Chapter 8: Pertussis

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I. Disease description

Pertussis, or whooping cough, is caused by the bacterium *Bordetella pertussis.* It is characterized by paroxysmal coughing followed by a characteristic inspiratory whoop. Pneumonia is the cause of most pertussis-related deaths. Other complications, though infrequent, can include neurological complications such as seizures and encephalopathy; secondary bacterial infections such as otitis media, pneumonia, or sepsis; and conditions resulting from the pressure effects of severe paroxysmal coughing including pneumothorax, epistaxis, subdural hematomas, hernias, and rectal prolapse. Disease rates and risk of serious complications, including death, are highest among young children. All infants aged < 6 months and any infants who have not yet received 3 doses of diphtheria and tetanus toxoids and acellular pertussis (DTaP) vaccine are especially vulnerable to *B. pertussis*.[1] Disease in adolescents and adults tends to be less severe, although there have been reports of apnea, rib fractures, and other complications.

Parapertussis, caused by the bacterium *B. parapertussis*, is similar to pertussis. In addition, co-infections of *B. parapertussis* and *B. pertussis* have been reported. Parapertussis can be milder and generally is thought not to be vaccine-preventable. Differentiation between pertussis and parapertussis is based on isolation of the bacterium in culture. Parapertussis is not currently reportable to CDC.

II. Background

In the early- to mid-1900s, pertussis was one of the most common childhood diseases and a major cause of childhood mortality in the United States. Since the introduction of pertussis vaccine in the 1940s, the average incidence of pertussis decreased from 150 per 100,000 persons between 1922 and 1940, to 0.5 per 100,000 in 1976.[2] However, since the 1980s, the incidence of reported pertussis cases has increased. The increase has been primarily among infants aged < 4 months and among adolescents and adults.[3,4] An increase in the number of reported deaths from pertussis among very young infants has paralleled the increase in the number of reported cases.[5] Reasons for the increases in pertussis are not completely clear; improvements in diagnosis and reporting of pertussis in adolescents and adults appear to be important factors contributing to the overall increase.[3,4] Outbreaks are being recognized increasingly in high schools and middle schools. Sports teams have been the focus of infection in some

schools.[6] Infected school-aged children and adults may introduce pertussis into households where susceptible preschool-aged children are exposed.

In 2001, there were 7580 reported cases of pertussis (incidence 2.8 per 100,000).[3] Of these, 22% (incidence 88/100,000) and 14 deaths occurred among infants < 6 months. For all age groups, 25% of cases were among infants < 12 months of age (incidence 50/100,000), 13% of cases were among children 1–4 years of age (incidence 6/100,000, 10% of cases were among children 5–9 years of age (incidence 4/100,000), 30% of cases were among adolescents 10–19 years of age (incidence 6/100,000), and 22% of cases were among adults ≥ 20 years of age (incidence 0.8/100,000).

III. Importance of rapid case identification

Early diagnosis and antimicrobial treatment of cases may lessen the severity of symptoms and limit the period of communicability.[7] If suspicion of pertussis is low (sporadic case, no epidemiologic linkage to a confirmed pertussis case, no paroxysms, etc.), investigators may wait for laboratory confirmation of the case to initiate the investigation and intervention. However, if pertussis is strongly suspected (in a child with acute paroxysmal cough illness of less than 14 days duration at the time of report, or in an infant with apnea, or in a child who is epidemiologically linked to a confirmed case, etc.), then an investigation to identify and recommend prophylaxis to close contacts should be initiated even before the case is confirmed.

Prompt identification of cases will help to identify unvaccinated or undervaccinated children among contacts. These children can be vaccinated, and antimicrobial prophylaxis administered. Because pertussis can be severe or life-threatening among young infants, early antimicrobial prophylaxis of contacts and infants in households with an infant is important.

IV. Importance of surveillance

Information obtained through surveillance is used to identify persons or areas in which additional efforts are required to decrease disease. Surveillance data also help promptly identify outbreaks in which vaccination of unvaccinated or undervaccinated children and antimicrobial prophylaxis of contacts can help limit the spread of disease. Effectiveness of outbreak control strategies is monitored by using surveillance data. Investigation of pertussis cases, including an analysis of vaccination status by age, can be used to determine whether the problem is predominantly failure to vaccinate or vaccine failure. Surveillance data also provide information that is used in evaluating vaccination policies at the state or national level. With licensure of several DTaP vaccines for use in infants, surveillance is even more important. Surveillance data are being used to monitor the effectiveness of these new vaccines.

Surveillance for resistance to erythromycin is also important. Erythromycin is the drug of choice for treating persons with *B. pertussis* disease and for

post-exposure prophylaxis of household members and other close contacts. Erythromycin prophylaxis is the primary control measure for adults with a decrease in vaccine-induced immunity and for infants too young to be adequately vaccinated.

Because resistance of *B. pertussis* to erythromycin is very rare, antimicrobial susceptibility testing is not routinely recommended. However, it is recommended when persons with pertussis do not improve with erythromycin therapy and treatment failure is suspected. Isolates from persons who meet CDC's criteria for treatment failure should be sent to the CDC Pertussis Laboratory. [8]

V. Disease reduction goals

By the year 2010, a disease reduction goal of 2000 indigenous cases of pertussis in children aged less than seven years has been proposed.[9]

VI. Case definitions

The following case definition for pertussis was approved by the Council of State and Territorial Epidemiologists (CSTE) in June 1997.[10]

Clinical case definition

A cough illness lasting at least 2 weeks with one of the following: paroxysms of coughing, inspiratory "whoop," or post-tussive vomiting, and without other apparent cause (as reported by a health-care professional).

Laboratory criteria for diagnosis

- Isolation of *B. pertussis* from a clinical specimen
- Positive polymerase chain reaction (PCR) assay for *B. pertussis* DNA

Case classification

Probable: Meets the clinical case definition, is not laboratory-confirmed, and is not epidemiologically linked to a laboratory confirmed case.

Confirmed:

- A case of acute cough illness of any duration with a positive culture for *B. pertussis*
- A case that meets the clinical case definition and is confirmed by PCR
- A case that meets the clinical definition and is epidemiologically linked directly to a case confirmed by either culture or PCR

Comment: The clinical case definition is appropriate for endemic or sporadic cases. In outbreak settings, including household exposures, a

case can be defined as an acute cough illness lasting ≥ 2 weeks without other symptoms. The clinical case definition for pertussis was intended to provide increased sensitivity for detecting pertussis cases in situations where the disease was clinically compatible with pertussis but where confirmatory laboratory testing was not done or was negative.[11] Laboratory tests can be negative even when the patient has pertussis.

Occasionally, patients with an acute cough illness lasting < 14 days but who have a positive *B. pertussis* culture result are detected. Cases should be reported as confirmed cases of pertussis. Among infants aged < 6 months, apnea may occur and a cough with whoop or with paroxysms may be absent. In young unvaccinated children, leukocytoses are common findings during the early paroxysmal stage.[10-13] However, because PCR is less specific than culture, cases with positive PCR results in persons with < 14 days of cough should not be considered confirmed. Also because of this lack of specificity, outbreaks should ideally be confirmed to be pertussis by positive culture results among ≥1 case. To confirm a clinical case by epidemiologic linkage, the case must be directly epidemiologic linked to a case confirmed by either culture or PCR (i.e., a first generation contact).

Information on paroxysms of cough, whoop, and post-tussive vomiting should be routinely sought as part of case investigations. In an outbreak investigation in Missouri, a case definition of cough illness with whoop lasting ≥ 14 days was found to have a sensitivity of 81% and a specificity of 58%.[14] In other outbreaks in 1985 and 1986, a surveillance case definition of cough illness lasting for ≥ 14 days was found to be 84% sensitive and 63% specific for detecting culture-positive pertussis cases.[14] If it is not possible to collect information on paroxysms, whoop, and post-tussive vomiting, information on duration of cough (less than or more than 14 days) should be obtained in the course of the case investigation of each case of suspected pertussis. If the case investigation occurs in the early stage of the disease, the patient should be contacted later to determine if the duration of cough was at least 14 days.

Studies have documented that direct fluorescent antibody (DFA) testing of nasopharyngeal secretions has low sensitivity (i.e., many persons who have pertussis test negative by DFA) and variable specificity (i.e., persons who don't have pertussis can test positive by DFA) compared with culture.[15, 16] For this reason, DFA should not be relied on as a criterion for laboratory confirmation.[17] With few exceptions (as in Massachusetts),[18] serologic testing for pertussis is not standardized. Thus, in most areas, serology should not be relied on as a criterion for laboratory confirmation.

Both probable and confirmed cases should be reported to the National Notifiable Diseases Surveillance System (NNDSS) by the state health department via the National Electronic Telecommunications System for Surveillance (NETSS) or National Electronic Disease Surveillance System (NEDSS), when available.

VII. Laboratory testing

Determining who has pertussis and who does not is often difficult, even in outbreaks. Whenever possible, all suspected cases of pertussis should have a nasopharyngeal swab or aspirate obtained for bacterial culture. Among household contacts of culture-confirmed cases, diagnosis of pertussis is usually based on a characteristic history and physical examination. Laboratory tests may be particularly useful for sporadic cases or for young infants, and in all cases with a history of prior vaccination, including older children and adults.

A properly obtained nasopharyngeal swab or aspirate is essential for optimal results. Health department personnel who are asked to obtain these specimens should receive training and supervision from persons experienced in collection of nasopharyngeal specimens.

For additional information on use of the laboratory for support of vaccine-preventable disease surveillance, see Chapter 19, "Laboratory Support for Surveillance of Vaccine-Preventable Diseases."

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Culture

The standard and preferred laboratory test for diagnosis of pertussis is isolation of *B. pertussis* by bacterial culture. A positive culture for *B. pertussis* confirms the diagnosis of pertussis. For this reason, access to a microbiology laboratory that is prepared to perform this service for no cost or for limited cost to the patient is a key component of pertussis surveillance. Culture of the organism is also necessary to permit testing for antimicrobial susceptibility and for molecular typing by pulse-field gel electrophoresis (PFGE).

Although bacterial culture is specific for the diagnosis, it is relatively insensitive. Fastidious growth requirements make *B. pertussis* difficult to isolate. Isolation of the organism using direct plating is most successful during the catarrhal stage (i.e., first 1–2 weeks of cough). All suspected cases of pertussis should have a nasopharyngeal aspirate or swab obtained from the posterior nasopharynx for culture. For *B. pertussis*, nasopharyngeal aspirates have similar or higher rates of recovery than nasopharyngeal swabs;[16, 19–21] throat and anterior nasal swabs have unacceptably low rates of recovery of *B. pertussis*. Therefore, specimens from the posterior nasopharynx (see **Figure 1**), not the throat, should be obtained using Dacron® or calcium alginate swabs, not cotton, and should be plated directly onto selective culture medium or placed in transport medium. Regan-Lowe agar or freshly prepared Bordet-Gengou medium generally is used for culture; half-strength Regan-Lowe can be used as the transport medium. Success in isolating the organism declines with prior antibiotic therapy effective against susceptible *B. pertussis* (erythromycin or trimethoprim-sulfamethoxazole), delay in specimen collection beyond the first 2 weeks of illness, or in vaccinated individuals. Under optimal conditions 80% of

suspected cases in outbreak investigations can be confirmed by culture; in most clinical situations isolation rates are much lower. Because patients can remain culture-positive even while taking effective antibiotics (e.g., infection with strains that are resistant to the antibiotic), nasopharyngeal swab for culture should be obtained regardless of concurrent use of an antibiotic.

Polymerase chain reaction (PCR)

PCR testing of nasopharyngeal swabs or aspirates can be a rapid, sensitive, and specific method for diagnosing pertussis.[22] However, false positive results may be obtained because of contamination in the laboratory or during specimen collection.[22,23] PCR currently is available in some laboratories; the assay varies among laboratories and is not standardized. **Calcium alginate swabs cannot be used to collect nasopharyngeal specimens for PCR.** Direct comparison with culture is necessary for validation. Even if a laboratory has validated its PCR method, the result should be considered presumptive and isolation of *B. pertussis* by culture should be attempted to assure that the disease is truly pertussis. *B. pertussis* isolates can then be evaluated for erythromycin susceptibility and by PFGE. PFGE can help define the molecular epidemiology of strains circulating in the U.S.

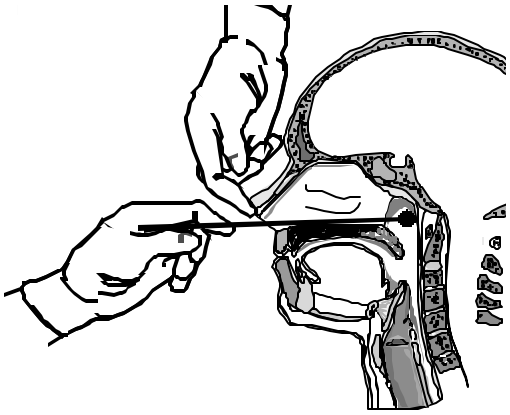

Figure 1: Proper technique for obtaining a nasopharyngeal specimen for isolation of *B. pertussis*

Even if a laboratory has validated its PCR method, culture should be used in addition to PCR.

Serologic testing

Although serological testing has proven useful in clinical studies, it is not yet standardized. Because of the lack of association between antibody levels and disease, results of serologic testing are difficult to interpret. For these reasons, serologic testing is not widely available. In Massachusetts, serologic testing is used for clinical diagnosis and reporting.[18] Elsewhere, with few exceptions, it is unknown if serologic testing has been appropriately validated or standardized. Therefore, serologic testing should not be relied upon to confirm cases for the purpose of national reporting. Cases meeting

the clinical case definition that are serologically positive but not culture positive or PCR positive should be reported as probable cases.

A positive DFA result may increase the probability that the patient has pertussis, but it has limited specificity and is not a confirmatory test.

Direct fluorescent antibody (DFA) testing

DFA testing of nasopharyngeal secretions may be useful as a screening test for pertussis. A positive DFA result may increase the probability that the patient has pertussis, but it has limited specificity (frequent false positive results) and is not a confirmatory test. A monoclonal DFA test is available (Accu-Mab™, Biotex Laboratories, Inc., Edmonton, Canada) but the sensitivity and specificity are variable.

Elevated white blood-cell count (WBC)

An elevated WBC with a lymphocytosis (i.e., increase in lymphocyte count) is usually present in cases of pertussis. The absolute lymphocyte count can reach ≥ 20,000/mm. However, there may be no lymphocytosis in very young infants, vaccinated children, or in mild cases of pertussis among adults. The white blood-cell count is not a confirmatory test.

Pulsed-field gel electrophoresis (PFGE)

Pulsed-field gel electrophoresis (PFGE) is a type of DNA fingerprinting. This technique has been a useful tool to distinguish among epidemiologically-related strains (e.g., strains from the same household or small community), while showing diversity within larger geographic areas such as cities, counties, and states.[25-26]

Questions about performing PFGE on *B. pertussis* isolates, as well as questions about isolating *B. pertussis*, performing erythromycin susceptibility testing, and performing PCR can be directed to the CDC Epidemic Investigations Laboratory: Dr. Gary Sanden at 404-639-3024, or Ms. Pam Cassiday at 404-639-1231. If needed, *B. pertussis* isolates can be sent to:

CDC, Epidemic Investigations Laboratory
Pertussis
Attention: Pam Cassiday
Building 17, Room 2227
1600 Clifton Road NE MS-D11
Atlanta, GA 30333

VIII. Reporting

Each state and territory has regulations or laws governing the reporting of diseases and conditions of public health importance.[27] These regulations and laws list the diseases to be reported and describe those persons or institutions responsible for reporting, including health-care providers, hospitals, laboratories, schools, daycare and childcare facilities, and other institutions. Contact the state health department for reporting requirements in your state.

Reporting to CDC

Provisional reports should be sent to the National Notifiable Diseases Surveillance System by the state health department via the National Electronic Telecommunications System for Surveillance (NETSS) or National Electronic Disease Surveillance System (NEDSS), when available. Data should be collected for each probable and confirmed case of pertussis; the Pertussis Surveillance Worksheet (**Appendix 9**) and the Active Laboratory-Based Surveillance Pertussis Worksheet (**Appendix 10**) can be used as a guideline in case investigation. Each death associated with *B. pertussis* infection requires a more extensive investigation that includes completion of the death report worksheet (**Appendix 11**) including age, vaccination history, and exposure to ill contacts, and a copy of the medical record, autopsy report, and death certificate. Reporting should not be delayed because of incomplete information or lack of confirmation; following completion of case investigations, data previously submitted to NETSS should be updated with the available new information.

Most state health departments now access NETSS and input epidemiologically important information at the supplementary pertussis screens. The screen layout is similar to the Pertussis Surveillance Worksheet (**Appendix 9**). A few states continue to report this information in paper format to the Supplementary Pertussis Surveillance System (SPSS). These data, once entered into a computer database at the CDC, are concatenated with NETSS data for analysis.

Information to collect

The following data are epidemiologically important and should be collected in the course of a case investigation. Additional information may be collected at the direction of the state health department.

- Demographic information
  - Name
  - Address
  - State of residence
  - Date of birth
  - Age
  - Sex
  - Ethnicity
  - Race
  - Occupation

- Reporting Source
  - County
  - Earliest date reported

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Information to collect (con't.)

- Clinical
  - Hospitalization and duration of stay
  - Cough, date of cough onset and duration
  - Paroxysms, whoop, post-tussive vomiting, apnea, cyanosis, etc.
  - Positive x-ray for pneumonia
  - Complications
    - Pneumonia documented by chest x-ray
    - Seizures
    - Encephalopathy
  - Outcome (case survived or died)
  - Date of death

- Treatment
  - Antibiotics used
  - Date started and duration of therapy

- Laboratory
  - Culture
  - PCR
  - Serology for antibody to pertussis antigens

- Vaccine Information
  - Dates of vaccination with pertussis-containing vaccine
  - Type of vaccine
  - Manufacturer name
  - Lot number
  - Number of doses of pertussis-containing vaccine prior to illness onset
  - If not vaccinated, reason

- Epidemiological
  - Date case investigation initiated
  - Epidemiologic linkage to a laboratory-confirmed case
  - Association with an outbreak
  - Transmission setting
  - Setting outside of household for further documented spread
  - Contact investigation

It is important that information on the duration of cough be obtained, especially if the first interview is conducted within 14 days of cough onset and cough is still present.

Comments on reporting

It is important that information on the duration of cough be obtained, especially if the first interview is conducted within 14 days of cough onset and cough is still present. In these circumstances, a follow-up interview after 14 days of onset must be conducted to identify persons with cough duration ≥ 14 days. Because of the limitations of laboratory testing mentioned above, use of clinical case definitions is particularly important in the surveillance of pertussis.

The following definitions may be useful in pertussis case investigations.

Paroxysmal or spasmodic cough. Sudden uncontrollable "fits" or spells of coughing where one cough follows the next without a break for breath.

Whoop. High-pitched noise heard when breathing in after a coughing spasm.

Apnea. Prolonged breathlessness which may occur in any age group, either after a coughing spasm or spontaneously, and is associated with cyanosis *or* syncope (passing out). Apnea can be accompanied by slowing of the heartbeat (bradycardia). Apnea can also be the presenting sign of pertussis in young infants without cough.

Cyanosis. Paleness or blueness of the skin, often most noticeable on the lips and tongue, occurring after coughing paroxysm.

Post-tussive vomiting. Vomiting that follows a paroxysm of coughing.

Cold-like symptoms. Coryza (runny nose), conjunctival injection (redness of the eyes), or both.

Positive chest x-ray for pneumonia. Evidence of acute pneumonia found on chest x-ray.

Acute encephalopathy. Acute illness of the brain manifested by decreased level of consciousness (excluding transient drowsiness after a seizure), with or without seizures. Such patients are almost always hospitalized, and have undergone extensive diagnostic evaluations.

Vaccination information. The details of past vaccinations are especially important to collect, including dates of each pertussis vaccination, type of vaccine, lot number, and manufacturer.

It is unknown if children receiving DTP and/or DTaP vaccines from different manufacturers will be optimally protected from pertussis. Thus, collection of a complete vaccination history is important.

Whole-cell pertussis vaccines are killed-bacteria vaccines provided in combination with diphtheria and tetanus toxoids as DTP or as DTP combined with *Haemophilus influenzae* type b conjugate vaccine (DTP-Hib). The first two combination diphtheria and tetanus toxoids and acellular pertussis vaccines (DTaP) were licensed in 1991 (ACEL-IMUNE®) and in 1992 (Tripedia®) for use as the fourth (first booster) and fifth (second booster) doses following three doses of whole-cell DTP. Since then, five DTaP vaccines have been licensed for use in infants (Tripedia®, ACEL-IMUNE®, Infanrix™, Certiva™, and DAPTACEL™). As of November 2002, three DTaP vaccines were available in the U.S. (Tripedia™, Infanrix™, and DAPTACEL™); the other two vaccines are no longer being manufactured.

Children or adults with pertussis could have received no vaccine or a variable number of doses of DTP from one or more manufacturers. In addition, children with pertussis could have received a variable number of doses of DTaP or combination vaccines that included DTP or DTaP. It is unknown if children who received DTP, DTaP, or both DTP and DTaP vaccines from different manufacturers are optimally protected from pertussis.

Thus, collection of a complete vaccination history is important to monitor the effectiveness of the pertussis vaccination program.

IX. Vaccination

Currently, only acellular pertussis vaccines combined with diphtheria and tetanus toxoids (DTaP) are available in the U.S. Whole cell (DTP) vaccines are available in other countries. The five DTaP doses should be administered to children at age 2, 4, 6, and 15–18 months, and 4–6 years.[28] The fourth dose is needed to maintain adequate immunity during preschool years and should be administered ≥ 6 months after the third. If the interval between the third and fourth doses is ≥ 6 months and the child is unlikely to return for a visit at the recommended age, the fourth dose of DTaP may be administered as early as age 12 months. The fifth dose helps to confer continued protection against disease during the early school years. A fifth dose is not necessary if the fourth dose in the series is administered on or after the fourth birthday.[28]

Because of the lower frequency of adverse events, DTaP is preferred over whole-cell DTP.[28, 29] Whole-cell DTP remains an acceptable alternative to DTaP in other countries.[28] In the U.S., DTaP vaccines are recommended for all five doses of the vaccination series. The vaccine safety and efficacy data are considered to be insufficient to select one acellular pertussis vaccine over another formulation.[28, 29] For children who have started the vaccination series with one or more doses of whole-cell DTP, DTaP is recommended for all remaining doses in the schedule in the U.S.

X. Enhancing surveillance

A number of surveillance activities can improve the detection and reporting of cases, and can improve the comprehensiveness and quality of reporting. Six states are conducting enhanced pertussis surveillance. The following activities may be undertaken to enhance surveillance of pertussis. Chapter 16, “Enhancing Surveillance,” lists additional activities for enhancing surveillance that may be applicable to pertussis surveillance.

Heightening the awareness of clinicians about pertussis, especially in adolescents and adults

Several recent studies suggest that pertussis is a common cause of cough illness of > 7 days duration in adolescents and adults.[30,31] Because the disease is often atypical in presentation and many clinicians think of pertussis as a disease only of children, the diagnosis may not be considered. Cases among adolescents and adults are epidemiologically important because of their role in exposing infants and young children to pertussis.

Assuring that diagnostic testing for pertussis is being performed regularly

Unlike many of the other traditional vaccine-preventable diseases of childhood, pertussis is an endemic disease in the United States. Pertussis cases are expected to occur in all communities, and several years with no reported cases from a jurisdiction may reflect failure of diagnosis or failure of reporting rather than a true absence of pertussis. The level of diagnostic testing being undertaken can be evaluated by reviewing the number of pertussis diagnostic tests (e.g., cultures) submitted by a jurisdiction.

Monitoring surveillance indicators

Regular monitoring of surveillance indicators may identify specific areas of the surveillance and reporting system that need improvement. Important indicators for the thoroughness of case investigation and the timeliness of reporting include:

- The proportion of probable and confirmed cases with complete information on vaccination history (dates of pertussis vaccination, pertussis vaccine type and manufacturer) and duration of cough.

- Median interval between onset of cough and notification of state or local public health authorities in probable and confirmed cases.

XI. Case investigation

Laboratory, hospital, and clinic records should be reviewed by health department personnel during case investigations in order to collect important information such as description of the clinical illness, outcome, immunization status, dates of vaccination, and vaccine lot numbers. The Pertussis Surveillance Worksheet (**Appendix 9**) may be used as a guideline for conducting a case investigation.

Treatment and chemoprophylaxis

The spread of pertussis can be limited by decreasing the infectivity of the patient and by protecting close contacts.[7,32] To reduce infectivity of a case as quickly as possible, a course of oral erythromycin given in 4 divided doses each day for 14 days (children: 40 mg/kg/day; adults: 1 g/day) or trimethoprim—sulfamethoxazole in 2 divided doses for 14 days (children: trimethoprim 8 mg/kg/day, sulfamethoxazole 40 mg/kg/day; adults: trimethoprim 320 mg/day, sulfamethoxazole 1,600 mg/day) is recommended for patients with clinical pertussis. Antimicrobial therapy should be continued for the full 14 days to minimize any chance of treatment failure. The antibiotics and dosages used for chemoprophylaxis of contacts are the same as those recommended for treatment of a clinical case. For treatment and prophylaxis of pertussis, some physicians may choose to recommend use of other macrolides (e.g., azithromycin, clarithromycin). Treatment regimens with these antibiotics are simple and these newer agents may be better

tolerated than erythromycin. However, data on the efficacy of the new macrolides against pertussis are limited and optimal duration of treatment is unknown. [7, 32]

Prophylaxis of all household members and other close contacts may prevent or minimize transmission, although confirmatory data from controlled clinical trials are lacking. A non-household close contact may be described as a non-household member who has direct contact with respiratory secretions from the case (an explosive cough or sneeze in the face, sharing food, sharing eating utensils during a meal, kissing, mouth-to-mouth resuscitation, or conducting a full medical exam including examination of the nose and throat).[7,32,33] Erythromycin or trimethoprim-sulfamethoxazole prophylaxis should be administered for 14 days to all household and other close contacts of persons with pertussis, regardless of age and vaccination status.[28]

Prophylaxis of close contacts of persons with *B. parapertussis* should be considered when one or more close contacts is an infant. Infants with *B. parapertussis* should be treated. The same antibiotics that are used for treatment and prophylaxis of pertussis should be used to treat parapertussis.

Vaccination

All close contacts < 7 years of age who have not received four doses of vaccine should complete the series with the minimal intervals (minimum age for first dose is 6 weeks; minimum intervals from dose one to two and from dose two to three are 4 weeks; minimum interval from dose three to four is 6 months). Close contacts who are 4–6 years of age and who have not yet received the second booster dose (usually the fifth dose of DTaP) should be vaccinated.

XII. Outbreak control

Currently available pediatric formulations are not licensed for use among adults and should not be used for adults as full or half doses because of the risk of adverse events from the higher diphtheria toxoid content of DTaP.

If cases are occurring among young infants, consideration should be given to lowering the age of vaccination of infants; the first dose of DTaP or whole-cell DTP can be given as early as 6 weeks of age, with a minimum interval of 4 weeks between each of the first 3 doses. Implementation of an accelerated schedule might cause difficulties in achieving full coverage with other antigens, and efforts should be made to assure timely completion of all recommended childhood vaccinations.[7]

Adult formulations of acellular pertussis vaccine may be available in the future, but at present their use must be considered investigational (i.e., as part of a formal research study with FDA approval as an investigational new drug, approval by an appropriate institutional review board, and with informed consent of participants). Available pediatric formulations are not licensed for use among adults and should not be used for adults, even if administered in a reduced dosage, because of the risk of adverse events from the higher diphtheria toxoid content of DTaP.

In school outbreaks, provision of antimicrobial prophylaxis to close classroom or team contacts of confirmed cases is recommended, but it is

unclear under what conditions more aggressive school-wide prophylaxis should be administered.[7]

During outbreaks, symptomatic persons should be considered contagious until 3 weeks after the onset of paroxysmal cough and should be excluded from school or childcare until after receiving antimicrobial therapy for 5 days.[7] Health-care workers with pertussis, or health-care workers who are symptomatic after exposure to a case should be relieved from direct patient contact from the beginning of the catarrhal stage through the third week after onset of paroxysms, or until 5 days after the start of antimicrobial treatment. Some experts believe exclusion for 7 days is more appropriate for health-care workers.[7,33] A comprehensive document, *Guidelines for the Control of Pertussis Outbreaks,* has been written to provide further guidelines for the control of pertussis outbreaks in households, schools and childcare settings, hospitals, institutions and clinics, and community settings, and can be accessed at http:/www.cdc.gov/nip/publications.[7]

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