Vaccine Safety and Administration

Overview

In an era where new diseases continue to emerge and existing ones evolve, vaccines serve as a pivotal line of defense. The necessity of widespread immunization programs has been underscored by the global pandemic, making vaccine education more critical than ever. However, with the rapid pace of vaccine development, coupled with widespread misinformation and public skepticism, healthcare professionals are faced with a challenging task: to stay current with vaccine safety and administration information and to convey this knowledge effectively to their patients.

This course is designed to address this very need. By enhancing healthcare professionals' understanding of vaccine development, safety measures, potential side-effects, and administration techniques, it provides the tools to effectively counter vaccine hesitancy and misinformation. This course aims to equip healthcare professionals to not only provide safe and efficient immunization services but also foster trust and understanding about vaccines among the general public.

Learning Objectives

1. Describe preparation for vaccine administration, including supply selection (e.g., reconstitution, needle length)
2. Outline procedures for vaccine administration: SQ, IM, IN
3. Identify safety considerations during vaccine administration (e.g., handling and disposal of sharps)
4. Describe the procedures for immunization-related documentation
5. Describe best practices for managing vaccine-related adverse reactions and emergency situations
6. Recall best practices in receiving, storing, and handling vaccines

Faculty

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Credits

2.0

For More Information

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Course Outline

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Vaccine Safety and Administration

Introduction

Healthcare professionals who administer vaccinations play a key role in maintaining public health. Vaccines are responsible for saving between 2 and 3 million lives annually. Despite their proven effectiveness in preventing the spread of disease, there is significant room for improvement in the United States. Studies have shown that approximately 12% of parents refuse to allow their child to have at least one recommended childhood vaccine, and over 30% of parents delay one or more childhood vaccines, putting their children at risk of vaccine-preventable diseases at a time when they are most vulnerable. In addition, less than 45% of adults receive the recommended flu vaccine annually (US Department of Health and Human Services, 2021).

High vaccination rates are required to create the 'herd immunity' necessary to protect individuals and the community from vaccine-preventable diseases. To ensure high vaccination rates, the community must have trust in vaccinations. Vaccine confidence represents the public's trust in vaccines, vaccine providers, and the vaccine development, licensure, and recommendation process. Low vaccine confidence can result in patients being more likely to delay or refuse recommended vaccinations. Vaccine providers are responsible for supporting public confidence in vaccines to prevent vaccine-preventable diseases from re-emerging (US Department of Health and Human Services, 2021).

Appropriate administration of immunizations is critically important to ensure vaccines are safe and effective and therefore plays a crucial role in maintaining public vaccine confidence. Vaccine administration errors can erode public confidence in vaccines, so healthcare professionals involved in vaccine administration should be thoroughly trained to follow guidance from the Centers for Disease Control and Prevention (CDC) and facility protocols on vaccine delivery. Ensuring vaccines are administered properly can significantly impact public health and prevent disease spread (US Department of Health and Human Services, 2021).

Preparing to Administer a Vaccination

Determine Which Vaccinations the Patient Needs

Providers should assess the patient's immunization history before administering any vaccinations to a patient. This allows the provider to determine what vaccinations are necessary for a given patient and administer as many required vaccines in one visit as possible. If the patient's vaccination record is unavailable, vaccines indicated for the patient's age, medical condition, and other risk factors should be administered to avoid missed vaccination opportunities (CDC, 2021).

Healthcare providers have a responsibility to educate patients on the importance of vaccination. Studies have shown that a strong recommendation from a healthcare provider on immunization leads to a

patient being four to five times more likely to receive a vaccination. Using presumptive language is an effective method for initiating vaccine conversations. Starting the conversation with strong language, such as "you need two vaccines today" rather than asking "are you interested in receiving vaccines today?" can result in significantly more parents choosing to vaccinate their children (CDC, 2021).

In the United States, vaccines are typically given as recommended by the Advisory Committee on Immunization Practices (ACIP). The vaccine schedule published by the ACIP is designed to be used as a tool to help patients, parents, and providers make sure that protection against disease is initiated when patients are most vulnerable. The vaccine schedules take into account the burden and timing of vaccine-preventable illnesses and the immunogenicity of the vaccines used to prevent them. Two schedules are available – one for children from birth to 18 years of age and one for adults. The vaccine schedules are updated annually to incorporate new evidence that arises. Current vaccine schedules can be found at cdc.gov/vaccines/schedules (CDC, 2021).

WHAT WOULD YOU DO?

Jeremy, who is two weeks shy of his fourth birthday, is in your office for a standard physical. His chart shows that he has had all age-appropriate immunizations, the exam shows that he is in good health, and Jeremy's mother reports that he is enjoying and doing well in preschool. Jeremy's mother is concerned that there have been measles outbreaks reported in several preschools and elementary schools in your city and asks if it would be possible to give Jeremy his second dose of the mumps-measles-rubella vaccine even though he is not quite four. How do you respond?

CDC Recommendations

CDC recommends all children get two doses of MMR vaccine starting with the first dose at 12 through 15 months of age, and the second dose at 4 through 6 years of age. Children can receive the second dose earlier as long as it is at least 28 days after the first dose.

Most of the vaccines recommended in the immunization schedules require two or more doses to initiate an adequate immune response. Evidence has shown that following the recommended intervals between doses and the recommended ages to administer them provides the best immune protection available from the vaccinations. In general, reducing the timing between doses can prevent the adequate development of an immune response. There are, however, a few exceptions to this rule. For example, vaccine doses given up to 4 days before the minimum dosing interval or age is reached are considered valid; this can help reduce missed opportunities to vaccinate. Doses given five days or more before the minimum dosing interval or age should be regarded as invalid and must be repeated when appropriate. Earlier ages or shorter intervals are also acceptable when patients need to be brought up to date quickly; for example, administering a second measles mumps rubella vaccine to a patient before age four due to a measles outbreak (CDC, 2021).

There are also times when scheduled vaccine doses are administered late. Late doses should be given at the next available clinic visit. Research shows that longer than recommended intervals between vaccine doses do not affect the overall immune response when the schedule is completed. This means

restarting vaccine series or administering additional doses of any vaccine is unnecessary if the patient is late (CDC, 2021).

Screening Patients

Before administering vaccines, patients should be screened for contraindications and precautions using standardized screening tools. It is important to screen patients every time vaccines are given, even if they received the same vaccine previously, because their health status or allergies may have changed since the last dose. Using screening tools prior to vaccine administration helps prevent adverse reactions, such as anaphylaxis (CDC, 2021).

Screening is commonly completed using questionnaires that are given to the patient to fill out prior to vaccination. The Immunization Action Coalition (2022) recommends asking patients 11 core questions before administering immunizations to prevent adverse events from occurring:

1. Are you sick today? While there have not been any studies showing that illness decreases the efficacy of vaccines or increases adverse events, patients with moderate to severe acute infections should delay vaccination until they have improved. This will ensure that If adverse events occur, they can be isolated from illnesses. Mild illnesses are not considered contraindications to vaccinations, and patients receiving antibiotics should not be denied vaccinations.

2. Do you have any allergies to vaccine components, latex, medications, or food?

3. Have you ever had a serious reaction after receiving a vaccination? Patients who have experienced anaphylactic reactions to vaccines or vaccine components, including latex, should not receive these products in an outpatient setting. It may be appropriate to administer these in a controlled, supervised medical setting after approval by their provider. Those who have skin reactions to latex should only receive vaccines that do not contain latex as a part of their packaging and should only receive bandages that do not contain latex.

4. Do you have a chronic lung, heart, or kidney condition, or have asthma, diabetes, a blood disorder, no spleen, a cochlear implant, a spinal fluid leak, a complement component deficiency, or take aspirin daily? These medical conditions are considered precautions for certain vaccines; the manufacturer's package insert should be consulted before administration to verify if it is appropriate to administer the vaccine.

5. Do you have an immune system condition such as cancer, leukemia, or HIV/AIDS? Patients with compromised immune systems typically have a contraindication to receiving live virus vaccines.

6. Do you have a sibling or parent with an immune system condition? Certain vaccines, such as measles, mumps, rubella, or varicella, should not be given to patients with a family history of hereditary or congenital immunodeficiency.

7. In the past three months, have you taken medications affecting your immune system, such as prednisone, steroids, chemotherapy, or radiation? Patients on high doses of steroids, or those

taking chemotherapy or radiation treatments, should generally delay vaccination with live virus vaccines until therapy has ended.

8. Have you had a seizure, brain disorder, or other nervous system condition? Patients with a history of certain nervous system conditions, such as encephalopathy caused by a vaccine, should avoid revaccination with that product.

9. Have you received a blood transfusion or immune globulin treatment in the past year? Some live virus vaccines should be delayed in patients with a recent history of these treatments.

10. For women: Are you pregnant or planning to become pregnant in the next month? Live virus vaccines should not be given to pregnant women or within one month before pregnancy due to potential risks to the baby.

11. Have you received any vaccines in the last 28 days? Patients who received a live virus vaccine in the past 28 days should wait before receiving another live virus vaccine.).

Get Ready to Prepare Vaccines

The Centers for Disease Control and Prevention recommends drawing up vaccines just prior to vaccine administration. A clean environment free from distractions should be used to prepare vaccines to prevent errors from occurring during vaccine preparation. Hand hygiene should be performed prior to preparing vaccines. Vaccines should be prepared for one patient at a time, and the manufacturer's package insert should be consulted for product-specific directions on how to prepare the vaccine (CDC, 2021).

Make Sure to Choose the Correct Vaccine

Since there may be a number of vaccines stored in the same refrigerator, it is critical to ensure the correct vaccine is chosen for administration. Always check the label to ensure the correct vaccine (and diluent if needed) has been selected before drawing up the dose for administration. Inspect the vaccine packaging to ensure it is not damaged or contaminated before using it. Storage temperatures should be verified to ensure the vaccine has been stored properly (CDC, 2021).

Vaccines are available in several different containers, including multi-dose vials, single-dose vials, prefilled syringes, oral applicators, and even a nasal sprayer. Single dose vials contain one dose of a vaccine for one patient. They are designed to be punctured with a needle once and discarded after the dose is withdrawn, so preservatives to prevent microorganism growth in the vial are unnecessary. Some single-dose vials contain slightly more vaccine than needed for one patient. When preparing a vaccine, it is important to ensure the appropriate amount is drawn out of the vial and the remainder discarded. The excess vaccine remaining after a dose is withdrawn should never be saved or combined with other leftovers to administer the vaccine to another person (CDC, 2021).

Multi-dose vials contain more than one dose of a vaccine. Preservatives are typically utilized to help prevent the growth of harmful microbes in multi-dose vials because they are punctured more than once to retrieve doses for multiple patients. The manufacturer's package insert will specify the number of

doses that should be withdrawn from a single multi-dose vial. After the specified number of doses has been removed, the remainder should be discarded. Partial doses should not be withdrawn and combined with remnants from other multi-dose vials to make a single dose due to the risk of contamination or inaccurate dosing. When using a multi-dose vial for more than one patient, the vial should be kept in a clean area dedicated to preparing medications and away from patient treatment areas to prevent contamination (CDC, 2021).

Prefilled syringes are syringes prepared under sterile conditions by the vaccine manufacturer that contain the exact amount of vaccine needed for a single dose. They are typically wrapped individually and are designed to be used for one injection for one patient. Since they are only used once, they do not contain preservatives. Once they are removed from their sterile packaging, the vaccine should be used or discarded by the end of the workday (CDC, 2021).

Oral applicators contain a single dose of a vaccine administered orally. This type of packaging is utilized for the oral rotavirus vaccine and does not contain preservatives. There is also a nasal sprayer that is used to administer the live attenuated influenza vaccine (CDC, 2021).).

Expiration Dates

Prior to preparing a vaccine, the expiration date should be checked to ensure it has not passed. Products with expiration dates that only have a month and year noted can be used until the end of the last day of the month printed on the product packaging. If a day is included in the expiration date, the product can be used through the end of the day. Products that have been contaminated or otherwise compromised should be discarded immediately, regardless of the expiration date (CDC, 2021).

Beyond use dates (BUD) are used in certain instances to shorten a product's expiration date. When vaccines are reconstituted, the time period in which they must be used or discarded is limited. The time period is different for each vaccine and can be found in the manufacturer's package insert; for example, some vaccines are only good for 30 minutes after reconstitution, and if not used within that time, they must be discarded. In addition, some multi-dose vials have a limited time frame for use after they have been punctured with a needle; for example, some state in their package insert that they must be used within 28 days of the first puncture. Beyond use dates may also be utilized when vaccines have been stored inappropriately when, depending on the situation, the manufacturer may allow the vaccine to be used within a shorter timeframe than the expiration date printed on the label. Beyond use, dates should never exceed the manufacturer's expiration date and should be recorded on the label with the initials of the person who calculated the BUD (CDC, 2021).

Choosing Supplies for Vaccine Administration

The Occupational Safety and Health Administration (OSHA) requires that vaccines be administered in all clinical settings using safety-engineered injection devices, such as syringes that shield the needle immediately after injection. This requirement is designed to decrease the risk of needlesticks and disease transmission. Syringes and needles are designed to be used for a single patient – neither should ever be reused. The packaging should be checked before use, and supplies with compromised

packaging should be discarded. If the needle or syringe has an expiration date, it must be checked and observed; expired supplies should never be used (CDC, 2021).

What Would You Do?

You are preparing to administer an IM vaccine injection to Terrance, a 25-year-old male weighing 160 pounds. Which of the following would be the most appropriate?

a) Administer in the deltoid muscle using a 5/8-inch needle
b) Administer in the anterolateral thigh using a 1-inch needle
c) Administer in the deltoid muscle using a 1-to-1.5-inch needle
d) Administer in the anterolateral thigh using a 5/8-inch needle

Based upon CDC recommendations, option C would be the most appropriate based on the patient's age, gender, and weight.

Injectable vaccines can be administered with either 1ml or 3ml syringes. Needles are classified by their length, typically in inches, as well as the thickness of the needle, known as its gauge. When choosing a needle, clinical judgment should be used to ensure the vaccine will reach the appropriate tissue to create its optimal immune response and decrease the risk of injection site reactions. Needle selection must factor in the patient's age, gender, and weight, injection site and technique, and the route of administration. Table 1 can help with needle selection in specific circumstances (CDC, 2021).

Table 1. Needle length and injection site of IM injections for children aged ≤18 years (by age) and adults aged ≥19 years (by sex and weight)

Age group	Needle length	Injection site
Children (birth-18 years)		
Neonates[a]	5/8 inch (16 mm)[b]	Anterolateral thigh
Infants, 1-12 months	1 inch (25 mm)	Anterolateral thigh
Toddlers, 1-2 years	1-1.25 inch (25-32 mm)	Anterolateral thigh[c]
	5/8[b]-1 inch (16-25 mm)	Deltoid muscle of arm
Children, 3-10 years	5/8[b]-1 inch (16-25 mm)	Deltoid muscle of arm[c]
	1-1.25 inches (25-32 mm)	Anterolateral thigh
Children, 11-18 years	5/8[b]-1 inch (16-25 mm)	Deltoid muscle of arm[c]
	1-1.5 inches (25-38 mm)	Anterolateral thigh
Adults (≥19 years)		
Men and women, <60 kg (130 lbs)	1 inch (25 mm)[d]	Deltoid muscle of arm
Men and women, 60-70 kg (130-152 lbs)	1 inch (25 mm)	
Men, 70-118 kg (152-260 lbs)	1-1.5 inches (25-38 mm)	
Women, 70-90 kg (152-200 lbs)		
Men, >118 kg (260 lbs)	1.5 inches (38 mm)	
Women, >90 kg (200 lbs)		
Men and women, any weight	1.5 inches (38 mm)[e]	Anterolateral thigh

Abbreviation: IM = intramuscular. Source: CDC, 2021.

[a] First 28 days of life.

[b] If skin is stretched tightly and subcutaneous tissues are not bunched.
[c] Preferred site.
[d] Some experts recommend a 5/8-inch needle for men and women who weigh <60 kg, if used, skin must be stretched tightly (do not bunch subcutaneous tissue)
[e] Some experts recommend a 1-inch needle if the skin is stretched tightly and subcutaneous tissues are not bunched.

Reconstituting Vaccines

Some vaccines come in two vials: one containing a dry powder or pellet and one containing a liquid diluent. These two must be combined to produce the vaccine in a process called reconstitution. Both parts are provided by the vaccine manufacturer and should be combined according to the manufacturer's recommendations found in the product's package insert. Typically, this involves drawing all of the diluent out of its vial and injecting it slowly into the vial containing the dry vaccine. Only the diluent provided by the manufacturer should be used to reconstitute a vaccine because they are specifically designed to match their corresponding vaccine's chemical, volume, and pH requirements. Vaccine doses reconstituted with the wrong diluent are considered invalid and must be repeated with the correct diluent (CDC, 2021).

Reconstitution should occur just before vaccine administration to prevent waste. Each vaccine manufacturer specifies the time frame that the vaccine must be used in, so the preparer can calculate its new beyond-use date. If the vaccine is not used within this timeframe, it must be discarded. The needle used to reconstitute the vaccine may be used for administration unless the needle is damaged or contaminated (CDC, 2021).

Drawing Vaccines into Syringes

Unopened vaccine vials come with caps on them that serve as a dust cover over the stopper. The cap does not guarantee that the stopper underneath is sterile, so the top should be wiped using a sterile alcohol swab and friction to remove any potential microorganisms. The alcohol wiped on the stopper will dry quickly while the needle is prepared (CDC, 2021).

The vial should be agitated prior to drawing out a dose to ensure the vaccine is mixed thoroughly. Some manufacturers require gentle mixing to prevent bubbles from forming, so verify the mixing process provided in the manufacturer's package insert before drawing the vaccine into the syringe. In addition, vials should be visually inspected before drawing up a dose to verify if any discoloration or contaminants are present. Vials with noted issues should not be used (CDC, 2021).

Vaccine doses should be drawn up with a brand new needle and syringe; used syringes or needles should never be used. The syringe should be used to draw up the vaccine from only one vial. Partial doses from separate vials and different vaccine products should not be drawn into the same syringe. Once the vaccine dose has been drawn into a syringe, it should not be transferred to another syringe. After drawing up a dose, the syringe should be labeled with the vaccine name to prevent confusion (CDC, 2021).

Pre-drawing Vaccines

What Would You Do?

Your clinic is preparing for a flu vaccination event. The day before the event, one of the nurses asks if she should pre-draw some syringes in order to save time at the event. What is your response?

Vaccines should only be drawn up immediately before administration. Syringes are designed for injecting products immediately after drawing them up – they are not designed to be used for vaccine or drug storage. Vaccines that do not contain preservatives can become contaminated with microorganism growth if stored in syringes. Vaccine potency can also be reduced over time through reactions with polymers found in plastic syringes. In addition, pre-drawing vaccine doses can result in vaccine waste if the doses are not used (CDC, 2021).

Vaccine manufacturers do not recommend pre-drawing doses of vaccines, even for large vaccine administration events. The CDC recommends using manufacturer-prefilled syringes for these events if possible. If vaccine doses must be prepared for large events, the CDC recommends drawing up vaccine doses only after arriving on-site at the vaccine administration location and using a separate station to prepare each type of vaccine to prevent errors. No more than one multi-dose vial, or ten doses, should be drawn up at one time. Clinic operators should monitor the flow of patients to ensure unnecessary doses are not drawn up. A reconstituted vaccine should only be drawn up immediately before administration. If reconstituted doses are drawn up and not used within 30 minutes, the manufacturer's guidance should be followed for time limits and storage requirements. Pre-drawn products should never be transferred back to the vial for storage. Any unused pre-drawn vaccines should be discarded at the end of the workday (CDC, 2021).

Procedures for Vaccine Administration

Give the Patient or Caregiver the Vaccine Information Statement (VIS)

Vaccine information statements are required by federal law to be provided prior to administering a routinely recommended childhood vaccine. This document provides vaccine-specific information on the benefits and risks of the vaccine. The VIS must be given to every patient prior to vaccination, regardless of age, and must be given prior to every dose of a vaccine, even if the patient has received the same vaccine and VIS before. The Centers for Disease Control and Prevention encourages vaccine information statements to be given to patients prior to all vaccines, regardless of whether it is federally required or not, since they are informative documents that can help patients understand the risks and benefits of vaccination. Vaccine information statements are available in paper and electronic formats (CDC, 2021).

Hand Hygiene

It is critical to perform hand hygiene before vaccine preparation, between patients, and when hands become soiled. Vaccine providers can use soap and water or an alcohol-based hand rub to clean hands. If hands become visibly dirty, they should be washed with soap and water (CDC, 2021).

Gloves are not required by the Occupational Safety and Health Administration (OSHA) unless the vaccine provider has open sores on their hands or it is likely that they will come in contact with infectious bodily fluids. In light of the COVID-19 pandemic, gloves are recommended when administering oral or nasal vaccines. If the vaccine provider chooses to wear gloves, they should be changed between patients, and hand hygiene should be performed with each change (CDC, 2021).

Routes of Administration

The specifics of the route, site, and dosage amounts of various vaccines are derived from clinical trails, practical experience, and other considerations. Table 2 outlines the normally recommended dosing and route information for common vaccines.

Table 2. Dose and Route Administration for Selected Vaccines

Vaccine	Dose	Route
DEN4CYD	0.5 mL	Subcut
DTaP, DT, Td, Tdap	0.5 mL	IM
DTaP-HepB-IPV	0.5 mL	IM
DTaP/Hib	0.5 mL	IM
DTaP-IPV/Hib	0.5 mL	IM
DTaP-IPV	0.5 mL	IM
Hib	0.5 mL	IM
Hib-MenCY	0.5 mL	IM
HepA	≤18 years: 0.5 mL ≥19 years: 1.0 mL	IM
HepB	≤19 years: 0.5 mL[(a)] ≥20 years: 1.0 mL	IM
HepA-HepB	≥18 years: 1.0 mL	IM
LAIV	0.2 mL divided dose between nares	Intranasal spray
IIV	6-35 months: 0.25 mL or 0.5 mL ≥3 years: 0.5 mL[(b)]	IM
MenB	0.5 mL	IM
MMR	0.5 mL	Subcut
MMRV	0.5 mL	Subcut
MenACWY	0.5 mL	IM
MPSV4	0.5 mL	Subcut

PCV13	0.5 mL	IM
PPSV23	0.5 mL	IM or Subcut
HPV	0.5 mL	IM
IPV	0.5 mL	IM or Subcut
Rotavirus (RV1 or RV5)	(1.0 mL or 2.0 mL)	Oral
Varicella	0.5 mL	Subcut
RZV	0.5 mL[c]	IM

Abbreviations: DEN4CYD = dengue vaccine; DT = diphtheria and tetanus toxoids; DTaP = diphtheria and tetanus toxoids and acellular pertussis; HepA = hepatitis A; HepB = hepatitis B; Hib = Haemophilus influenzae type b; HPV = human papillomavirus; IIV = inactivated influenza vaccine; IM = intramuscular; IPV = inactivated poliovirus; LAIV = live, attenuated influenza vaccine; MenACWY = quadrivalent meningococcal conjugate vaccine; MenB = serogroup B meningococcal vaccine; MenCY = bivalent meningococcal conjugate vaccine component; MMR = measles, mumps, and rubella; MMRV = measles, mumps, rubella, and varicella; MPSV4 = quadrivalent meningococcal polysaccharide vaccine; PCV13 = pneumococcal conjugate vaccine; PPSV23= pneumococcal polysaccharide vaccine; RV1 = live, attenuated monovalent rotavirus vaccine; RV5 = live, reassortment pentavalent rotavirus vaccine; RZV = recombinant adjuvanted zoster vaccine; Subcut = subcutaneous; Td = tetanus and diphtheria toxoids; Tdap = tetanus toxoid, reduced diphtheria toxoid, and acellular pertussis.

[a] Persons aged 11-15 years may be administered Recombivax HB (Merck), 1.0 mL (adult formulation) on a 2-dose schedule.

[b] Note that prefilled syringes of High-Dose Fluzone have a volume of 0.7 cc and the recommended volume of administration is 0.7 ccs.

[c] Do not withdraw more than 0.5 mL from the reconstituted product, even if some product is left in the vial.stopper

Intramuscular Vaccine Administration

Many vaccines are recommended for intramuscular injection, including tetanus, pneumonia, hepatitis, meningococcal, and shingles. These vaccinations are injected into the muscle located under the skin and subcutaneous tissue. The two muscles recommended for administering intramuscular injections are the vastus lateralis muscle found in the anterolateral thigh and the deltoid muscle in the upper arm. Using these muscles for intramuscular injections decreases the risk of inadvertently injecting into nerves or veins. Vaccinations for infants under 12 months of age should be given in the vastus lateralis muscle in the thigh. In toddlers 1-2 years of age, the vastus lateralis is preferred, though the deltoid muscle can be used if it has adequate muscle mass. The deltoid muscle is preferred in patients older than three, though the vastus lateralis can be used if the deltoid is insufficient or inaccessible (CDC, 2021).

When administering an intramuscular injection, proper hand hygiene should be performed first. The muscle used for injection should then be identified, and the area should be cleaned with a sterile alcohol swab and allowed to dry. The skin should be spread tight to isolate the muscle, and the needle can then be inserted into the middle of the muscle at a 90-degree angle. The vaccine is then injected, the needle is withdrawn, and a bandage can be applied to stop any bleeding (CDC, 2021).

Subcutaneous Vaccine Administration

Subcutaneous vaccines are injected into the fatty tissue located just below the dermis and above the muscle tissue. Patients 1 year and older are given subcutaneous vaccine injections in the fatty tissue found above the upper outer triceps in the arm. Infants younger than one year of age are typically given subcutaneous vaccinations in the fatty tissue of the thigh. Vaccines administered by subcutaneous injection include MMR (measles, mumps, and rubella) and varicella (CDC, 2021).

In order to administer a subcutaneous vaccination, proper hand hygiene must be performed first. Then the skin must be cleaned using a sterile alcohol swab and allowed to dry. Next, the skin and underlying fatty tissue should be pinched up, and the needle should be inserted at a 45-degree angle into the subcutaneous tissue. The vaccine is then injected quickly, and the needle is withdrawn afterward. A bandage can then be applied to stop any bleeding (CDC, 2021).

Intranasal Vaccine Administration

Only one vaccine is administered through the intranasal route: the live attenuated influenza vaccine (LAIV). This vaccine is sprayed into each nostril using a prefilled nasal sprayer. In order to administer the live attenuated influenza vaccine, hand hygiene should be performed first. Next, the rubber stopper on the nasal sprayer should be removed, and the tip of the applicator should be placed just inside the patient's nostril. Then the plunger should be pushed in a single, rapid motion until up to the dose divider clip. The dose divider clip is then removed, and the remaining vaccine can be administered in the other nostril. If the patient coughs or sneezes, the dose does not need to be repeated (CDC, 2021).

What Would You Do?

Your 6-year-old patient is behind on vaccinations. To help your patient get up to date, you are going to have to administer multiple vaccines during one visit. What is the best way to accomplish this in order to decrease the number of injections that have to be performed?

Multiple Vaccinations at Once

Administering multiple vaccines in one clinical visit is ideal for helping keep patients up to date with the vaccination schedule. Combination vaccines can help to decrease the number of injections performed at once, but even with a variety of combination vaccines available, it is often necessary to administer two or more vaccines in one visit. When giving multiple vaccinations at once, each vaccine should be given at a different injection site. Both the deltoid and vastus lateralis muscles have more than one injection site in each muscle. Injection sites should be separated by an inch or more to allow providers to identify injection site reactions if they occur (CDC, 2021).

For children receiving more than one intramuscular injection in the same limb, the vastus lateralis muscle is preferred due to its greater muscle mass and ability to separate injections from one another. Older children and adults with adequate muscle mass can use the deltoid muscle for multiple injections.

Vaccines more likely to cause pain or an injection site reaction, such as MMR or tetanus, should be administered in different limbs if possible (CDC, 2021).

Disposal of Supplies

All syringes and needles should be discarded immediately after use in a sharps container. These puncture-resistant, closeable containers help to prevent accidental needlestick injuries and the reuse of needles. Vaccine vials that are empty or expired should be discarded according to state regulations for medical waste set by each state's environmental agency (CDC, 2021).

Safety Considerations During Vaccine Administration

When administering vaccines, general precautions should be followed to reduce the risk of exposure to disease. Since the most significant risk of disease spread during vaccination is through person-to-person contact, proper hand hygiene should be performed before preparing vaccines and between each patient (CDC, 2021; CDC, 2022B).

Theoretical Exposure to Vaccine Components

Vaccine providers may have concerns when they have contraindications or precautions to the vaccines they are administering. There is no evidence showing any risk to the vaccine provider when administering routinely recommended vaccinations. Therefore, allergies, contraindications, or precautions present in the vaccine provider should not be considered a reason to avoid administering vaccinations (CDC, 2022B).

Preventing Bloodborne Disease

Bloodborne illnesses, such as hepatitis and HIV, are occupational hazards for vaccine providers. In 2000, the Needlestick Safety and Prevention Act was passed to reduce the risk of needlestick injuries and the subsequent spread of bloodborne illnesses. This act requires the use of engineered safety devices, such as self-sheathing needles and sharps containers, that prevent needlesticks. It also requires documentation of needlestick injuries (CDC, 2022B).

Preventing needlestick injuries requires consistent use of needle safety mechanisms every time a vaccine is administered. Once the needle is uncapped, the person administering the vaccine should never take their eye off the needle until it is safely disposed of in a sharps container. After injection, safety mechanisms that shield the needle should be used immediately, and used syringes should be immediately discarded in puncture-resistant sharps containers located in the same room used for vaccine administration. Caps should never be replaced on used needles (CDC, 2022B).

Vaccine Administration Errors

WHAT WOULD YOU DO?

It is an extremely busy day at the clinic. The provider has ordered the hepatitis B vaccine for patient Daniel. You discover that in your rush you accidentally administered the hepatitis A vaccine. What do you do?

Administration errors can have a number of consequences for the patient, including inadequate immunological response, cost, inconvenience, potential injury, and decreased confidence in the healthcare system. A number of administration errors can lead to these preventable events, including (CDC, 2021):

- Administering the wrong vaccine, such as giving the hepatitis A vaccine to a patient needing hepatitis B vaccination
- Administering the right vaccine in the wrong dosage, such as giving a pediatric vaccine dose to an adult
- Administering the right vaccine through the wrong route of administration, such as giving the Tdap vaccine through subcutaneous injection
- Administering vaccine or diluent that is expired
- Using the wrong diluent to reconstitute a vaccine or administering only the diluent
- Giving doses too early, such as giving the second dose of a vaccine too close to the first dose
- Administering a vaccine outside of its approved age range
- Administering a vaccine that was stored improperly
- Administering a vaccine to a patient with a contraindication

Some vaccine administration errors require revaccination. These include (CDC, 2021):

- Any immunization that is given using less than the required dosage must be repeated unless serologic testing shows an adequate immune response has developed. This includes partial doses given due to faulty syringes or needles or if the patient moves away during vaccination.
- Hepatitis B vaccine that is given by any route other than intramuscularly or at any site other than the deltoid or vastus lateralis muscle in the thigh
- Influenza vaccine administered through the subcutaneous route
- HPV vaccine that is given through any route other than intramuscularly

Vaccine administration errors that do not require revaccination include (CDC, 2021):

- Any vaccine that is given using more than the required dosage

- Vaccines that are given four or fewer days earlier than the minimum age or interval between doses
- Measles, mumps, rubella, or varicella vaccinations that are given through the intramuscular route
- Hepatitis A or meningococcal conjugate vaccines that are given through the subcutaneous route

Vaccine providers should be encouraged to report errors when an error occurs. Rather than trying to assign blame to a particular person, vaccine administration errors should be evaluated to find the root cause of the error to prevent recurrence as a part of the quality improvement process (CDC, 2021).

Procedures of Immunization-Related Documentation

All vaccines must be documented on the patient's permanent medical record. Providers who administer vaccines covered by the National Vaccine Injury Compensation Program, which includes all vaccines recommended on the child and adolescent vaccination schedules published by the Advisory Committee on Immunization Practices, are required to document several pieces of information regarding the vaccination. These include the vaccine name, manufacturer and lot number, the date the vaccine was administered, the name and title of the person administering the vaccine, the address of the facility where it was administered, and the publication date on the vaccine information statement (VIS) form given to the patient with vaccination (CDC, 2021).

Many states require providers to submit data to a state-sponsored immunization information system. These confidential digital databases collect data on all immunization doses provided to patients within the state. Since many patients have received vaccinations from more than one healthcare provider, immunization information systems ensure immunization records are collected in a centralized location to keep them easily accessible and updated. This helps improve access to immunization histories for patient recordkeeping and providers' clinical needs (CDC, 2021).

Reporting Adverse Reactions to Vaccines

Vaccine administration errors and adverse events related to vaccination must be reported to the Vaccine Adverse Event Reporting System (VAERS). This national surveillance system is managed by the CDC and the Food and Drug Administration (FDA) and is designed to monitor vaccine safety in the United States. It collects reports of vaccination errors and adverse events that occur after the administration of a vaccine. Adverse event reports are reviewed by VAERS staff to determine if further investigation is needed to see if an adverse event may be vaccine-related. This information is then further monitored and compared against new reports that come in to confirm if an adverse event is related to vaccination (CDC, 2021).

The VAERS system is reliant on adverse event reports submitted to their system. While healthcare providers and manufacturers of vaccines most commonly submit these reports, anyone can submit a report to the VAERS system. Healthcare providers are required to report adverse events after immunization and are encouraged to report events even if it is unclear if it was related to vaccination. Reports can be made online at vaers.hhs.gov (CDC, 2021).

Vaccine-Related Adverse Reactions

Administration of any vaccine has the potential to create an adverse reaction. Patients should be screened every time for contraindications and precautions prior to receiving an immunization in order to decrease the risk of an adverse event developing. Reactions that develop as a result of vaccination can range from minor to life-threatening. Vaccine providers should ensure they are able to identify and prevent adverse reactions to vaccinations. All providers should be certified in cardiopulmonary resuscitation (CPR) and be trained on the administration of epinephrine (CDC, 2021; Immunization Action Coalition, n.d.).

Local Reactions

Vaccinations commonly cause reactions at the injection site. A cold compress can treat itching, redness, soreness, or swelling. A pain reliever, such as acetaminophen, or anti-itch medication, such as hydrocortisone cream, can be used if local reactions are significant. Slight bleeding is common and can be treated with slight pressure and an adhesive bandage. Continuous bleeding can be treated with a thick layer of gauze pads over the injection site applied with firm pressure and raising the injection site above the level of the patient's heart (Immunization Action Coalition, n.d.).

What Would You Do?

You are administering a vaccine to Andrea, a 30-year-old female with no prior history of vaccine allergies or anaphylaxis. About 10 minutes after the injection, Andrea starts complaining of dizziness, shortness of breath, and tightness in her throat. You also notice hives on her face and neck. What do you do?

Severe Allergic Reactions

Life-threatening allergic reactions, known as anaphylaxis, are rare events that can be caused by vaccination. Many fear this reaction, but it is essential to remember that it is so rare that most vaccine providers will never see a true case of anaphylaxis caused by a vaccine. However, it is important to be prepared to diagnose and respond to this medical emergency in the event that it does arise (CDC, 2021; Immunization Action Coalition, n.d.).

Anaphylaxis is associated with a number of symptoms that can affect several organ systems. Respiratory symptoms can range from nasal congestion to wheezing, coughing, shortness of breath,

and a sensation of the throat closing. Skin and mucosal symptoms can include itching, hives, flushing, and swelling of the face, throat, eyes, and lips. Cardiovascular symptoms can occur, including dizziness, low blood pressure, and a racing heartbeat. Gastrointestinal symptoms are also possible, including nausea, vomiting, diarrhea, and abdominal pain. Since it can affect so many organ systems, the presentation of anaphylaxis is highly variable. Symptoms of anaphylaxis typically develop within 30 minutes after vaccination (CDC, 2021; Immunization Action Coalition, n.d.).

Patients who develop local reactions immediately following immunization should be monitored closely to watch for the development of symptoms of anaphylaxis. If symptoms of anaphylaxis develop, emergency medical services should be contacted immediately because most fatalities that occur in response to anaphylaxis are due to delayed treatment. If possible, this should be done by a second person so the primary vaccine provider can remain with the patient and assess their airway, breathing, circulation, level of consciousness, and vital signs. The patient should be monitored closely until emergency medical services arrive, and CPR can be performed if necessary to maintain the patient's airway. If the patient has difficulty breathing, their head can be elevated, as long as their blood pressure is high enough to prevent loss of consciousness. If the patient's blood pressure is low, their legs should be elevated. Blood pressure and pulse should be monitored every 5 minutes (CDC, 2021; Immunization Action Coalition, n.d.).

The first-line treatment of anaphylaxis is epinephrine. For patients with anaphylaxis, there are not any absolute contraindications to using this medication. The recommended dose for adults and children greater than 30kg (66lb) is 0.3mg; children under 30kg are given 0.15mg. The recommended dose should be injected into the muscle, preferably in the mid to outer thigh. The dose can be repeated two additional times every 5 to 15 minutes while waiting for emergency medical services to arrive. Emergency medical services should always be contacted if epinephrine is administered so the patient can be monitored due to the risk of cardiac complications following administration (CDC, 2021; Immunization Action Coalition, n.d.).

An optional treatment during anaphylaxis is the use of H1 antihistamines such as diphenhydramine. These medications can be used to help with itching or hives but do not replace the use of epinephrine, as they do not relieve airway obstruction, hypotension, or shock. Liquid diphenhydramine in a dose of 1-2mg/kg can be given every 4 to 6 hours, up to a maximum of 100mg in a single dose (CDC, 2021; Immunization Action Coalition, n.d.).

Once the patient has been stabilized or transferred to emergency medical services, they should be monitored for several hours because anaphylaxis can recur, even after symptoms have completely resolved. After the patient is transferred to the care of another provider, the vaccine provider should document the incident. The patient's reaction, vital signs, and medications administered, including the dosage, time, response, and name of the person administering, as well as all other relevant clinical information, should be recorded. The patient's primary care provider should be notified of the reaction. In addition, the reaction should be reported to the Vaccine Adverse Event Reporting System (VAERS) at www.vaers.hhs.gov (CDC, 2021; Immunization Action Coalition, n.d.).

Syncope

Syncope, or a temporary loss of consciousness caused by a reduction in blood pressure, can occur after vaccination. Since syncope can cause falls, leading to injuries, vaccine providers should ensure proper measures are taken to prevent injuries. Patients should be sitting or lying down during vaccination, so if dizziness or a loss of consciousness occurs, they will be in a safer position than standing. Vaccine providers should be encouraged to observe patients for 15 minutes after they receive a vaccination and monitor for symptoms that precede fainting, including dizziness, weakness, and an unhealthy pale appearance known as pallor. If syncope does occur, supportive care should be provided to prevent injuries (CDC, 2021).

How do I distinguish between syncope and anaphylaxis?

It is essential to differentiate between syncope and anaphylaxis when responding to vaccine-related adverse reactions. Accidentally treating a patient for anaphylaxis when they do not have it can lead to increased healthcare costs, potential cardiac complications, unnecessary trauma and anxiety, and avoidance of further immunizations. The following points can help differentiate between the two conditions and prevent confusion (Gustafson, n.d.):

- Anaphylaxis due to vaccination is very rare, while syncope is common, especially among teenage girls.
- Anaphylaxis typically occurs between 5 to 30 minutes after vaccination and has a prolonged recovery period. Syncope is sudden, can occur before, during, or immediately after vaccination, and has a quick recovery period of 1 to 2 minutes.
- Patients with anaphylaxis commonly experience agitation that is often described as a 'sense of impending doom', and if a loss of consciousness occurs, it generally occurs gradually. Syncope patients experience dizziness, weakness, and slump to the floor quickly.
- The skin of patients with anaphylaxis commonly appears flushed or red, may have rapidly developing hives spreading from the injection site, and may experience progressive swelling of the face, mouth, or tongue. A syncope patient's skin is commonly pale, cold, clammy, and perspiring excessively.
- Anaphylaxis patients often experience breathing abnormalities, including coughing, wheezing, or labored breathing, while syncope patients experience normal or shallow breathing.
- The pulse of anaphylaxis patients is typically rapid and weak, while syncope patients have a slower pulse.

Table 3 and Table 4 provide a quick reference for managing anaphylaxis in adults and children.

Table 3. Rapid overview: Emergent management of anaphylaxis in infants and children

Diagnosis is made clinically	The most common signs and symptoms are cutaneous (e.g., sudden onset of generalized urticaria, angioedema, flushing, pruritus). However, 10 to 20% of patients have no skin findings.
	Danger signs: Rapid progression of symptoms, evidence of respiratory distress (e.g., stridor, wheezing, dyspnea, increased work of breathing, retractions, persistent cough, cyanosis), signs of poor perfusion, abdominal pain, vomiting, dysrhythmia, hypotension, collapse.
Acute management	The first and most important therapy in anaphylaxis is epinephrine. There are NO absolute contraindications to epinephrine in the setting of anaphylaxis.
	Airway: Immediate intubation if evidence of impending airway obstruction from angioedema. Delay may lead to complete obstruction. Intubation can be difficult and should be performed by the most experienced clinician available. Cricothyrotomy may be necessary.
	IM epinephrine (1 mg/mL preparation): Epinephrine 0.01 mg/kg should be injected intramuscularly in the mid-outer thigh. For large children (>50 kg), the maximum is 0.5 mg per dose. If there is no response or the response is inadequate, the injection can be repeated in 5 to 15 minutes (or more frequently). If epinephrine is injected promptly IM, patients respond to one, two, or at most, three injections. If signs of poor perfusion are present or symptoms are not responding to epinephrine injections, prepare IV epinephrine for infusion (see below).
	Place patient in recumbent position, if tolerated, and elevate lower extremities.
	Oxygen: Give 8 to 10 L/minute via facemask or up to 100% oxygen, as needed.
	Normal saline rapid bolus: Treat poor perfusion with rapid infusion of 20 mL/kg. Reevaluate and repeat fluid boluses (20 mL/kg), as needed. Massive fluid shifts with severe loss of intravascular volume can occur. Monitor urine output.
	Albuterol: For bronchospasm resistant to IM epinephrine, give albuterol 0.15 mg/kg (minimum dose: 2.5 mg) in 3 mL saline inhaled via nebulizer. Repeat, as needed.
	H1 antihistamine: Consider giving diphenhydramine 1 mg/kg (max 50 mg) IV given over 5 minutes, or cetirizine (children age 6 months to 5 years can receive 2.5 mg IV, those 6 to 11 years of age can receive 5 or 10 mg IV, over 2 minutes).
	H2 antihistamine: Consider giving famotidine 0.25 mg/kg (max 20 mg) IV, over at least 2 minutes.
	Glucocorticoid: Consider giving methylprednisolone 1 mg/kg (max 125 mg) IV.

	Monitoring: Continuous noninvasive hemodynamic monitoring and pulse oximetry monitoring should be performed. Urine output should be monitored in patients receiving IV fluid resuscitation for severe hypotension or shock.
Treatment of refractory symptoms	Epinephrine infusion:[b] In patients with inadequate response to IM epinephrine and IV saline, give epinephrine continuous infusion at 0.1 to 1 mcg/kg/minute, titrated to effect.
	Vasopressors:[b] Patients may require large amounts of IV crystalloid to maintain blood pressure. Some patients may require a second vasopressor (in addition to epinephrine). All vasopressors should be given by infusion pump, with the doses titrated continuously according to blood pressure and cardiac rate/function monitored continuously and oxygenation monitored by pulse oximetry

IM: intramuscular; IV: intravenous.

[a] A child is defined as a prepubertal patient weighing less than 40 kg.

[b] All patients receiving an infusion of epinephrine and/or another vasopressor require continuous noninvasive monitoring of blood pressure, heart rate and function, and oxygen saturation. We suggest that pediatric centers provide instructions for preparation of standard concentrations and also provide charts for established infusion rate for epinephrine and other vasopressors in infants and children.

Source: Campbell RL, Kelso JM. Anaphylaxis: Emergency treatment. In: UpToDate, Post TW (Ed), UpToDate, Waltham, MA. (Accessed on December 9, 2021)

Table 4. Rapid overview: Emergency management of anaphylaxis in adults

Diagnosis is made clinically:	The most common signs and symptoms are cutaneous (e.g., sudden onset of generalized urticaria, angioedema, flushing, pruritus). However, 10 to 20% of patients have no skin findings.
	Danger signs: Rapid progression of symptoms, respiratory distress (e.g., stridor, wheezing, dyspnea, increased work of breathing, persistent cough, cyanosis), vomiting, abdominal pain, hypotension, dysrhythmia, chest pain, collapse.
Acute management:	The first and most important treatment in anaphylaxis is epinephrine. There are NO absolute contraindications to epinephrine in the setting of anaphylaxis.
	Airway: Immediate intubation if evidence of impending airway obstruction from angioedema. Delay may lead to complete obstruction. Intubation can be difficult and should be performed by the most experienced clinician available. Cricothyrotomy may be necessary.
Promptly and simultaneously, give:	IM epinephrine (1 mg/mL preparation): Give epinephrine 0.3 to 0.5 mg intramuscularly, preferably in the mid-outer thigh. Can repeat every 5 to 15 minutes (or more frequently), as needed. If epinephrine is injected promptly IM, most patients respond to one, two, or at most, three doses. If symptoms are not responding to epinephrine injections, prepare IV epinephrine for infusion.
	Place patient in recumbent position, if tolerated, and elevate lower extremities.
	Oxygen: Give 8 to 10 L/minute via facemask or up to 100% oxygen, as needed.
	Normal saline rapid bolus: Treat hypotension with rapid infusion of 1 to 2 liters IV. Repeat, as needed. Massive fluid shifts with severe loss of intravascular volume can occur.
	Albuterol (salbutamol): For bronchospasm resistant to IM epinephrine, give 2.5 to 5 mg in 3 mL saline via nebulizer. Repeat, as needed.
Adjunctive therapies:	H1 antihistamine:[a] Consider giving cetirizine 10 mg IV (given over 2 minutes) or diphenhydramine 25 to 50 mg IV (given over 5 minutes) (for relief of urticaria and itching only)
	H2 antihistamine:[a] Consider giving famotidine 20 mg IV (given over 2 minutes).
	Glucocorticoid:[a] Consider giving methylprednisolone 125 mg IV.
	Monitoring: Continuous noninvasive hemodynamic monitoring and pulse oximetry monitoring should be performed. Urine output should be monitored in patients receiving IV fluid resuscitation for severe hypotension or shock.
Treatment of refractory symptoms:	Epinephrine infusion:[b] For patients with inadequate response to IM epinephrine and IV saline, give epinephrine continuous infusion, beginning at 0.1 mcg/kg/minute by infusion pump[c]. Titrate the dose continuously according to blood pressure, cardiac rate and function, and oxygenation.
	Vasopressors:[b] Some patients may require a second vasopressor (in addition to epinephrine). All vasopressors should be given by infusion pump, with the doses titrated continuously according to blood pressure and cardiac rate/function and oxygenation monitored by pulse oximetry.

	Glucagon: Patients on beta blockers may not respond to epinephrine and can be given glucagon 1 to 5 mg IV over 5 minutes, followed by infusion of 5 to 15 mcg/minute. Rapid administration of glucagon can cause vomiting.

IM: intramuscular; IV: intravenous.
[a] These medications should not be used as initial or sole treatment.
[b] All patients receiving an infusion of epinephrine and another vasopressor require continuous noninvasive monitoring of blood pressure, heart rate and function, and oxygen saturation.
[c] For example, the initial infusion rate for a 70 kg patient would be 7 mcg/minute. This is consistent with the recommended range for non–weight-based dosing for adults, which is 2 to 10 mcg/minute. Non–weight-based dosing can be used if the patient's weight is not known and cannot be estimated.
Source: Campbell RL, Kelso JM. Anaphylaxis: Emergency treatment. In: UpToDate, Post TW (Ed), UpToDate, Waltham, MA. (Accessed on December 9, 2021)

Pain

Procedural pain from vaccine administration is common and can lead to the development of needle phobias, preprocedural anxiety, and avoiding necessary healthcare in patients of all ages. Injection fear and procedural pain are common reasons for vaccine refusals; up to 25% of adults report a fear of needles, and most of these fears develop in childhood. While procedural pain during vaccine administration is somewhat unavoidable, evidence-based interventions can be used to ease injection pain (CDC, 2021).

Vaccines should be injected quickly to reduce pain and the needle should be withdrawn quickly. Aspiration, or the process of pulling back on the plunger of the syringe prior to administering medication, should not be done. Aspiration was previously performed to ensure the vaccine was being injected into the muscle rather than into a vein, but no reports have been made of injuries due to a failure to aspirate. Aspiration can be painful and requires the needle to be in the tissue for a longer time, which can lead to increased pain. A 2007 Canadian study compared the use of rapid injection, no aspiration, and rapid withdrawal to slow injection, aspiration, and slow withdrawal in infants and found that rapid injection/withdrawal and no aspiration resulted in less pain (CDC, 2021).

Some vaccines are associated with a painful stinging sensation when administered. These include the pneumococcal conjugate vaccine, the MMR (measles, mumps, rubella) vaccine, and the human papillomavirus vaccine. When administering multiple vaccinations, pain often increases with each injection, so giving the more painful vaccines last can decrease the pain felt throughout the procedure (CDC, 2021).

Breastfed children two years of age and younger can experience less pain if fed before, during, and after vaccination. Several mechanisms are thought to reduce pain during breastfeeding, including distraction, being held by the mother, skin-to-skin contact, suckling, and swallowing breastmilk. Adverse reactions, such as spitting up or choking, have not been reported. Alternatives to breastfeeding include bottle feeding with expressed breast milk or formula or administering a sweet-tasting solution 1-2 minutes before vaccine administration (CDC, 2021).

Topical pain relievers, such as lidocaine, can also be used to decrease injection pain. They inhibit pain signal transmission from the skin to reduce pain felt with needle penetration and muscle spasms triggered during injection, especially when more than one injection is administered. Topical products must be given time to start working before vaccine administration, so coordination with the patient or parent may be required. The use of systemic pain relievers such as acetaminophen or ibuprofen is not recommended because there is no evidence proving their effectiveness in reducing injection pain, and they may have a role in suppressing the immune response to some vaccine antigens (CDC, 2021).

Appropriate body positioning can also have an impact on reducing procedural pain with vaccine administration. Parents of children up to age three should be encouraged to embrace their child during vaccination. This prevents children from moving their limbs during injection, reduces acute distress, and encourages parents to nurture their children. Studies have shown that children three years and older experience less pain and fear when receiving an injection sitting up rather than lying down. It is thought to be due to a reduction in anxiety, thereby reducing the perception of pain, though the exact mechanism is unknown. Moderate tactile stimulation, such as rubbing or stroking the skin near the injection site before and during injection, can also decrease pain in patients four years and older. This reduction of pain is thought to be related to tactile sensations competing with feelings of pain, resulting in less pain (CDC, 2021).

Adverse Reactions in Children

Children receive many vaccines in the first few years of their lives, and mild side effects can occur as a result. Fevers are possible and can be treated with ibuprofen or acetaminophen as appropriate for the child's age and weight. Children experiencing fevers should never be given aspirin. The child should also be given plenty of fluids to drink and dressed lightly. High temperatures or concerning behaviors should be reported to the child's healthcare provider (Immunization Action Coalition, 2019).

Children may also become fussy after vaccination due to pain or fever. Acetaminophen or ibuprofen can be given as appropriate for the child's age and weight to ease discomfort. Fussiness that remains for more than 24 hours should be reported to the child's healthcare provider (Immunization Action Coalition, 2019).

Swollen injection sites are also possible adverse reactions to vaccinations. Acetaminophen or ibuprofen can be given to treat pain. A clean washcloth dampened with cold water can be applied to the sore area can help comfort the child. Injection sites with redness or tenderness that increases after 24 hours should be reported to the child's healthcare provider (Immunization Action Coalition, 2019).

Parents should be counseled to seek medical attention right away in the following situations (Immunization Action Coalition, 2019):

- If the child is pale or limp.
- If the child has a temperature that the provider said would be alarming.
- If the child has been crying for more than 3 hours and won't stop.
- If the child is significantly less responsive or active.
- If the child is shaking, jerking, or twitching.

Best Practices for Receiving, Storing, and Handling Vaccines

Vaccines have specific requirements for storage and handling, and improperly stored or handled vaccines may have reduced efficacy and often cannot be used due to the risk of an inadequate immune response. The costs associated with wasted vaccines can be significant. During the COVID-19 pandemic, North Carolina reported wasting over 703,000 COVID-19 vaccine doses between December 2020 and October 2021, costing approximately $12 million (Kummerer, 2021).

Maintaining the Cold Chain

Once a vaccine is manufactured, it must be transported from the manufacturer to health clinics worldwide and stored at proper temperatures throughout its travels. This global network of freezers, refrigerators, cold rooms, and coolers is known as the vaccine cold chain. It ensures vaccines are kept at the correct temperature throughout the entire journey from the manufacturing plant, through transport, to storage at the provider's facility, and all the way to vaccine administration. Maintaining the cold chain is the responsibility of everyone involved in handling vaccines and relies on well-trained staff, dependable temperature monitoring equipment, and effective inventory management. When vaccines are exposed to temperatures outside their recommended storage range, vaccine potency is lost and cannot be restored. This can result in increased costs for vaccine providers, extra doses for patients, and decreased public confidence in vaccination (CDC, 2022AA; CDC, 2021).

What Would You Do?

A new aide is helping to unload a new vaccine shipment into the storage refrigerator. You notice that she has placed vaccines on the top and bottom shelf and door of the refrigerator. How do you respond?

Facilities that provide vaccinations should have storage and monitoring equipment in working order, maintained appropriately, and monitored regularly. When using a household-grade refrigerator/freezer combination unit, only the refrigerator portion should be used for vaccine storage. The freezer compartment is not recommended for vaccine storage because temperature fluctuations can expose vaccines to inappropriate storage conditions. Crisper bins should be replaced with bottles of water labeled 'do not drink or remove' to maintain a consistent temperature. The refrigerator should never be unplugged; signs should be placed near the electrical outlet to ensure temperatures remain consistent (CDC, 2018). Vaccines should never be stored in dormitory-style refrigerators with a cooling plate for a freezer; these units put vaccines at significant risk of freezing, even if used for temporary storage (CDC, 2022AA; CDC, 2021).

Every storage unit used for vaccines must have a reliable temperature monitoring device. The CDC recommends using a continuous temperature monitoring and data recording device that records temperatures at least every 30 minutes. If a continuously recording device is unavailable, temperatures

should be monitored at least twice daily. Temperature monitoring devices should have an alarm that sounds when temperatures are out of range, an indicator for when its battery is low, and a display showing the current temperature and the lowest and highest temperatures recorded. Reliable temperature monitoring devices should be used on every vaccine storage unit and transportation unit, and backups should be available in case of device failure. Temperature monitoring devices should be calibrated according to the manufacturer's suggested timeline to ensure measured temperatures are accurate (CDC, 2022AA; CDC, 2021).

Vaccine storage units should be set up in an area with good ventilation, with space left between the unit and any walls. The CDC recommends setting up the unit and monitoring minimum and maximum temperatures for 2 to 7 workdays to ensure the temperatures are stable for vaccine storage. The power supply to the unit should be protected; signs should be posted not to unplug the unit, and child safety outlet covers can be used to prevent accidental unplugging. Breaker boxes should be labeled to avoid accidental shutoff, and plugs connected to a wall switch, those with a reset button, and multi-outlet power strips should be avoided (CDC, 2022AA; CDC, 2021).

Regular maintenance of vaccine storage units is critical to ensuring the vaccine cold chain remains intact. Door seals should be checked regularly to assess for signs of wear and tear. Doors should be adjusted to ensure they close smoothly and properly; using open door alarms and self-closing doors can help ensure doors remain closed. The inside of vaccine storage units should be disinfected regularly to discourage the growth of pathogens, though this should be done quickly to ensure temperatures remain stable. Freezers should be defrosted when frost levels exceed either 1cm or the manufacturer's recommendation; vaccines should be stored in an alternative location during defrosting. Temperature adjustments may be necessary over time; these should only be done after confirming that other issues are not present, such as accidental unplugging or a door left open. If backup generators are used, they should be tested at least once every three months and serviced annually according to the manufacturer's recommendation (CDC, 2022AA; CDC, 2021).

Vaccine Storage

Vaccines should be stored in their original packaging until it is time to administer them. Vials and prefilled syringes should not be taken out of their packaging due to the risk of exposure to light, vaccine administration errors, and more complicated inventory management. Vaccines and diluents should be arranged in neat rows with 2 to 3 inches of space between them to allow for adequate air circulation. Diluents should be stored next to their vaccines whenever possible to prevent vaccine preparation errors, though diluents should never be stored in the freezer. Vaccines and diluents with the earliest expiration date should be placed in front of products with later expiration dates; this ensures vaccines that are expiring soon will be used first, minimizing waste. Vaccines with similar packaging, names, or pediatric and adult formulations of the same vaccine should be stored on separate shelves to prevent errors (CDC, 2022A; CDC, 2021).

Vaccines should be stored at least 2 to 3 inches from the refrigerator walls, and vaccines should never be stored on the top shelf of the fridge, on the floor, in drawers, or on shelves located on the door. This is because the center of the refrigerator has the most stable temperature and appropriate airflow. The

temperature monitoring device should be placed in the center of the unit with vaccines surrounding it to display the most accurate vaccine storage temperature. Food or beverages should never be stored in the same refrigerator as vaccines, and the refrigerator door should always remain closed when vaccines are not being accessed (CDC, 2022A; CDC, 2021).

Refrigerators should maintain temperatures between 36°F and 46°F (2°C and 8°C), and freezers should maintain temperatures between -58°F and +5°F (-50°C and -15°C). If temperatures are not monitored continuously, temperatures should be recorded on a log sheet at least twice daily, at the beginning and end of the workday. The log sheet should include the date, time, and name of the person recording the temperature. If the vaccine storage temperature is out of range, immediate action should be taken. The facility vaccine coordinator or supervisor should be notified immediately, and exposed vaccines should be labeled 'do not use' and separated from other viable vaccines. Facility protocols should be followed, and manufacturers can be consulted to help determine if the improperly stored vaccine has any viable use (CDC, 2022A; CDC, 2021).

Receiving Vaccines

Receiving and unpacking vaccine deliveries is an essential element of vaccine inventory management. Vaccines should only be scheduled for delivery on days and times when staff are present. Packages containing vaccines should never be left unattended or delivered when the facility is closed because this could result in a break in the cold chain (CDC, 2022A; CDC, 2021).

Vaccine deliveries should always be opened immediately upon receipt; vaccines should not be stored in an unopened shipping container or left to open at a later time after delivery. The shipping box should be examined for signs of damage to ensure the vaccines were stored properly in transit. The packing list should be reviewed, and each item should be verified to ensure the entire order is accounted for and present. Vaccines with diluents should be verified to ensure the correct type and amount of diluent was shipped. Expiration dates for all products should be checked to be sure nothing is expired or will expire soon. If a temperature monitoring system is present on or in the packaging, it should be checked to see if any temperature excursions occurred during shipment (CDC, 2022A; CDC, 2021).

If any issues arise when checking in the vaccines, such as temperature excursions or discrepancies in the quantity delivered, the vaccine manufacturer should be contacted immediately. In the event of temperature excursions during transit, the vaccine should be stored in its appropriate temperature conditions and labeled 'do not use' until it can be determined if the vaccine is viable (CDC, 2022A; CDC, 2021).

Inventory Management

Vaccine inventories should be evaluated monthly as well as before placing orders to ensure there are enough doses on hand for the facility's needs, without ordering excessive amounts that will expire before they can be used. Vaccine inventory should be checked for expired products regularly; expired products should be removed immediately to prevent accidental administration. Inventory should be rotated periodically to ensure soon-to-expire products are used first (CDC, 2022A; CDC, 2021).

There are times when unused vaccines, expired vials, and potentially contaminated vaccines can be returned for credit, even if they are unusable. The vaccine manufacturer or distributor can provide more information on which products can be accepted for credit. Vaccines that have been drawn up, open or broken vials, and opened manufacturer-filled syringes typically cannot be returned for credit and must be discarded according to state and local requirements (CDC, 2022A; CDC, 2021).

WHAT WOULD YOU DO?

One of your aides is helping you pack vaccines in a Styrofoam cooler for transport to an off-site vaccination clinic. You observe her placing frozen gel packs into the container. How do you respond?

Transporting Vaccines

In general, vaccines should always be delivered straight to the facility where they will be administered. However, there are times when vaccines need to be transported to an off-site clinic or satellite facility. Emergencies, such as power outages or natural disasters, may also require vaccines to be transported from one location to another. Vaccines should be packaged carefully using the following recommendations to ensure the cold chain is not broken prior to vaccine administration (CDC, 2022A; CDC, 2021).

Using specially engineered vaccine transport containers is ideal for vaccine transport, though Styrofoam containers or the manufacturer's original shipping container can be used if these are not available. Food and beverage coolers should not be used for transporting vaccines. Coolant materials, such as water bottles conditioned to 39° F to 41° F or specially engineered cooling shipping materials, should be used to ensure adequate temperatures are maintained for the entire time the vaccines are away from the central storage unit. Frozen gel packs or coolant packs from the manufacturer's original vaccine shipping container should not be used for vaccine transport as these can potentially freeze vaccines. Temperature monitoring devices should be used during transport and anytime vaccines are away from their home storage unit to ensure the cold chain is not broken (CDC, 2022A; CDC, 2021).

If vaccines need to be transported to an off-site vaccine clinic, the vaccine should not be away from the facility storage unit for more than 8 hours. Diluents should be transported with their corresponding vaccines to make sure there are matching quantities of each. Only the amount of vaccine needed for the day should be transported. If a vehicle is used, the storage containers should be transported in the passenger area, not in the trunk (CDC, 2022A; CDC, 2021).

In the event of power outages, the door of the vaccine storage unit should only be opened when ready to pack the vaccine in a container for transport. The receiving storage units should be checked before packing up the vaccines to ensure they can accept them. If emergencies can be anticipated, such as in the event of a weather issue like a hurricane, immunization activities should be suspended before the

onset of emergency conditions to allow time for packaging and transporting vaccines (CDC, 2022A; CDC, 2021).

If frozen vaccines need to be transported, a portable vaccine freezer or qualified container that maintains temperatures between -58° F and +5° F (-50° C and -15° C) should be used. A temperature monitoring device should be placed as close to the vaccine as possible, and vaccines should be placed in a vaccine storage freezer immediately upon arrival at the destination. The time the vaccines are put into shipping packaging, the temperature during transport, and the time at the end of transport should all be recorded. Dry ice should never be used, even for temporary vaccine storage, because it can potentially expose vaccines to temperatures lower than 58° F (CDC, 2022A).

Conclusion

Vaccines are one of the most successful and effective public health tools to prevent illness and premature death from vaccine-preventable diseases. Ensuring vaccines are administered in a safe and effective manner is critical to the success of immunization programs both locally and across the United States. Safe vaccine administration has a positive impact on vaccine confidence, which leads to improved immunization rates, reduced disease burden, and safer communities. Healthcare professionals who administer vaccines have a responsibility to educate themselves on the best practices for vaccine preparation, administration, and storage, as well as the most appropriate steps to take in managing adverse events. This knowledge base can prepare professionals to actively prevent the spread or re-emergence of vaccine-preventable diseases.

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Post-Test

Activity tests must be completed online at www.AchieveCE.com.
A passing grade of 70 or higher and completion of an online activity evaluation are required to earn credit.

1. In the United States, vaccines are typically given as recommended by:
    a. The Advisory Committee on Immunization Practices (ACIP)
    b. The Food and Drug Administration
    c. The Immunization Action Coalition
    d. The US Department of Health and Human Services

2. Which of the following questions should be asked before administering immunizations to prevent adverse events from occurring?
    a. Have you received any vaccines in the last 6 months?
    b. Have you received a blood transfusion in the last 5 years?
    c. Are you planning to become pregnant in the next year?
    d. Are you sick today?

3. If a product has an expiration date of 03/2022, what is the last day/time that it can be used?
    a. Before the clinic closes on February 28, 2022
    b. Before the clinic closes on March 1, 2022
    c. Before the clinic closes on March 31, 2022
    d. Before the clinic opens on March 31, 2022

4. Which of the following needles should be used to administer an intramuscular injection to a 14-year-old child?
    a. A 24 gauge 0.25" needle
    b. A 23 gauge 1" needle
    c. A 25 gauge 1.5" needle
    d. A 24 gauge 2" needle

5. It is critical to perform hand hygiene at all of the following times:
    a. Before vaccine preparation
    b. Between patients
    c. When hands become soiled
    d. All of the above

6. Vaccinations for infants under 12 months of age should be given in which of the following locations?
    a. The vastus lateralis muscle in the thigh
    b. The gluteus maximus muscle in the hip
    c. The deltoid muscle in the upper arm
    d. The hamstring muscle in the leg

7. When administering multiple vaccinations at once, injection sites should be separated by _____ or more to allow providers to identify injection site reactions if they occur.

a. 2 inches
b. 1 inch
c. 1 centimeter
d. 6 inches

8. The Needlestick Safety and Prevention Act requires the use of all of the following EXCEPT:
    a. Self-sheathing needles
    b. Sharps containers
    c. Documentation of needlestick injuries
    d. Hepatitis B testing for employees

9. Once the needle is uncapped, the person administering the vaccine should never take their eye off the needle until it is safely disposed of in which of the following:
    a. A garbage can
    b. A medical waste bucket
    c. A sharps container
    d. A recycle bin

10. Which of the following vaccine administration errors requires revaccination?
    a. Influenza vaccine administered through the subcutaneous route
    b. A vaccine given using more than the required dosage
    c. Vaccines that are given four or fewer days earlier than the minimum age or interval between doses
    d. Varicella vaccinations that are given through the intramuscular route

11. Providers who administer vaccines covered by the National Vaccine Injury Compensation Program are required to document all of the following EXCEPT:
    a. The vaccine manufacturer
    b. The phone number of the facility where it was administered
    c. The date the vaccine was administered
    d. The publication date on the vaccine information statement (VIS) form given to the patient

12. Since many patients have received vaccinations from more than one healthcare provider, _____ ensure immunization records are collected in a centralized location to keep them easily accessible and updated.
    a. The Vaccine Adverse Event Reporting System (VAERS)
    b. The Centers for Disease Control and Prevention (CDC)
    c. The Food and Drug Administration (FDA)
    d. Immunization information systems

13. Which of the following should be reported to the Vaccine Adverse Event Reporting System (VAERS)?
    a. 10 doses of M-M-R vaccine that expired and were discarded prior to use
    b. A pediatric dose of the COVID-19 vaccine was given to an adult
    c. A Shingles vaccine that was reconstituted incorrectly and discarded prior to use
    d. A second dose of Hepatitis B vaccine that was given 2 days late

14. All of the following are appropriate to treat a local reaction at the vaccine injection site EXCEPT:
    a. A cold compress
    b. Hydrocortisone cream
    c. Acetaminophen
    d. Epinephrine

15. Which of the following is the first step in responding to an anaphylactic reaction to a vaccine?
    a. Call for emergency medical services
    b. Start CPR
    c. Administer diphenhydramine
    d. Document the patient's vaccine in their medical record

16. Which of the following steps can help to decrease injection pain associated with vaccination?
    a. When administering multiple vaccinations, give the more painful vaccines first
    b. Inject the vaccine slowly
    c. Withdraw the needle quickly after vaccination
    d. Aspirate prior to administering the vaccine

17. Parents should be counseled to seek medical attention right away in all of the following situations following a vaccination EXCEPT:
    a. If the child is pale or limp
    b. If the child has been crying for more than 10 minutes and won't stop
    c. If the child is significantly less responsive or active
    d. If the child is shaking, jerking, or twitching

18. Which of the following vaccine storage recommendations is correct?
    a. Vaccines should be stored on the top shelf of the refrigerator
    b. Pediatric and adult formulations of the same vaccine should be stored next to each other
    c. Food can be stored in the same refrigerator as vaccines, as long as it is on a separate shelf
    d. Vaccines should be stored in the center of the fridge, at least 2 to 3 inches away from refrigerator walls, and not on the top shelf, on the floor, in drawers, or on the door shelves.

19. All of the following are correct procedures for receiving vaccines EXCEPT:
    a. Vaccine deliveries should always be opened immediately upon receipt
    b. The packing list should be reviewed, and each item should be verified to ensure the entire order is accounted for and present
    c. Vaccines can be delivered on a Sunday when the clinic is closed
    d. Vaccines with diluents should be verified to ensure the correct type and amount of diluent was shipped

20. If vaccines need to be transported to an off-site vaccine clinic, the vaccine should not be away from the facility storage unit for more than _____.
    a. 8 hours
    b. 4 hours

c. 24 hours
d. 12 hours