14 Pertussis (whooping cough)

Key information

Mode of transmission	By aerosolised droplets.
Incubation period	7–10 days (range 5–21 days).
Period of communicability	For control purposes, the communicable stage lasts from the catarrhal stage to 3 weeks after the onset of paroxysmal cough in a case not treated with antimicrobials. When treated with an effective antibiotic (eg, erythromycin), infectivity lasts until 5 days of antibiotics have been taken.
At-risk populations	Infants aged under 12 months, particularly those too young to be immunised.
Funded vaccines	DTaP-IPV-HepB/Hib (Infanrix-hexa). DTaP-IPV (Infanrix-IPV). Tdap (Boostrix).
Dose, presentation, route	0.5 mL per dose. DTaP-IPV-HepB/Hib: pre-filled syringe and glass vial. The vaccine must be reconstituted prior to injection. DTaP-IPV, Tdap: pre-filled syringe. Intramuscular injection.
Funded vaccine indications and schedule	Usual childhood schedule: • at age 6 weeks, 3 months and 5 months: DTaP-IPV-HepB/Hib • at age 4 years: DTaP-IPV • at age 11 years: Tdap During pregnancy (from 28 to 38 weeks' gestation): Tdap. For (re-)vaccination of eligible patients: DTaP-IPV-HepB/Hib, DTaP-IPV or Tdap.
Dose interval between Td and Tdap	No minimum interval is required between Td and Tdap, unless Tdap is being given as part of a primary immunisation course.

Continued overleaf

Vaccine efficacy/ effectiveness	84 percent efficacy after the 3-dose primary course in infants, lasting up to age 6 years. Immunity (whether from natural infection or immunisation) wanes over time.
Precautions	Children with an evolving neurological disorder.
Adverse events from vaccine	Thigh or upper arm swelling occurs in 2–3 percent of children after the fourth and fifth doses.

14.1 Bacteriology

Pertussis (whooping cough) is a bacterial respiratory infection caused by *Bordetella pertussis*, a gram-negative bacillus. The bacillus is fastidious (it requires special media to culture), and will often have cleared or decreased in numbers by the time the typical cough develops, making laboratory confirmation by culture difficult. The development of sensitive and specific PCR and serological assays has improved our ability to demonstrate *B. pertussis* infection (see section 14.8).

14.2 Clinical features

Pertussis is highly transmissible and it is one of the most infectious vaccine-preventable diseases. The expected number of secondary cases caused by an infectious individual with pertussis (R_0) is approximately 14, similar to measles, and several-fold greater than influenza[1] (see section 1.2.1). Transmission occurs by aerosolised droplets, and the incubation period is 7 to 10 days (range 5 to 21 days).

The initial catarrhal stage, during which infectivity is greatest, is of insidious onset with rhinorrhoea and an irritating cough that can progress to severe paroxysms of coughing. In the catarrhal stage, which usually lasts one to two weeks, the only clue to diagnosis may be contact with a known case. This stage is followed by the paroxysmal stage, with coughing episodes characterised by a series of short expiratory bursts, followed by an inspiratory gasp or typical whoop, and/or vomiting. Patients appear relatively well between paroxysms and are usually afebrile.

Clinical presentation varies with age, immunisation status and previous infection. In young infants apnoea and/or cyanosis may precede paroxysmal cough, and it is important they are recognised as presenting symptoms of severe disease. Thus pertussis must be considered in

infants presenting with an acute life-threatening event, or apnoea.[2] In school-aged children immunised in infancy, symptoms that distinguish pertussis from other causes of coughing illnesses are inspiratory whoop, post-tussive vomiting and the absence of wheezing and fever.[3]

Almost all pertussis infections in adolescents and adults occur in the context of previous infection and/or immunisation. Persistent cough, sometimes for more than four weeks, is the cardinal feature in adults.[4] Cough is worse at night and often paroxysmal, the patient waking with a choking sensation. Post-tussive vomiting and whoop are infrequent. A scratchy throat and sweating attacks are common.

Studies performed in several countries during both epidemic and non-epidemic periods have shown that between 12 and 37 percent of school-aged children, adolescents and adults with persistent cough (lasting 14 days or more) have evidence of recent *B. pertussis* infection.[3, 4, 5, 6, 7, 8, 9] A primary care-based study in New Zealand performed during the early phase of the 2011 to 2013 epidemic showed recent *B. pertussis* infection in 17 percent of children aged 5–16 years and 7 percent of adults aged 17–49 years presenting to primary care with a persistent cough of two or more weeks' duration.[10]

The most common complications of pertussis are secondary infections, such as otitis media and pneumonia, and the physical sequelae of paroxysmal coughing (eg, subconjunctival haemorrhages, petechiae, epistaxes, central nervous system haemorrhages, pneumothoraces and herniae). At the peak of the paroxysmal phase, vomiting can lead to weight loss, especially in infants and young children. The disease is most often severe in infants in the first few months of life. Of infants with pertussis sufficiently severe to require intensive care admission, one in six will either die or be left with brain or lung damage.[11]

14.3 Epidemiology

The epidemiology of *B. pertussis* infection and pertussis disease differ. Infection occurs across the age spectrum, and repeated infection without disease is common.[12] The endemic circulation of *B. pertussis* in older children and adults provides a reservoir for spread of the infection and the development of severe disease in incompletely vaccinated infants.

14.3.1 Global burden of disease

Pertussis mortality rates have always been highest in the first year of life.[13, 14] In the US during the 1940s pertussis resulted in more infant deaths than measles, diphtheria, poliomyelitis and scarlet fever combined.[13] Beyond age 3 years mortality rates have always been relatively low. In immunised populations virtually all deaths occur in the first two months of life, and deaths in toddlers and preschool-aged children have largely disappeared. Among infants, younger age, lack of immunisation, low socioeconomic status, premature gestation, low birthweight and female gender are associated with an increased risk of fatal pertussis.[14]

Pertussis mortality and morbidity[15] is under-reported. It is estimated that in high-income countries three times more deaths are due to pertussis than are reported.[15, 16, 17, 18] Infants continue to die from pertussis despite state-of-the-art intensive care.[11, 19, 20, 21, 22]

Since the introduction of mass immunisation, countries with consistently high immunisation coverage rates achieve consistently low pertussis incidence rates.[23, 24] Higher pertussis incidence rates are due primarily to lower immunisation coverage, but also in some instances to lower vaccine efficacy or less-than-optimal immunisation schedules.[25, 26, 27, 28, 29]

The decrease in incidence following the introduction of mass immunisation has been most pronounced in those aged under 10 years. Despite this, the reported pertussis disease rates have remained highest in infants and young children.[30, 31, 32] Infants aged under 3 months have the highest rate of notification and hospitalisation.[33, 34]

Pertussis is an epidemic disease with two- to five-yearly epidemic cycles. Epidemics are frequently sustained over 18 months or more, during which there are dramatic increases in hospital admission rates. Pertussis does not show the seasonal variability that is typical of most respiratory infections.

The epidemic periodicity of pertussis has not lengthened with the introduction of mass immunisation, unlike other epidemic diseases for which mass immunisation is used, such as measles. This lack of lengthening of the pertussis epidemic cycle implies minimal impact of mass immunisation on the circulation of *B. pertussis* in the human population.[12, 35, 36]

14.3.2 New Zealand epidemiology

Pertussis mortality in New Zealand

On average, there are zero to one deaths from pertussis each year in New Zealand. During the most recent pertussis epidemic (see below) there were three deaths in children: two in infants aged under 6 weeks and one in an unimmunised preschooler. There were no deaths from pertussis (as recorded in EpiSurv) in 2014 or 2015.[37]

Pertussis morbidity in New Zealand

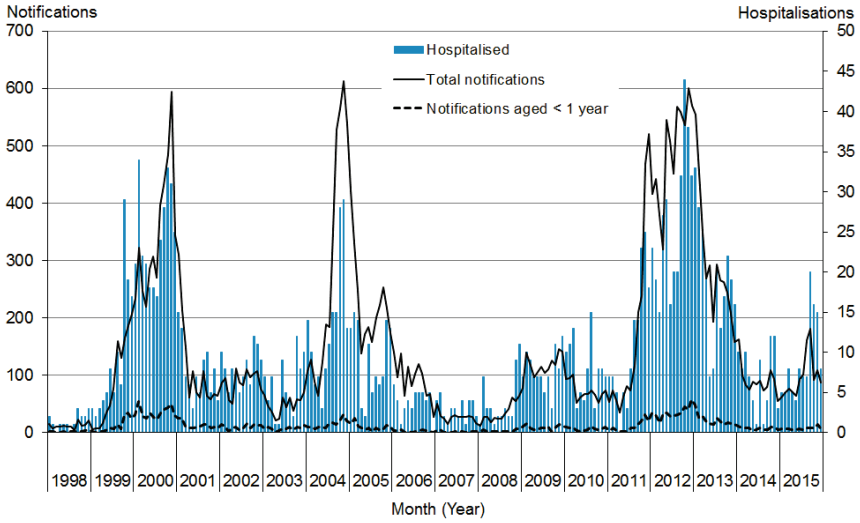
Pertussis morbidity in New Zealand has usually been described using hospital discharge data. National passive surveillance data has been available since 1996, when pertussis became a notifiable disease.

Pertussis morbidity in New Zealand as described by notification data

In 2015, 1,168 cases were notified, of which 650 were laboratory-confirmed.[37] The 2015 notification rate was 25.4 per 100,000 population, similar to the rate in 2014 (24.4 per 100,000, 1,099 cases). Infants had the highest notification rate (152.3 per 100,000, 90 cases), followed by children aged 1–4 years (55.1 per 100,000, 136 cases). By ethnicity, Pacific peoples had the highest notification rate (31.8 per 100,000, 90 cases), followed by European/Other (26.2 per 100,000, 800 cases) and Māori (25.7 per 100,000, 176 cases).

Three epidemics have occurred since pertussis became a notifiable disease, with an epidemic peak annual number of notified cases of 4,140 in 2000, 3,485 in 2004, and 5,897 in 2012 (see Figure 14.1).[37]

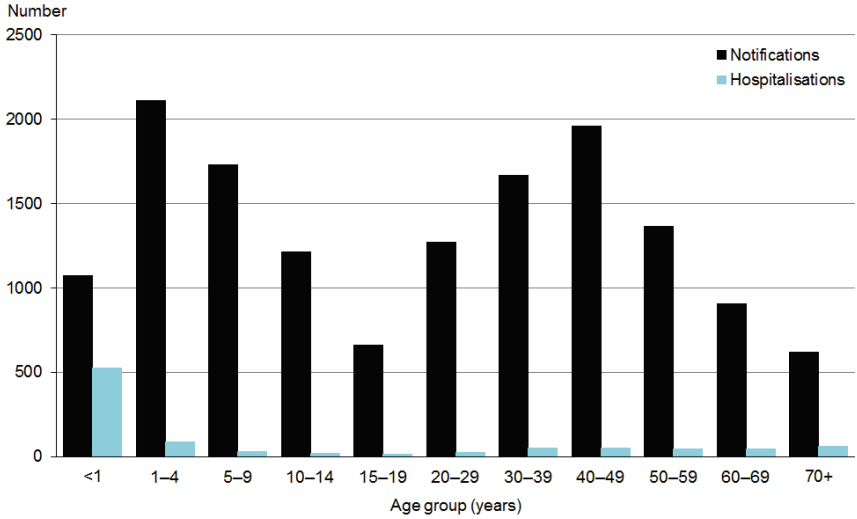
Figure 14.1: Pertussis notifications and hospitalisations, 1998–2015



Note: Includes confirmed, probable and suspect cases, and notifications still under investigation.
Source: ESR

Since pertussis became notifiable, the annual proportion of notified cases aged 30 years or older has increased from 23 percent (in 1997) to 44 percent in 2015.[37] However, the highest proportion of hospitalised cases continues to be in infants. From 2010 to 2015 there were 1,075 notified cases in infants. Hospitalisation status was recorded for 977 of the infant cases; of these, 527 (54 percent) were hospitalised (Figure 14.2).

Figure 14.2: Age distribution of notified and hospitalised pertussis cases, 2010–2015 cumulative data



Source: ESR

Pertussis morbidity in New Zealand, as described by hospital discharge data

Hospitalisation rates for pertussis, as measured by ICD discharge diagnostic codes, provide a measure of severe pertussis disease. The discharge rate in the 2000s was lower than in the 1990s (2000s versus 1990s, relative risk 0.79 [95% CI: 0.74–0.84]). Despite this decrease, the infant hospitalisation rate for pertussis in New Zealand in the 2000s (196 per 100,000) remained three times higher than contemporary rates in Australia (2001 infant rate: 56 per 100,000) and the US (2003 infant rate: 65 per 100,000).[38, 39, 40]

Pertussis hospital admission rates vary with ethnicity and household deprivation. From 2006 to 2010 the infant (aged under 12 months) pertussis hospital discharge rate (per 1,000) was higher for Māori (1.49; relative risk 2.29 [95% CI: 1.77–2.96]) and Pacific peoples (2.03; relative risk 3.11 [95% CI: 2.30–4.22]) and lower for Asian/Indian (0.31; relative risk 0.47 [95% CI: 0.25–0.90]) compared with European/Other people (0.65 per 1,000).[41]

From 2006 to 2010 an infant living in a household in the most deprived quintile was at a four-fold increased risk of being hospitalised with pertussis compared with an infant in the least deprived quintile (1.89 versus 0.39 per 1,000; relative risk 4.81 [95% CI: 2.99–7.75]).[41]

14.4 Vaccines

Whole-cell pertussis vaccine for routine use was introduced in 1960 and was replaced with acellular pertussis vaccine in 2000. The current schedule of three acellular pertussis-containing vaccines in the first year of life plus booster doses at ages 4 and 11 years has been in effect since 2006. See Appendix 1 for more information about the history of pertussis-containing vaccines in New Zealand.

14.4.1 Available vaccines

Funded pertussis vaccines

The acellular pertussis-containing vaccines funded as part of the Schedule are:

- DTaP-IPV-HepB/Hib (Infanrix-hexa, GSK): diphtheria, tetanus, acellular pertussis, inactivated polio, hepatitis B and *Haemophilus influenzae* type b vaccine
- DTaP-IPV (Infanrix-IPV, GSK): diphtheria, tetanus, acellular pertussis and inactivated polio vaccine
- Tdap (Boostrix, GSK): a smaller adult dose of diphtheria and pertussis vaccine, together with tetanus vaccine.

See section 5.4.1 for more information.

Other vaccines

Other acellular pertussis-containing vaccines registered (approved for use) and available (marketed) in New Zealand include:

- Tdap: Adacel (Sanofi)
- Tdap-IPV: Adacel Polio (Sanofi).

14.4.2 Efficacy and effectiveness

Immunogenicity

A review of published data on DTaP-IPV-HepB/Hib found it to be highly immunogenic in infants aged under 2 years for primary and booster vaccination.[42] In clinical studies there was a strong immune response against the vaccine antigens, which persisted for up to approximately six years after vaccination. A review of published clinical trial and post-marketing surveillance data supported the immunogenicity of DTaP-IPV-HepB/Hib across a range of schedules and when administered concurrently with other vaccines.[43]

Efficacy and effectiveness

The acellular pertussis vaccines approved for use in New Zealand have been shown to provide around 81–85 percent efficacy (95% CI: 51–100) after three infant doses, with follow-up studies suggesting sustained efficacy to age 6 years.[44, 45, 46]

Observational study data suggests that acellular pertussis vaccines, while effective, may be less effective than the best performing whole-cell vaccines in preventing whooping cough.[47, 48] Children and adolescents who have received acellular pertussis vaccine for their entire pertussis immunisation series are at greater risk of pertussis than children whose immunisation series included some doses of whole-cell vaccine and some doses of acellular vaccine.[49]

See section 4.1.2 for information about maternal pertussis vaccine effectiveness and safety.

Duration of protection

Protection against pertussis begins to wane within several years of completion of a three-dose primary and two-dose booster dose immunisation series. The US has a pertussis immunisation schedule that includes three doses of acellular vaccine during infancy and booster doses at 15 to 18 months and 4 to 6 years.[50] The risk of pertussis increases in the six years after receipt of the fifth dose of this series, indicating a waning in vaccine-induced immunity over this time interval.

In adults, a trial of a monovalent acellular pertussis vaccine in the US among people aged 15–65 years found an efficacy of 92 percent (95% CI: 32–99) after a median of 22 months of follow-up.[51] Antibodies to pertussis toxoid, filamentous hemagglutinin and pertactin have been shown to persist five years after receipt of Tdap (Boostrix) in a study of Australian adults aged 18 years and older.[52] However, the duration of protection is unknown.

14.4.3 Transport, storage and handling

Transport according to the *National Standards for Vaccine Storage and Transportation for Immunisation Providers 2017*.[53] Store at +2°C to +8°C. Do not freeze.

DTaP-IPV-HepB/Hib should be stored in the dark.

DTaP-IPV-HepB/Hib (Infanrix-hexa) must be reconstituted by adding the entire contents of the supplied container of the DTaP-IPV-HepB vaccine to the vial containing the Hib pellet. After adding the vaccine to the pellet, the mixture should be shaken until the pellet is completely dissolved. Use the reconstituted vaccine as soon as possible. If storage is necessary, the reconstituted vaccine may be kept for up to eight hours at 21°C.

14.4.4 Dosage and administration

The dose of DTaP-IPV-HepB/Hib, DTaP-IPV and Tdap is 0.5 mL, administered by intramuscular injection (see section 2.2.3).

Co-administration with other vaccines

DTaP-IPV-HepB/Hib, DTaP-IPV and Tdap can be administered simultaneously (at separate sites) with other vaccines or IGs.

14.5 Recommended immunisation schedule

Table 14.1: Immunisation schedule for pertussis-containing vaccines (excluding catch-up)

Age	Vaccine	Comment
6 weeks	DTaP-IPV-HepB/Hib	Primary series
3 months	DTaP-IPV-HepB/Hib	Primary series
5 months	DTaP-IPV-HepB/Hib	Primary series
4 years	DTaP-IPV	Booster
11 years	Tdap	Booster
Pregnant women (weeks 28–38 of each pregnancy)	Tdap	Booster

14.5.1 Children

A primary course of pertussis vaccine is given as DTaP-IPV-HepB/Hib (Infanrix-hexa) at ages 6 weeks, 3 months and 5 months, followed by a dose of DTaP-IPV (Infanrix-IPV) at age 4 years (Table 14.1). A further booster is given at age 11 years (school year 7) as Tdap (Boostrix).

Dose intervals

The minimum interval between doses is four weeks, and the first dose should not be given before four weeks of age. If a course of immunisation is interrupted for any reason it may be resumed without repeating prior doses (see Appendix 2). A booster dose should be given no earlier than six months after the primary series.

Catch-up immunisation

See Appendix 2 for detailed catch-up immunisation information.

- DTaP-IPV-HepB/Hib or DTaP-IPV may be used for primary immunisation of children aged under 10 years.
- Tdap may be used for primary immunisation of children aged 7 to under 18 years.

Dose interval between Td and Tdap

When Tdap is to be given to adolescents or adults to protect infants or other vulnerable individuals from pertussis, no minimum interval is required between Td and Tdap,[54, 55, 56] – unless Tdap is being given as part of a primary immunisation course.

14.5.2 Pregnancy and breastfeeding

Pregnant women should receive a dose of Tdap (funded) from 28 to 38 weeks' gestation. This should be given during each pregnancy[57] to protect the mother and so that antibodies can pass to the fetus; post-partum maternal vaccination will reduce the risk of a mother infecting her baby but does not have the added benefit of providing passive antibodies.

See section 4.1.2 for information about maternal pertussis vaccine effectiveness and safety.

Tdap vaccines can be given to breastfeeding women.[58]

14.5.3 (Re-)vaccination

Pertussis-containing vaccines are funded for (re-)vaccination of eligible patients, as follows. See also sections 4.2 and 4.3.

DTaP-IPV-HepB/Hib (Infanrix-hexa) and DTaP-IPV (Infanrix-IPV)

An additional four doses (as appropriate) of DTaP-IPV-HepB/Hib (for children aged under 10 years) or DTaP-IPV are funded for (re-)vaccination of patients:

- post-HSCT or chemotherapy
- pre- or post-splenectomy
- pre- or post-solid organ transplant
- undergoing renal dialysis
- with other severely immunosuppressive regimens.

Up to five doses of DTaP-IPV-HepB/Hib (for children aged under 10 years) or DTaP-IPV are funded for children requiring solid organ transplantation.

Tdap (Boostrix)

An additional four doses (as appropriate) of Tdap (Boostrix) are funded for patients:

- post-HSCT or chemotherapy
- pre- or post-splenectomy
- pre- or post-solid organ transplant
- undergoing renal dialysis
- with other severely immunosuppressive regimens.

14.5.4 Recommended but not funded

Tdap is recommended but not funded for:

- lead maternity carers and other health care personnel who work in neonatal units and other clinical settings (such as GPs and practice nurses), where they are exposed to infants, especially those with respiratory, cardiac, neurological or other co-morbid conditions (with a booster dose at 10-year intervals)
- household contacts of newborns, including adult household and other close contacts (contacts who are aged under 18 years and who are unimmunised or incompletely immunised for their age can receive funded pertussis vaccine; see Appendix 2 for catch-up schedules)
- early childhood workers (with a booster dose at 10-year intervals), although the priority is to ensure all children attending child care have received age-appropriate vaccination
- wound care (see section 19.5.5).

14.6 Contraindications and precautions

See also section 2.1.3 for pre-vaccination screening guidelines and section 2.1.4 for general contraindications for all vaccines.

14.6.1 Contraindications

The only contraindication is an immediate severe anaphylactic reaction to the vaccine, or any component of the vaccine, following a previous dose.

14.6.2 Precautions

For children with an undiagnosed or evolving neurological disorder (eg, uncontrolled epilepsy or deteriorating neurological state), there is the potential for confusion about the role of vaccination in the context of a clinically unstable illness. The risks and benefits of withholding vaccination until the clinical situation has stabilised should be considered on an individual basis.

14.7 Expected responses and AEFIs

Unless the specific contraindications and precautions outlined in section 14.6 above are present, practitioners should have no hesitation in advising the administration of acellular pertussis vaccine. Although whole-cell pertussis vaccine has been associated with febrile seizures, there was never any good-quality evidence that it caused any more significant neurological disorder. Disorders for which any causal association with pertussis vaccine have been disproved include infantile spasms, Reye syndrome and SUDI.[59, 60, 61, 62, 63, 64, 65, 66] Similar to previous studies, the New Zealand Cot Death Study found a lower rate of SUDI in immunised children.[67] Acellular pertussis vaccine has been used in New Zealand since 2000 and is significantly less reactogenic than was the whole-cell pertussis vaccine.

14.7.1 DTaP-containing vaccines

DTaP-containing vaccines (eg, DTaP-IPV-HepB/Hib and DTaP-IPV) are generally well tolerated in children,[68] including preterm (24 to 36 weeks' gestation) and/or low birthweight (820–2,020 grams) infants.[69, 70]

Local reactions commonly include pain, redness, swelling and induration at the injection site.[68] Less common reactions include fretfulness, anorexia, vomiting, crying, and slight to moderate fever.[68] These local and systemic reactions usually occur within several hours of pertussis immunisation and spontaneously resolve within 48 hours without sequelae.[68]

Local reactions increase with age and additional doses of vaccine. The reaction may be due to some of the other vaccine components, such as aluminium. These reactions are usually minor and only last a day or so. In a small percentage of vaccine recipients the reactions will be severe enough to limit movement of the arm and may last for about a week.

14.7.2 Tdap vaccine

The adult reduced-concentration Td and Tdap (Boostrix) vaccines have been found to have no safety concerns in those aged 10–64 years and those aged over 65 years.[71, 72, 73] Administration of Tdap to pregnant women did not identify any concerning patterns in maternal, infant, or fetal outcomes.[74, 75]

Local reactions following immunisation of adolescents with Tdap are common, but are usually mild. They include pain (in 75 percent of recipients), swelling (21 percent) and redness (23 percent) at the injection site.[76]

Expected systemic reactions following immunisation of adolescents with Tdap include fever >38°C (5 percent), headache (16 percent), fatigue (14 percent) and gastrointestinal symptoms (10 percent).[76]

14.7.3 Major adverse events associated with pertussis-containing vaccines

The incidence of major adverse events following primary pertussis immunisation is summarised in Table 14.2.

Table 14.2: Incidence (per 100,000 doses) of major adverse reactions following acellular pertussis vaccine

Event following immunisation	Timing post-vaccination	Incidence per 100,000 doses
Persistent (>3 hours) inconsolable screaming	0–24 hours	44
Seizures	0–2 days	7
Hypotonic-hyporesponsive episode	0–24 hours	0–47 in trials of acellular vaccines
Anaphylaxis	0–1 hour	Very rare

Source: Edwards KM, Decker MD. 2008. Pertussis vaccine. In: Plotkin SA, Orenstein WA, Offit PA (eds). *Vaccines* (5th edition). Philadelphia, PA: WB Saunders Company. Table 21.15.

Swelling involving the entire thigh or upper arm occurs in 2–3 percent of children after administration of the fourth and fifth doses of acellular pertussis vaccine.[68] The pathogenesis is unknown. Resolution occurs without sequelae. Extensive limb swelling after the fourth dose does not predict an increased risk of a similar reaction following the fifth dose of pertussis vaccine and is not a contraindication to receipt of the fifth dose.

Neither a hypotonic-hyporesponsive episode nor seizures are associated with long-term consequences for the child[77, 78, 79] (see section 2.3.3). Children who have febrile seizures after pertussis immunisation do not have an increased risk of subsequent seizures or neurodevelopmental disability.[80] It is safe to give acellular pertussis vaccine after a hypotonic-hyporesponsive episode has occurred following a previous dose.[81]

14.8 Public health measures

14.8.1 Improving pertussis control

The goal of the pertussis immunisation programme is to protect those most at risk of developing severe disease; that is, infants in the first year of life. Two key strategies for reducing the burden of disease in infants are the administration of Tdap vaccination during pregnancy and on-time infant immunisation. Vaccination during pregnancy is recommended and funded for women from 28 to 38 weeks' gestation (see section 14.5.2). More complete and timely delivery of the current

infant immunisation schedule would reduce the infant pertussis disease burden.[82] It is important that all children attending early childhood services should be fully vaccinated for their age.

In October 2012 the UK introduced a pertussis vaccination programme for pregnant women in response to a nationwide pertussis outbreak. The vaccine effectiveness for preventing laboratory-confirmed pertussis in infants aged under 3 months was estimated to be 91 percent (95% CI: 84–95).[83] This high vaccine effectiveness is likely to be a result of protection of infants by both passive antibody transfer and reduced exposure to maternal disease.[83]

Data on the protective effects of indirect strategies is currently incomplete. Infants can be protected by immunisation of others at risk of developing pertussis, with whom the infant may come into contact.[84] The 'cocoon strategy' is the term used to describe the protection of infants by immunising those who are potential sources of *B. pertussis*.[84] This involves the targeted immunisation of adult groups who have the most contact with young and vulnerable infants. Three identified groups are (1) new mothers who have not had recent immunisation, family, and close contacts of newborns; (2) health care workers; and (3) early childhood workers.

Health care workers in particular are at increased risk of pertussis and can transmit pertussis to other health care workers and to patients.[85] Outbreaks in maternity wards, neonatal units and outpatient settings have been described.[86] Fatalities occur as a result of such nosocomial spread.[87]

Immunisation cannot be used to control a community outbreak, although action to update age-appropriate vaccination in institutional settings (schools and early childhood services) is appropriate. When an outbreak occurs, individual immunisation status should be checked and immunisation completed. In an outbreak setting, infants as young as four weeks of age can commence immunisation.

14.8.2 Notification

It is a legal requirement that all cases of pertussis be notified immediately on suspicion to the local medical officer of health.

A suspected pertussis case can be confirmed if a clinically compatible illness is laboratory confirmed, or is epidemiologically linked to a confirmed case. Because transmission is by aerosolised droplets, health care personnel looking after pertussis cases should wear a mask even if vaccinated.

14.8.3 Laboratory diagnosis of *Bordetella pertussis* infection

PCR is the most sensitive method for diagnosing *B. pertussis* infection. In general, *B. pertussis* can be identified by PCR from most upper respiratory tract samples, including throat swabs, for up to four to six weeks after symptom onset. Serology may be useful when symptoms have been present for more than two weeks, at a time when PCR and culture are more likely to be negative.

The local laboratory should be consulted for the specifics of which swabs and transport media to use.

14.8.4 Antimicrobial treatment of case

A number of antibiotics are available for the treatment and prophylaxis of pertussis. Macrolide antibiotics can be used to reduce the severity and duration of clinical disease but only if started during the catarrhal phase. Antibiotics commenced after coughing paroxysms have begun have no effect on the clinical disease but do reduce the risk of spread of disease to others.[68, 88, 89] Antibiotics are of limited value if started after 21 days of illness, but should be considered for high-risk contacts (eg, young infants and pregnant women). To minimise transmission to newborn infants, it is recommended that pregnant women diagnosed with pertussis in the third trimester be treated with appropriate antibiotics (see Table 14.3), even if six to eight weeks have elapsed since the onset of cough.[90]

Macrolide use during pregnancy, lactation and in the neonatal period is associated with an increased risk of infantile pyloric stenosis.[91, 92] With erythromycin, the risk increases with decreasing age and increased duration of treatment.[93] The risk is presumed to be lower with azithromycin, although there are case reports of infantile pyloric stenosis occurring when azithromycin has been used during pregnancy.

Parents should be informed of the risks of this complication and of the symptoms and signs of infantile hypertrophic pyloric stenosis. The infant should be monitored for this complication for four weeks after completion of treatment.[68, 94, 95]

Table 14.3: Recommended antimicrobial therapy and post-exposure prophylaxis for pertussis in infants, children, adolescents and adults

Age	Recommended	Alternative		
	Azithromycin[a]	Erythromycin	Clarithromycin[b]	TMP-SMX[c]
Younger than 4 weeks	Day 1: 10 mg/kg/day in a single daily dose Days 2–5: 5 mg/kg/day in a single daily dose	40 mg/kg/day in 4 divided doses for 14 days	Not recommended	Contraindicated under age 2 months (risk for kernicterus)
1–5 months	Day 1: 10 mg/kg/day in a single daily dose Days 2–5: 5 mg/kg/day in a single daily dose	40 mg/kg/day in 4 divided doses for 14 days	15 mg/kg per day in 2 divided doses for 7 days	Aged 2 months or older: TMP, 8 mg/kg/day; SMX, 40 mg/kg/ day in 2 divided doses for 14 days
6 months or older and children	Day 1: 10 mg/kg/day in a single daily dose (maximum 500 mg) Days 2–5: 5 mg/kg/ day in a single daily dose (max 250 mg per day)	40 mg/kg/day in 4 divided doses for 14 days (maximum 2 g/day)	15 mg/kg/day in 2 divided doses for 7 days (maximum 1 g/day)	Aged 2 months or older: TMP, 8 mg/kg/day; SMX, 40 mg/kg/ day in 2 divided doses for 14 days
Adolescents and adults	Day 1: 500 mg as a single dose Days 2–5: 250 mg once daily	2 g/day in 4 divided doses for 14 days	1 g/day in 2 divided doses for 7 days	TMP, 320 mg/ day; SMX, 1,600 mg/day in 2 divided doses for 14 days

a Preferred macrolide during pregnancy, lactation and in infants <1 month old because of risk of idiopathic hypertrophic pyloric stenosis associated with erythromycin.

b Not funded for treatment or post-exposure prophylaxis in New Zealand.

c TMP = trimethoprim; SMX = sulfamethoxazole. TMP-SMX can be used as an alternative agent to macrolides in patients aged ≥2 months who are allergic to macrolides, who cannot tolerate macrolides, or who are infected with a rare macrolide-resistant strain of *Bordetella pertussis*.

Adapted from: Centers for Disease Control and Prevention. 2005. Recommended antimicrobial agents for treatment and post exposure prophylaxis of pertussis. *Morbidity and Mortality Weekly Report* 54(RR14): 1–16.

Cases should be excluded from early childhood services, school, or community gatherings until:

- they are well enough to attend, *and*
- either they have received five days of antibiotics, *or* exclude them for three weeks from the date of onset of the coughing paroxysms (at which point they are unlikely to be infectious) or until the end of their coughing (whichever comes first).

Children who have culture-proven pertussis should complete their immunisation series with all of the scheduled doses recommended for their age.

14.8.5 Management of contacts

The local medical officer of health will advise on the management of contacts. For more details on control measures, refer to the 'Pertussis' chapter of the *Communicable Disease Control Manual 2012*.[96]

A contact can be defined as someone who has been in close proximity (within one metre)[97] of the index case for one hour or more during the case's infectious period. Contacts include household members, those who have stayed overnight in the same room, and those who have had face-to-face contact with the case.[96]

Those most at risk from pertussis and who are therefore high-priority contacts for public health follow-up are:

- infants, especially those aged under 6 months
- children and adults who live with, or spend time around, infants, including health care and education settings
- pregnant women, especially in the last month of pregnancy
- individuals at risk of severe illness or complications (eg, with chronic respiratory conditions, congenital heart disease or immune deficiency).

The evidence for the effectiveness of chemoprophylaxis of contacts is limited. Antibiotics are currently only recommended for high-priority contacts as listed above and if given within three weeks of initial exposure to an infectious case.

Health care workers are frequently exposed to *B. pertussis*. Although the greatest priority is given to protecting young infants and unimmunised children, there are well-documented examples of spread from staff to older adult patients. Pertussis in adults can be debilitating and can cause significant morbidity in those with respiratory disease.

Chemoprophylaxis may therefore be useful for adults exposed to a health care worker with pertussis, and infection control or public health services should normally be involved. Factors to be considered when discussing chemoprophylaxis include whether adult pertussis vaccine has been administered within the last five years, the health status of the individual who has been exposed, how recent the exposure was, and the nature of the health care or special community setting.

Where a case worked in a maternity ward or newborn nursery for more than an hour while infectious, then all babies in that ward and their parents/carers who were exposed to the case (within one metre for more than one hour) should receive antibiotics. Note: If the minimum duration of exposure is uncertain, a neonate exposed to an infectious case for less than one hour may warrant being considered a close contact and receive antibiotics.[98]

Any contacts, high priority or otherwise, should be advised to avoid attending early childhood services, school, work or community gatherings if they become symptomatic. Additional restrictions may be advised by the local medical officer of health, in particular if there is significant risk of transmission of infection to high-priority individuals.

14.9 Variations from the vaccine data sheets

The DTaP-IPV-HepB/Hib (Infanrix-hexa) and DTaP-IPV (Infanrix-IPV) data sheets state that these vaccines are indicated for primary immunisation of infants and as a booster dose for children. The Ministry of Health recommends that DTaP-IPV-HepB/Hib and DTaP-IPV vaccines may also be used for catch-up of the primary schedule in children aged under 10 years (see Appendix 2).

The data sheets for DTaP-IPV-HepB/Hib, DTaP-IPV and Tdap (Boostrix) state that these vaccines are contraindicated in children with encephalopathy of unknown aetiology or with neurologic complications occurring within seven days following a vaccine dose. The Ministry of Health recommends instead that the only contraindication is a history of anaphylaxis to a previous dose or to any of the vaccine components (see section 14.6.1). The risks and benefits of withholding vaccination until the clinical situation has stabilised should be considered on an individual basis (see section 14.6.2).

Tdap is not approved for use (registered) for primary immunisation. However, the Ministry of Health recommends that children aged 7 to under 18 years may receive Tdap (funded) and adults aged over 18 years may receive Tdap (unfunded) for catch-up of the primary schedule (see Appendix 2).

The Tdap data sheet states that the vaccine may be used during pregnancy when the possible advantages outweigh the possible risks for the fetus. However, the Ministry of Health recommends and funds Tdap vaccine for all pregnant women from 28 to 38 weeks' gestation (see section 14.5.2).

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