Immunizations and pregnancy: An update for pharmacists

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Abstract

Objective: To review the safety of immunizations in pregnancy.

Data sources: PubMed search using the terms *vaccine*, *immunizations*, and *pregnancy*, as well as current national guidelines.

Data synthesis: Immunizations for women of childbearing age are an integral component of pregnancy planning. Some vaccines are compatible with pregnancy, whereas others, in particular live-attenuated vaccines, are contraindicated because of the theoretical risk to the fetus. The immunizing pharmacist must be aware of updated guidelines regarding the safe and appropriate use of vaccines during pregnancy. Certain routine adult vaccines are contraindicated during pregnancy, including the live-attenuated intranasal influenza, measles–mumps–rubella, varicella, zoster, and human papillomavirus vaccines. The trivalent inactivated influenza vaccine is specifically recommended for all women who are pregnant during influenza season. The hepatitis B, tetanus–diphtheria–acellular pertussis, and several other routine adult and travel vaccines may be administered safely in pregnancy if the patient meets certain risk criteria. Breast-feeding is compatible with all routine adult vaccines. Vaccinia (smallpox) and yellow fever vaccines are cautioned against use except in certain circumstances.

Conclusion: Pharmacists can play an important role in recommending safe and appropriate vaccines before and during pregnancy.

Keywords: Vaccine, immunization, pregnancy.

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Learning objectives

At the conclusion of this knowledge-based activity, the pharmacist will be able to:

- Describe the current vaccine issues facing pregnant women.
- List vaccines that should be avoided in pregnant women.
- List vaccines that may be administered during pregnancy and breast-feeding and describe the recommended dosing schedule.
- Identify resources for vaccine information including travel vaccine recommendations during pregnancy.
- Describe the role of the pharmacist in vaccinating women during pregnancy.

Case study 1
A 22-year-old woman who is at 14 weeks' gestation and has no noteworthy medical history presents to her pharmacist for a physician-recommended influenza vaccine. She states that she is afraid of needles and requests to have the nasal formulation of the influenza vaccine that she has had in the past. What do you think about this patient's request? Is the influenza vaccine indicated for use in pregnant women? Are both the nasal and injectable influenza vaccine formulations recommended for use in pregnant women?

Case study 2
A 26-year-old woman with asthma and allergic rhinitis receives preconception counseling from her physician as she makes plans to discontinue oral contraceptives. A review of her immunization record shows that she needs the following vaccines: tetanus–diphtheria–acellular pertussis, pneumococcal polysaccharide, and varicella. What do you think of administering these vaccinations? Are they indicated for this patient, and what counseling points should be emphasized with this patient?

Pharmacists today are actively involved in providing immunizations, with more than 150,000 pharmacists trained nationwide.[1] In all 50 states, the District of Columbia, and Puerto Rico, pharmacists are authorized to provide influenza vaccines.[2] A majority of other states allow pharmacists to provide a variety of immunizations in addition to the influenza vaccine. One patient population that is of particular importance is pregnant women. Unfortunately, the ambiguity of immunizing during pregnancy may lead clinicians to avoid vaccines that could provide important protection to the mother and fetus. Understanding appropriate vaccine indications and contraindications is necessary to maximize pregnancy and public health outcomes.

Ideally, preconception care consists of family planning; assessment of weight and intake of various nutrients such as folic acid; screening for sexually transmitted infections and cervical cancer; identification of chronic medical conditions such as diabetes, substance abuse, thyroid conditions, autoimmune disorders, seizure disorders, cardiovascular disease, hypertension, and psychological conditions; and screening for appropriate immunizations and evidence of immunity.[3] Up-to-date immunizations are particularly important because some infections contracted during pregnancy may cause considerable harm to the fetus or mother. At the same time, some vaccines administered during pregnancy or near the time of conception may also have serious adverse effects on the fetus. Therefore, immunization screening before conception is preferred. Some women, however, do not receive adequate preconception care or become pregnant unexpectedly, necessitating a possible need for vaccination during pregnancy.

Concerns with vaccinating pregnant women have stemmed from a variety of issues. The safety of preservatives used in certain vaccine formulations has been questioned. Thimerosal is a vaccine preservative used since the 1930s that consists of approximately 50% mercury by weight and is metabolized to ethylmercury and thiosalicylate.[4] Overexposure to ethylmercury through childhood immunizations and in utero was once thought to be linked to autism and other neurodevelopmental conditions. Recent studies refute this conclusion. A study of more than 2,000 pregnant women receiving thimerosal-containing influenza vaccines showed no adverse fetal effects.[5,6] A case–control study examined the risk of autistic disorders in children exposed to thimerosal-containing vaccines prenatally up to 20 months of age and did not find an increased risk associated with vaccines.[7] Despite these findings, manufacturers are developing more vaccines that contain smaller quantities of thimerosal or are "preservative free."

Confusion regarding live and inactivated vaccines administered during pregnancy may also cause providers to avoid vaccinating pregnant women. Some vaccines are compatible with pregnancy, whereas others, in particular live-attenuated vaccines, are contraindicated because of the theoretical risk to the fetus.[8] This review focuses on common vaccines provided by pharmacists and their indications in pregnant women. It is not intended to be an all-inclusive review of vaccine administration issues such as product-specific dosing, allergy warnings, and storage recommendations. Table 1 summarizes the appropriateness of select vaccines during pregnancy.

Vaccines that should be avoided in pregnancy

Human papillomavirus vaccine

Routine administration. The human papillomavirus (HPV) vaccine is available in two inactivated injectable formulations. The bivalent vaccine covers HPV strains 16 and 18, which are thought to cause a majority of cervical cancers. The quadrivalent vaccine covers HPV strains 6, 11, 16, and 18 and provides protection against cervical cancer and genital herpes. They are both three-dose series recommended between the ages of 9 and 26 years. The recommended age of administration for the bivalent HPV vaccine is in girls age 11 or 12 years at 0, 1, and 6 month intervals. The quadrivalent vaccine is also recommended to start at the age of 11 or 12 years in both boys and girls at 0, 2, and 6 month intervals. Catch-up series may be provided through 26 years of age.[9,10]

Administration in pregnant women. Both HPV vaccines should be avoided in pregnant women. To date, no studies have evaluated HPV vaccine during pregnancy. A pregnancy test before administration of the vaccine is not required. If the vaccine is inadvertently provided to a pregnant woman, no intervention is required; however, the patient or health care provider should contact the appropriate manufacturer to report the exposure.[11] The remaining doses of the vaccine series should be delayed until after pregnancy.

Clinical issues. HPV is the leading cause of cervical cancer. Providing the vaccine to girls at 11 to 12 years of age may prevent the occurrence of cervical cancer later in life, including during pregnancy. An additional preventive measure includes routine Papanicolaou testing. The American Cancer Society recommends annual tests beginning 3 years after the first act

Table 1. Summary of immunizations in pregnancy[11]

Immunization	Considerations during pregnancy
Human papillomavirus (HPV)	Avoid during pregnancy. The HPV vaccine is best provided to women aged 9–26 years before pregnancy and should not be given during pregnancy. The vaccine may be given after pregnancy, if desired.
Influenza (live attenuated influenza vaccine [LAIV]) nasal spray	Avoid during pregnancy. Pregnant women should not be vaccinated with the LAIV nasal spray but should receive the injectable inactivated influenza vaccine.
Measles–mumps–rubella	Avoid during pregnancy. Avoid in pregnant women and wait 28 days before conceiving in nonpregnant women who have recently received the vaccine.
Varicella	Avoid during pregnancy. Avoid use in pregnant women or in women planning to become pregnant within 4 weeks of receiving the vaccine.
Zoster	Avoid during pregnancy. Avoid use in pregnant women or in women planning to become pregnant within 4 weeks of receiving the vaccine.
Influenza (trivalent inactivated influenza vaccine	May administer during pregnancy. Can be administered during any trimester in all women who are pregnant during influenza season.
Tetanus–diphtheria–acellular pertussis (Tdap)	May administer during pregnancy. Provide to all women who have not received a Tdap booster, preferably after 20 weeks' gestation.
Hepatitis B	May administer during pregnancy. Provide to all unvaccinated women who meet risk criteria. Also perform prenatal screening for hepatitis B surface antigen to determine need for postexposure prophylaxis of the newborn.
Hepatitis A	May administer during pregnancy. Because of limited safety data, recommend avoiding during pregnancy unless high exposure risk.
Pneumococcal polysaccharide	May administer during pregnancy. Provide to unvaccinated women who meet risk criteria
Meningococcal polysaccharide	May administer during pregnancy. Provide to unvaccinated women who meet risk criteria. Less data available for meningococcal conjugate vaccine in pregnancy.

of sexual intercourse and by no later than 21 years of age. The test interval is extended to every 2 to 3 years in women older than 30 years after three confirmed negative cytology tests.[12,13] The American College of Obstetricians and Gynecologists recommends tests every 2 years for women age 21 to 29 years, then every 3 years after age 30 with three consecutive negative cytology tests.[14] Prevention and early detection is particularly important for women who are planning to conceive. Detecting and treating any grade of cervical cancer before pregnancy, whenever possible, is preferred. Treatment of cervical cancer during pregnancy can be very complicated and in some cases not possible without preterm delivery of the neonate.

Influenza vaccine (live-attenuated influenza vaccine)

Routine administration. The live-attenuated influenza vaccine (LAIV) is available in an intranasal formulation. It is recommended for individuals aged 2 to 49 years and is usually administered once a year during influenza season. Children up to 8 years may require two doses given at least 4 weeks apart depending on their prior influenza vaccine history.[6]

Administration in pregnant women. Because the intranasal influenza formulation is a live-attenuated vaccine, it is contraindicated in pregnant women. Of important note, pregnant women should be vaccinated against influenza but should only receive the inactivated injectable formulation discussed previously.[6,11]

Clinical issues. Contracting the influenza virus is especially of concern in the second and third trimester of pregnancy. Pregnant women have a higher risk of influenza-related morbidity and mortality during this time when the fetus impairs breathing through increased pressure on the diaphragm and lungs. In spring 2009, about 13% of deaths reported during the H1N1 pandemic were among pregnant women.[15] In addition, contracting the influenza virus during the first trimester has been implicated in a higher risk of schizophrenia in the infant.[16] To maximize protection but minimize theoretical risks to the fetus from the live vaccine formulation, the intranasal influenza vaccine should be avoided during pregnancy.

Measles–mumps–rubella vaccine

Routine administration. The measles–mumps–rubella (MMR) vaccine is a live-attenuated injectable formulation recommended to be administered to infants in a two-dose series. The first dose is given between 12 and 15 months and the second between 4 and 6 years.[9] Adults who do not have evidence of immunity should receive one or two doses of the vaccine depending on their current risk for exposure and type of vaccine received, if vaccinated previously.[10]

Administration in pregnant women. Because the MMR vaccine is live attenuated, concerns exist regarding possible effects on the fetus; therefore, it is not recommended in pregnant women. Nonpregnant women receiving the MMR vaccine should be counseled to avoid pregnancy for at least 28 days postvaccination.[8,11] Accidental administration of the vaccine during pregnancy, however, does not warrant termination of the pregnancy, and the woman should be counseled to enroll in a pregnancy registry for the vaccine.[11]

Clinical issues. Vaccination against measles, mumps, and rubella is particularly important before pregnancy. Although the risk for infection is much lower since vaccines have become available, lapses in herd immunity resulting from unvaccinated populations have resulted in recent outbreaks and increased concern. Measles during pregnancy has been associated with spontaneous abortion, premature labor, and low birth weight but has not been associated with birth defects.[17] An increased risk for fetal death has been reported in women who contract mumps during the first trimester of pregnancy, but infection during pregnancy has not been associated with congenital mal-

formations.[17] Rubella infection during pregnancy, particularly in the first trimester and up to 20 weeks, may result in stillbirth, spontaneous abortion, or congenital rubella syndrome (CRS).[17] Manifestations of CRS in an infant include deafness, eye problems (e.g., cataracts, microphthalmia, glaucoma, chorioretinitis), cardiovascular anomalies (e.g., patent ductus arteriosus, peripheral pulmonary artery stenosis, septal defects), and neurologic issues (e.g., microcephaly, meningoencephalitis, mental retardation).[17] CRS may also cause intrauterine growth retardation and growth retardation after birth. Bone defects, enlarged spleen or liver, thrombocytopenia, and purpuric skin lesions have also been reported in cases of CRS.[17] Women without evidence of MMR immunity who are considering pregnancy should have MMR antibody titers drawn to ensure adequate protection against rubella. If titers are low, the vaccine should be provided in two doses if the woman is not pregnant, and she should be instructed to avoid pregnancy for 28 days after the vaccine. The effects on the fetus are unknown, but some studies have shown rubella-specific immunoglobulin M detected in cord blood, suggesting possible subclinical infection and necessitating the recommendations.17 Household members of a pregnant woman may receive the vaccine without contraindication.[8]

Varicella vaccine

Routine administration. Varicella vaccine is a live-attenuated injectable formulation indicated for routine administration to infants in a two-dose series. The first dose is given between 12 and 15 months and the second between 4 and 6 years.[9] Unvaccinated adults who do not have evidence of varicella immunity should also receive the vaccine.[10]

Administration in pregnant women. Because the varicella vaccine is live attenuated, it is not recommended in pregnant women or women planning to conceive within 4 weeks of receiving the vaccine. Accidental administration of the vaccine during pregnancy, however, does not warrant termination of the pregnancy and the woman should be counseled to enroll in a pregnancy registry for the vaccine.[11]

Clinical issues. Women with active disease may suffer from severe infection, which in addition to skin lesions may include potentially fatal varicella pneumonia.[18] Infants of women with active disease in the first trimester of pregnancy are at risk for severe limb atrophy, eye problems such as cataracts or chorioretinitis, scarred skin, and brain abnormalities such as microcephaly and cortical atrophy.[18] Therefore, adequate vaccination is recommended before conception. Prenatal screening for evidence of varicella immunity is recommended.[19] The vaccine should be provided in two doses if the woman is not pregnant and does not have evidence of varicella immunity. She should be instructed to avoid pregnancy for 28 days after the vaccine. Household members of a pregnant woman may receive the vaccine without contraindication. Unvaccinated pregnant women exposed to infection should receive Varicella Zoster Immune Globulin (VZIG) to prevent maternal complications. Unfortunately, VZIG has not been found to prevent viremia, fetal infection, or congenital or neonatal varicella. Patients receiving VZIG should also receive the varicella vaccine after delivery but must wait 5 months after the immune globulin dose.[11]

Zoster vaccine

Routine administration. Zoster (shingles) vaccine is a live-attenuated injectable formulation indicated for routine administration in adults aged 60 years or older based on the current CDC adult immunization schedule. The vaccine is licensed for use in adults 50 years or older.[10]

Administration in pregnant women. Because the zoster vaccine is live attenuated, it is not recommended in pregnant women or women planning to conceive within 4 weeks of receiving the vaccine.[11] If a woman is vaccinated while pregnant or becomes pregnant within 4 weeks of receiving the vaccine, she should be counseled about possible effects on the fetus and instructed to contact the manufacturer for enrollment in a pregnancy registry for exposure. Termination of the pregnancy is generally not warranted if a woman has inadvertently been exposed.[11]

Vaccines that can be administered during pregnancy

Influenza vaccine (trivalent inactivated influenza vaccine)

Routine administration. The trivalent inactivated influenza vaccine (TIV) is an injectable formulation recommended for annual administration during the influenza season for all individuals aged 6 months or older.[9,10] Children aged 6 months through 8 years may require two doses given at least 4 weeks apart depending on their previous influenza vaccine history.[9,20]

Administration in pregnant women. One dose of TIV is recommended for all women who will be pregnant during the influenza season (October through March).[11,21] The vaccine may be administered during any trimester.[21]

Clinical issues. As previously discussed, the recommendation to administer TIV during pregnancy is based on the known risks of influenza infection during pregnancy, as well as risks to the newborn exposed before vaccination at 6 months of age. Long-term surveillance reveals no safety concerns with the administration of TIV during pregnancy.[22] In addition, maternal vaccination may lower the risk of influenza in the newborn through transfer of maternal antibodies.[6] Despite these recommendations, many pregnant women do not receive the vaccine as a result of misinformation regarding vaccine efficacy and safety.[21] A recent survey of approximately 1,500 women who were pregnant during the 2010–11 influenza season showed that 49% received an influenza vaccine before, during, or after their pregnancies.[23] Although this is higher than the annual vaccination rates of approximately 15% in pregnant women before 2009, it does not reach the Healthy People 2020 target of 80%.[23,24] CDC, in collaboration with 12 medical organizations including APhA, continues to advise health care providers of the importance of influenza vaccination during pregnancy through an annual letter. CDC also actively supports a patient-focused website on pregnancy and influenza (www.cdc.gov/Features/PregnancyAndFlu).

Tetanus–diphtheria–acellular pertussis/tetanus–diphtheria toxoid vaccine

Routine administration. The tetanus–diphtheria toxoid (Td) vaccine is an inactivated injectable formulation administered every 10 years in all adults who have completed a primary series of tetanus–diphtheria–pertussis–containing vaccines. A one-time booster of tetanus–diphtheria–acellular pertussis (Tdap) vaccine is recommended for all adults in place of the next scheduled Td booster to reduce the risk for pertussis transmission, particularly to children who have not completed their primary four-dose series of the diphtheria–tetanus–acellular pertussis (DTaP) vaccine.[9,10] Children who receive their primary series should be given a booster dose of DTaP at 4 to 6 years of age before entering school, then one dose of Tdap at 11 to 12 years of age.[9]

Administration in pregnant women. Td vaccine was recommended as the primary tetanus-containing formulation during pregnancy before 2011. As data accumulated in pregnancy registries showing positive pregnancy outcomes with Tdap, the recommendations were updated to support the use of Tdap during pregnancy. Any pregnant woman who has not received her Tdap booster as an adult should receive one dose after 20 weeks' gestation, in the late second or third trimester. Because maximal antibody development occurs several weeks after vaccination, administration during pregnancy provides immediate protection at the time of delivery. In addition, maternal antibodies transferred to the fetus late in pregnancy may provide some protection to the infant postdelivery. If not given during pregnancy, Tdap should be administered immediately after delivery. If a patient's immunization status is unknown, then a three-dose series of Td should be initiated in a schedule of 0 and 4 weeks and 6 to 12 months. One of these doses should be replaced by Tdap, occurring after 20 weeks' gestation.[11,25,26]

Updated vaccination against tetanus is an important consideration for acute wound management during pregnancy. A tetanus toxoid–containing vaccine is recommended if 5 or more years have passed since the previous Td booster. Tdap is the preferred vaccine in this situation if the patient has not previously received the Tdap booster.[11,26]

Clinical issues. Appropriate vaccination against pertussis is intended to protect the newborn upon delivery, as infants 12 months or younger have the highest risk of morbidity and mortality associated with pertussis infection.[27] Routine pertussis vaccination of an infant does not begin until 2 months of age with the first dose of the DTaP series, leaving newborns particularly at risk.[9] "Cocooning" is the practice of immunizing the household contacts and caregivers of infants who are not vaccinated to reduce the potential exposure to infections such as pertussis. Unvaccinated adult household contacts and caregivers of infants younger than 12 months should receive the Tdap vaccine.[10] If possible, this should occur at least 2 weeks before anticipated contact with the infant.[26]

Hepatitis B vaccine

Routine administration. The hepatitis B vaccine is an inactivated injectable formulation administered as a routine three-dose series beginning at birth. The dosing schedule is typically 0, 1, and 6 months. The vaccine also is routinely targeted at children and adolescents who did not receive the vaccine as an infant or did not complete the series.[9] Unvaccinated adults should receive the vaccine series if they meet certain risk criteria. Examples of indications for the vaccine include sexual activity with multiple partners; injection drug users; health care and emergency response personnel; patients with diabetes, end-stage renal disease, HIV, or liver disease; international travelers; and residents of correctional, drug abuse, or HIV treatment facilities.[10]

Administration in pregnant women. The hepatitis B vaccine series can be initiated during pregnancy for any unvaccinated woman as soon as a risk factor is identified. In addition, serologic testing for hepatitis B surface antigen (HBsAg) is recommended during routine prenatal care to plan for prevention of perinatal transmission.[11,28]

Clinical issues. Perinatal transmission of the hepatitis B virus from an HBsAg-positive mother results in chronic infection in approximately 90% of infants. Postexposure prophylaxis through the use of hepatitis B immune globulin (HBIG) and hepatitis B vaccine reduces the risk of acute and chronic infection by 85% to 95%.[27] A healthy term infant who is born to an HBsAg-positive mother should receive the first dose of the hepatitis B vaccine and HBIG within 12 hours of birth. The remaining two doses of hepatitis B vaccine are administered at 1 to 2 months and 6 to 18 months. Testing for HBsAg and antibody to HBsAg is recommended 1 to 2 months after the completion of the series to confirm response to the prophylaxis regimen. Specific recommendations for infants born to HBsAg-positive women who weigh less than 2,000 g at birth or whose mother's HBsAg status is unknown at the time of birth are outlined by the Advisory Committee on Immunization Practices.[28]

Hepatitis A vaccine

Routine administration. The hepatitis A vaccine is an inactivated injectable formulation administered in a two-dose series to children 12 to 24 months of age. The second dose should be administered 6 to 18 months after the first.[9] It is also recommended for unvaccinated adults with certain risk factors including but not limited to men who have sex with men, injection drug users, international travelers, contacts with international adoptees, and those with chronic liver disease.[10]

Administration in pregnant women. Because data regarding the safety of the hepatitis A vaccine during pregnancy are limited, it should be administered before pregnancy if possible. However, because it is an inactivated formulation, vaccination during pregnancy may be considered with caution in women at high risk for infection.[11,27]

Pneumococcal polysaccharide vaccine

Routine administration. The pneumococcal polysaccharide vaccine (PPSV) is an inactivated injectable formulation recommended as a single dose for all adults 65 years or older. Adults and children younger than 65 years meeting certain risk criteria should also receive the vaccine, with revaccination recommendations specific to the indication. Examples include chronic lung, cardiovascular, or liver disease, diabetes, alcoholism, cochlear implants, cerebrospinal fluid leaks, immunocompromised conditions, asplenia, residents of long-term care facilities, and smokers.[10] The pneumococcal conjugate vaccine is recommended as a routine childhood vaccine provided in a four-dose series beginning at 2 months of age.[9]

Administration in pregnant women. Because data are limited regarding the safety of PPSV during pregnancy, it should be administered before pregnancy if possible. However, it may be given during pregnancy to an unvaccinated woman who meets risk criteria. Limited data do not indicate a risk to infants exposed to the vaccine in utero.[11,27]

Meningococcal vaccine

Routine administration. Vaccination with the inactivated injectable quadrivalent meningococcal polysaccharide vaccine (MPSV4) or meningococcal conjugate vaccine (MCV4) is recommended for adults who have asplenia or HIV infection or who are at high risk for exposure (e.g., microbiologists, military recruits, travelers to endemic areas, first-year college students living in residence halls). MCV4 is preferred for those 55 years or younger, whereas MPSV4 is preferred for those 56 years or older. The vaccine may be administered as a single dose or two-dose series depending on the indication. For example, patients infected with HIV or who have functional asplenia should receive two doses while those who have an exposure risk resulting from travel, military service, or occupation should receive one dose.[10] Children 9 months of age and older who meet certain risk criteria may receive MCV4. All adolescents should receive one dose of MCV4 at 11 to 12 years of age with a booster at 16 years.[9]

Administration in pregnant women. Although administering meningococcal vaccine before pregnancy is preferable, a pregnant woman who is at risk and unvaccinated may receive the vaccine. Earlier studies of MPSV4 in pregnancy did not reveal a safety concern. Information regarding the safety of MCV4 is lacking.[11,27,29]

Travel vaccines

Travel during pregnancy requires careful planning and consideration of a wide variety of exposures, including infectious diseases. Patients should be encouraged to update their immunizations before pregnancy and travel, if possible. The CDC Traveler's Health website (wwwnc.cdc.gov/travel) provides destination-specific immunization recommendations. The CDC Yellow Book is published every 2 years and provides health information for international travelers, including those who are pregnant.[30] The recommendations for administration of the inactivated influenza (TIV), hepatitis B, and Td/Tdap vaccines for travel during pregnancy are consistent with the instructions previously described. Hepatitis A vaccination is also supported; however, the use of immune globulin rather than the vaccine is suggested as an alternative because of the lack of safety data. Meningococcal polysaccharide, pneumococcal polysaccharide, Japanese encephalitis, rabies, inactivated polio, typhoid, and yellow fever vaccines may be administered with caution during pregnancy in specific scenarios when the benefits outweigh the risks, such as travel to endemic areas or in high-risk situations. Vaccine-specific instructions for these situations are outlined in the document. Certain vaccines are contraindicated, including varicella, MMR, influenza (LAIV), HPV, and tuberculosis (Bacillus Calmette-Guérin).[11,30] Although smallpox vaccine (vaccinia) is no longer routinely recommended for international travelers, it is a live virus vaccine that is also contraindicated during pregnancy for nonemergency situations.8,31 Cases of fetal vaccinia resulting from maternal vaccination resulted in high rates of infant mortality.[31]

Other considerations

Vaccine safety during breast-feeding is a common concern postpartum. At this time, no recommendations suggest avoiding any routine vaccines during breast-feeding.[8] Vaccinia (smallpox) and yellow fever vaccines should not be administered to a breast-feeding mother.[31,32] Unavoidable travel to a yellow fever endemic area, however, may warrant administration of the vaccine.[30] Infants who are breast-fed should receive routine vaccines at the recommended intervals. No concern exists that maternal antibodies in breast milk will interfere with routine infant immunizations.[8]

Another concern is vaccination of household contacts of pregnant women. Most live vaccines such as MMR, varicella, LAIV, and rotavirus can be administered to household contacts as recommended in the current immunization schedules.[6,8] Nonemergency administration of vaccinia vaccine to household contacts of pregnant women is contraindicated, however.[8,31]

Certain live vaccines, such as MMR and varicella, are recommended to delay until immediately after delivery to minimize risk to the fetus. Vaccination of the mother before hospital discharge not only reduces the newborn's risk of exposure but provides protection for future pregnancies. However, the administration of an immune globulin preparation during pregnancy for prophylaxis of conditions such as tetanus, hepatitis A or B, varicella, or rabies affects the timing of MMR and varicella vaccines postdelivery. A product-specific interval ranging from 3 to 6 months from the immune globulin dose is necessary to avoid antibody interference. Women who receive human anti-Rho(D) immune globulin (Rhogam) or other blood products during labor and delivery may receive the MMR vaccine postdelivery without delay, but serologic testing 6 to 8 weeks later is recommended to confirm adequate antibody response. Other live vaccines such as zoster, yellow fever, and LAIV may be administered at any time before or after immune globulin products.[8]

Pharmacist role

Immunizing pharmacists play an important role in the safe and appropriate use of vaccines in pregnant women. Resources for maintaining up-to-date pregnancy-related vaccine information are listed in Table 2. Pharmacists can be a key source of patient education, dispelling common vaccine myths and identifying applicable indications and contraindications for vaccine administration. Because data on vaccine safety during pregnancy are lacking, pharmacists are also an important referral source for reporting to the Vaccine Adverse Event Reporting System and patient enrollment in pregnancy exposure registries. Finally, pharmacists can direct immunization campaigns toward women of childbearing age and emphasize preconception administration of routine vaccines whenever possible.

Case study 1: Answers

Providing the influenza vaccine to pregnant women is recommended; however, both formulations are not indicated for use in pregnant women. TIV is the injectable formulation recommended for annual administration during the influenza season for all individuals 6 months or older. One dose of TIV is recommended for all women who will be pregnant during the influenza season (October through March) and may be administered during any trimester. The intranasal formulation is an LAIV and is contraindicated in pregnant women. Women are at greater risk of morbidity and mortality from the influenza virus during pregnancy. Vaccinating this patient against influenza is important, but she should only receive the inactivated injectable formulation. She should be counseled on the contraindications of LAIV and the risks of not receiving TIV during pregnancy. She should be encouraged to receive TIV despite her fear of needles.

Case study 2: Answers

Reviewing vaccine needs before pregnancy is ideal to maximize maternal and fetal protection against infection and minimize risks associated with administering the vaccine during pregnancy. Tdap is an inactivated vaccine that can be safely administered during pregnancy after 20 weeks' gestation. However, providing the Tdap dose now will prevent the need for a vaccine during pregnancy and will protect the newborn from pertussis immediately postpartum. In addition, it is not too early to update Tdap vaccines for all children and adults who will likely be in contact with the newborn.

PPSV is an inactivated vaccine with limited data regarding safety during pregnancy. Asthma is an indication for PPSV, so she should be given one dose now to avoid the need to give it during pregnancy and provide her with more immediate protection against pneumococcal disease.

Varicella is a live vaccine that is contraindicated during pregnancy as a result of the theoretical risk to the fetus. If the woman contracts varicella during her pregnancy, severe complications exist for the mother and fetus. She should receive a dose of varicella vaccine now and plan to delay pregnancy for at least 28 days.

Table 2. Immunization resources

Resource	Website
American College of Obstetricians and Gynecologists	www.immunizationforwomen.org/resources/acog_resources
Centers for Disease Control and Prevention	www.cdc.gov/vaccines
Immunization Action Coalition	www.immunize.org
Vaccine Adverse Event Reporting System	http://vaers.hhs.gov/index
Food and Drug Administration pregnancy registries	www.fda.gov/ScienceResearch/SpecialTopics/WomensHealthResearch/ucm134848.htm

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CPE assessment

Instructions: This exam must be taken online; please see "CPE information" for further instructions. The online system will present these questions in random order to help reinforce the learning opportunity. There is only one correct answer to each question. This CPE activity will be available online at www.pharmacist.com between October 1, 2012, and October 1, 2015.

1. **Although refuted by recent studies, which of the following preservatives has been linked to autism?**
   a. Benzyl alcohol
   b. Benzoic acid
   c. Methylparaben
   d. Thimerosal

2. **Previous concerns about using thimerosal-containing vaccines during pregnancy include an increased:**
   a. Risk of miscarriage.
   b. Risk of muscular disorders.
   c. Level of the metabolite ethylmercury.
   d. Level of microbes.

3. **After receiving the measles–mumps–rubella (MMR) vaccine, women should avoid becoming pregnant for how many days?**
   a. 0
   b. 14
   c. 28
   d. 60

4. **After receiving the varicella vaccine, women should avoid becoming pregnant for how many weeks?**
   a. 0
   b. 4
   c. 6
   d. 12

5. **A 23-year-old woman comes to the pharmacy with a prescription for the human papillomavirus (HPV) vaccine series. She states she is not pregnant and would like to receive the vaccine from the pharmacist. The pharmacist has been trained to administer immunizations and practices in a state that allows HPV immunization by pharmacists. Which of the following actions should be taken by the pharmacist?**
   a. Have the patient take a pregnancy test before providing the vaccine
   b. Provide the vaccine to the patient
   c. Do not administer the vaccine because of the patient's age
   d. Do not administer the vaccine because of the likelihood that the patient is already sexually active

6. **Which of the following vaccines may be administered to a pregnant woman?**
   a. Varicella
   b. MMR
   c. HPV
   d. Tetanus–diphtheria–acellular pertussis (Tdap)

7. **A 22-year-old woman had a preconception planning visit and was sent to the pharmacy to receive the following vaccinations: varicella, Tdap, influenza, and HPV. She tells the pharmacist that she can only afford one vaccination at this time but will be able to afford more during the next few months. Which of the following vaccines should the patient receive now before she becomes pregnant?**
   a. HPV
   b. Tdap
   c. Influenza
   d. Varicella

8. **Which of the following vaccines is recommended to be given at 20 weeks' gestation if not administered before pregnancy?**
   a. HPV
   b. Varicella
   c. Tdap
   d. MMR

9. **Which of the following, if contracted during the first trimester or second trimester of pregnancy, may result in infant deafness?**
   a. Measles
   b. Mumps
   c. Rubella
   d. HPV

10. **Which of the following is a concern if influenza is contracted during the second or third trimester of pregnancy?**
    a. No maternal or fetal concerns exist during the second and third trimester.
    b. Increased maternal morbidity and mortality related to increased pressure on the diaphragm and lungs from the fetus
    c. Increased risk of cardiovascular anomalies (e.g., patent ductus arteriosus, peripheral pulmonary artery stenosis, septal defects) in the infant
    d. Increased risk of schizophrenia in the infant from exposure to the influenza virus during the second or third trimester

11. A pregnant woman in her second trimester requests an influenza vaccine in January. Which of the following should you recommend?
a. Administer the trivalent inactivated influenza vaccine (TIV) vaccine now
b. Administer the live-attenuated influenza vaccine (LAIV) vaccine now
c. No influenza vaccine is indicated because it is too late in the season to give the vaccine
d. Wait to administer the TIV vaccine immediately upon delivery before discharge from the hospital

12. A 34-year-old woman is 10 weeks' pregnant and her immunization records show her last tetanus–diphtheria toxoid (Td) booster was given at 22 years of age. Which of the following would be the best recommendation regarding her vaccination needs?
a. No tetanus-containing vaccine is needed; she is up to date.
b. Administer Td vaccine immediately after delivery before discharge from the hospital
c. Administer Tdap vaccine now and discuss enrollment in the vaccine manufacturer's pregnancy registry
d. Administer Tdap after 20 weeks' gestation and discuss enrollment in the vaccine manufacturer's pregnancy registry

13. A 60-year-old woman will be caring for her 12-week-old newborn granddaughter when her daughter returns to work. The woman's last Td booster was 8 years ago, and she has never received a Tdap vaccine. Which of the following would be the correct immunization plan for the woman?
a. Administer a dose of Tdap vaccine now
b. Administer a dose of Td vaccine now
c. Administer Tdap vaccine in 2 years, after the 10-year interval between tetanus–diphtheria boosters has been met
d. Administer Td vaccine in 2 years, after the 10-year interval between tetanus–diphtheria boosters has been met

14. To prevent perinatal transmission of hepatitis B, an infant born to an HBsAg-positive mother should receive:
a. The first dose of hepatitis B vaccine and hepatitis B immune globulin (HBIG) by 2 months of age.
b. The first dose of hepatitis B vaccine and HBIG within 12 hours of birth.
c. The first dose of hepatitis B vaccine only within 12 hours of birth.
d. HBIG only within 24 hours of birth.

15. A pregnant patient in her second trimester has never received the hepatitis B vaccine but has an indication for the vaccine based on risk factors. Which of the following would be the correct recommendation for this patient?
a. Administer the first dose of the hepatitis B vaccine series now
b. Administer the first dose of the hepatitis B vaccine series at delivery
c. Administer the first dose of the hepatitis B vaccine series after she completes breast-feeding
d. Administer HBIG now

16. A 33-year-old woman is diagnosed with type 2 diabetes 6 months postpartum. Her primary care provider recommends that she receive the pneumococcal polysaccharide vaccine (PPSV) and begin the hepatitis B vaccine series. Her other immunizations are up to date. The patient is concerned about receiving the vaccines while she is breast-feeding. You should recommend:
a. That she stop breast-feeding so she can receive the vaccines.
b. That she stop breast-feeding for 48 hours after she receives each dose of the vaccines.
c. Administration of both vaccines while she continues to breast-feed.
d. Administration of the hepatitis B vaccine series while she continues to breast-feed and delay the PPSV dose until she stops breast-feeding.

17. Which of the following is a true contraindication for vaccination?
a. Administration of LAIV by a pregnant pharmacist to a nonpregnant adult patient.
b. Administration of a vaccinia (smallpox) vaccine to a pregnant woman.
c. Administration of an MMR vaccine to a 4-year-old child of a pregnant woman.
d. Administration of a varicella vaccine to a breast-feeding mother.

18. A 19-year-old woman delivered a healthy baby 2 days ago and has an order for a dose of the MMR vaccine before discharge. She was not up to date with this vaccine during her prenatal care. She received one dose of human anti-Rho(D) immune globulin (Rhogam) during the delivery. Which of the following recommendations should you provide?
a. Give the MMR vaccine now and obtain serologic testing in 6 to 8 weeks to confirm response
b. Delay the MMR vaccine until she has stopped breast-feeding
c. Delay the MMR vaccine for 6 months to avoid antibody interference
d. Delay the MMR vaccine for 12 months to avoid antibody interference

19. A pregnant patient is traveling to Guatemala and is requesting vaccine recommendations. Which of the following would be the best resource to use to address her concerns?

a. The CDC *Yellow Book*
b. The CDC *Pink Book*
c. Manufacturer product insert for vaccine preparations
d. The CDC 2012 immunization schedule

20. A 27-year-old woman at 14 weeks' gestation needs to travel internationally for a family emergency. She is up to date on all vaccines considered necessary for her intended destination except meningococcal. Which of the following should you recommend?

a. The meningococcal vaccine is contraindicated during pregnancy.
b. The patient can receive the vaccine now, and the preferred formulation is quadrivalent meningococcal polysaccharide vaccine (MPSV4).
c. The patient can receive the vaccine now, and the preferred formulation is meningococcal conjugate vaccine (MCV4).
d. The patient should delay the vaccine until the third trimester and may receive either MPSV4 or MCV4.

CPE information

To obtain 2.0 contact hours (0.2 CEUs) of CPE credit for this activity, you must complete the Assessment, the Learning Evaluation, and the Activity Evaluation. A Statement of Credit will be awarded for a passing grade of 70% or better on the Assessment. You will have two opportunities to successfully complete the CPE Assessment. Pharmacists who successfully complete this activity before October 1, 2015, can receive CPE credit. Your Statement of Credit will be available upon successful completion of the Assessment, Learning and Activity Evaluations and will be stored in your 'My Training Page' and on CPE Monitor for future viewing/printing.

CPE instructions:

1. Log in or create an account at pharmacist.com and select LEARN from the top of the page; select Continuing Education, then Home Study CPE to access the Library.
2. Select the activity title from the listing. Select "Click here to view the activity" to start the home study.
3. To receive CPE credit, select Enroll Now or Add to Cart from the left navigation and successfully complete the Assessment (with randomized questions), Learning Evaluation, and Activity Evaluation for access to your Statement of Credit. You will need to provide your NABP e-profile ID number to access your Statement of Credit.

Live step-by-step assistance is available Monday through Friday from 8:30 am to 5:00 pm ET at APhA Member Services at 800-237-APhA (2742) or by e-mailing education@aphanet.com.