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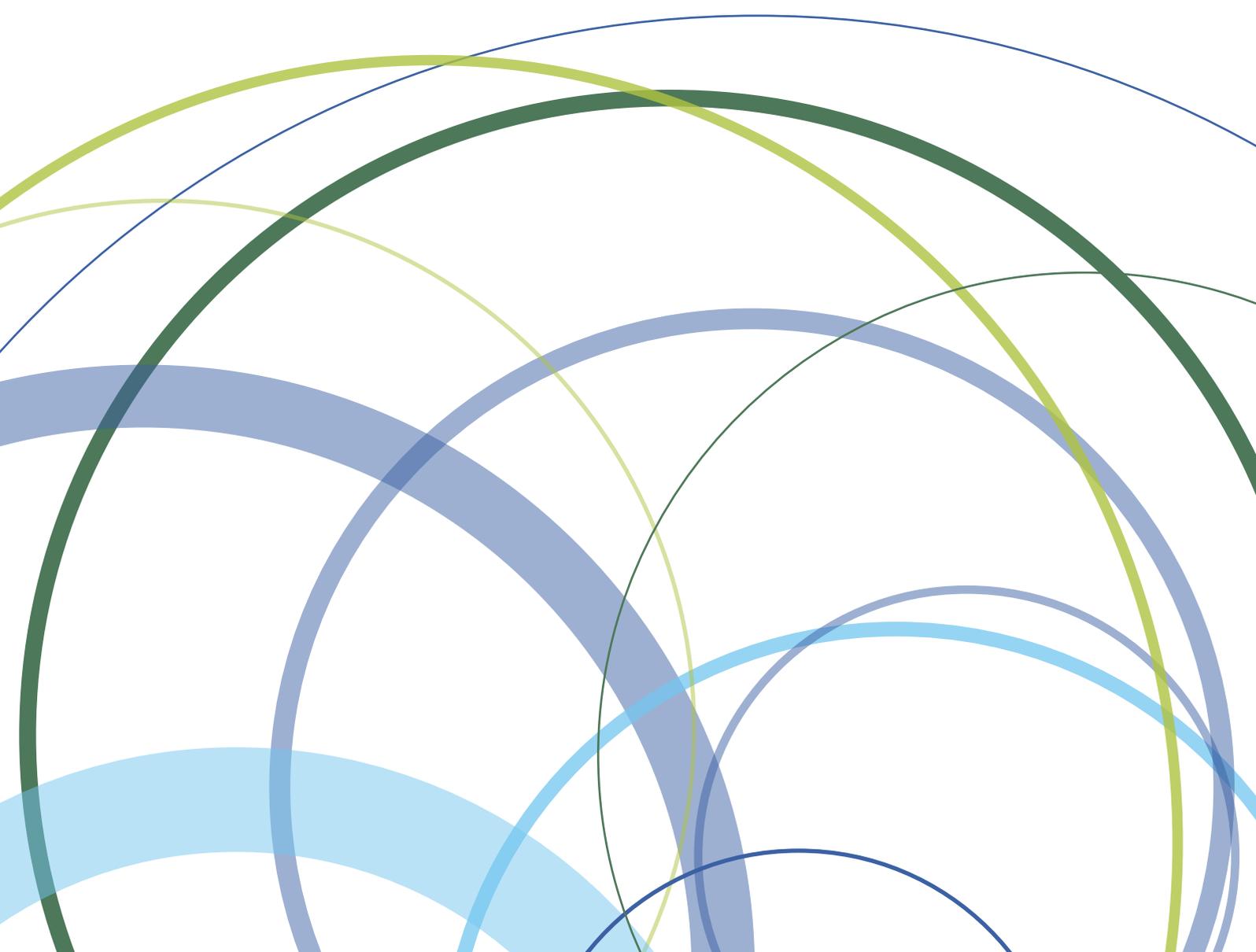


**Child and Youth
Mortality Review
Committee**

Mortality and morbidity of pertussis in children and young people in New Zealand

Special report

2002–14



This report was written for the Child and Youth Mortality Review Committee by Joanna Minster,
Dr Gabrielle McDonald, Dr Stuart Dalziel and Dr Felicity Dumble.

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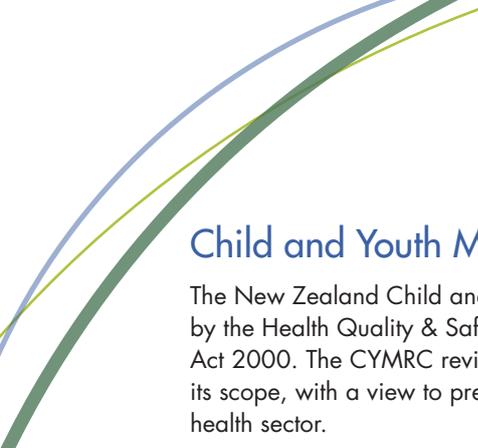
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Child and Youth Mortality Review Committee

The New Zealand Child and Youth Mortality Review Committee (CYMRC) is a mortality review committee appointed by the Health Quality & Safety Commission under section 59E of the New Zealand Public Health and Disability Act 2000. The CYMRC reviews and reports to the Health Quality & Safety Commission on deaths that fall within its scope, with a view to preventing these deaths and supporting continuous quality improvement throughout the health sector.

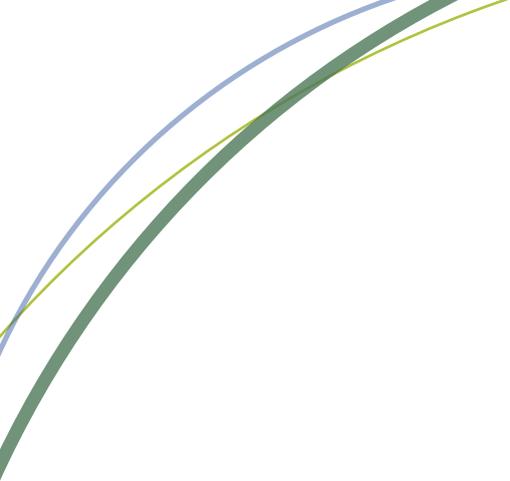
One of the ways this is achieved is through Local Child and Youth Mortality Review Groups (LCYMRGs). LCYMRGs collect data and review deaths of children and young persons aged between 28 days and 24 years. The local review process provides a mechanism for identifying causal pathways associated with deaths in this age group. By monitoring patterns over time, or specific clusters of events, the review process can provide evidence-based information on systems and services. This information is used to guide the formation of sector-wide recommendations and assist the development of strategies and initiatives that have the potential to reduce preventable deaths.

CYMRC members

- Dr Felicity Dumble (Chair)
- Dr Stuart Dalziel (Deputy Chair)
- Dr Terryann Clark
- Dr Paula King
- Dr Ed Mitchell
- Dr Janine Ryland (ex-officio member, Ministry of Health)
- Paul Nixon (ex-officio member, Ministry of Social Development) and Gillian Buchanan (Child, Youth and Family), who attends CYMRC meetings on behalf of Paul.
- Jacqui Moynihan (co-opted member, Horowhenua/Otaki Children's Team director)

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Foreword

The Health Quality & Safety Commission is pleased to release *Mortality and morbidity of pertussis in children and young people in New Zealand: Special report 2002–14* by the Child and Youth Mortality Review Committee (CYMRC).

Pertussis (whooping cough) occurs in cycles of epidemics every 3–5 years in New Zealand. This report shows infants under 3 months of age are most at risk of being affected by severe pertussis. The higher hospitalisation rate and disproportionate number of deaths in these infants reflect their incomplete protection from the three pertussis vaccinations in their primary course, scheduled for 5 weeks, 3 months and 5 months.

These findings emphasise the need for extending existing immunisation strategies to ensure very young infants are protected from birth until they receive the third vaccination from their primary course. Immunising pregnant women in their third trimester with a pertussis-containing booster vaccination is a cost-effective strategy, recommended by the World Health Organization, that is increasingly being adopted in countries comparable with New Zealand. Maternal immunisation provides protection against pertussis for young infants for the first few months of life because the mother's antibodies cross the placenta to the unborn baby. It is therefore very pleasing that in New Zealand the pertussis-containing Tdap vaccination has recently become free for pregnant women, regardless of epidemic status.

The CYMRC's recommendations acknowledge that there needs to be a number of actions to support increasing maternal immunisation. These include raising awareness among pregnant women and health care workers, particularly lead maternity carers, who are a key source of information during pregnancy. Having national systems to record uptake of antenatal vaccinations and transferring this to the infant's immunisation record are important for monitoring the effectiveness of the strategy. We also need systems for recalling pregnant women for the vaccination in their third trimester to encourage uptake.

This report also highlights significant equity issues for Māori and Pacific infants, who experience significantly more hospitalisations for pertussis. The health sector has seen impressive improvements in immunisation coverage for Māori and Pacific children at 8 months and 2 years. Timeliness is still problematic during the first 6 months of life, particularly for those living in high deprivation areas. Data from the most recent pertussis epidemic, between August 2011 and December 2013, show complete coverage of the three pertussis doses at age 6 months is lowest among Māori and Pacific infants, and those living in the most deprived households (Kiedrzyński et al 2015). These populations face a number of barriers that impact their ability to access immunisations.

There is clearly still work to be done to ensure our vaccination strategy suits the broad range of settings we need to cover. Integrated primary care models should be supported to ensure the timely immunisation of all New Zealanders.

This report draws attention to some very precious lives that could have been saved relatively easily – we need to save similar lives in the future.

Prof Alan Merry, ONZM FRSNZ
Chair, Health Quality & Safety Commission



Chair's introduction

Outbreaks of pertussis have been occurring regularly in our communities and are expected to continue to do so for some time.

Pertussis (also known as whooping cough) can be very serious, even fatal. This report demonstrates that the impact of the illness is not distributed equitably among New Zealand children and young people. There is significant variation by age and ethnicity, with very young babies being most at risk.

Vaccination against pertussis reduces the incidence and severity of disease. The Child and Youth Mortality Review Committee strongly supports timely vaccination as outlined in the National Immunisation Schedule.

Maternal immunisation with a pertussis-containing vaccine is a key strategy for protecting mothers and children. It results in protective antibodies passing directly from mother to baby (via the placenta) before birth, and also reduces the risk of a mother passing pertussis on to her baby. This provides protection for young babies in the early months of life, before they can gain lasting protection from their own vaccinations. It is now funded for pregnant women in their third trimester.

During pregnancy, mothers must be very careful about what is taken into their bodies. There needs to be increased awareness that, while some vaccines are not to be given during pregnancy, vaccination against pertussis is safe and effective. The recommendations of this report include measures to better inform the public about the benefits of pertussis vaccination and improve access to the vaccine during pregnancy for all ages and ethnicities.

Midwives and general practitioners are essential in this process. Working together with them, we can significantly improve pertussis vaccination coverage and save lives.

A handwritten signature in dark ink, appearing to read 'FDumble'.

Dr Felicity Dumble

Chair, Child and Youth Mortality Review Committee

Key findings

Over the last 13 years (during 2002–14) for which data are available in New Zealand for children and young people aged under 25 years:

- there were eight deaths attributable to pertussis. Seven of these deaths were in infants under 3 months of age, who had either no or inadequate protection against pertussis¹
- there were just under 13,000 notified cases of confirmed, probable or suspected pertussis – an average of 992 cases per year
- there were 1515 hospital admissions attributable to pertussis. Over three-quarters of these admissions were in infants under 6 months of age who had either no or inadequate protection against pertussis
- infants aged under 3 months had the highest notification rate (407.9 per 100,000) and the highest hospitalisation rate (468.2 per 100,000) for pertussis
- when examined by ethnicity, Māori and Pacific infants, children and young people were significantly more likely to be hospitalised with pertussis than non-Māori/non-Pacific infants. Ethnic inequities were particularly marked for both Māori and Pacific infants aged under 3 months of age, who were an estimated 2.7 and 3.6 times more likely to be hospitalised for pertussis compared with non-Māori/non-Pacific infants respectively.

The Child and Youth Mortality Review Committee (CYMRC) notes:

- maternal immunisation with pertussis booster vaccinations is protective for infants under 3 months of age
- maternal immunisation with pertussis booster vaccinations is safe for pregnant women and their infants
- increasing uptake of antenatal pertussis booster vaccinations among pregnant women in the third trimester requires increasing awareness of the vaccine among health care providers and pregnant women. A wide range of educational resources targeting pregnant women, lead maternity carers and primary health care providers are needed to achieve this
- having local- and national-level systems in place can help both improve coverage and record the uptake of pertussis booster vaccinations among pregnant women. Systems in primary care settings that recall pregnant women for the vaccination in their third trimester can help increase uptake. Uptake of the vaccination by pregnant women should also be recorded at a national level and transferred onto the infant's immunisation record at birth
- barriers to immunisation service access should be addressed through national policies that aim to achieve equitable and on-time immunisation coverage by providing pertussis booster vaccinations in a broad range of settings.

Maternal immunisation for pertussis involves giving pregnant women a pertussis-containing booster vaccination in their third trimester (between 28 and 38 weeks gestation). This vaccination protects the baby from pertussis during the first few months of life because antibodies from the mother cross the placenta to the baby during pregnancy, providing passive immunity against the disease. Maternal immunisation also protects the mother against disease, limiting transmission from mother to baby.

¹ Infants receive three doses of a pertussis-containing vaccination at 6 weeks, 3 months and 5 months of age under the current National Immunisation Schedule. Protection from pertussis increases with each successive dose and infants are not fully protected until the third dose (Ministry of Health 2014).

Introduction

Pertussis (or 'whooping cough') is a contagious respiratory disease caused by the bacterium *Bordetella pertussis*. It is one of the most infectious vaccine-preventable diseases and is transmitted by droplets in the air from infected individuals. Pertussis illness is characterised by prolonged coughing episodes, often accompanied by an inspiratory 'whoop' sound (Faulkner et al 2015; World Health Organization (WHO) 2015).

Box 1: What is pertussis?

Pertussis is characterised by progression through a series of clinical stages: (1) the catarrhal stage, during which the disease is most infectious and those infected develop a runny nose and cough; (2) the paroxysmal stage, in which those infected develop short coughing episodes or 'paroxysms' characterised by a gasping 'whoop' sound when breathing in; and (3) the convalescent stage (WHO 2015). In very young infants or immunocompromised children, severe bouts of coughing may be accompanied by apnoea, cyanosis and vomiting. This severe disease presentation commonly requires hospitalisation. In very severe cases, the disease may progress to seizures and encephalopathy, due to cerebral oxygen deprivation (Ministry of Health 2014a; WHO 2015).

Pertussis affects people of all ages and is most common among children aged under 5 years (WHO 2015). Disease presentation differs among age groups. Healthy adults and adolescents with acquired immunity from vaccination or previous infection may experience few or mild symptoms, and can unknowingly transmit disease to young infants (Faulkner et al 2015; WHO 2015). Infants aged under 12 months and those too young to be immunised are most at risk from infection (Ministry of Health 2014a). Around 5 in 10 infants who catch pertussis before age 6 months will require hospitalisation (Immunisation Advisory Centre 2015).

Globally, pertussis was a common cause of child and infant mortality in the pre-vaccine era. With the introduction of routine child vaccination programmes in developed countries in the 1940s, the incidence of pertussis began to decline. However, recently there has been an increase in pertussis incidence in some developed countries, despite high immunisation coverage among children (Faulkner et al 2015; WHO 2014). Multiple factors likely to have contributed to this resurgence include improved diagnostic testing, switching from whole-cell to acellular vaccines,² and possible molecular changes in the bacterium over time (Faulkner et al 2015; WHO 2015).

Pertussis is a notifiable disease in New Zealand and data on case notifications have been collected under the national surveillance system since 1996. Pertussis occurs in cycles of outbreaks, with epidemics recurring every 3–5 years (Immunisation Advisory Centre 2015). Since the disease became notifiable, three epidemics have occurred, with case notifications peaking in 2000, 2004 and 2012. The most recent New Zealand pertussis epidemic occurred between 2011 and 2014 (bpac^{NZ} 2014; Grant 2015; Ministry of Health 2014a).

Pertussis notification data analysed for the peak time of the most recent epidemic, from August 2011 to December 2013, showed an average annual total population rate of 102 per 100,000, with the highest rate (801 per 100,000) observed in infants aged under 6 months. There were three deaths from pertussis during this period – all among children and two among infants aged under 1 year (Kiedrzyński et al 2015). Overall, there are marked inequities in hospitalisations for pertussis, with Māori and Pacific infants and infants living in households in the most deprived quintiles being more likely to be hospitalised with the disease than European/Other infants and those living in households in the least deprived quintiles (Ministry of Health 2014a).

² Whole-cell vaccines were the first type of pertussis vaccination introduced. These were gradually replaced with acellular vaccines in the 1990s, due to a need to reduce adverse reactions among those vaccinated. However, recent evidence suggests acellular pertussis vaccines may provide a shorter duration of protection against infection compared with whole-cell vaccines (eg, see Burns et al 2014; Meade et al 2014; WHO 2015; Witt et al 2013).

The pertussis vaccine was introduced into New Zealand in 1945 (Grant 2015; Ministry of Health 2014a). A whole-cell vaccine was used for routine immunisation from 1960 and replaced with an acellular pertussis vaccine in 2000. Under the current National Immunisation Schedule, a primary course of three pertussis vaccines are given in the first year of life, with doses at 6 weeks, 3 months and 5 months of age (Ministry of Health 2014a). The entire primary course of pertussis immunisations is required to achieve the most effective protection, resulting in young infants having incomplete protection until they have completed the full series of three vaccine doses.

Protection with the primary course is effective against severe disease through to the booster vaccination given at 4 years of age (Radke et al 2015, manuscript in preparation). However, immunity following booster doses wanes after several years as the acellular vaccines currently used do not give long-lasting protection and cannot eliminate pertussis from the community. Therefore pertussis immunisation strategies focus on preventing severe disease in infants who are most at risk.

Pertussis immunisations are delivered as pertussis-containing vaccines that protect against a number of other vaccine-preventable diseases. The Tdap vaccination available for pregnant women, for example, protects against tetanus, diphtheria and pertussis. For the purposes of this report, the CYMRC refers to pertussis-containing vaccinations simply as 'pertussis vaccinations', although the former is technically correct.

Structure of this report

In this report, the CYMRC has examined pertussis as an example vaccine-preventable disease. Both morbidity data and mortality data have been included, as this gives a wider picture of the burden of disease caused by pertussis.

Section A provides an overview of mortality and morbidity associated with pertussis. Mortality data are provided from the Mortality Review Database from 2002 to 2014. Morbidity data from the same period are provided via pertussis notification data from the EpiSurv database and hospitalisation data from the Ministry of Health.

Section B discusses the current strategies used for pertussis prevention in New Zealand and other prevention strategies discussed in the literature. This section also discusses the issues and themes identified from local reviews and the national committee.

Section C presents the national policy recommendations, local recommendations and community messages for pertussis prevention.

Method

Definition

The analyses in this report include children and young people between birth and 24 years of age with mortality and morbidity from pertussis in New Zealand between 1 January 2002 and 31 December 2014.

In all analyses, the year of death relates to the calendar year in which the individual died, rather than the year the death was registered. This is different to some official collections, where the year the death is registered is used.

Data sources

The data used in this report were taken from three sources: the Mortality Review Database, EpiSurv and the Ministry of Health.

1. Mortality Review Database: This database is housed by the New Zealand Mortality Review Data Group on behalf of the CYMRC. It contains information from a number of sources, including the Ministry of Health; Births, Deaths and Marriages; Coronial Services Unit and individual coroners; Child, Youth and Family; Ministry of Transport; Water Safety New Zealand; and data entered by the LCYMRG coordinator on completion of an LCYMRG death review. These data were extracted on 7 July 2015 and also viewed on the live database (October and November 2015).

2. EpiSurv is the national notifiable disease surveillance database. Information about notifiable diseases is collected from public health services and collated on a real-time basis. Information includes demographic details on cases, clinical features and risk factors. It is operated by the Institute for Environmental and Scientific Research (ESR), on behalf of the Ministry of Health (EpiSurv 2015). Data on notifications and deaths were taken from an extract from EpiSurv taken on 7 October 2015 and the details of the deaths were checked with the Mortality Review Database. Only cases of pertussis with a status of 'suspect', 'probable' or 'confirmed' were used for the tabulations. These definitions are:

- suspect (in children under 5 years of age): any paroxysmal cough with whoop, vomit or apnoea for which there is no other known cause
- probable: a clinically compatible illness with a high *B. pertussis* IgA test or a significant increase in antibody levels between paired sera at the same laboratory, or a cough lasting longer than two weeks and with one or more of the following, for which there is no other known cause:
 - paroxysmal cough
 - cough ending in vomiting or apnoea
 - inspiratory whoop
- confirmed: a clinically compatible illness that is laboratory confirmed, or is epidemiologically linked to a confirmed case (Ministry of Health 2012).

The 'report date' was used to indicate 'year' for tables with notifications. This is because the information regarding the onset date of disease was too incomplete.

Immunisation status on EpiSurv is based on documentary evidence from the patient record or parental recall. 'Immunised' means the individual had received at least one dose of a pertussis-containing vaccination at any time before becoming ill. This includes infants who have completed the primary course of all three pertussis-containing vaccination doses and those infants who have received at least one dose of the vaccine but not yet completed the full primary course. 'Not immunised' means the individual had not received any doses of a pertussis-containing vaccination at any time before becoming ill.

3. Ministry of Health: The Ministry of Health provided data on the number of publicly funded hospital discharges with an ICD-10 code of A37 (Whooping cough). Day cases were excluded from the analyses. Ethnicity was provided in three groups: Māori, Pacific and Other. These data were extracted on 10 August 2015.

Denominators

The denominators used in the analyses are from two sources. The denominator for those aged 1–24 years is based on the estimated resident population from census years 2001, 2006 and 2013, as supplied by Statistics New Zealand. Data for the years in between censuses and for 2014 were calculated by applying fitting quadratic polynomial functions to the estimated resident population by prioritised ethnic and age groups.

The denominator used for those aged under 1 year was the live births data set, as supplied by the Ministry of Health. The number of births each year was divided by four to obtain the population estimates for those aged under 3 months and those aged 3–5 months. The number of live births each year was divided by two to obtain the population estimate for those aged 6–11 months.

Ethnicity

Prioritised ethnic group data for the cases where pertussis caused death were determined using the information in the Mortality Review Database. The sources of ethnicity data in the Mortality Review Database are Births, Deaths and Marriages; the Ministry of Health; and Coronial Services records. These data sources are prioritised based on evidence as to their accuracy generally in New Zealand.

Ethnic group data for publicly funded hospital discharges were supplied by the Ministry of Health.

Statistical method

The data presented in this report were computed from the above sources by the New Zealand Mortality Review Data Group. Percentages, rates and confidence intervals are expressed to one decimal point.

Rates in this report are presented as per 100,000 age-specific population for all age groups.

Where presented, 95 percent confidence intervals for rates have been calculated using the method described by Fay and Feuer (1997) according to the Centers for Disease Control and Prevention's National Vital Statistics Report (Murphy et al 2013).

Discrepancies with other collections

When interpreting CYMRC data it must be remembered they are derived from a database that is constantly being updated. As well as details of new cases, there can also be new information for existing cases, and at times changing information for existing cases. The result of this is that details can change from year to year, even for cases where death occurred some years previously.

The data presented in this report may differ from other official collections. This is due, in part, to the multiple data sources, which may provide more comprehensive data than other collections. In addition, the way that data are coded may result in variations from official collections. For example, as mentioned above, the CYMRC uses the date of death to assign year of death, whereas some other collections use date of registration of death.

Limitations

It should be noted that disease notifications do not reflect the true incidence of disease. While it is a legal requirement for health professionals to notify the relevant medical officer of health where pertussis is suspected or diagnosed, this does not always occur. It is estimated that only about 6–25 percent of cases are notified and these will represent the severe end of the disease spectrum (Ministry of Health 2014a). For example, in this report the notification rate for infants under 3 months of age is smaller than the hospitalisation rate.

A. Analysis of pertussis notifications, hospitalisations and data from the Mortality Review Database

Pertussis case notifications

There were nearly 13,000 notifications of pertussis infection during the 13-year study period from 2002 to 2014, with an average of 992 cases per year. However, the total annual notifications over this time period varied widely, ranging from 133 cases in 2007 to 3173 cases in 2012. There was a marked variation in notification rate by age group. Infants aged under 3 months had the highest notification rate of 407.9 per 100,000 for the study period, compared with young people aged 20–24 years who had a rate of notification of 26.2 per 100,000 population. This infant notification rate was statistically significantly higher than the rate in any other age group. Pertussis notification rates decreased with increasing age, with each age group being statistically significantly less likely than the age group younger than them to have notified disease (Table 1).

Table 1: Annual notifications of pertussis by age group and year of notification, New Zealand 2002–14

AGE GROUP	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Total	Rate (CI)
<3 months	58	44	81	49	13	19	29	66	42	71	176	110	47	805	407.9 (379.7–436.1)
3–5 months	32	14	45	38	9	7	6	28	24	23	120	71	16	433	219.4 (198.7–240.1)
6–11 months	36	30	46	30	12	1	5	23	20	34	123	83	25	468	118.6 (107.8–129.3)
1–4 years	233	110	349	194	52	30	21	142	119	272	897	556	129	3104	99.6 (96.1–103.1)
5–9 years	287	121	646	305	74	19	26	146	90	302	759	367	70	3212	83.8 (80.9–86.7)
10–14 years	134	75	592	335	89	21	41	103	47	229	539	221	55	2481	62.7 (60.2–65.1)
15–19 years	36	33	258	197	89	23	27	120	54	95	280	136	38	1386	34.3 (32.5–36.2)
20–24 years	24	7	101	95	62	13	13	62	48	75	279	178	58	1015	26.2 (24.5–27.8)
Total	840	434	2118	1243	400	133	168	690	444	1101	3173	1722	438	12,904	65.8 (64.7–66.9)

Note: Rates are per 100,000 population; 'CI' indicates 95% confidence interval.

Sources:

Numerator: EpiSurv.

Denominator: Ministry of Health live births, Mortality Review Population Estimates 2002–14.

Pertussis hospitalisations

As with case notifications, there was a marked decrease in hospitalisations for pertussis with increasing age during the period 2002–14. The hospitalisation rate in infants aged under 3 months was over 2000 times higher than the hospitalisation rate in young people aged 20–24 years. The rate of hospitalisation was highest in infants aged under 3 months at 468.2 per 100,000 followed by infants aged 3–5 months (145.9 per 100,000) (Table 2).

The yearly fluctuation in notifications was also evident in the hospitalisation data, with these following the same trends year by year (Figure 1).

Table 2: Annual hospitalisations due to pertussis by age group and year of discharge, New Zealand 2002–14

AGE GROUP	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Total	Rate (CI)
<3 months	64	59	113	63	20	26	37	62	61	81	168	125	45	924	468.2 (438–498.4)
3–5 months	23	12	20	31	8	12	18	14	19	17	60	42	12	288	145.9 (129.1–162.8)
6–11 months	7	8	16	4	9	1	2	4	14	1	19	16	4	105	26.6 (21.5–31.7)
1–4 years	14	7	16	13	6	1	4	8	8	10	12	9	5	113	3.6 (3–4.3)
5–9 years	4	6	8	1	4	2		2			7	3	2	39	1 (0.7–1.4)
10–14 years	2	2	2	6		1	1	1	2		7	4		28	0.7 (0.5–1)
15–19 years			1	1		1		1	1		5			10	0.2 (0.1–0.5)
20–24 years			2	1					1	1	2		1	8	0.2 (0.1–0.4)
Total	114	94	178	120	47	44	62	92	106	110	280	199	69	1515	7.7 (7.3–8.1)

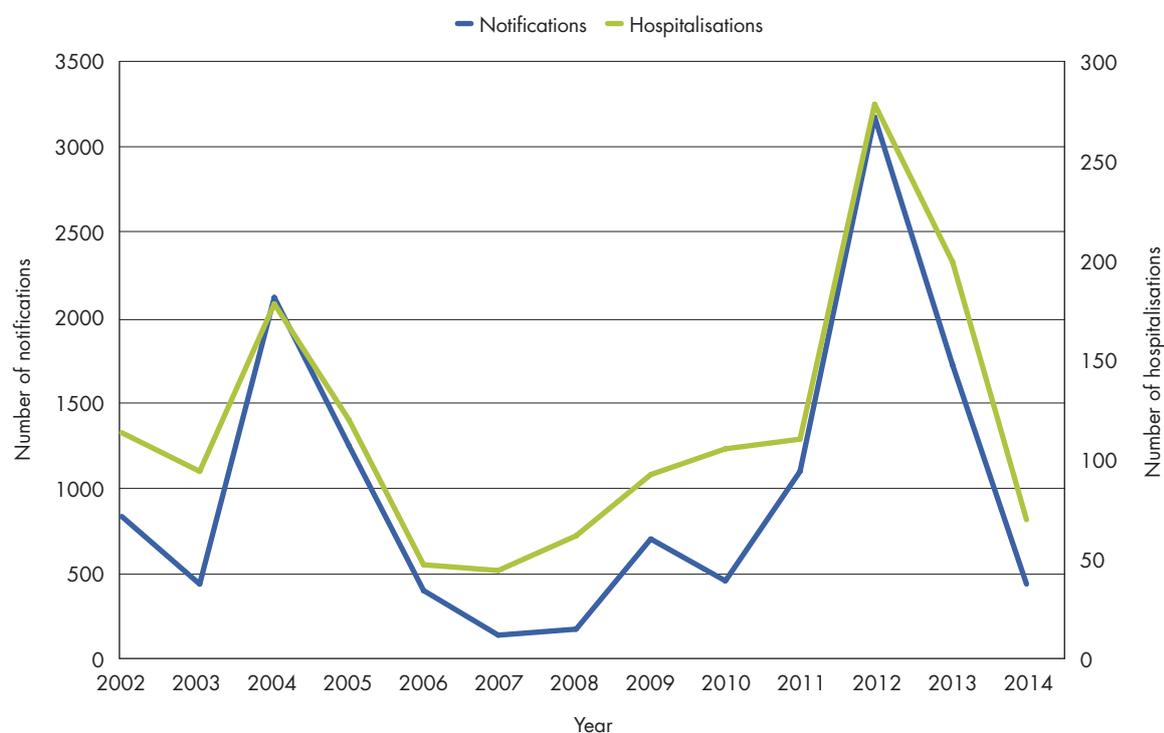
Note: Rates are per 100,000 population; 'CI' indicates 95% confidence interval.

Sources:

Numerator: Ministry of Health.

Denominator: Ministry of Health live births, Mortality Review Population Estimates 2002–14.

Figure 1: Annual notifications and hospitalisations due to pertussis by year, children and young people aged 0–24 years, New Zealand 2002–14



Sources:

Notifications: EpiSurv.

Hospitalisations: Ministry of Health.

When hospitalisation rates are examined by ethnicity, Māori and Pacific children and young people were statistically significantly more likely to be hospitalised with pertussis than non-Māori/non-Pacific children and young people. For Māori the rate was 14.0 per 100,000 and for Pacific 16.1 per 100,000, compared with a rate of 4.6 per 100,000 for non-Māori/non-Pacific (Table 3).

Statistically significant ethnic inequities were observed for Māori and Pacific infants compared with non-Māori/non-Pacific infants. For example, Māori infants aged under 3 months were 2.7 times more likely (rate ratio 2.7, 95 percent CI 2.4–3.2) to be admitted to hospital and Pacific infants aged less than 3 months were 3.6 times more likely (rate ratio 3.6, 95 percent CI 3.0–4.3) to be admitted to hospital for pertussis than non-Māori/non-Pacific infants in the same age group (data not shown in table).

Table 3: Annual hospitalisations due to pertussis by age group and ethnicity, New Zealand 2002–14

AGE GROUP	Māori		Pacific peoples		Non-Māori/Non-Pacific		Total	
	number	rate (CI)	number	rate (CI)	number	rate (CI)	number	rate (CI)
<3 months	409	718.1 (648.5–787.7)	203	939.2 (810–1068.4)	312	262.6 (233.5–291.8)	924	468.2 (438–498.4)
3–5 months	129	226.5 (187.4–265.6)	53	245.2 (183.7–320.7)	106	89.2 (72.2–106.2)	288	145.9 (129.1–162.8)
6–11 months	34	29.8 (20.7–41.7)	12	27.8 (14.3–48.5)	59	24.8 (18.9–32)	105	26.6 (21.5–31.7)
1–4 years	32	4.1 (2.8–5.7)	6	2 (0.7–4.4)	75	3.7 (2.9–4.6)	113	3.6 (3–4.3)
5–9 years	11	1.2 (0.6–2.1)	2	s	26	1 (0.7–1.5)	39	1 (0.7–1.4)
10–14 years	3	0.3 (0.1–0.9)	3	0.8 (0.2–2.5)	22	0.8 (0.5–1.2)	28	0.7 (0.5–1)
15–19 years	1	s			9	0.3 (0.1–0.6)	10	0.2 (0.1–0.5)
20–24 years	3	0.4 (0.1–1.3)	1	s	4	0.1 (0–0.4)	8	0.2 (0.1–0.4)
Total	622	14 (12.9–15.1)	280	16.1 (14.2–17.9)	613	4.6 (4.2–4.9)	1515	7.7 (7.3–8.1)

s – no rate calculated due to small numbers.

Note: Rates are per 100,000 population; 'CI' indicates 95% confidence interval.

Sources:

Numerator: Ministry of Health.

Denominator: Ministry of Health live births, Mortality Review Population Estimates 2002–14.

Pertussis mortality

There were eight deaths due to pertussis during the study period. All but one of these deaths occurred in an infant aged under 3 months (Table 4). When mortality rates are examined by ethnicity, there was a disproportionately high number of deaths for Māori and Pacific infants compared with non-Māori/non-Pacific infants, although the numbers were too small to calculate meaningful rates (Table 5).

Table 4: Pertussis deaths by age group and year of death, New Zealand 2002–14

AGE GROUP	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Total
<3 months	1	1	1	1					1		1	1		7
3–5 months														
6–11 months														
1–24 years											1			1
Total	1	1	1	1					1		2	1		8

Sources: EpiSurv and Mortality Review Database.

Table 5: Pertussis deaths by age group and ethnicity, New Zealand 2002–14 combined

AGE GROUP	Māori	Pacific peoples	Non-Māori/ Non-Pacific	Total
<3 months	3	3	1	7
3–5 months				
6–11 months				
1–24 years			1	1
Total	3	3	2	8

Source: Mortality Review Database.

Pertussis notifications and mortality by immunisation status

Notifications on EpiSurv indicate immunisation status of affected individuals. However, as only children born in New Zealand from 2005 onwards are included in the National Immunisation Register, the vast majority of this information is based on parental recall or review of the Well Child immunisation record. The immunisation status was confirmed from documentary evidence in 51.2 percent of cases and parental recall in 14.7 percent. The source of information was recorded as 'unknown' in 33.8 percent of those recorded as 'immunised' (data not shown). Children aged under 3 months who were notified as having pertussis were the least likely to have been immunised (Table 6).

Table 6: Immunisation status of cases notified with pertussis by age group, New Zealand 2002–14 combined

AGE GROUP	Immunised	Not immunised	Unknown*	% immunised**	Total
<3 months	285	443	77	35.4	805
3–5 months	295	104	34	68.1	433
6–11 months	298	126	44	63.7	468
1–4 years	2080	805	219	67.0	3104
5–9 years	2106	719	387	65.6	3212
10–14 years	1697	379	405	68.4	2481
15–19 years	775	118	493	55.9	1386
20–24 years	356	97	562	35.1	1015
Total	7892	2791	2221	61.2	12,904

* 'Unknown' indicates the immunisation status was either recorded as 'unknown', or this field was blank.

** Where percent immunised is equal to the percentage of total cases within each age group recorded as being immunised on the EpiSurv database.

Source: EpiSurv.

Immunisation records of the eight deceased cases were further checked against the data supplied by the Ministry of Health and contained in the Mortality Review Database. One case had received pertussis immunisation according to the current National Immunisation Schedule, but due to their young age had only received the first dose of the vaccine. The remaining seven cases either were not vaccinated, or they died or were admitted with pertussis infection prior to the age of 6 weeks, when the first vaccination is scheduled to occur (Table 7).

Table 7: Immunisation status of notified cases of pertussis who died from the disease by age group, New Zealand 2002–14 combined

AGE GROUP	Immunised	Not immunised	Unknown	Total
<3 months	1	6		7
3–5 months				
6–11 months				
1–24 years		1		1
Total	1	7		8

Sources: EpiSurv and Mortality Review Database.

B. Strategies for pertussis prevention and issues, and themes identified from mortality review

Strategies for pertussis prevention

Child immunisation in New Zealand

In New Zealand, pertussis immunisation for infants and children is included in the National Immunisation Schedule and offered free of charge. A primary course of the pertussis-containing vaccine DTaP-IPV-HepB/Hib (which protects against diphtheria, tetanus, pertussis, poliomyelitis, hepatitis B and *Haemophilus influenzae* type b diseases) is offered to infants in three doses at 6 weeks, 3 months and 5 months of age. The primary course is followed by pertussis-containing boosters, with a dose of DTaP-IPV offered at 4 years and a Tdap booster vaccination given at age 11 years (Ministry of Health 2014a).

The timeliness of the three primary doses among young infants is an important factor that contributes to the level of protection against pertussis. Studies have consistently shown that protection from pertussis infection increases incrementally after each dose, demonstrating the importance of completing all three doses to obtain full protection (WHO 2015). Current New Zealand data suggest pertussis immunisation in infants is effective at 41 percent (95 percent CI 23–55) after the first dose of the primary series, 78 percent (95 percent CI 68–95) after the second dose, and 89 percent (95 percent CI 85–92) following the third dose (Immunisation Advisory Centre 2015).

To help prevent a number of vaccine-preventable diseases in New Zealand, improving immunisation coverage in children has been a national health target since 2009–10. Initially the target was set so that 85 percent of 2-year-olds would be fully immunised by July 2010; this increased to 90 percent by July 2011 and 95 percent by July 2012 (Ministry of Health 2015a).

The introduction of the immunisation targets helped increase coverage among 2-year-olds to 93 percent in 2012; however, outbreaks of vaccine-preventable diseases such as pertussis and measles continued to occur due to low immunisation rates in preceding years (Ministry of Health 2015a). In 2012, the focus of the target was shifted to infants aged 8 months, so that 85 percent of 8-month-olds would have received their primary course of immunisation (at 6 weeks, 3 months and 5 months) on time, increasing to 90 percent by July 2014 and 95 percent by December 2015. National coverage in 8-month-olds has increased from 86 percent in June 2012 to 93 percent in September 2015 (Ministry of Health 2015b).

There is still room to improve pertussis immunisation coverage at age 6 months for Māori and Pacific peoples, as well as those from deprived households. Data from the peak of the most recent 2011–14 pertussis epidemic show coverage of infants with the three vaccine doses at age 6 months is lowest among those living in the most deprived household areas and among Māori and Pacific infants (Kiedrzyński et al 2015).

Coverage of all three pertussis vaccine doses at 6 months was lowest for Māori (62 percent) and Pacific peoples (73 percent) compared with NZ Europeans (81 percent) and for those living in most deprived households (67 percent coverage compared with 81 percent coverage for those in the least deprived households). For these populations, lower immunisation coverage in infants aged under 6 months, but improved coverage seen by 12 months, suggests underlying issues associated with receiving their scheduled immunisations on time in the early stages of life (Kiedrzyński et al 2015). Ensuring the three pertussis vaccine doses are received on time is important for maximising protection against the disease and reducing inequities.

Maternal immunisation in New Zealand

Because very young infants are not fully protected from pertussis until they complete their third dose of the primary vaccine schedule, developed countries are increasingly complementing routine childhood pertussis immunisation strategies with vaccinating pregnant women (WHO 2015). Maternal pertussis vaccinations provide passive immunity in the unborn child, as an immunised mother's antibodies are passed through the placenta to the baby before birth, providing increased protection against pertussis for young infants during the first few months of life (Amirthalingam et al 2014). This protection occurs during the time of greatest risk of pertussis as demonstrated by the New Zealand data. The timing of the vaccination given during pregnancy is important as the concentration of antibodies produced by the mother decreases relatively quickly after pertussis immunisation (bpac^{NZ} 2013; 2014).

Pertussis booster vaccinations are recommended for pregnant women in the third trimester between 28 and 38 weeks gestation (Ministry of Health 2014a). In New Zealand, PHARMAC has funded pertussis boosters to all pregnant women in the third trimester of pregnancy since January 2013. This funded pertussis immunisation was initially introduced as an epidemic control strategy for disease outbreak situations. Since 1 August 2015, PHARMAC agreed to fund a pertussis booster for all pregnant women in the third trimester of pregnancy via the community pharmaceutical section of the New Zealand Pharmaceutical Schedule, irrespective of the current level of disease in the community.

Box 2: Effectiveness and safety of maternal pertussis immunisation

A maternal pertussis vaccination programme was trialled across the UK in October 2012, in response to a pertussis outbreak in England. The UK Department of Health offered all pregnant women a five-component DTaP-IPV booster vaccination between 28 and 38 weeks of pregnancy (Amirthalingham et al 2014). Analyses of national surveillance data and hospital admissions between 2008 and 2013 showed confirmed pertussis cases and hospitalisations decreased more among those infants whose mothers received the maternal vaccination compared with infants with unvaccinated mothers. The greatest decline in confirmed cases and hospital admissions was observed among infants aged under 3 months (Amirthalingham et al 2014).

The UK maternal pertussis vaccination programme quickly achieved vaccine coverage of 64 percent over the study period. Vaccine effectiveness was assessed based on comparing maternal immunisation status of mothers of infants with confirmed pertussis, with immunisation coverage among pregnant women. Findings showed that a pertussis booster given to women during the third trimester of pregnancy is 91 percent (95 percent CI 84–95) effective in reducing pertussis infection in infants up to 3 months of age – the period of greatest risk of severe disease (Amirthalingham et al 2014).

A national strategy for protecting pregnant women (and their babies) against pertussis with the Tdap vaccine has also been implemented in Argentina since 2012, with recent analyses showing an 87 percent reduction in absolute pertussis mortality. No adverse events involving the vaccine were reported (Vizzotti et al 2015).

A recent study compared adverse events related to pregnancy (eg, stillbirth, accelerated time to delivery) in a large cohort of the pregnant women who received pertussis vaccination under the UK maternal vaccination programme, with a matched cohort of unvaccinated women. Findings showed there was no increased risk of stillbirth immediately after the vaccination or throughout the remainder of the pregnancy among vaccinated pregnant women. There was also no increased risk of maternal or neonatal death, (pre-)eclampsia, haemorrhage, fetal distress, uterine rupture, caesarean delivery or low birthweight (Donegan et al 2014). The safety of maternal pertussis vaccination has also been corroborated by other retrospective cohort studies in the USA (eg, Kharbanda et al 2014; Sukamran et al 2015).

Cocooning

Cocooning is a strategy involving immunising those in close contact with infants who are too young (under 6 months) to have completed their full pertussis vaccination course (WHO 2015; Wiley et al 2013). The aim of the strategy is to limit the risk of pertussis exposure through household and other contacts by providing a protective 'cocoon' around infants in the early months of life (Swamy and Wheeler 2014).

Cocooning was initially recommended by a number of health institutions in developed countries (eg, Centers for Disease Control and Prevention, European Centre for Disease Prevention and Control) as a prevention response to continuing high-incidence pertussis, despite existing routine child immunisation strategies (Rivero-Santana et al 2014). A number of countries trialled various cocooning strategies, most of which targeted household members, as they were identified as the most common source of pertussis infection among young infants (Amirthalingham 2013; Wiley et al 2013).

Current evidence for the effectiveness of cocooning strategies is inconclusive as there are very few cohort studies demonstrating direct evidence of the strategy's efficacy (Rivero-Santana et al 2014). Among the existing body

of evidence, recent reviews show there are mixed findings, with some studies reporting reduced risk of pertussis among infants and others reporting no effect (Berti et al 2014; Bechini et al 2012; Rivero-Santana et al 2014; Wiley et al 2013).

Cocooning approaches require delivering multiple vaccinations to protect one infant and, therefore, are not as cost-effective or as easy to implement as maternal immunisation strategies (Amirthalingham 2013). Although there is some evidence of the acceptability of opportunistic cocooning (eg, vaccinations offered to both parents in maternity wards after birth before discharge; see Rossmann Beel et al 2014; Frère et al 2013), so far only small-scale cohort studies have been conducted.

Because of the logistical and practical difficulties associated with implementation, some researchers recommend a cocooning strategy sits alongside other strategies, such as maternal immunisation (eg, Canteley et al 2014; Chiappini et al 2013; Lugner et al 2013). Others recommend a more selective form of cocooning, targeting those infants most at risk from infection (eg, Guzman-Cottrill et al 2012).

Overall, more evidence is required to evaluate both the efficacy and cost-effectiveness of cocooning strategies, though it is generally agreed the impact and cost-effectiveness of cocooning is likely lower than that of maternal immunisation strategies (WHO 2015).

Immunising health care workers

Health care workers are a source of pertussis transmission, particularly those who work with newborns and neonates in community and hospital maternity settings, or those who work with immunocompromised infants and children (WHO 2015). Establishing immunisation programmes for health care workers is an important strategy for preventing disease transmission to patients. Vaccinating health care workers for pertussis is a recommended strategy in some countries and a mandatory strategy in others (WHO 2015). The Advisory Committee on Immunization Practices provides advice to the Centers for Disease Control and Prevention, and recommends all adults (including health care workers) aged over 65 years receive a single dose of Tdap if they have not received one previously. Priority should be given to those in direct contact with infants aged under 12 months (CDC 2011).

There is no published evidence assessing the effectiveness of immunising health care workers for preventing pertussis transmission in health care settings (WHO 2015). Although health care personnel immunisation programmes have been established, very few of these incorporate evaluation processes into the programme to assess their effectiveness (Carrico et al 2014). The extent to which disease transmission from health care workers is prevented is, therefore, unclear, and immunising health care workers is only considered a partially effective prevention strategy (WHO 2015).

In New Zealand, the Tdap booster vaccination for pertussis is recommended by the Ministry of Health, but not funded in the community for lead maternity carers (LMCs) and other health care personnel working in neonatal units and other clinical settings where they are exposed to infants, especially those with pre-existing conditions (Ministry of Health 2014a). There have been known outbreaks of pertussis in New Zealand in maternity and neonatal units and childcare facilities. Some district health boards (DHBs) have responded to these outbreaks by providing pertussis immunisation programmes for staff in close contact with infants (Grant and Reid 2010; Grant 2015).

Issues and themes identified by the CYMRC and LCYMRGs

The following key issues and themes were identified by the CYMRC from the data analysed in Section A and mortality reviews from the LCYMRGs. These issues and themes, together with current trends identified in the international literature on strategies for pertussis prevention, led to the development of the recommendations in Section C of this report.

1. Maternal immunisation for pertussis – uptake and awareness in pregnant women

Young infants aged under 6 months who have not fully completed the course of their three pertussis-containing vaccinations are most at risk from infection as they are not fully protected. Maternal immunisation strategies are a more cost-effective way to prevent pertussis among very young infants compared with cocooning strategies (WHO 2015). There is strong evidence demonstrating the effectiveness of maternal immunisation strategies in reducing infant pertussis cases, hospitalisations and deaths, in both the UK and the USA (Amirthalingham et al 2014; Terranella et al 2013).

Current data in New Zealand suggest uptake of the Tdap booster vaccination is low among pregnant women – estimated at around 13 percent (bpac^{NZ} 2014). There is evidence suggesting maternal vaccination is viewed as acceptable by pregnant mothers if the motivation is to protect their unborn child and give them the best start in life (see Box 3).

The CYMRC recognises a need to raise awareness of the safety and efficacy of the booster vaccination to increase uptake. LMCs, general practitioners (GPs) and antenatal educators are crucial for providing immunisation information to pregnant women. The most common source of immunisation information that parents reported encouraged immunisation uptake in the Growing Up in New Zealand study was a midwife, followed by GPs (Growing Up in New Zealand 2015). The Ministry of Health is central to ensuring a wide range of information resources are available for both health care workers and pregnant women, and has been developing such resources during the completion of this report. The first of these 'Let's talk about immunisation' resources is a guide for health professionals to use when talking about immunisation to expectant and new parents; this is due for release in December 2015.

Box 3: Evidence for acceptability of immunisations during pregnancy in New Zealand

A recent qualitative study in New Zealand used interviews with 59 pregnant women and women who had given birth in the previous 12 months to examine their beliefs about immunisation during pregnancy (Litmus Ltd 2015). Key findings showed:

- most women's key contact for the provision of pregnancy-related information and advice is their LMC. Approximately half of women interviewed reported having a conversation with their LMC about immunisation for influenza and/or pertussis
- pregnant women find immunisation during pregnancy acceptable if the primary reason for the immunisation is to protect their unborn child
- women are concerned about the safety of immunisation for their unborn baby; messages that emphasise the safety of immunisation during pregnancy are reassuring (Litmus Ltd 2015).

A recent survey study of 596 post-partum women in the Canterbury DHB region showed the two main motivations among women who received the Tdap vaccination in pregnancy were the desire to protect their unborn baby (96 percent) and because it was recommended by a health professional (84 percent). Among those who did not have the Tdap vaccine, the main reasons were that they did not know it was available (73 percent), they feared vaccine side effects (68 percent) and they were doubtful of the vaccine's effectiveness (56 percent) (Hill 2015).

2. Having systems to facilitate maternal immunisation

Increasing awareness and uptake of the pertussis booster vaccination among pregnant women requires having systems in place to facilitate the processes involved. At a general practice level, those who confirm pregnancies (eg, nurses and GPs) should be able to initiate the recall of their patients in the third trimester for their booster vaccination. A system should also be in place to notify LMCs when their clients have received their vaccination. At a national level, a system should be in place that records maternal immunisations on the National Immunisation Register and also transfers this information to the infant's immunisation record after birth.

The National Health IT Board is currently developing a national maternity clinical information system. The system will link information from hospital- and community-based maternity care settings about women and their babies, from pregnancy until the baby is 4–6 weeks old (Ministry of Health 2014b).

A shared maternity record view is also being developed alongside the maternity clinical information system. This shared record will enable all health professionals caring for a woman and her baby to record details of care, including midwifery notes, medications prescribed, and screening and test results, as well as access the information via a secure online portal. Over time, women will also be able to access their summary maternity care information via an online portal (Ministry of Health 2014b).

Having a shared source of maternity information will allow health practitioners to work together more effectively when caring for pregnant women. The CYMRC recognises the importance of these systems for strengthening communication between GPs and LMCs on maternal pertussis booster vaccination referrals. To help facilitate referrals, LMCs should be able to notify GPs when a patient is in their care and wishes to be referred for their booster vaccination. LMCs should also be able to see when the vaccination has been administered. Once the shared maternity record is available for viewing by pregnant women, GPs could also use the system to assist with recalling their patients in the third trimester for a booster vaccination.

3. Equity issues for Māori and Pacific infants and infants living in deprived areas

Analyses from section B in this report show Māori and Pacific infants are over-represented in pertussis hospitalisations and mortality. Other recent analyses corroborate these findings and show that, at 6 months of age, Māori and Pacific infants have the highest disease incidence and the lowest coverage. A similar trend is seen among infants aged under 6 months living in the most deprived areas in New Zealand (Kiedrzyński 2015).

The higher hospitalisation rates among Māori and Pacific infants aged under 6 months observed in this report partly reflect pertussis immunisation coverage inequities in Māori and Pacific infants under 6 months (see Kiedrzyński et al 2015). Although overall immunisation coverage has improved for Māori and Pacific infants aged 8 months and 2 years (Health Quality & Safety Commission 2015), improvements are still needed to ensure Māori and Pacific infants receive all three doses from their primary pertussis vaccination course on time.

For these infant populations, immunisation timeliness is affected by a number of barriers, such as a lack of transport, that restrict parents' ability to access the vaccination through general practices. These barriers could be addressed by the adoption of a broad range of service delivery models, such as outreach immunisation services that deliver the vaccines to these groups in their local community. For Māori and Pacific peoples, the development of targeted and culturally appropriate resources that resonate with pregnant women, and Māori and Pacific non-governmental organisations (NGOs) and health providers could help improve immunisation uptake.

4. Minimising transmission among those in close contact with young infants

Immunising health care workers is a reasonably cost-effective way to limit pertussis transmission, particularly among newborns and neonates in clinical and community settings. Immunising health care workers with booster doses every 10 years is recommended in the current *Immunisation Handbook* by the Ministry of Health (Ministry of Health 2014a). Immunising health care workers could be a useful complementary prevention strategy to adopt, particularly in times of epidemics. Individual DHBs are currently responsible for deciding which health care workers should be immunised and for funding those immunisations. Many DHBs offer pertussis booster vaccinations selectively to staff working in close contact with children aged under 12 months. However, vaccinating DHB health care workers is not guided by any national policies, and there is some variability in the frequency with which DHBs offer the vaccinations. Some DHBs currently recommend booster doses every 5 years and others recommend doses every 10 years.

5. Providing no-cost immunisation

The CYMRC is aware that some pregnant women have been referred to their general practice by their LMC to receive their free Tdap booster vaccination for pertussis, but were told by their general practice they need to have a consultation in order to receive the vaccination. These consultations are not always free and, in some instances, have led to pregnant women not having the vaccination to avoid the consultation fee. Having no-cost immunisation plays an important role in pregnant women's decision to get immunised (Litmus Ltd 2015).

The CYMRC recognises that general practices may be requesting women to have a consultation prior to receiving the pertussis booster vaccination because these women may not have seen their GP for some time. Some of the consultation feedback from the CYMRC's stakeholders suggested having a fully funded free third trimester consultation with GPs available to all pregnant women. A fully funded GP visit could remove any remaining cost barrier experienced by pregnant women as well as help establish relationships for post-natal care and ongoing family health care.



6. Maximising coverage – using national policies to drive local goals

Over the last 5 years, New Zealand has made excellent gains in equitable immunisation coverage and now almost 95 percent of infants are immunised by 8 months of age. These gains are mainly the result of changes in policy and practice following the Government's decision to place child immunisation targets within the national health targets and set Better Public Services targets for government agencies.

Immunisation targets are currently transitioning to being included in the new Integrated Performance Incentive Framework (IPIF). The aim of the IPIF is to support the health system to address issues of access, equity, quality, safety and the cost of health services (Ashton 2015). The IPIF programme shifts the performance improvement focus from primary health organisations (PHOs) to the whole-of-health system. The IPIF provides a framework that links national system-level measures (set by the Ministry of Health) with various local-level measures elected by DHBs for their contribution to the system-level measures (Ashton 2015). The CYMRC believes the IPIF is important for improving immunisation timeliness and coverage inequities that exist among Māori and Pacific peoples, and deprived populations at 6 months of age.

The IPIF aligns strongly with the value and high performance theme of the draft Health Strategy currently out for consultation. Action 8 of the draft health strategy roadmap of actions refers to building on the IPIF work to date to develop and implement a health outcome-focused framework for the whole health system (Ministry of Health 2015c). Local alliances that have been forming since 2013 are pivotal to helping develop the IPIF and facilitating the development of integrated models of primary care (Ashton 2015).

C. Recommendations

National policy and practice recommendations

The CYMRC expects the health system to deliver high-quality equitable services that are culturally competent, health literate, and meet the health needs and aspirations of pregnant women and their whānau.

1. The Ministry of Health should make equitable coverage of the pertussis booster vaccination during pregnancy a quality improvement measure, or target, for DHBs.
2. The Ministry of Health should record pertussis booster vaccinations given to pregnant women in the National Immunisation Register and develop a national system for transferring the information to the infant's immunisation health record at birth.³
3. The Ministry of Health should deliver a suite of education resources for pregnant women, LMCs and other primary health care service providers, informing them of the benefits of maternal pertussis immunisation.
4. The Ministry of Health and DHBs should include a maternal immunisation topic in the DHB Funded Pregnancy and Parenting Information and Education service specifications, to ensure antenatal classes provide information on pertussis booster vaccinations to expectant parents.
5. A national system should be developed that helps facilitate pertussis booster vaccination referrals and improves two-way communication between GPs and LMCs. This system should:
 - a. facilitate the safe⁴ and appropriate recall of pregnant women for their third trimester immunisation
 - b. allow GPs and other immunisation providers to notify LMCs when the immunisation has been provided.
6. The Ministry of Health should support health providers to address barriers to immunisation service access for pregnant Māori and Pacific women and their whānau.

Local recommendations for DHBs, PHOs, LMCs and NGOs

1. All health providers in a general practice setting (ie, practice nurses and GPs) who confirm a pregnancy should initiate a plan to safely recall the pregnant woman for a pertussis booster vaccination in the third trimester.
2. LMCs in contact with pregnant women in the third trimester should ensure those women:
 - a. are aware that a pertussis booster vaccination in the third trimester can protect young infants from pertussis
 - b. understand where they can go to receive a pertussis booster vaccination in their region, and are offered the vaccination, or referred to an appropriate immunisation provider.
3. All health providers should ensure that the pregnant women they are in contact with are aware of the need for a pertussis booster vaccination in the third trimester.
4. General practices and PHOs should support the development of integrated primary care services that enable equitable and no-cost access to a pertussis booster vaccination for pregnant women in the third trimester.
5. DHBs and PHOs should establish policies that offer regular pertussis booster vaccinations to clinical and community health care workers in contact with neonates and newborns.
6. All health providers, including LMCs, should address barriers to immunisation service access for pregnant Māori and Pacific women and their whānau.

³ After the point of information transfer, the antenatal pertussis immunisation should be considered the 'first' immunisation on the child's immunisation record and be included in the parents' copy of the Well Child/Tamariki Ora My Health Book.

⁴ The 'safe' recall of pregnant women should take into account those pregnant women who have experienced a miscarriage or a stillbirth before the point of recall.



Best practice in community messaging

1. Parents and caregivers should continue to immunise infants on time with the primary course of pertussis vaccinations listed in the National Immunisation Schedule (with doses at 6 weeks, 3 months and 5 months of age).
2. All pregnant women should receive a pertussis booster vaccination in their third trimester in order to protect their young infants from pertussis. This booster should be delivered in every pregnancy.

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Appendix: Statistical significance testing

Introduction

Inferential statistics are used when it is necessary to use a sample to draw conclusions about the population as a whole (eg, weighing 1000 newborn babies to estimate the average birth weight of all babies in New Zealand). Any measurement based on a sample, however, will always differ from that of the underlying population, simply because of chance. Similarly, in assessing whether the risk of a particular condition (eg, sudden infant death syndrome) is different between two groups (eg, babies whose mothers smoked or did not smoke during pregnancy), the possibility that any differences seen arose simply by chance must always be considered (Craig et al 2008).

Statisticians have developed a range of measures to try to quantify the role chance plays when samples are used to make inferences about the population as a whole. Of these, one that is used in this report is the confidence interval. A 95 percent confidence interval suggests that if you were to randomly sample from the same population 100 times, in 95 times out of 100 the confidence interval would include the true value. In general, if the 95 percent confidence intervals of two samples overlap, there is no statistically significant difference between them. If the 95 percent confidence intervals do not overlap, they are thought to be statistically different (Webb et al 2005).

The use of statistical significance testing in this report

Descriptive statistics: The data presented in this report are derived from administrative data sets (eg, National Mortality Collection, EpiSurv) that capture information on all of the events (eg, deaths, hospital discharges) occurring during a particular period. Such data sets can thus be viewed as providing information on the entire population, rather than a sample. As a consequence, 95 percent confidence intervals are not required to quantify the precision of the estimate (eg, the number of pertussis deaths during 2002–14, although small, is not an estimate, but rather reflects the total number of deaths from pertussis during this period). Therefore, 95 percent confidence intervals are not provided for any of the data presented in this report where the intention is purely to describe the number of deaths occurring in a particular category (eg, number of deaths), on the basis that the numbers presented reflect the total population under study.

Measures of association: In considering whether statistical significance testing is ever required when using total population data, Rothman (2002) notes that if one wishes only to consider descriptive information (eg, rates) relating to the population in question (eg, New Zealand during 2002–14), then statistical significance testing is probably not required (as per the argument above). If, however, one wishes to use total population data to explore causal associations more generally, then the same population can be considered a sample of a larger super-population, for which statistical significance testing may be required. For example, the fact that mortality from pertussis is higher for children of Pacific ethnic groups might be used to draw conclusions about the impact of ethnicity on disease risk more generally. Similarly, the strength of any observed associations is likely to vary over time (eg, in updating 5-year pertussis hospitalisation data from 2005–11 to 2006–12, rate ratios for Māori infants are likely to fluctuate in line with variations in the underlying rates, even though the data include all hospitalisations for the 7-year period).

Therefore, whenever measures of association (ie, rate ratios) are presented, 95 percent confidence intervals are provided, so that the reader can assess the extent to which the associations presented may have arisen by chance (Rothman 2002). Examples of such measures of association would include an exploration of differences by deprivation or DHB.



**Child and Youth
Mortality Review
Committee**

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“...taken away too early...”



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