

Pertussis



DISEASE AND VACCINE CHARACTERISTICS

Pertussis (whooping cough), caused by *Bordetella pertussis*, is endemic in all countries. Globally, it is estimated that there were 24.1 million pertussis cases and 160 700 deaths from pertussis in children < 5 years of age in 2014 (1), with periodic epidemics occurring every two to five years. Pertussis is transmitted from infected to susceptible individuals by airborne droplets. There are three phases of symptoms.

- **Catarrhal stage.** In the early catarrhal stage, pertussis is highly contagious, with a secondary attack rate of up to 90% among non-immune household contacts. Untreated patients may transmit the infection for three weeks or more following the onset of typical coughing attacks, although communicability diminishes rapidly after the catarrhal stage.
- **Paroxysmal stage.** The paroxysmal stage is marked by more frequent and spasmodic coughing, and it is during this stage when the classic whoop can be heard (but not always present).
- **Convalescent stage.** The convalescent stage is marked by less frequent and less severe coughing.

Asymptomatic or mildly symptomatic infections are common, especially in older previously vaccinated persons. The incubation period is typically 9–10 days (range 6–20 days). The classic clinical presentation in children is paroxysms of coughing, ending with the characteristic whoop with post-tussive emesis (vomiting). However, in young infants, pertussis can initially present as apneic (stopped breathing) or

cyanotic (bluish colour) episodes prior to development of cough. In developed countries, up to 6% of unimmunized children can have complications, such as bronchopneumonia, with higher rates in young infants. In developing countries, although pertussis surveillance data is less robust, the average case-fatality ratio has been estimated at 4% in infants < 12 months and 1% in children 1–4 years old; pertussis might account for 1% of mortality of children < 5 years of age, with infants too young to be vaccinated at highest risk (2) (3).

The aim of pertussis vaccination is to reduce risk of severe disease in infants and young children. Two types of pertussis vaccines are available: whole cell vaccines based on killed *B. pertussis* organisms and acellular pertussis vaccines based on one or several highly purified pertussis antigens. WHO recommends providing all infants with three doses of pertussis vaccine in infancy, with one booster dose in children 1–6 years of age. Additional pertussis vaccination strategies in some countries include booster doses in adolescents and adults, as well as immunization of pregnant women to protect newborn infants too young for direct vaccination through transfer of maternal antibodies. Recently, some countries with long-standing high coverage with acellular pertussis vaccine have seen a resurgence of reported pertussis, even after taking into account changes in diagnostic and surveillance practices (2). This highlights the importance of surveillance, even many years post-vaccine introduction.



RATIONALE AND OBJECTIVES OF SURVEILLANCE

The objectives of pertussis surveillance are to:

- monitor disease burden and the impact of the pertussis vaccination programme, with a special focus on understanding the morbidity and mortality in children < 5 years of age
- generate data to inform vaccine schedule and delivery strategy decisions to optimize the impact of vaccination
- detect and guide public health response to outbreaks of pertussis.



TYPES OF SURVEILLANCE RECOMMENDED

Table 1 shows the recommended minimal and enhanced surveillance to meet each surveillance objective.

TABLE
1

Recommended types of surveillance for pertussis

SURVEILLANCE OBJECTIVE	MINIMAL RECOMMENDED SURVEILLANCE TO MEET OBJECTIVE	ENHANCED SURVEILLANCE TO MEET OBJECTIVE
BURDEN OF DISEASE AND EPIDEMIOLOGY	Sentinel hospital-based, case-based surveillance, with lab confirmation limited to children < 5 years of age	Case-based, nationwide, population-based, facility-based surveillance with lab confirmation. <ul style="list-style-type: none"> - Focus age group can continue in children < 5 years of age or expand to all ages. - Can continue with hospitalized patients or expand to include outpatients.
VACCINE INTRODUCTION/ POLICY DECISION: BOOSTER DOSES <i>(including maternal immunization)</i>	Sentinel hospital-based, case-based surveillance, with lab confirmation with a focus on morbidity and mortality in children < 5 years of age	Case-based, nationwide, population-based, facility-based surveillance with lab confirmation. <ul style="list-style-type: none"> - Focus age group can continue in children < 5 years of age or expand to all ages. - Can continue with hospitalized patients or expand to include outpatients.
OUTBREAK DETECTION	Event-based surveillance or aggregate syndromic surveillance, hospital-based; once cluster identified, lab confirmation of some cases to confirm pertussis, and switch to case-based surveillance (see section below, Surveillance, investigation and response in outbreak settings).	Case-based, nationwide, population-based, facility-based surveillance with lab confirmation. <ul style="list-style-type: none"> - Focus age group can be children < 5 years of age or expand to all ages. - Can continue with hospitalized patients or include outpatients.

Given the complexity of pertussis epidemiology and diagnostics, the recommended minimal standard surveillance in most countries is case-based surveillance with laboratory confirmation in one or more sentinel facilities, with a focus on hospitalized children < 5 years of age, where the majority of severe disease will be captured. Prioritize facilities with a large number of children < 5 years of age in their catchment populations for sentinel site selection. Sentinel site selection is based on a variety of factors including the objectives of surveillance, catchment population, specialization of hospital (paediatric hospital versus general population), health-seeking behaviour of population and capacity to conduct laboratory diagnostic testing. General hospitals that serve children with general infectious diseases (such as pneumonia) are usually better suited to capture pertussis cases than specialty hospitals that

receive most patients through referrals. While pertussis morbidity surveillance should focus on children < 5 years of age, pertussis mortality will be concentrated among infants. When surveillance includes older children and adults, sentinel sites could also include outpatient departments/facilities since older children and adults typically have milder disease and are often less likely to be hospitalized. It should be noted that in community outbreaks in areas with poor care-seeking, many pertussis deaths might occur outside of health care settings, and would be missed by facility-based surveillance (4).

The recommended minimal standard to detect pertussis outbreaks can be either event-based or aggregate surveillance using the suspected case definition, with laboratory confirmation only once a cluster of clinically

compatible cases is identified. Thorough investigation of all outbreaks, including case-based surveillance, should be done (see section below, **Surveillance, investigation and response in outbreak settings**). However, it is difficult to use this type of approach to achieve the other stated objectives of pertussis surveillance, namely defining disease burden and informing vaccine programmes, since outbreaks only constitute one aspect of the pertussis epidemiologic picture.

In countries with more resources or a special interest in informing their pertussis vaccination programme, enhanced surveillance constitutes moving from sentinel site surveillance to national case-based surveillance, expanding the age group from < 5 years to all ages and including outpatients in the surveillance.

LINKAGES TO OTHER SURVEILLANCE

At all levels, surveillance for pertussis can potentially be linked with surveillance for other respiratory illnesses, such as influenza-like illness (ILI) or pneumonia. However, as these other case definitions usually focus on acute illness rather than chronic cough, this could result in reduced sensitivity for detecting pertussis cases. Additionally, case definitions for influenza and pneumonia frequently include fever, which is not often a sign among pertussis cases. Therefore, existing case definitions might need to be modified to capture suspected pertussis cases. On the other hand, use of existing pneumonia or ILI case definitions might lead to identification of pertussis among patients that do not meet the suspected pertussis case definition. Whether to count these as confirmed pertussis cases should be evaluated on a case-by-case basis based on clinical characteristics and alternative diagnoses (3).



CASE DEFINITIONS AND FINAL CLASSIFICATION

SUSPECTED CASE DEFINITION FOR CASE FINDING

A suspected case is a person of any age with a cough lasting ≥ 2 weeks, or of any duration in an infant or any person in an outbreak setting, without a more likely diagnosis and with at least one of the following symptoms, based on observation or parental report:

- paroxysms (fits) of coughing
- inspiratory whooping
- post-tussive vomiting, or vomiting without other apparent cause
- apnea (only in < 1 year of age)

OR

- clinician suspicion of pertussis.

Note that pertussis in immunized or previously infected individuals can present without the classic signs of pertussis, and therefore might not be captured by the above case definition.

BOX
1

Bordetella parapertussis

Bordetella parapertussis can cause signs and symptoms similar to pertussis, and surveillance for *Bordetella pertussis* could encompass lab testing for *Bordetella parapertussis* depending on the country's objectives. However, because there is no vaccine currently for *Bordetella parapertussis*, it is not considered a vaccine preventable disease and is not discussed in this chapter.

FINAL CASE CLASSIFICATION

A confirmed case of pertussis may be determined by laboratory confirmation or epidemiological linkage.

Laboratory confirmation. A laboratory-confirmed case is a person who meets the suspected case definition with laboratory confirmation by one of the following:

- isolation of *B. pertussis*
- OR
- detection of genomic sequences of *B. pertussis* by means of polymerase chain reaction (PCR) assay, if polymerase chain reaction (PCR) meets performance criteria outlined below
- OR
- elevated IgG antibodies to pertussis toxin in an individual ≥ 11 years of age, one year or longer after last vaccine dose.

Culture and PCR detection of acute pertussis infection have higher specificity and are preferred diagnostic methodologies over serology. Serology should be reserved for cases ≥ 4 weeks from cough onset; however,

IgG can sometimes remain elevated for more than a year after infection or vaccination, leading to potential false positives.

Epidemiologically linked. An epidemiologically linked case is a person meeting the suspected case definition with close contact to a laboratory-confirmed case (or another epidemiologically linked case in an outbreak setting) in the three weeks prior to onset of cough.

- Close contact is defined as having face-to-face exposure to a case, which includes household or family contact, people having stayed overnight in the same room with a case, and people having direct contact with respiratory, oral or nasal secretions with a laboratory-confirmed case.

Possible. A person who meets the suspected case definition but does not meet confirmed classification as defined above should be considered a possible case. This includes suspected cases who did not have laboratory testing done and those who tested negative.



CASE INVESTIGATION

For case-based surveillance, suspected cases of pertussis should be reported to public health authorities as soon as possible to initiate case investigation. Individual cases should be investigated within two days of notification. If an outbreak is identified, it should be investigated within two days. Every suspected case (both sporadic and outbreak-related) should have a case investigation form completed and a specimen collected (the type of specimen is determined by the time since cough onset – see **Specimen collection** below). Suspected cases should be advised to avoid contact with young infants, children and women in late pregnancy for the three weeks post cough onset or until five days of antibiotic treatment are completed, whichever is first.

Each suspected case should result in contact tracing and identification of other suspected cases in the community. The purpose of this is to identify potential cases,

determine the size of the problem, limit transmission to young infants at risk of severe disease, and determine who is un- or under-vaccinated in order to close the vaccination gap. If case detection is insensitive and the number of cases small, a line list can be made of all close and high-risk contacts to assure proper follow-up and case detection.

In aggregate/event-based surveillance, individual cases are usually not investigated and samples are not collected unless an outbreak is detected. Local health authorities are encouraged, however, to investigate individual suspected cases and take public health action when appropriate.



SPECIMEN COLLECTION

In case-based surveillance, a specimen should be collected from every suspected case. The timing of the cough should determine the type of specimen to be collected for case-based surveillance (Figure 1). Ideally, a sample for both culture and PCR should be collected simultaneously up until four weeks after cough onset, after which the probability of detection using these methods is reduced.

SPECIMEN COLLECTION AMONG CASES IDENTIFIED WITHIN FOUR WEEKS OF COUGH ONSET

- It is ideal to collect two nasopharyngeal swabs: one for culture and one for PCR. Do NOT collect throat and anterior nasal swabs. Specimens should be obtained using sterile polyester, rayon or nylon flocked swabs, NOT cotton swabs.
- Specimens for culture should be plated directly onto selective culture medium or placed in half-strength Regan-Lowe transport medium. Do NOT use Amies or universal transport media. Regan-Lowe agar or freshly prepared Bordet-Gengou medium is generally used for culture; half-strength Regan-Lowe is generally used as the transport medium. Specimens should be transported at room temperature and plated at the laboratory within 24 hours.
- Specimens solely for PCR testing should be placed in a sterile tube or universal transport media for transport to the laboratory. It is possible to use one swab for both culture and PCR. In this case, the swab should be placed in Regan-Lowe transport before being sent to the lab.

- As an alternate to nasopharyngeal swabs, a saline nasopharyngeal aspirate may be collected from suspected cases.

Surveillance personnel and other health care practitioners that are asked to obtain these specimens should receive training and supervision from persons experienced in collection of nasopharyngeal specimens. The U.S. Centers for Disease Control and Prevention has developed two short training videos for collection of nasopharyngeal aspirate and swab specimens, which can be accessed on the CDC pertussis website (www.cdc.gov/pertussis/clinical/diagnostic-testing/specimen-collection.html) (5).

SPECIMEN COLLECTION AMONG CASES IDENTIFIED 4–12 WEEKS POST COUGH ONSET

Among suspected cases identified 4–12 weeks post cough onset, a serum sample can be collected for IgG anti-pertussis toxin antibody testing. Serology is most beneficial for diagnosing adolescent and adult cases with at least two weeks of cough. Serology is also useful for confirming diagnosis during outbreaks, where diagnosis can often be retrospective and the timing for culture or PCR is not ideal. Do not use serology in children ≤ 10 years of age due to lack of sensitivity or in patients vaccinated within one year, due to persistence of IgG antibodies.



LABORATORY TESTING

CULTURE

- ▶ Isolation of *B. pertussis* by bacterial culture remains the gold standard for diagnosing pertussis. A positive culture for *B. pertussis* confirms the diagnosis of pertussis. Growth of *B. pertussis* in culture averages three to seven days, but can take up to 10 days. Culture of the organism is also necessary for antimicrobial susceptibility testing and molecular typing.
- ▶ Although bacterial culture is specific for diagnosis, it is relatively insensitive (< 60%) (6). Success in isolating the organism declines if the patient has received prior antibiotic therapy effective against *B. pertussis*, specimen collection has been delayed beyond the first two weeks of illness, transport of the specimen to the lab is delayed or the patient has been vaccinated. The highest positive rates are obtained from infants. It is not optimally sensitive in adolescents and adults.

POLYMERASE CHAIN REACTION (PCR)

- ▶ PCR is more sensitive and rapid than culture. Despite these advantages, PCR can give false-negative or false-positive results.
 - » False-positive results can occur from specimen cross-contamination during specimen collection and testing.
 - » False negative results increase with increasing time elapsed from cough onset (> 4 weeks after onset) or after antibiotic treatment (> 5 days).
 - » Cross-reaction with other *Bordetella* species can occur as no single gene target is specific for *B. pertussis*. A combination of several PCR targets is needed to differentiate between *Bordetella* species (7) (8).

- ▶ Many laboratories now use only PCR to confirm pertussis. However, there are no standardized PCR assays for pertussis across laboratories. In addition, assay procedures, as well as sensitivity and specificity, can vary greatly between laboratories. Use of External Quality Assurance (EQA) panels and regular testing in a reference lab are encouraged.

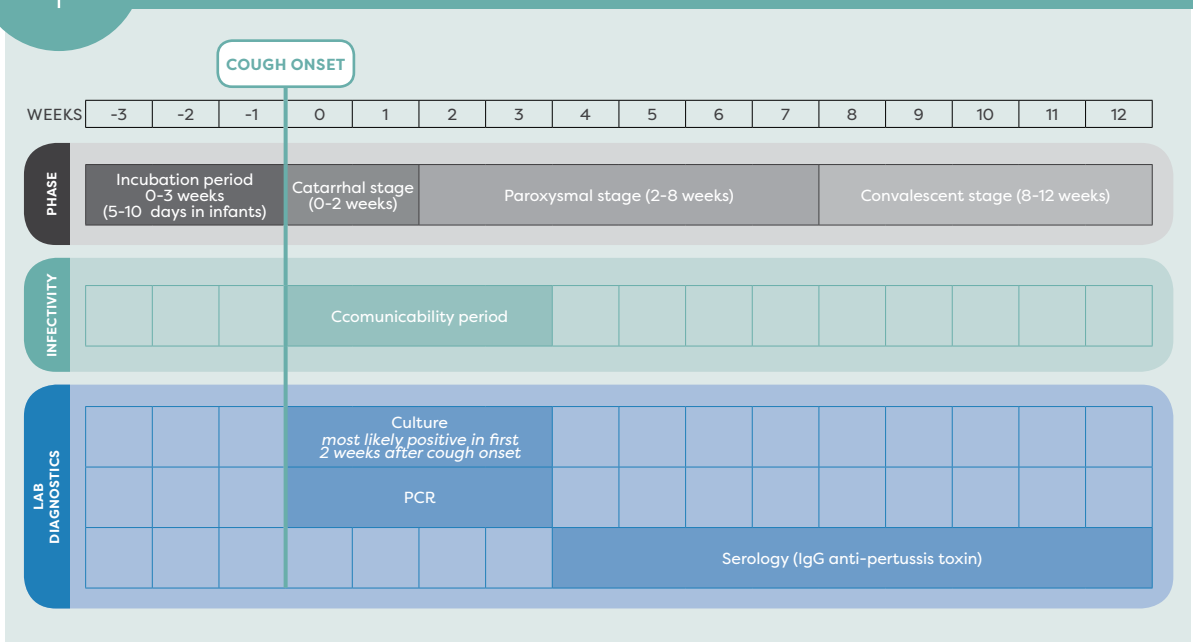
SEROLOGIC TESTING

- ▶ Research has shown that measuring IgG antibody titers to pertussis toxin is the most specific and sensitive assay, but needs to be calibrated to the reference standard for single time point assays, such as the WHO International Standard. Serology based on other pertussis antigens should be avoided. Unlike with other diseases, IgM is not used to diagnose pertussis cases due a lack of adequate sensitivity and specificity.
- ▶ Single serum should be considered positive in combination with clinically suspected pertussis. IgG is present from 4–12 weeks after cough onset. Serology is unreliable in infants due to presence of maternal antibodies, and is insensitive in children ≤ 10 years old. Moreover, serology should not be done if pertussis vaccination occurred within the past year among persons of all ages due to presence of vaccine-induced IgG.

DIRECT FLUORESCENT ANTIBODY (DFA) STAINING

Direct fluorescent antibody (DFA) staining of nasopharyngeal specimens is NOT recommended because of the high rates of false-positive and false-negative results.

FIGURE 1 Timing of laboratory diagnosis of *B. pertussis*



DATA COLLECTION, REPORTING AND USE

RECOMMENDED DATA ELEMENTS

If conducting aggregated data collection:

- Number of total cases by age group (< 6 months, 6–11 months, 1–4 years, ≥ 5 years), month, geographical area and immunization status (0, 1–2, 3+ doses), if available

If conducting case-based data collection¹:

➤ Demographic Information

- » Name (if confidentiality is a concern the name can be omitted so long as a unique identifier exists)
- » Unique case identifier
- » Date of birth (or age if date of birth not available)
- » Sex
- » Place of residence (city, district and province)

➤ Reporting information

- » Date of notification to public health
- » Date of investigation

➤ Clinical

- » Date of onset of cough (or apnea if no cough)
- » Signs and symptoms (at a minimum)
 - Paroxysms of cough
 - Inspiratory whooping
 - Post-tussive vomiting
 - Apnea
 - Treated with antibiotics for illness?
 - Date of start of treatment
- » Hospitalization status
- » Outcome (patient survived, died, unknown)
- » Clinician suspects pertussis?

¹ If the response for certain data elements is unknown, this should be stated rather than leaving variable blank.

- Laboratory methods and results
 - » Date and type(s) of specimen(s) collected (nasopharyngeal aspirate, nasopharyngeal swab, blood)
 - » Specimen collected before antibiotic provision?
 - » Date specimen sent to laboratory
 - » Date specimen(s) received in laboratory
 - » Laboratory testing methods (culture, PCR, serology, none)
 - For serology and PCR, which tests/targets were used, if known?
 - » Laboratory testing results (positive, negative, indeterminate) for each specimen
- Vaccination status
 - » Total number and dates of pertussis vaccine doses
 - » Type of pertussis vaccine doses (if both acellular and whole cell vaccines are used in country, or a change was made to the programme schedule)
 - » If < 1 year, maternal immunization status during pregnancy, including date of administration and type of vaccine given
- Classification
 - » Epidemiologically linked to a laboratory-confirmed case?
 - » Final case classification (laboratory-confirmed, epidemiologically linked, possible)

REPORTING REQUIREMENTS AND RECOMMENDATIONS

- Designated reporting sites at all levels should report laboratory-confirmed, epidemiologically linked confirmed and possible cases at a specified frequency (weekly or monthly), even if there are zero cases (often referred to as “zero reporting”).
- Case-based data should be provided to the next reporting level.
- International Health Regulations (IHR) does not require reporting of pertussis cases.
- Pertussis is included on the WHO/UNICEF Joint Reporting Form (JRF), which should be completed annually.

RECOMMENDED DATA ANALYSES

Analysis can be done on just confirmed cases (laboratory-confirmed and epidemiologically linked) or on all cases (laboratory-confirmed, epidemiologically linked and possible cases). National and subnational coverage, schedule and type of pertussis-containing vaccines should be considered in the interpretation of the data.

- **Aggregated data**
 - » Number of cases and incidence rate (where possible) by month, year, age group and geographical area (suggested age groupings depending on local priorities: < 6 months, 6–11 months, 1–4 years, ≥ 5 years)

- » Proportion of cases by number of doses received by district and age group
 - » Number of cases by pertussis immunization status (0, 1–2, 3+ doses), if available
 - **Case-based data, in addition to those listed for aggregated data**
 - » Crude and age-specific case fatality ratio overall and by district
 - » Age-specific, sex-specific and district-specific number of cases, or incidence rates by month and year (if able to determine population denominator)
 - » Proportion of cases receiving antibiotics after diagnosis
 - » Proportion of cases by final classification (report lab-confirmed and epidemiologically linked separately)
- USING DATA FOR DECISION-MAKING**
- Monitor disease burden with incidence rates where available to assess impact of the immunization system and policy (for example, immunization schedule or type of pertussis vaccine in use).
 - Monitor disease burden with incidence rates by geographical area where available to identify high-risk areas or those with poor immunization system performance (so that corrective actions can be taken).
 - Monitor age distribution of cases (age-specific attack rates) to identify age groups at risk, which may affect immunization policy.
 - Identify outbreaks and conduct investigations to determine the cause and understand the epidemiology of pertussis.
 - Monitor case fatality ratios and, if they are high, determine the causes (poor/late diagnosis, poor case management, poor/late access to care, underlying conditions).



SURVEILLANCE PERFORMANCE INDICATORS

Regular monitoring of surveillance indicators might identify specific areas of the surveillance system that need improvement. If performance indicators are not

being met, explore and correct the reasons for this. Some suggested surveillance indicators to monitor are listed in Table 2 below.

TABLE
2

Recommended surveillance indicators for pertussis

SURVEILLANCE ATTRIBUTE	INDICATOR	TARGET	HOW TO CALCULATE (NUMERATOR / DENOMINATOR)	COMMENTS
COMPLETENESS OF REPORTING	Percentage of designated units reporting pertussis data, even in the absence of cases	≥ 80%	# designated reporting units reporting pertussis / # designated reporting units for pertussis surveillance x 100 (for a given time period)	
TIMELINESS OF REPORTING	Percentage of designated units reporting to the national level on time, even in the absence of cases	≥ 80%	# of designated reporting units in the country reporting by the deadline / # of designated reporting units in the country x 100	At each level reports should be received on or before the requested date.
ADEQUACY OF INVESTIGATION <i>(applicable only if conducting case-based surveillance)</i>	Percentage of all suspected pertussis cases that have had an adequate investigation	≥ 80%	# of suspected cases of pertussis for which an adequate investigation was done / # of suspected pertussis cases x 100	Note 1: Adequate investigations include completing a case investigation form, collecting a specimen and line listing of close contacts in small outbreaks. Note 2: For any case, if any of the above are not conducted, the investigation is considered inadequate.
TIMELINESS OF INVESTIGATION <i>(applicable only if conducting case-based surveillance)</i>	Percentage of all suspected pertussis cases that have had an investigation initiated within 48 hours of notification	≥ 80%	# of suspected cases of pertussis for which an investigation is initiated within 48 hours of notification / # of suspected pertussis cases x 100	
SPECIMEN COLLECTION ADEQUACY <i>(applicable only if conducting case-based surveillance)</i>	Percentage of suspected pertussis cases with at least one specimen collected	≥ 80%	# of suspected cases of pertussis with at least one specimen collected / # of suspected pertussis cases x 100	
TIMELINESS OF SPECIMEN TRANSPORT	Percentage of specimens received at the laboratory within two days of collection	≥ 80%	# of specimens received within two days of collection by laboratory / # of specimens x 100	Indicator only applies to public laboratories.
TIMELINESS OF REPORTING PCR LABORATORY RESULTS	Percentage of PCR specimens with results reported within two days of receipt of specimen for PCR	≥ 80%	# of specimens tested by PCR with results reported within two days of receipt / # of specimens tested by PCR x 100	Indicator only applies to public laboratories.
TIMELINESS OF REPORTING CULTURE LABORATORY RESULTS	Percentage of culture specimens with results reported within seven days of receipt of specimen for culture	≥ 80%	# of specimens tested by culture with results reported within seven days of receipt / # of specimens tested by culture x 100	Indicator only applies to public laboratories.



CLINICAL CASE MANAGEMENT

ANTIBIOTIC TREATMENT

Macrolide antibiotics, such as erythromycin, may prevent or mitigate clinical pertussis when given during the incubation period or the early catarrhal stage. When given during the paroxysmal phase of the disease, antimicrobial drugs do not change the clinical course, but may eliminate bacteria from the nasopharynx and thus reduce transmission.

ISOLATION

Suspected cases should avoid contact with young children and women in late pregnancy, especially the unimmunized, until at least five days of antibiotics are taken. Ideally, untreated cases should avoid contact with high-risk individuals for the full infectious period. Hospitalized patients should be placed under respiratory isolation, or at a minimum apply contact and respiratory droplet precautions (such as wearing a mask when around other patients).



CONTACT TRACING AND MANAGEMENT

Contact investigation and management should focus on high-risk contacts at a minimum and, ideally, all close and high-risk contacts. Close contacts are people who have had face-to-face exposure to an infected case, which includes household or family contact, people having stayed overnight in the same room with a case, and people having direct contact with respiratory, oral or nasal secretions with a laboratory-confirmed case. High-risk contacts are not necessarily close contacts, but have been exposed to a suspected case and are themselves at increased risk of complications from pertussis or are at risk of transmitting the infection to other persons at risk of severe pertussis disease. These include the following: infants, pregnant women in the third trimester of pregnancy, health care workers working with infants or pregnant women, and persons of any age working or sharing a house with infants.

TESTING

Contacts should be tested only if they have symptoms consistent with pertussis infection. Asymptomatic contacts of confirmed cases should not be tested, and

testing of contacts should not be used for post-exposure prophylaxis decisions.

EARLY TREATMENT AND POST-EXPOSURE PROPHYLAXIS (PEP)

Early treatment with macrolide antibiotics (such as erythromycin) should be administered to close contacts who are infants < 6 months of age who develop symptoms of a respiratory infection (9). In addition to early treatment of young infants, some countries have chosen to apply post-exposure antibiotic prophylaxis to asymptomatic high-risk contacts even when symptoms are not present (10)(11)(12).

VACCINATION

During the course of a pertussis investigation, under-vaccinated persons with contact to pertussis cases may be identified. Pertussis-containing vaccine should be given to any person who is not fully immunized according to the recommended immunization schedule. Vaccination might not prevent illness in a person who has already been infected with *B. pertussis*.



SURVEILLANCE, INVESTIGATION AND RESPONSE IN OUTBREAK SETTINGS

DEFINITION OF AN OUTBREAK

An outbreak is an increase of incidence or number of cases over the reported baseline in a specific geographic area. This increase is difficult to define exactly and involves some level of local judgment. Outbreaks can occur in facilities such as schools, hospitals, or in larger geographic areas (for example, district). Pertussis outbreaks can be difficult to identify and manage, given the regular periodicity of pertussis (increased rates every three to five years) and the existence of other respiratory pathogens causing similar symptoms. To respond appropriately, it is important to confirm that *B. pertussis* is circulating in the outbreak setting and to determine whether other pathogens are contributing to the outbreak. Epidemiologic outbreak investigations can provide useful information on vaccine effectiveness and pertussis epidemiology, including the distribution of cases and case fatality ratio by age group. An outbreak of high severity among infants suggests gaps in immunization coverage, whereas an outbreak in older age groups might signal changing epidemiology (due to waning immunity) or changes in surveillance itself. Details on how to conduct outbreak investigations can be found elsewhere (13).

CHANGES TO SURVEILLANCE DURING AN OUTBREAK

If a country is conducting event-based or aggregate surveillance for the purpose of outbreak detection, once a cluster of cases is identified, cases should be investigated with a case investigation form (individual sporadic cases are not investigated or laboratory tested in an aggregate surveillance system). In small outbreaks, surveillance should move to line listing individual cases. In larger

outbreaks, information should be collected on a subset of cases to help understand the evolving epidemiology of the outbreak. Investigations of individual pertussis cases and their contacts should aid implementation of outbreak control preventive measures. If resources are limited, specimens may only be collected on a subset of cases (for example, the first 5–10 cases) to confirm the outbreak. After this point, epidemiological linking should be conducted to save resources. After two or three incubation periods (approximately one to two months), the process might need to be repeated to confirm that it is still a pertussis outbreak.

If a country is conducting case-based surveillance in sentinel sites, surveillance can be expanded to encompass more reporting sites or include a wider age range to better understand the epidemiology of the outbreak. However, consistency over time is required for monitoring trends over time among the sentinel sites. Again, a country may choose to rely more on epidemiologically linking as many cases as possible to limit the burden on the laboratory.

PUBLIC HEALTH RESPONSE

During outbreaks, vaccination efforts should focus on the un- or under-immunized. At the same time, routine immunization in the outbreak area should be strengthened. Contact management is the same as mentioned above, with a focus on early treatment among infants < 6 months of age with signs of a respiratory illness. Vaccination campaigns are not part of pertussis outbreak response. In some countries, PEP with macrolides is provided to asymptomatic household contacts or other close contacts of pertussis cases at the

highest risk of developing clinical illness, those at high risk of developing severe pertussis such as infants, and persons who will have close contact with those at high risk of developing severe pertussis.

With increasing incidence and widespread community transmission of pertussis, extensive contact tracing and broad scale use of PEP among contacts may not be an effective use of limited public health resources. While antibiotics may prevent pertussis disease if given prior to symptom onset, there are no data to indicate that widespread use of PEP among contacts effectively controls or limits the scope of community-wide pertussis outbreaks (14). A broader use of PEP may be appropriate in limited closed settings when the number of identified cases is small and when a community-wide outbreak is not ongoing. However, when continued transmission of pertussis is evident, multiple rounds of antibiotics would not be recommended.

Active screening for symptomatic patients with suspected pertussis should be done during outbreaks in settings such as schools, daycare centers and hospitals. Active screening for suspected cases potentially reduces exposure to more persons, especially vulnerable infants.

Notify all public and private health facilities in the affected and nearby areas of the outbreak and inform them to have a high index of suspicion for pertussis cases. Conduct health promotion activities and distribute education materials to provide basic information about pertussis and its prevention, particularly vaccination.



SPECIAL CONSIDERATIONS FOR PERTUSSIS SURVEILLANCE

WHO provides guidance on how to use surveillance data to estimate pertussis burden that might be useful (13).



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