved by the FDA to help prevent several important infectious diseases. Each year the Advisory Committee for Immunization Practices (ACIP) and the FDA release guidelines and recommendations for the use of new vaccines. In the last few years the ACIP has made recommendations for several new vaccines developed for adolescents and adults. Among the new vaccines are those for pertussis, meningococcal disease, human papilloma virus and

herpes zoster. This article will provide the pharmacist with an overview of the use, safety and efficacy of these four vaccines.

Pertussis

Since the 1980s, the incidence of pertussis, or whooping cough, among adolescents and adults has increased. *Bordatella pertussis*, a Gram-negative coccobacillus, is a mucosal pathogen spread by respiratory droplets. Pertussis infection is characterized by three phases: catarrhal, paroxysmal and convalescent. The catarrhal phase starts with an intermittent cough lasting one to two weeks. This is followed by the paroxysmal phase, which usually lasts four to six weeks. This phase encompasses the classic symptoms of whooping cough infection including a spasmodic cough, usually preceded by an inspiratory whoop, and post-tussive vomiting. Finally, the convalescent phase can last anywhere from weeks to months. Consequences of whooping cough include pneumonia, rib fractures, loss of consciousness and hospitalizations. While most adolescents and adults receive a booster shot for tetanus and diphtheria every ten years, no booster for pertussis has been available until recently.

Immunity to pertussis decreases five to ten years after childhood immunization and two to five years after natural infection. Waning immunity and increased incidence led to the 2005 release of two pertussis boosters. Adacel® is licensed for persons 11-64 years old, while Boostrix® is only indicated for adolescents 10-18 years old. Both vaccines have comparable antibody response. The adult and adolescent boosters are referred to as Tdap, while the childhood vaccine is referred to as DTaP. The lowercase letters “d” and “p” in Tdap symbolize that there are reduced quantities of diphtheria and pertussis compared to the childhood vaccine. The “a” refers to the fact that the pertussis component is acellular. This nomenclature has created confusion resulting in people receiving the wrong vaccine. If the childhood vaccine (DTaP) is administered mistakenly to an adult, it should count as a dose. However, if the booster dose (Tdap) is administered to a child, the child will need to be re-vaccinated with the childhood vaccine. Both Adacel® and Boostrix® are IM injections and can be co-administered with other vaccines. They are also safe to use in immunocompromised patients, contain no thimerosal (a preservative that can cause allergic reactions in some people) and are latex-free.

Table 2
ACIP guidelines regarding pertussis booster (Tdap)

| |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. Adolescents (11-12 years old) should receive a single Tdap dose in place of a Td booster if they have completed the childhood series and have not received Td or Tdap. |
| 2. Adults (19-64 years old) should receive Tdap in place of one Td booster if last booster was ≥10 years ago. |
| 3. Women should receive Tdap before becoming pregnant or immediately post-partum. |
| 4. Healthcare providers with direct patient contact should receive a single dose as soon as feasible. |

A period of two years or more between a patient’s last Td booster and administration of the Tdap vaccine is considered safe. Contraindications to Tdap include history of a serious allergic reaction to any vaccine component or history of encephalopathy, without an identifiable cause, within seven days of receiving the vaccine. Precaution should be taken in administering the vaccine to individuals with a history of Guillain-Barré syndrome within six weeks after a previous tetanus vaccination or with a history of Arthus-type reaction or extensive limb swelling with previous diphtheria or tetanus vaccination. Common side

effects of the vaccine include injection site pain, headache, fatigue, sore or swollen joints and fever.

Meningococcal disease

Neisseria meningitidis is a mucosal pathogen responsible for 1,400-2,800 cases of meningococcal disease in the U.S. each year. Of those infected, 10-14% will die. Complications of the infection include severe neurological disability, limb loss, hearing loss and bacteremia. Risk factors for meningococcal infection include active or passive smoking, recent respiratory illness, corticosteroid use, Medicaid insurance and household crowding. Populations at

risk for the disease include college freshmen in dorms, microbiologists exposed to *N. meningitides*, military recruits, persons who travel to the “meningitis belt” of sub-Saharan Africa, persons with complement deficiencies and persons with anatomic or functional asplenia. The incidence of meningococcal infection is highest among children less than one year of age and in adolescents between the ages of 12-18. There are 13 different forms of the pathogen, referred to as serogroups. The serogroups differ by the polysaccharide structure that surrounds the bacteria. Currently licensed vaccines are only effective against serogroups A, C, Y & W-135. Serogroup A causes most of the epidemics. Serogroups C, Y & W-135 are responsible for 75% of the infections in persons 11 years of age or older. Serogroup B is responsible for 50% of the infections in infants less than one year of age. Despite the high prevalence of Serogroup B infection in infants, it is not included as a component in vaccines because it elicits a poor immune response when given to humans in a vaccine.

Menomune® is one of the available vaccines against meningococcal infection. It is a

polysaccharide vaccine that has been available since 1981. Unfortunately, the polysaccharide component of the bacteria included in the vaccine elicited a poor T-cell response and antibody levels in immunized persons waned between three to five years post-vaccination. Research to develop a new vaccine that would provide longer lasting immunity finally came to fruition in 2005 with Menactra®. Menactra® provides comparable immunological efficacy to Menomune®, but by pairing the polysaccharide component with the diphtheria toxoid a stronger T-cell response is initiated by the immune system.

In a randomized, controlled trial of adolescents between the ages of 11-18 comparing the immune response between Menactra® and Menomune®, there was no difference in immune response. Table 3 shows the percentage of subjects that sustained a greater than four-fold increase in their titer from baseline 28 days post-vaccination. This was the criterion used by the FDA when it approved Menomune®. There was no statistically significant difference between the groups.

Table 3
Menactra® vs. Menomune® adolescent subject’s response

| | % Ss with ≥ fourfold increase in titer response | |
|-----------|-------------------------------------------------|-----------|
| Serogroup | Menactra® | Menomune® |
| A | 92.7 | 92.4 |
| C | 91.7 | 88.7 |
| Y | 81.8 | 80.1 |
| W-135 | 96.7 | 95.3 |

A similar trial conducted in adults between the ages of 18-55 years showed similar results. As in the previous study, Table 4 shows the percent of subjects that sustained a greater than four-fold

increase in their titer from baseline 28 days post-vaccination. There was no statistically significant difference between the groups.

Table 4
Menactra® vs. Menomune® adult subject's response

| Serogroup | % Ss with \geq fourfold increase in titer response | |
|-----------|------------------------------------------------------|-----------|
| | Menactra® | Menomune® |
| A | 80.5 | 84.6 |
| C | 88.5 | 89.7 |
| Y | 73.5 | 79.4 |
| W-135 | 89.4 | 94.4 |

The duration of protection against meningococcal infection with Menactra® is unknown, but it is expected to be eight years or longer. In a randomized, blinded, multicenter trial of adolescents between the ages of 11-18 years, subjects vaccinated with Menomune® showed no protection against serogroups C and W-135 after three years. Additionally, the titer response was higher in the subjects vaccinated with Menactra®.

Further studies are needed to determine when and if booster doses of Menactra® will be needed.

Finally, some other differences exist between the vaccines. Menactra® is an IM injection, while Menomune® is given subcutaneously. Both can be administered with other vaccines. Local adverse reactions occur more frequently with Menactra®, but are similar to the types of reactions seen with the tetanus-diphtheria booster.

Table 5
ACIP guidelines regarding Menactra®

| |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. Adolescents 11-12 years old should receive Menactra® with other routine vaccinations or before entering high school. |
| 2. Populations at risk for the disease including college freshmen living in dorms, persons who travel to the “meningitis belt” of sub-Saharan Africa, persons with complement deficiencies and persons with anatomic or functional asplenia should be vaccinated. |
| 3. Children 2-10 years who are at increased risk for meningococcal disease including, travelers to or residents of countries in which meningococcal disease is hyper-endemic or epidemic, children who have terminal complement component deficiencies, and children who have anatomic or functional asplenia should be vaccinated. |
| 4. Routine vaccination in adults 55 years or older is not currently recommended. |

On October 19, 2007, FDA approval for Menactra® was expanded to include use in children between the ages of 2-10. This new indication was based on the results of a randomized, blinded, multicenter trial that showed a similar immune response between the two vaccines as indicated by titer response 28 days post-vaccination in this population¹⁵.

Contraindications to Menactra® include a history of a severe reaction to any vaccine component, including diphtheria toxoid or latex. It is recommended to defer vaccination in persons with moderate to severe illness. There are no data to support the use of Menactra® in pregnant women; however, Menomune® has been administered during pregnancy without any adverse events.

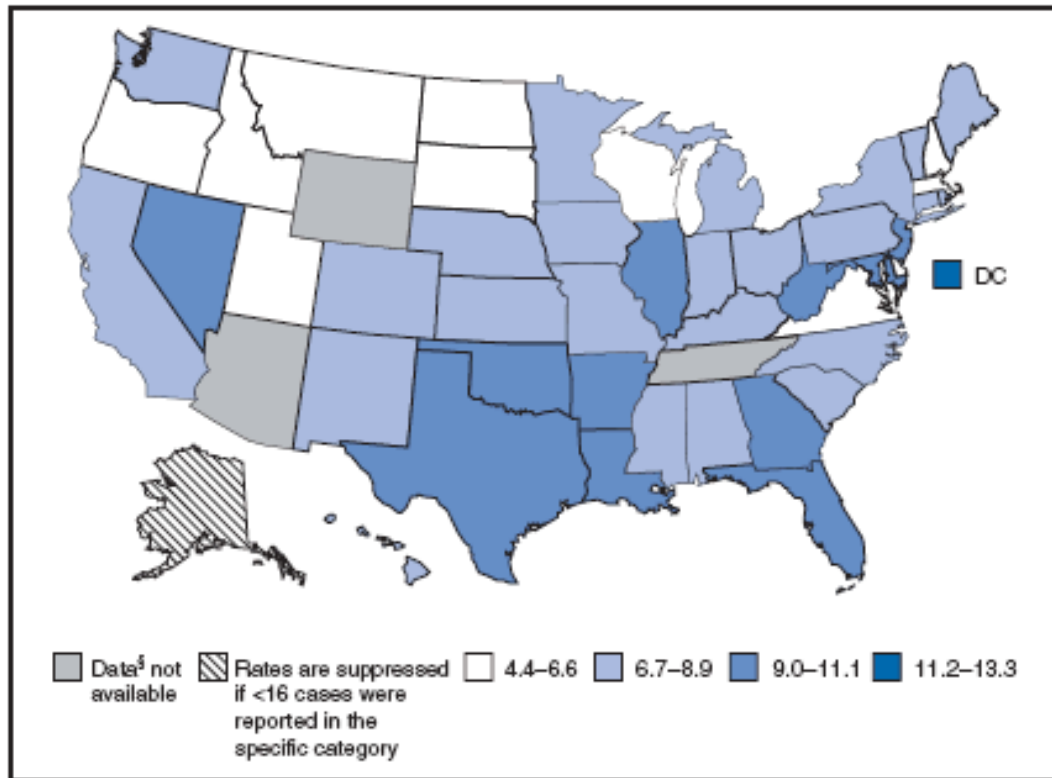
Human Papilloma Virus

Human papilloma virus (HPV) is the most common sexually transmitted infection in the U.S.

Approximately 6.2 million persons are newly infected each year. There are 82 different strains of

the virus. Low risk types, such as 6 and 11, are associated with low-grade cervical changes or genital warts, while some high risk types, such as 16 and 18, are associated with cervical and anogenital cancers.

Figure 1
Cervical cancer incidence, United States, 2003



Source: U.S. Cancer Statistics Working Group. United States cancer statistics: 2003 Incidence and mortality. Atlanta, GA: US Department of Health and Human Services, CDC, and National Cancer Institute; 2006. Available at <http://www.cdc.gov/uscs>.

* Invasive cancers only.

† Per 100,000 persons and age-adjusted to the 2000 U.S. standard population (19 age groups — Census P25-1130).

§ Data are from selected statewide and metropolitan area cancer registries that meet the data quality criteria for all invasive cancer sites combined. Incidence covers approximately 96% of the U.S. population.

HPV is a non-enveloped, double-stranded DNA virus that integrates itself into the host chromosome. Infected cells can result in epithelial lesions. Interestingly, 70-90% of infections clear within one to two years without any intervention. The biggest predictor of infection is the number of sexual partners a person has in his or her lifetime.

HPV is associated with the development of cervical cancer in women. There are different types of cervical cancer; 75% are squamous cell and 25%

are adenocarcinomas. HPV 16 and 18 account for 70% of the cases of squamous cell carcinoma and 80% of the cases of adenocarcinoma. HPV can also cause changes in the epithelial tissue, which do not always progress to cancer. Histological changes are classified as cervical intraepithelial neoplasias (CIN) and are graded one through three. Sixty percent of CIN 1 neoplasias clear spontaneously and rarely progress to cancer. On the other hand, only 35% of CIN 2 and 3 neoplasias clear

spontaneously and greater than 12% of these cases will progress to cancer if left untreated.

In 2006, a vaccine to protect against HPV was approved and marketed. Gardasil® is made from an HPV L1 capsid protein that is expressed in yeast cells. The proteins self-assemble into non-infectious virus-like particles that get adsorbed onto aluminum plates. Gardasil® is a quadrivalent vaccine containing HPV 6, 11, 16 and 18, those most likely to lead to cervical cancer. Gardasil® contains no thimerosal. The vaccine is licensed for females between 9 through 26 years of age. A series of three IM injections must be administered. The second injection is given two months after the first and the third injection is given six months after the first. If a dose is missed, the series does not need to be restarted. If the second dose is missed it should be given as soon as possible and the third dose given 12 weeks later. If the third dose is missed, it should be given as soon as possible.

Current ACIP guidelines recommend that all females between the ages of 11-12 years should be administered the vaccine. It can be co-administered with Tdap and Menactra®. Cervical screening is not required before administering the vaccine, but it is highly recommended.

Administration of the vaccine is associated with a high rate of syncope so patients should be monitored for at least 15 minutes following administration. The vaccine has not been studied for

use during pregnancy. It is recommended to defer vaccination during periods of acute illness.

Several trials have assessed efficacy of Gardasil®. A phase II, multicenter, randomized, double-blind, placebo-controlled trial studied immunogenicity and efficacy. A total of 1158 women from Brazil, Europe and the USA were included in the study. The study enrolled healthy women, with no history of abnormal Pap smears or history of low-grade squamous intraepithelial lesions (LSIL), and who had four or fewer lifetime sexual partners. Subjects were required to be HPV negative at baseline, meaning they showed no evidence of active infection. Prior infection with a strain of HPV that had cleared, however, was not a contraindication for inclusion in the study. The primary endpoint was persistent infection with HPV types 6, 11, 16 or 18 or evidence of cervical or genital disease at 36 months. At baseline, the subjects were between 13-24 years of age and 75% were Caucasian. The mean age at first sexual intercourse was 16. Forty percent of subjects had between 3-4 lifetime sexual partners. Sixty percent of subjects used oral contraceptives, while only 25% used condoms.

Results of the per-protocol analysis included subjects who received all three vaccinations as scheduled. As seen in Table 6, the vaccine group had a statistically significant lower incidence of infection with HPV and of disease-related HPV infection.

Table 6
Incidence of HPV infections and disease for vaccine vs. placebo, per protocol analysis

| N=468 | Vaccine: Incidence* | Placebo: Incidence* | Efficacy diff (95% CI) | p |
|------------|------------------------|------------------------|---------------------------|---------|
| Infections | 0.7 | 6.5 | 89 (70-97) | <0.0001 |
| Disease^ | 0 | 6 | 100 (16-100) | 0.0151 |

*Per 100 women-years at risk

^ Either neoplasias, genital warts or cancers

Results of the intention to treat analysis included subjects who received at least one or more of their vaccinations, but not necessarily all three. As shown

in Table 7, there was still a statistically lower incidence of infection and disease in the vaccine group.

Table 7**Incidence of HPV infections and disease for vaccine vs. placebo, intention to treat analysis**

| N=510 | Vaccine: Incidence* | Placebo: Incidence* | Efficacy diff (95% CI) | p |
|------------|------------------------|------------------------|---------------------------|---------|
| Infections | 0.8 | 7.1 | 88 (72-96) | <0.0001 |
| Disease^ | 0 | 1.4 | 100 (56-100) | 0.0009 |

The same phase II study group was used to test immunogenicity of the vaccine. The purpose was to compare response of HPV-naïve subjects to those with a prior history of infection. At baseline, 18.5% of subjects were seropositive, meaning that their sera showed they had been infected previously, mounted an immune response and then cleared the infection before enrollment. Seropositive subjects had titers 12-16 times higher than naïve subjects. These results indicate that the seropositive subjects had a “booster” response to the vaccine.

Finally, one of the major outcome trials was from the FUTURE II study group. FUTURE stands for Females United to Unilaterally Reduce Endocervical disease. This was a randomized, double-blind, placebo-controlled trial carried out in thirteen countries that enrolled 12,167 women. As

in the Phase II trial, this study enrolled healthy women, with no history of abnormal Pap smears or history of LSIL, and who had four or fewer lifetime sexual partners. Subjects were followed up at 48 months and the primary endpoint was the incidence of neoplasias caused by HPV 16 or 18. At baseline, the mean age was 20, 11% of subjects were HPV 16 seropositive and 4% were HPV 18 seropositive. Sixty-five percent of subjects were from Europe, 26% from Latin America, 7.5% from North America and 1.5% from Asia. The median number of lifetime sex partners was two. Results of the per-protocol analysis included subjects who received all three vaccinations as scheduled. As seen in Table 8, the vaccine group had a lower rate of CIN 2 and 3 and incidence of infection with HPV 16 and 18. Adenocarcinoma rates were too low to power significant results.

Table 8**Vaccine vs. placebo response comparison, per-protocol analysis**

| N=10,565 | Vaccine | | Placebo | | Efficacy (95% CI) |
|------------------------|---------|-------|---------|-------|----------------------|
| | Cases | Rate* | Cases | Rate* | |
| CIN 2 | 0 | 0 | 28 | 0.2 | 100 (86-100) |
| CIN 3 | 1 | <0.1 | 29 | 0.2 | 97 (79-100) |
| Adenocarcinoma in situ | 0 | 0 | 1 | <0.1 | 100 (<0-100) |
| HPV-16 | 1 | <0.1 | 35 | 0.3 | 97 (84-100) |
| HPV-18 | 0 | 0 | 11 | 0.1 | 100 (61-100) |

* Rate per 100 person-years at risk

Results of the intention to treat analysis included subjects who received at least one or more of their vaccinations, but not necessarily all three. There was still a lower incidence of infection and disease in the vaccine group (Table 9). However, these results indicated that the efficacy of the vaccine

waned dramatically when all three shots were not administered. These results underscore the need for patients to follow-up and obtain the entire vaccination series for full protective benefits against HPV and related infections.

Table 9
Vaccine vs. placebo response comparison, intention to treat analysis

| N=12,167 | Vaccine | | Placebo | | Efficacy (95% CI) |
|------------------------|---------|-------|---------|-------|----------------------|
| | Cases | Rate* | Cases | Rate* | |
| CIN 2 | 41 | 0.2 | 96 | 0.5 | 57 (38-71) |
| CIN 3 | 57 | 0.3 | 104 | 0.6 | 45 (23-61) |
| Adenocarcinoma in situ | 5 | <0.1 | 7 | <0.1 | 28 (<0-82) |
| HPV-16 | 77 | 0.4 | 132 | 0.8 | 42 (22-56) |
| HPV-18 | 6 | <0.1 | 29 | 0.2 | 79 (49-93) |

* Rate per 100 person-years at risk

Herpes Zoster

Herpes zoster, or shingles, is caused by the varicella zoster virus (VZV). Primary infection by VZV leads to chicken pox. Following primary infection, VZV lies dormant in the dorsal root or sensory ganglia. In some people, however, the virus gets reactivated causing herpes zoster. Reactivation can result in unilateral, vesicular lesions that are very painful. There are 3 phases of herpes zoster outbreak. The prodrome phase consists of the period right before the outbreak occurs and some patients report a tingling sensation. The eruptive phase is when the lesions are present. Finally, the post herpetic phase is when the rash is dissipating; however, this phase often causes great pain for the patient due to post herpetic neuralgia (PHN). Other complications of infection include scarring, super infection, cranial and motor neuron palsies, encephalitis, visual impairment, hearing loss and death.

In 2006, a vaccine to prevent herpes zoster, Zostavax®, was approved and marketed²⁰. Zostavax® is a live, attenuated virus given as a subcutaneous injection in the deltoid region. The

vaccine should be stored frozen. The vaccine must be reconstituted with the diluent provided. The vaccine must be used within 30 minutes of reconstitution; if not used within that timeframe, the vaccine must be discarded. Reconstituted vaccine should not be re-frozen.

The ACIP recommends Zostavax® for all adults ≥ 60 years old regardless of prior history with herpes zoster. Contraindications to the vaccine include hypersensitivity to gelatin or neomycin, which are contained in the vaccine. Patients with immunodeficiency states including lymphomas, AIDS, HIV and persons on immunosuppressants should not receive the vaccine. The vaccine virus may be transmitted to susceptible contacts of persons who have been vaccinated. The vaccine has not been studied during pregnancy. Vaccination should be deferred in patients with untreated tuberculosis.

Zostavax® is not indicated for preventing chicken pox. The vaccine for chicken pox is called Varivax® and it is much less potent than

Zostavax®. The higher dose of virus contained in Zostavax® is thought to be needed to obtain a robust immune response in older individuals.

The major trial that led to the approval of Zostavax® was the Shingles Prevention Study. This was a randomized, double-blind, placebo-controlled VA Cooperative study carried out at 22 sites. Over 38,000 subjects were enrolled. Subjects were greater than 60 years old, and had to have a history of varicella infection or they must have resided in the U.S. for longer than 30 years. Twelve different vaccine lots were used in the study and the potency ranged from 18,700-60,000 plaque-forming units per dose. Monthly follow-ups were done using an interactive, automated telephone response system. Subjects were required to call and answer a series of questions to determine whether they had an outbreak of herpes zoster. If there was suspicion of an outbreak, they were asked to come in to a local research center to verify the diagnosis.

Before unblinding, each suspected case of herpes zoster was verified via a polymerase chain reaction assay. The primary endpoint was a 47% or greater relative reduction in the herpes zoster burden of illness (BOI) score. The reduction in BOI in the vaccine group was compared to the placebo group using the seven-item Zoster Brief Pain Inventory, which consisted of Likert pain scale questions. The BOI score represented the average score among all subjects in each group. The secondary endpoint was a 62% or greater relative reduction in the incidence of PHN.

The mean duration of follow-up was three years. During that time there were 957 confirmed cases of herpes zoster cases: 315 in the vaccine group and 642 in the placebo group. The vaccine resulted in a 61.1% (95% CI 51.1-69.1) reduction in BOI compared to the placebo, which exceeded the preset criteria. Results from the study are summarized in Table 10.

Table 10
Zostavax® vaccine vs. placebo results²¹

| | Vaccine N=19,254 | Placebo N=19,247 | p |
|--------------------|----------------------------|----------------------------|----------|
| BOI score | 2.21 | 5.68 | <0.001 |
| HZ (cases) | 5.42* (315) | 11.12* (642) | <0.001 |
| PHN (cases) | 0.46* (27) | 1.38* (80) | <0.001 |

*Incidence per 1000 person-years. HZ = herpes zoster. PHN = post herpetic neuralgia

While these results indicated a relatively positive outcome in reducing the incidence of herpes zoster and PHN, the story looks different when the data are analyzed by age group. The efficacy of the vaccine at preventing herpes zoster declines

dramatically with age and the efficacy in preventing the incidence of post herpetic neuralgia is mixed (Table 11). These results should be considered when deciding whether or not a patient would be a good candidate for the vaccine.

Table 11
Effect of age on Zostavax® efficacy in VZ and PHN²²

| Age | % Efficacy VZ (95% CI) | % Efficacy PHN (95% CI) |
|-------|---------------------------|----------------------------|
| 60-69 | 64 (56, 71) | 5 (-107, 56) |
| 70-79 | 41 (28, 52) | 55 (18, 76) |
| ≥80 | 18 (-29, 48) | 26 (-69, 68) |

Adverse events were relatively minor. A subset of subjects (N=6616) was evaluated up to 42 days post-vaccination. The vaccine group had more injection site reactions including rash, erythema, pain, swelling and pruritus.

Summary

Vaccine research and development has come a long way in the last 60 years. This article provided an overview of the use, safety and efficacy of the new

vaccines for pertussis, meningococcal disease, human papilloma virus and herpes zoster. Despite the advances made over the past century, there are many diseases, such as hepatitis C and HIV, for which no vaccines exist. As our knowledge of these diseases grows and as biomedical research becomes more advanced at finding ways to formulate and develop new vaccines, the potential for eradicating diseases of the future could be limitless.