

# PERTUSSIS

## Introduction

Pertussis (whooping cough) is a highly contagious acute respiratory tract infection caused by the bacterium *Bordetella pertussis*. It is spread by aerosol droplets. Neither vaccination nor natural disease provides complete or lifelong immunity. “Classic” pertussis follows an incubation period of a few days to a few weeks and is recognised as having three stages: a catarrhal stage with a runny nose and sneezing (1-2 weeks), a paroxysmal stage (2-6 weeks) in which prolonged bursts of uninterrupted coughing are followed by a characteristic inspiratory whoop, and a convalescent stage ( $\geq 2$  weeks). Young infants, who make up  $> 90\%$  of the fatalities from pertussis, do not display the classic stages and apnoea and cyanosis may be the only signs of the disease initially. Young infants suspected of having pertussis need hospitalisation and the most severely affected can require intubation, drug-induced paralysis and ventilation [146]. In New Zealand morbidity from pertussis remains significant with hospitalisation rates being considerably higher than in other developed countries [147].

Routine pertussis vaccination began in New Zealand in 1960 and the current schedule recommends vaccination at 6 weeks, 3 months, and 5 months of age with booster doses at 4 years and 11 years [148]. The extra booster at 11 years was added to the schedule in 2006. Despite improvements in immunisation coverage epidemics of pertussis continue to occur, on average, every four years. This pattern is not significantly different from the pre-immunisation era, although rates of disease are less. Since pertussis became a notifiable disease in 1996, the proportion of notified cases aged  $\geq 30$  years has increased from 23% in 1997 to 54% in 2008. While this reflects what has occurred in other countries and is probably due to increased awareness and surveillance, it also indicates that infected adults are an important source of disease for infants.

In terms of reducing the burden of disease, besides improving coverage and timeliness of infant vaccination, which is the most important strategy, the Global Pertussis Initiative recommends universal preschool booster doses, universal adolescent immunisation, universal adult immunisation, selective immunisation of new mothers, family, and close contacts of newborns (the “cocoon strategy”), selective immunisation of healthcare workers, and selective immunisation of childcare workers [149,150].

The following section reviews pertussis rates in infants aged  $<1$  year using information from the National Minimum Dataset and Mortality Collection. The section concludes with a brief overview of policy and evidence-based review documents which consider interventions to reduce pertussis at the population level.

### Data Sources and Methods

#### Indicator

##### 1. Acute and Semi-Acute Hospital Admissions for Pertussis in Infants Aged $<1$ Year

**Numerator:** National Minimum Dataset: Acute and semi-acute hospital admissions for infants aged  $<1$  year with an ICD-10-AM primary diagnosis of Pertussis/Whooping Cough: Whooping cough due to *Bordetella pertussis* (A37.0); Whooping cough due to *Bordetella parapertussis* (A37.1); Whooping cough due to other *Bordetella* species (A37.8); Whooping cough, unspecified (A37.9).

**Denominator:** Birth Registration Dataset

##### 2. Mortality from Pertussis in Infants Aged $<1$ Year

**Numerator:** National Mortality Collection: Deaths in Infants Aged  $<1$  Year where the main underlying cause of death was Pertussis/Whooping Cough: Whooping cough due to *Bordetella pertussis* (A37.0); Whooping cough due to *Bordetella parapertussis* (A37.1); Whooping cough due to other *Bordetella* species (A37.8); Whooping cough, unspecified (A37.9).

**Denominator:** Birth Registration Dataset



### Notes on Interpretation

Note 1: An acute admission is an unplanned admission occurring on the day of presentation, while a semi-acute admission (referred to in the NMDS as an arranged admission) is a non-acute admission with an admission date <7 days after the date the decision was made that the admission was necessary.

Note 2: **Appendix 3** outlines the limitations of the hospital admission data used. The reader is urged to review this Appendix before interpreting any trends based on hospital admission data.

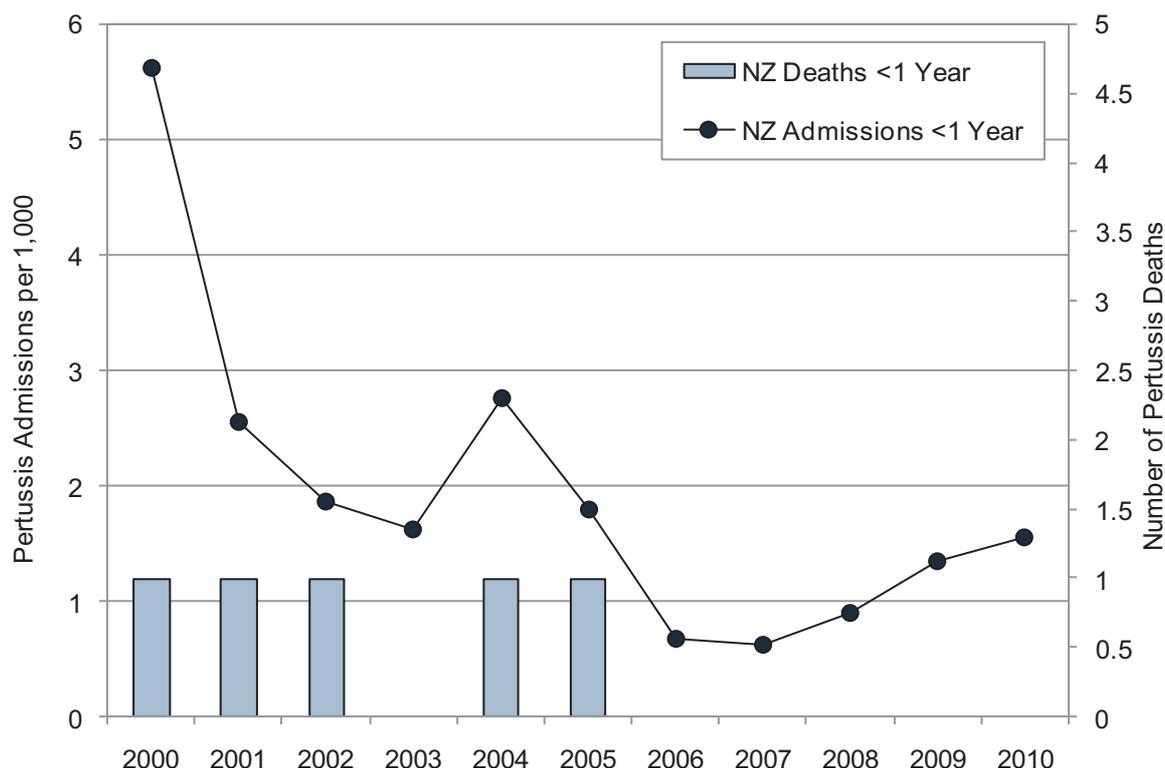
Note 3: 95% confidence intervals have been provided for the rate ratios in this section and where appropriate, the terms *significant* or not *significant* have been used to communicate the significance of the observed associations. Tests of statistical significance have not been applied to other data in this section, and thus (unless the terms *significant* or non-*significant* are specifically used) the associations described do not imply statistical significance or non-significance (see **Appendix 2** for further discussion of this issue).

## New Zealand Distribution and Trends

### New Zealand Trends

In New Zealand during 2000–2010, hospital admissions for pertussis in infants fluctuated, with peaks occurring in 2000 and 2004. Admission rates reached their lowest point in 2007, with rates increasing gradually thereafter. In addition, during the early-mid 2000s one infant each year died from pertussis, although no pertussis deaths occurred during 2006–2008 (**Figure 73**). (Note that the rates seen in 2000 represent the tip of a peak, with the rates before this being much lower. Thus rates during this period reflect a series of episodic peaks, rather than an overall downward trend.)

Figure 73. Acute and Semi-Acute Hospital Admissions (2000–2010) and Deaths (2000–2008) from Pertussis in New Zealand Infants <1 Year

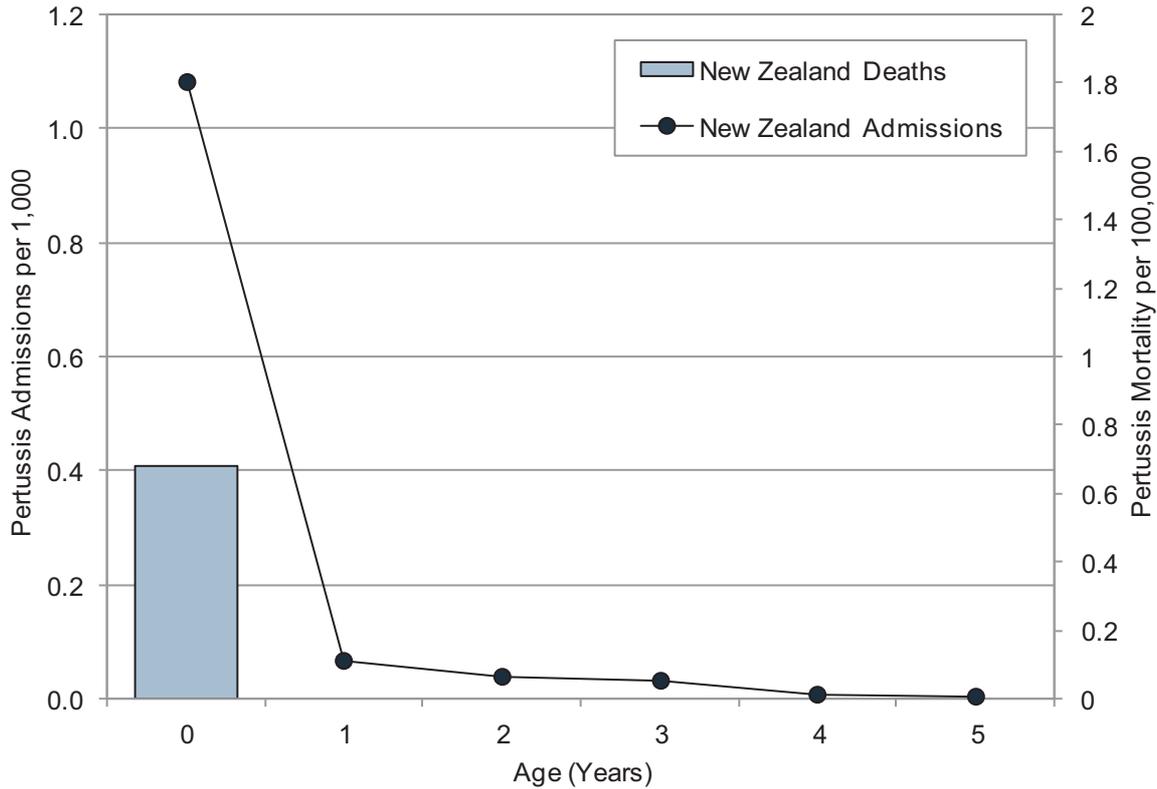


Source: Numerators: National Minimum Dataset (Acute and semi-acute admissions only) and National Mortality Collection; Denominator: Birth Registration Dataset

### New Zealand Distribution by Age

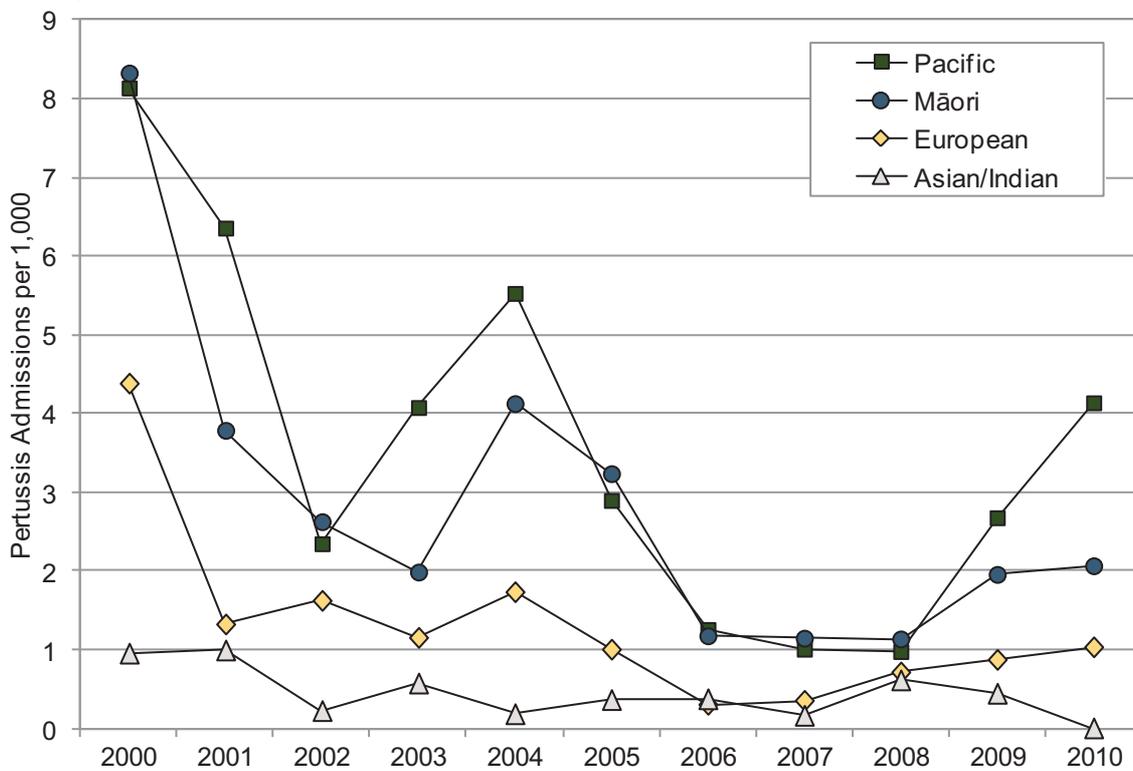
In New Zealand during 2006–2010, hospital admissions for pertussis were highest in infants <1 year, with rates declining rapidly with increasing age thereafter. Similarly, during 2004–2008, all pertussis deaths in children and young people occurred in infants <1 year of age (**Figure 74**).

Figure 74. Acute and Semi-Acute Hospital Admissions (2006–2010) and Deaths (2004–2008) from Pertussis in New Zealand Children by Age



Source: Numerators: National Minimum Dataset (Acute and semi-acute admissions only) and National Mortality Collection; Denominator: Statistics NZ Estimated Resident Population

Figure 75. Acute and Semi-Acute Hospital Admissions for Pertussis in Infants <1 Year by Ethnicity, New Zealand 2000–2010



Source: Numerator: National Minimum Dataset (Acute and semi-acute admissions only); Denominator: Birth Registration Dataset. Note: Ethnicity is Level 1 Prioritised.



## New Zealand Distribution by Ethnicity, NZDep Index Decile and Gender

In New Zealand during 2006–2010, hospital admissions for pertussis were *significantly* higher for Pacific and Māori > European > Asian/Indian infants and those from more deprived (NZDep decile 5–10) areas (**Table 80**). Similar ethnic differences were seen during 2000–2010 (**Figure 75**).

Table 80. Acute and Semi-Acute Hospital Admissions for Pertussis in Infants <1 Year by Ethnicity, NZ Deprivation Index Decile and Gender, New Zealand 2006–2010

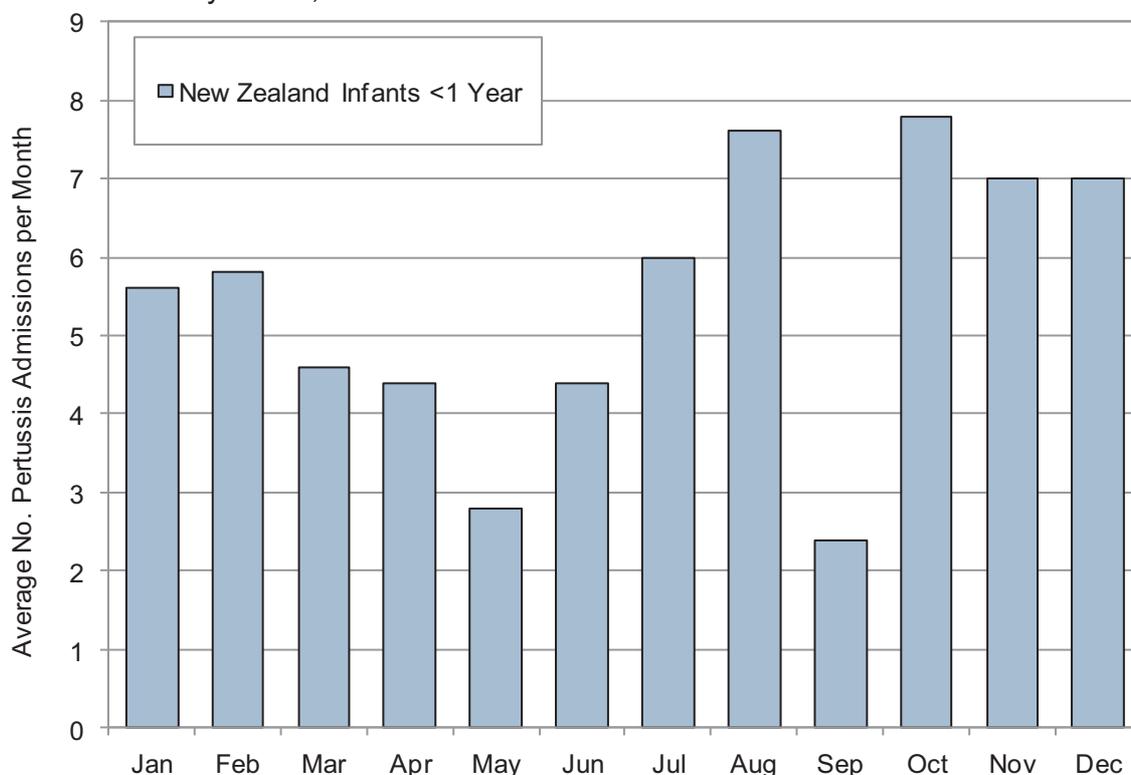
Variable	Rate	Rate Ratio	95% CI	Variable	Rate	Rate Ratio	95% CI
<b>Pertussis in Infants &lt;1 Year</b>							
NZ Deprivation Index Quintile				Prioritised Ethnicity			
Decile 1–2	0.39	1.00		European	0.65	1.00	
Decile 3–4	0.52	1.33	0.74–2.38	Māori	1.49	2.29	1.77–2.96
Decile 5–6	0.69	1.76	1.02–3.03	Pacific	2.03	3.11	2.30–4.22
Decile 7–8	1.10	2.80	1.69–4.62	Asian/Indian	0.31	0.47	0.25–0.90
Decile 9–10	1.89	4.81	2.99–7.75				
<b>Gender</b>							
Female	1.05	1.00		Male	1.00	0.95	0.77–1.18

Source: Numerator: National Minimum Dataset (Acute and semi-acute admissions only); Denominator: Birth Registration Dataset. Note: Rate is per 1,000; Ethnicity is Level 1 Prioritised; Decile is NZDep2001.

## New Zealand Distribution by Season

In New Zealand during 2006–2010 there were no consistent seasonal differences in hospital admissions for pertussis in infants aged <1 year (**Figure 76**).

Figure 76. Average Number of Acute and Semi-Acute Hospital Admissions for Pertussis in Infants <1 Year by Month, New Zealand 2006–2010



Source: National Minimum Dataset (Acute and semi-acute admissions only)

## South Island Distribution and Trends

### South Island DHBs vs. New Zealand

In Nelson Marlborough, Canterbury, Otago and Southland during 2006–2010, hospital admissions for pertussis in infants <1 year were lower than the New Zealand rate, although only in the case of Canterbury did these differences reach statistical significance. Small numbers precluded a valid comparison in the West Coast and South Canterbury (Table 81).

### South Island Trends

In the South Island during 2000–2010, there were large year to year fluctuations in hospital admissions for pertussis in infants aged <1 year in all DHBs (Figure 77).

Table 81. Acute and Semi-Acute Hospital Admissions for Pertussis in Infants <1 Year, South Island DHBs vs. New Zealand 2006–2010

DHB	Number: Total 2006– 2010	Number: Annual Average	Rate per 1,000	Rate Ratio	95% CI
Pertussis in Infants <1 Year					
Nelson Marlborough	8	1.6	0.95	0.93	0.46–1.87
West Coast	<3	s	s	s	s
Canterbury	15	3.0	0.46	0.44	0.26–0.74
South Canterbury	<3	s	s	s	s
Otago	5	1.0	0.48	0.47	0.19–1.14
Southland	4	0.8	0.49	0.48	0.18–1.29
New Zealand	327	65.4	1.03	1.00	

Source: Numerator: National Minimum Dataset (Acute and semi-acute admissions only); Denominator: Birth Registration Dataset. Note: s: suppressed due to small numbers.

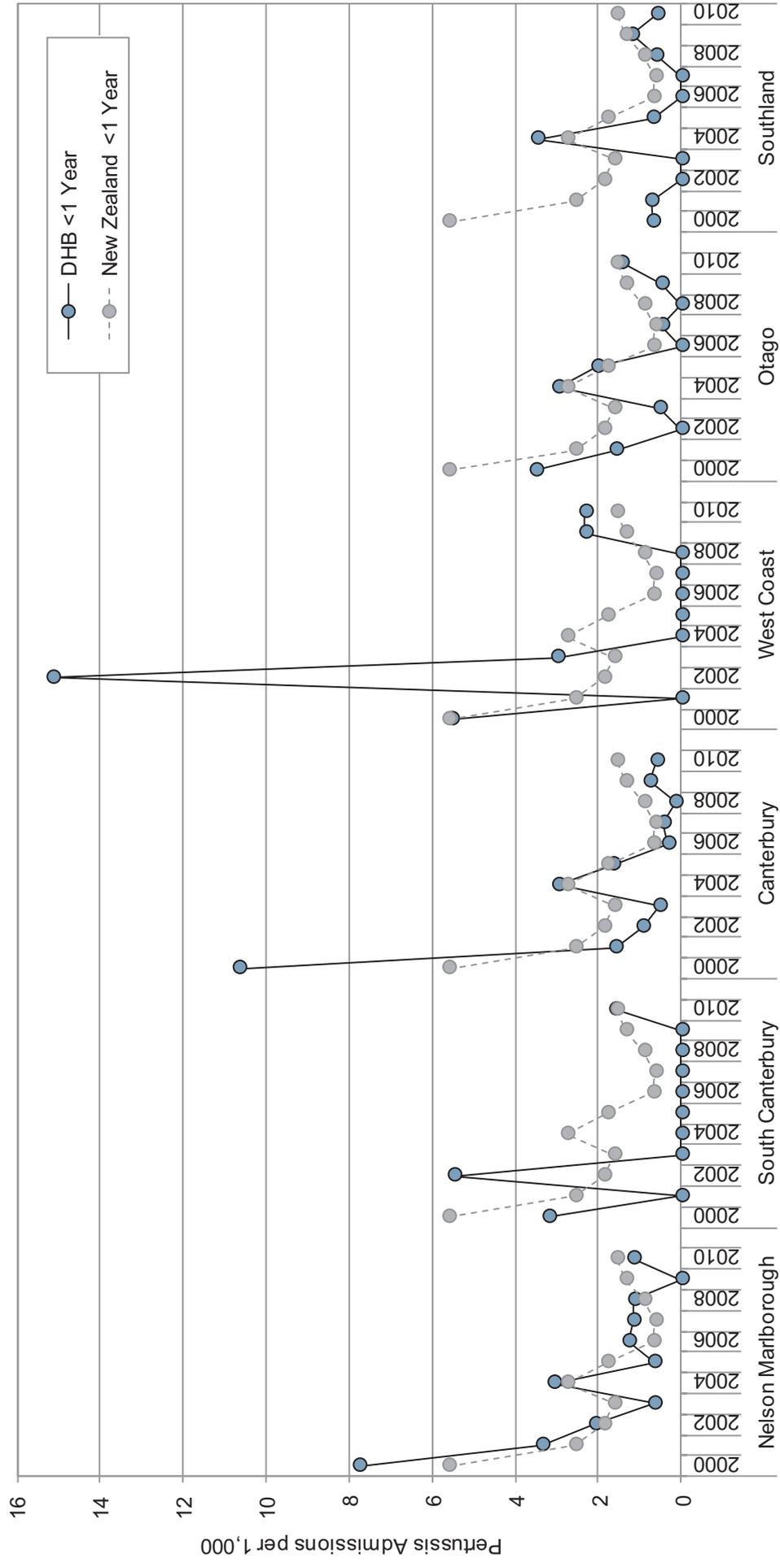
## Summary

In New Zealand during 2000–2010, hospital admissions for pertussis in infants fluctuated, with peaks occurring in 2000 and 2004. Admissions reached their lowest point in 2007, with rates increasing gradually thereafter. During the early-mid 2000s one infant each year died from pertussis, although no deaths occurred during 2006–2008. During 2006–2010, pertussis admissions were highest in infants <1 year, with rates declining rapidly thereafter. Similarly, during 2004–2008, all pertussis deaths occurred in infants <1 year. Admission rates were also *significantly* higher for Pacific and Māori > European > Asian/Indian infants and those from more deprived (NZDep decile 5–10) areas.

In the South Island during 2000–2010, there were large year to year fluctuations in hospital admissions for pertussis in infants aged <1 year in all DHBs. During 2006–2010, admissions were lower than the New Zealand rate in Nelson Marlborough, Canterbury, Otago and Southland, although only in Canterbury did these differences reach statistical significance. Small numbers precluded a valid comparison in the West Coast and South Canterbury.



Figure 77. Acute and Semi-Acute Hospital Admissions for Pertussis in Infants <1 Year, South Island DHBs vs. New Zealand 2000–2010



Source: Numerator: National Minimum Dataset (Acute and semi-acute admissions only); Denominator: Birth Registration Dataset

## Local Policy Documents and Evidence-Based Reviews Relevant to the Prevention and Management of Pertussis

In New Zealand a number of policy documents are relevant to the prevention of pertussis, and these are considered in **Table 82**, along with a range of reviews which consider these issues in the overseas context. In addition, a number of documents consider approaches to respiratory and infectious diseases more generally, and these are reviewed in other sections of this report:

1. **Generic Approaches to Infectious and Respiratory Disease:** Table 46 on Page 166
2. **The Prevention of Second Hand Smoke Exposure:** Table 47 on Page 168
3. **Interventions Aimed at Housing and Household Crowding:** Table 48 on Page 170
4. **Interventions to Improve Breastfeeding:** Table 27 on Page 107
5. **Interventions to Improve Immunisation Coverage Rates** will be reviewed in more detail in next year's report.

Table 82. Local Policy Documents and Evidence-Based Reviews Relevant to the Prevention of Pertussis

Ministry of Health Policy Documents
<p>Ministry of Health. 2011. <b>Immunisation Handbook 2011</b>. Wellington: Ministry of Health.  <a href="http://www.moh.govt.nz/moh.nsf/Files/immunise-handbook/\$file/6Pertussis.pdf">http://www.moh.govt.nz/moh.nsf/Files/immunise-handbook/\$file/6Pertussis.pdf</a></p> <p>Chapter 6 of this handbook provides information on pertussis, its epidemiology, immunisation both currently and historically, the benefits of improved immunisation coverage, the available vaccines, the immunisation schedule, expected responses, adverse reactions, contraindications and precautions, antimicrobial treatment and prophylaxis. Combined Tetanus, diphtheria and pertussis immunisation is recommended, but not funded for lead maternity carers and other health care workers who work in neonatal units or are exposed to infants, household contacts of newborns including older siblings (for whom update vaccines are funded) and mothers shortly after delivery, and early childhood workers. A ten yearly booster dose is recommended for those with on-going contact with infants.</p>
<p>Ministry of Health. 1998. <b>Communicable Disease Control Manual</b>. Wellington: Ministry of Health.  <a href="http://www.moh.govt.nz/moh.nsf/ea6005dc347e7bd44c2566a40079ae6f/019e54d1de5e73534c25666e00835b79/\$FILE/cdcm.pdf">http://www.moh.govt.nz/moh.nsf/ea6005dc347e7bd44c2566a40079ae6f/019e54d1de5e73534c25666e00835b79/\$FILE/cdcm.pdf</a></p> <p>Pages 1-21 to 1-23 of this manual contain concise information on the control of pertussis which is a notifiable disease.</p>
Systematic and Other Reviews from the International Literature
<p>Zhang L, Prietsch Silvio OM, Axelsson I, et al. 2011. <b>Acellular vaccines for preventing whooping cough in children</b>. Cochrane Database of Systematic Reviews 2011(1) Art. No.: CD001478. DOI: 10.1002/14651858.CD001478.pub4.</p> <p>The first pertussis vaccines were made from killed whole pertussis bacteria. Concerns about the possible association of these vaccines with neurological disorders led to the development of acellular vaccines which contain up to five <i>Bordetella pertussis</i> antigens. These vaccines were developed in the 1970s and widely used and tested in Japan in the 1980s. This review included six efficacy trials and 52 safety trials of acellular pertussis vaccines. Multi-component vaccines (≥ 3 antigens) had efficacy ranging from 84% to 85% in preventing typical whooping cough and 71% to 78% in preventing mild pertussis disease. One and two-component vaccines had efficacy ranging from 59% to 75% against typical whooping cough and 13% to 54% against mild pertussis disease. Multi-component acellular vaccines are more effective than low-efficacy whole cell vaccines but may be less effective than high efficacy whole cell vaccines however acellular vaccines were followed by significantly fewer local and systemic adverse events than whole cell vaccines both for the primary series and the booster doses.</p>
<p>Bar-On Edna S, Goldberg E, Fraser A, et al. 2009. <b>Combined DTP-HBV-HIB vaccine versus separately administered DTP-HBV and HIB vaccines for primary prevention of diphtheria, tetanus, pertussis, hepatitis B and Haemophilus influenzae B (HIB)</b>. Cochrane Database of Systematic Reviews 2009(3) Art.No.: CD005530. DOI: 10.1002/14651858.CD005530.pub2.</p> <p>This review compared the effectiveness of combined DTP-HBV-HIV vaccines with separate DTP-HBV and HIB vaccinations. The reviewers were unable to find any studies providing data on the prevention of disease i.e. the incidence of diphtheria, tetanus, pertussis and <i>H. influenzae</i> type B after vaccination. The review included 18 RCTs or quasi randomised clinical trials comparing vaccination with any combined DTP-HBV-HIB vaccine (with or without a variety of polio vaccines) with either separate DTP-HBV and HIB vaccinations or placebo. There were no significant differences found in immunogenicity for pertussis, diphtheria, polio and tetanus but two studies found less immunologic response for HBV and HIB after the combined vaccines and minor adverse events were more common after the combined vaccine. The authors state the studies' results were inconclusive and they were unable to conclude that the responses elicited by the combined vaccines were either different from, or equivalent to, those elicited by the separate vaccines.</p>

McIntyre P, Wood N. 2009. **Pertussis in early infancy: disease burden and preventive strategies.** Current Opinion in Infectious Diseases 22(3) 215-23.

This review summarises the current knowledge on the epidemiology and disease burden of pertussis in developed countries and discusses prevention strategies particularly those applicable to very young infants who are the group most vulnerable to severe pertussis and who are not protected by current immunisation schedules. Such strategies may either be direct (they aim to boost the infant's immunity) or indirect (they aim to reduce the infant's disease risk by boosting the immunity of those around the infant so that they will not catch the disease and transmit it to the infant). The direct strategies include maternal immunisation in pregnancy and immunisation at birth but the evidence for these is currently insufficient. Indirect strategies include ensuring universal and timely vaccination of infants and young children, boosters for older children and adolescents, and universal or targeted ("cocoon") adult immunisation. Of the indirect strategies, the review authors state that cocooning is probably the most effective but uptake has been low or unknown in countries where national immunisation advisory bodies currently recommend this.

#### Other Relevant Publications

Grant CC, Reid S. 2010. **Pertussis continues to put New Zealand's immunisation strategy to the test.** New Zealand Medical Journal 123(1313) 46-61. <http://journal.nzma.org.nz/journal/123-1313/4080/content.pdf>

This article reviews the epidemiology of pertussis in New Zealand and the history of pertussis immunisation in New Zealand. It discusses the pertussis control strategies recommended by the Global Pertussis Initiative and their relevance to New Zealand. These strategies, in order of priority, are: reinforcing and/or improving current infant and toddler immunisation strategies, universal preschool booster doses at 4 to 6 years of age, universal adolescent immunisation, selective immunisation of healthcare workers, selective immunisation of new mothers, family and close contacts of newborns (the "cocoon" strategy), universal adult immunisation and selective immunisation of childcare workers.

Forsyth KD, Wirsing von Konig C-H, Tan T, et al. 2007. **Prevention of pertussis: Recommendations derived from the second Global Pertussis Initiative roundtable meeting.** Vaccine 25(14) 2634-42.

This paper summarises the key points from the second roundtable meeting of the Global Pertussis Initiative (GPI) which is an international group of 37 experts in the field of pertussis (from 17 countries) whose work is supported by an unrestricted educational grant from Sanofi Pasteur. The GPI had previously recommended increased and improved surveillance, improved detection and greater awareness of pertussis as an important public health problem in order to ascertain both the true incidence of the disease and the effectiveness of immunisation, and it had also recommended the addition of an acellular pertussis vaccine into the adolescent diphtheria and tetanus booster. At their second meeting, the GPI addressed specifically the problem of neonatal and infant pertussis. After reviewing the available evidence the GPI has further endorsed the cocoon strategy (see above) and also the selective immunisation of health- and child-care workers. The GPI consider that universal adult vaccination may be justified by the epidemiological data but that the feasibility of this strategy is currently questionable. They say that as further data continues to support the immunogenicity and safety of combined diphtheria, tetanus and pertussis vaccines in adults it will become worthwhile to substitute these vaccines for the adult tetanus-diphtheria boosters currently recommended in many countries. (The U.S. Advisory Committee on Immunisation Practices recommends a single dose of tetanus toxoid, reduced diphtheria toxoid + acellular pertussis vaccine (Tdap) for adults, see <http://www.cdc.gov/mmwr/pdf/wk/mm6001.pdf> pp. 13-15.)