

# Teaching Immunization

*for Medical Education (TIME)*



MULTISTATION CLINICAL TEACHING SCENARIOS

## **Pertussis Prevention: Facilitator's Answer Key**

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## SOURCES OF INFORMATION ON PERTUSSIS VACCINE

1. Pertussis Vaccination: Use of Acellular Pertussis Vaccines Among Infants and Young Children Recommendations of the Advisory Committee on Immunization Practices March 28, 1997 / 46(RR-7);1-25.  
<http://www.cdc.gov/mmwr/PDF/rr/rr4607.pdf>
2. Broder, KR, Cortese MM, Iskander JK, et al. Preventing tetanus, diphtheria, and pertussis among adolescents: use of tetanus toxoid, reduced diphtheria toxoid and acellular pertussis vaccines. Recommendations of the Advisory Committee on Immunization Practices (ACIP). MMWR. 2006. 55(RR-03):1-34.  
[http://www.cdc.gov/mmwr/preview/mmwrhtml/rr5503a1.htm?s\\_cid=rr5503a1\\_e](http://www.cdc.gov/mmwr/preview/mmwrhtml/rr5503a1.htm?s_cid=rr5503a1_e)
3. Kretsinger K, Broder K, Cortese MM, et al. Preventing Tetanus, Diphtheria, and Pertussis Among Adults: Use of Tetanus Toxoid, Reduced Diphtheria Toxoid and Acellular Pertussis Vaccine. Recommendations of the Advisory Committee on Immunization Practices (ACIP) and Recommendation of ACIP, supported by the Healthcare Infection Control Practices Advisory Committee (HICPAC), for Use of Tdap Among Health-Care Personnel. MMWR 2006. 55(RR-17):1-33.  
<http://www.cdc.gov/mmwr/preview/mmwrhtml/rr5517a1.htm>
4. American Academy of Pediatrics. Pertussis. In: Pickering LK. ed. *Red Book: 2009 Report of the Committee on Infectious Diseases*. 27<sup>th</sup> ed. Elk Grove Village, IL: American Academy of Pediatrics; 2009.
5. Edwards KM, Decker MD. Pertussis vaccine. In: Plotkin SA, Orenstein WA, Offit PA, eds. *Vaccines*. 5<sup>th</sup> ed. W.B. Saunders Company; 2008:467-518.
6. Centers for Disease Control and Prevention. *Epidemiology and Prevention of Vaccine-Preventable Diseases*. Atkinson W, Wolfe S, Hamborsky J, McIntyre L, eds. 11<sup>th</sup> ed. Washington DC: Public Health Foundation, 2009. This book may be

viewed at <http://www.cdc.gov/vaccines/pubs/pinkbook/default.htm>, and may be purchased from the Public Health Foundation by calling 1-877-252-1200. The Pink Book: Slide Sets <http://www.cdc.gov/vaccines/pubs/pinkbook/pink-slides.htm> or a shortened version of the same slide set available at [http://www.aptrweb.org/resources/curriculum\\_time.html](http://www.aptrweb.org/resources/curriculum_time.html).

7. Centers for Disease Control and Prevention. Recommended childhood and adolescent immunization schedules for the United States. Available at: <http://www.cdc.gov/vaccines/recs/schedules/child-schedule.htm#printable>.
8. Centers for Disease Control and Prevention. Recommended adult immunization schedule for the United States. Available at: <http://www.cdc.gov/vaccines/recs/schedules/adult-schedule.htm>.
9. Recording of pertussis cough (from homepage at [www.ImmunizationEd.org](http://www.ImmunizationEd.org) Click on Pertussis Cough icon).

Please note that much of this information is available online. Immunization schedules and recommendations change periodically, and students should be encouraged to be familiar with immunization websites such as the National Center for Immunization and Respiratory Diseases (where ACIP recommendations can be found) and to check them for the latest information. <http://www.cdc.gov/vaccines>

**Answers to Questions for Learners – Scenario One**

1. What is the clinical stage of Shala's illness?

Pertussis occurs in three phases: catarrhal, paroxysmal, and convalescent. The catarrhal phase is characterized by upper respiratory tract symptoms and cough. The paroxysmal phase is characterized by paroxysmal cough, posttussive emesis, and inspiratory whoop. Shala is in the paroxysmal stage.

2. What are the serious complications of her current illness?

The serious complications of pertussis include apnea, seizures, secondary bacterial pneumonia, cyanosis, hypoxia, encephalopathy, and death.

3. How should a definitive diagnosis be made?

A clinical case of pertussis is defined as an acute cough illness lasting at least two weeks with either paroxysms of cough, inspiratory “whoop”, or posttussive vomiting without other apparent cause (as reported by a health professional). A confirmed case is a clinically compatible case that is laboratory confirmed or epidemiologically linked to a laboratory-confirmed case. Culture is considered by many to be the gold standard but the organism is hard to culture. Many laboratories now use polymerase chain reaction (PCR), although some laboratories experience high rates of false positive PCR results and the PCR assay is not standardized for pertussis.

4. What should be done for Shala?

Shala should be hospitalized and receive intravenous hydration, supplemental oxygen, and antibiotics (the choice should take into account effectiveness, safety (including the potential for adverse events and drug interactions), tolerability, ease of adherence to the regimen prescribed, and cost.) She should be placed on an apnea monitor or oximeter.

5. From whom did Shala contract pertussis?

The incubation period ranges from 5 to 21 days and is typically 7 to 10 days. Since Shala developed her cough on day 7 of her mother's cough (Shala's mother has had a cough illness for 3 weeks and Shala has coughed for 2 weeks), Shala most likely contracted pertussis from her mother.

**Take Home Points:**

- Pertussis has serious complications including pneumonia, apnea, hypoxia, encephalopathy, and death.
- Adults can transmit pertussis to infants.

**Answers to Questions for Learners – Scenario Two****Note to facilitator:**

This scenario covers a lot of information and may take the learners longer than 8 to 10 minutes.

**1. Do the persons with symptoms have pertussis?**

A clinical case of pertussis is defined as “a cough illness lasting  $\geq 2$  weeks with one of the following: paroxysms of coughing, inspiratory ‘whoop,’ or posttussive vomiting, without other apparent cause.” A case is considered to be confirmed if laboratory confirmed or epidemiologically linked to a laboratory-confirmed case [MMWR 1997;46 (RR-07):25] <http://www.cdc.gov/mmwr/PDF/rr/rr4607.pdf>

Yes, the persons with symptoms—Rose, Todd, and George—meet the clinical case definition of pertussis.

**2. Why did George and Todd develop pertussis? What should be done for them?**

Waning immunity and the high rate of pertussis transmission among household contacts are the most likely causes for the illness in George and Todd. Pertussis can occur in adolescents and adults because vaccine-induced immunity wanes over time, leaving many persons who received the DTaP dose at age 4 to 6 years unprotected by the time they reach adolescence. (The scenario does not give sufficient information to determine why Sheree did not develop pertussis; she may have had pertussis previously.) George and Todd should receive erythromycin. Erythromycin is unlikely to decrease the duration of pertussis symptoms when given in the later part of the paroxysmal stage, but it will decrease communicability to other persons. Erythromycin is effective in ameliorating symptoms if taken during the catarrhal stage, and some evidence suggests that it may help clinically if initiated early in the paroxysmal stage. Alternative choices are trimethoprim-

sulfamethoxazole for 14 days for patients who cannot tolerate erythromycin or azithromycin for 5 days or clarithromycin for 7 days.

3. Why did Rose develop pertussis? Was Rose's illness preventable?

Rose developed pertussis because she was undervaccinated.

Yes, Rose's illness was preventable. She could have received DTaP simultaneously with MMR, Hib, and PCV7 when she was 18 months old. She could have received DTaP two months ago when she was seen by her physician for upper respiratory tract infection. DTaP vaccine efficacy is estimated at 80% to 85% for vaccines licensed in the United States.

4. What should be done for Sheree and Skip?

Sheree and Skip are at risk of infection since they are household contacts; they should receive erythromycin. Skip, having been vaccinated rather recently, is at least risk but should still receive erythromycin. Alternative choices are trimethoprim-sulfamethoxazole for 14 days for patients who cannot tolerate erythromycin or azithromycin for 5 days or clarithromycin for 7 days. It is reasonable to administer Tdap to Sheree but the efficacy of postexposure Tdap is unknown.

5. Are George's patients at risk? What should be done for George's patients? Should he continue to see patients?

Yes, the risk of acquiring pertussis for patients with whom George has had close contact is high. Outbreaks have occurred in medical settings with transmission chains involving both patients and medical personnel. The patients that George has seen since his cough illness began should receive erythromycin. They should also receive DTaP vaccine if they are not up-to-date in their vaccination schedule, or if the patients are  $\leq 7$  years of age and the minimal interval has elapsed between doses of DTaP. George should stop seeing patients until he has taken erythromycin

for 5 days; he should complete a 14-day course of erythromycin. Alternative choices are trimethoprim-sulfamethoxazole for 14 days for patients who cannot tolerate erythromycin or azithromycin for 5 days or clarithromycin for 7 days.

**Take Home Points:**

- Pertussis is highly communicable.
- Protection from vaccination wanes in the years following the last preschool DTaP dose, resulting in the need of Tdap for adolescents and adults.

**Answers to Questions for Learners – Scenario Three**

1. Does Stephanie need any vaccinations? What is the minimal interval between DTaP doses?

Stephanie needs the fourth dose of pertussis vaccine, preferably as DTaP and a dose of MMR. Simultaneous administration of these vaccines is recommended and is safe.

The recommended minimum interval between the third and fourth doses of DTaP is  $\geq 6$  months; however, DTaP #4 does not need to be repeated if administered  $\geq 4$  months after DTaP #3. (The minimum interval between the first and second doses and between the second and third doses is 4 weeks.)

2. What antigens are in the various acellular pertussis vaccines and why?

Acellular pertussis vaccines contain purified antigenic components of *Bordetella pertussis*. In particular, acellular vaccines contain inactivated pertussis toxin and may contain one or more other components (e.g., filamentous hemagglutinin, a 69-kilodalton outer membrane protein called “pertactin,” and fimbriae types 2 and 3). Two acellular pertussis vaccines (DTaP) are available for use among infants: DAPTACEL® and Infanrix®. Two acellular vaccines (Tdap) are licensed for adolescents and adults: Boostrix® and Adacel®. Components that are important in the organism’s ability to cause disease include: (1) a tracheal cytotoxin which destroys cilia, making it difficult to clear the thick mucus; (2) pertussis toxin which causes lymphocytosis, contributes to damage of the cilia, and helps attachment to respiratory epithelium; (3) filamentous hemagglutinin, which helps the bacteria attach to cilia of the respiratory tract; (4) pertactin, which also helps bacterial attachment to the cilia; and (5) fimbriae, which are also involved in attachment to ciliated respiratory epithelium. Acellular vaccines target one or more of these antigens.

3. Can DTaP cause fever? What can be done to reduce the likelihood of fever after DTaP vaccination?

Yes, a temperature  $>38.3^{\circ}\text{C}$  occurs in 3% to 5% of infants after acellular pertussis vaccination (DTaP) [Table 3 in ACIP recommendations: MMWR 1997;46(No.RR-7):9]. <http://www.cdc.gov/mmwr/PDF/rr/rr4607.pdf>

DTaP is much less likely to cause fever than is whole-cell DTP. If pneumococcal conjugate vaccine (PCV7) was given with the third dose of DTaP, it could have contributed to the fever. When given with DTaP but at another site, fever  $\geq 38^{\circ}\text{C}$  occurred in 15% to 24% of those vaccinated with PCV7 compared with 9% to 17% of those receiving the control vaccine (experimental meningococcal conjugate vaccine). Acetaminophen or ibuprofen prophylaxis reduces postvaccination fever and may be used when there is a family history of seizure disorders or when fever is to be reduced. Acetaminophen or ibuprofen may be given at the time of vaccination and every 4 hours for 24 hours.

4. Should Stephanie receive any further doses of DTaP? What is a precaution?

Yes, neither a temperature of  $38.9^{\circ}\text{C}$  ( $102^{\circ}\text{F}$ ) nor a family history of seizures is a precaution or a contraindication to further doses of DTaP. Precautions are situations involving certain adverse events after vaccination (such as a hypotonic hyporesponsive episode or seizures) that prompt the vaccine provider and parents to evaluate, on an individual basis, the risks and benefits of administering subsequent doses of pertussis vaccine.

5. What is the Vaccine Injury Compensation Program (VICP)? Why does the VICP exist?

The Vaccine Injury Compensation Program (VICP) is a no-fault federal program established to provide compensation for injuries that are temporally related to administration of a vaccine covered by the program. (Stephanie's fever and

fussiness after the third dose of DTaP is not a compensable condition.) Since October 1, 1988, the VICP has been funded by a vaccine excise tax and has reduced the liability risks for physicians and manufacturers. Persons with alleged injuries are to go through the VICP before filing a civil tort claim, and the amount attorneys can obtain is limited. If a person accepts an award from the VICP, they cannot use the tort system for those injuries. If a person files a claim and does not accept or receive a VICP award, then they can file with the civil tort system against the provider or manufacturer. The VICP exists to protect patients, providers, and manufacturers.

**Take Home Points:**

- The minimal interval between doses should be used for catch-up vaccination of children who are behind schedule.
- Fever is a possible adverse reaction after DTaP.

**Answers to Questions for Learners – Scenario Four**

## 1. Why are the vaccination rates low?

Vaccination rates may be low for one or more of the following reasons:

- a. Overly cautious interpretation of vaccine contraindications.
- b. Valid deferral of DTaP vaccination for unvaccinated infants with an evolving neurologic disorder until the disorder is stabilized. It is also valid to defer DTaP vaccination for infants with neurological events, such as seizures between DTaP doses, until the disorder is clarified.
- c. Lack of simultaneous vaccine administration.
- d. Parental concerns about vaccine safety.
- e. Missed opportunities to vaccinate during acute and chronic care visits.
- f. Lack of transportation or other economic barriers. The Vaccines for Children Program (VFC) and Children's Health Insurance Program (CHIP) have greatly reduced economic barriers to vaccination.
- g. Inconvenient hours when the clinic is open.

The students or residents may suggest other reasons from their experience or outside reading.

## 2. What can be done to raise the rates?

Ways to improve parental compliance include the following:

- a. Mailed reminders or autodialing machine telephone messages to patients about needed vaccinations.
- b. Provision of personal vaccination cards for patients that list both the schedule and the date for the child's next vaccination or an online patient portal with this information.

- c. Office vaccination practices can be improved by the following:
- 1) Conducting periodic audits to assess vaccination rates in practice;
  - 2) Administering vaccines simultaneously if more than one is indicated;
  - 3) Having a dedicated spot in the medical record for vaccination information;
  - 4) Using all clinical encounters to screen and, when indicated, vaccinate; and
  - 5) Training on valid and invalid contraindications.

The Community Preventative Services Task Force has conducted a landmark review on ways to increase immunization rates:

<http://www.thecommunityguide.org/vaccines/universally/index.html>

3. What are the valid contraindications to DTaP? Is a cardiac disorder a valid contraindication to DTaP? Is a seizure disorder a valid contraindication to DTaP?

The contraindications and precautions to DTaP are given in the following table, which is adapted from ACIP recommendations. A cardiac disorder is not a valid contraindication to DTaP. Seizures prior to any dose of DTaP is a valid reason to delay DTaP until the neurological disorder is clarified; however, delaying DTaP until the second 6 months of life will increase the risk of febrile seizures. See Answer 1-b above.

## CONTRAINDICATIONS AND PRECAUTIONS TO FURTHER DTP AND DTAP VACCINATION

### Contraindications

- An immediate anaphylactic reaction to DTP or DTaP vaccination
- Encephalopathy not attributable to another identifiable cause occurring within 7 days following DTP or DTaP vaccination

### Precautions

- Temperatures of  $>40.5^{\circ}\text{C}$  ( $105^{\circ}\text{F}$ ) within 48 hours of DTP or DTaP vaccination, not due to another identifiable cause
- Collapse or shock-like state (hypotonic-hyporesponsive episode) within 48 hours of DTP or DTaP vaccination
- Persistent, inconsolable crying lasting  $>3$  hours, occurring within 48 hours of DTP or DTaP vaccination
- Convulsions with or without fever, occurring within 3 days of DTP or DTaP vaccination
- History of Guillain-Barré Syndrome within six weeks of a previous dose of tetanus toxoid containing vaccine.
- History of Arthus-type hypersensitivity reactions after a previous dose of tetanus or diphtheria toxoid containing vaccine: defer vaccination until at least 10 years have elapsed since the last tetanus-toxoid containing vaccine.
- Progressive neurologic disorder, including infantile spasms, uncontrolled epilepsy, progressive encephalopathy; defer DTaP until neurologic status clarified and stabilized.

<http://www.cdc.gov/vaccines/recs/vac-admin/contraindications-vacc.htm>

4. What is a precaution? What are the precautions to DTaP?

The precautions listed in the table above are situations in which a condition in a recipient that might increase the chance or severity of a serious adverse reaction, or that might compromise the ability of the vaccine to produce immunity; for DTaP, many of the

precautions involve a history of an adverse reaction that has occurred in temporal relation to receipt of DTP or DTaP. The decision to give subsequent doses of vaccine containing the pertussis component should be carefully considered.

These events have not been associated with permanent sequelae. In circumstances in which the benefits outweigh the possible risks, such as during an outbreak of pertussis, DTaP may be administered.

If a valid contraindication has occurred following administration of either DTaP or whole-cell DTP, **neither** DTP or DTaP should be given consequently. If the contraindication was encephalopathy, the series should be completed with DT. If the contraindication was an immediate anaphylactic reaction, further vaccination with any of the three components of DTaP or whole-cell DTP should be deferred because of uncertainty as to which component of the vaccine might be responsible. Because of the importance of tetanus vaccination, persons who experience anaphylactic reactions may be referred to an allergist for evaluation and, if specific allergy can be demonstrated, desensitized to tetanus toxoid.

**Take Home Point:**

- Multiple quality improvement methods can increase vaccination rates, including the proper interpretation of precautions and contraindications.

**Answers to Questions for Learners – Scenario Five**

1. Why do vaccines contain chemicals?

Vaccine excipients typically have a rationale.

Excipient	Rationale
Aluminum	Adjuvant to increase immune response
Formaldehyde, 2-phenoxyethanol	Preservatives
Gelatin	Stabilizer
Polysorbate 80	Surfactant
Glutaraldehyde	Toxin detoxifier

2. How would you approach Joshua's mother?

A compassionate approach that is clear and straightforward about the science may be best. Affirming that the physician has heard the concerns but feels that the disease risks outweigh these safety concerns. Stories of cases of vaccine-preventable diseases may help and are available online at [www.vaccineinformation.org](http://www.vaccineinformation.org); [www.pkids.org](http://www.pkids.org); or [www.facesofinfluenza.org](http://www.facesofinfluenza.org).

3. How would you respond to her concern and the website?

Excipients typically have a rationale. For instance, historically, severe infections occurred from administration of contaminated vaccines, prior to the addition of preservatives. Higher concentrations of the preservative formaldehyde are found naturally in infant blood than in any vaccine. Aluminum is an adjuvant that increases the immune response and is used at concentrations less than that found in infant formula.

**Take Home Point:**

- Vaccine excipients are important to protect vaccine stability and sterility; they have a good safety profile.

**PERTUSSIS PREVENTION SAMPLE TEST**

This test was developed using expert knowledge and psychometric methods for the construction of criterion-referenced tests. It may be used as a sample examination.

1. Which of the following is not a complication of pertussis?
  - a. Apnea
  - b. Pneumonia
  - c. Encephalopathy
  - d. Seizures
  - e. Metabolic alkalosis
  
2. Which of the following is a valid precaution for DTaP?
  - a. Family history of mental retardation
  - b. Personal history of allergic rhinitis
  - c. Temperature of 39.4°C (103°F) following last DTaP vaccination
  - d. Seizure 1 day after last DTaP vaccination
  - e. Premature infant who is 2 months old
  
3. Which of the following about DTaP vaccine is false?
  - a. Vaccine efficacy is 96 to 99 percent after three doses
  - b. Vaccine efficacy varies by the number of doses received
  - c. The routine schedule includes a series of five doses
  - d. Vaccine efficacy decreases with time since immunization
  - e. None of the above
  
4. The primary source of infant cases of pertussis is:
  - a. Grade-school children
  - b. Preschool-aged children, because they are not fully vaccinated
  - c. Adults, due to waning immunity
  - d. Other infants, due to immature immunity
  - e. None of the above

5. Which of the following children does not have a precaution or contraindication to subsequent doses of DTaP?
  - a. Child with a temperature of 39.4°C (103°F) following the first dose of DTaP
  - b. Child with a hypotonic-hyporesponsive episode following the second dose of DTaP
  - c. Child with high-pitched, prolonged crying following the third dose of DTaP
  - d. Child with anaphylaxis following the fourth dose of DTaP
  - e. Child with a seizure following the fourth dose of DTaP
  
6. The patients in a clinic have a vaccination rate of 55% at 2 years of age. Methods to increase patient compliance with vaccinations include all the following except:
  - a. Increase the number of hours that the clinic is open.
  - b. Send postcards reminding parents about vaccinations that their child needs.
  - c. Call parents to remind them about appointments for vaccinations.
  - d. Display posters about general benefits of vaccines.
  - e. Provide vaccination cards and list the dates for the child's next vaccinations on the cards.
  
7. Which of the following family members of a 5-year-old with pertussis is least likely to develop pertussis?
  - a. The 35-year-old mother who was fully vaccinated as a child.
  - b. The 13-year-old sister who was fully vaccinated as a preschool-aged child.
  - c. The 3-month-old brother who received the first dose of DTaP last month.
  - d. The 15-month-old sister who received 4 doses of DTaP.
  - e. All family members are equally likely to develop pertussis.
  
8. Which of the following DTaP vaccination records is entirely acceptable?
  - a. 2, 4, 7, and 12 months, and 4 years.
  - b. 2 weeks, 3 months, 5 months, and 15 months, and 4 years.
  - c. 2 (half dose), 3 (half dose), 4, 6, and 17 months, and 4 years
  - d. 6 weeks, 3 months, 6 months, 15 months, and 4 years.
  - e. None of the above.

9. Which of the following is true about vaccine ingredients?
- a. Prior to routine use of preservatives in multi-dose vials, a number of incidents of bacterial contamination of vials occurred.
  - b. The amount of aluminum in vaccines is similar to that found in infant formula.
  - c. The amount of formaldehyde that is found circulating naturally in infants is at least 10 times greater than that found in any childhood vaccine.
  - d. Aluminum is an adjuvant that boosts the immune response to a vaccine.
  - e. All of the above are true.

PERTUSSIS PREVENTION SAMPLE TEST ANSWER KEY

1. E
2. D
3. A
4. C
5. A
6. D
7. D
8. D
9. E