South Island Pertussis

An analysis of notifications (2009-2013) and a review of incidence (1997-2013) by District Health Board

Canterbury District Health Board
Te Poari Hauora ō Waitaha

Prepared by the Information Team
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Foreword
This report on pertussis has been produced to improve understanding of its local epidemiology in order to assist with its public health management.

Document availability
This document is available on the Community and Public Health website:
www.cph.co.nz

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Contents

Summary Points

- In the South Island pertussis epidemics occurred in 1999-2002, 2004-2005, and 2011-2013/14. Each region within the South Island experienced similar epidemic patterns with the greatest variations apparent in the smaller District Health Boards.
- The DHBs with the highest notification rates also tended to have the highest hospitalisation rates. Rates were highest in children aged between 6 weeks and 10 years. Overall 3.1 percent of notified South Island cases were admitted, although by age group, hospitalisations were highest for infants aged less than 3 months with over 65 percent of cases in this age group requiring admission.
- The notification rate for females was 1.3 times higher than for males although hospitalisation rates were the same.
- The importance of maternal vaccination in the latter stages of pregnancy was highlighted by the finding that if a woman has two pregnancies in a relatively short space of time, the baby is likely to be at greatest risk of being hospitalised from pertussis (6 weeks-3 months) when the older sibling is at greatest risk of contracting it (5 months-3 years).
- The proportion of notifications by ethnicity were similar for all DHBs, with Europeans over-represented. People of Asian ethnicity however, were under represented comprising only 2 percent of notifications but 5 percent of the population. Rates for Māori and Pacific Peoples were equal and twice that of Asians. These figures contrast with the national situation in which Māori rates were 30 percent higher than those for Pacific Peoples and more than four times that of Asian. In the South Island, Pacific Peoples and Other ethnicities had the highest percentages of notified cases that were hospitalised.
- Forty-one percent of notifications were aged 16 years or under and were not in the work force. Almost one third of pertussis notifications were in paid employment of whom one quarter were professionals.
- There was a slight decrease in notification rates in neighbourhoods across deprivation quintiles 1 to 4 but a sharp drop in rates in the most deprived quintile. The trend for hospitalisation rates, however, was the reverse; neighbourhoods with the highest deprivation scores (quintiles 4 and 5) had the highest rates.
- Vaccination possibly had an impact on reducing pertussis incidence in children, as suggested by an inverse association between vaccination coverage and pertussis notification rates, and an analysis of the cocooning strategy.
- Localised outbreaks in the Canterbury, West Coast and South Canterbury regions were usually either not identified or not specifically coded in EpiSurv. The majority of household clusters had only two cases but accounted for 17 percent of cases in Canterbury, South Canterbury and the West Coast. Household clusters had a lower average number of cases (2.1) than outbreaks (4.7).
- Three major epidemics peaked in 2000, 2004-5, and 2011-12. Canterbury had the most cases in every epidemic but either West Coast or Nelson Marlborough had the highest epidemic rates. From 1997 to 2013 DHBs had epidemic rates of notifications on average 46 percent of the time. The average duration of the most recent epidemic was 29 months.

- Minor epidemics occurred in the years between the major epidemics in all DHBs except Southern. Apart from a lower average age there were few epidemiological differences between the minor epidemic of 2009 and the major epidemic of 2012.
- Overall there was a 41.7 percent (p=0.03) reduction in the percentage of notifications due to infants aged less than 3 months in the 12 months following the implementation of the maternal Boostrix programme compared with the previous 12 months.

Recommendations

- Improve (on-time) vaccination coverage particularly in the West Coast and Nelson Marlborough regions.
- Improve EpiSurv vaccination status data collection.
- Maintain awareness that pertussis is at or above epidemic levels almost 50 percent of the time and that on-time vaccination is the best prevention currently available.
- Promote the maternal Boostrix programme and consider an extended cocooning strategy. Cocooning may be especially important for:
    - Nelson Marlborough (low immunisation rates), Canterbury and Southern (substantial population in the at risk age group)
    - Pacific and Other ethnicities, and/or
    - households with a newborn that also have a pre-schooler.
- Promote Boostrix vaccination of those for whom it is recommended but not funded (lead maternity carers and health care personnel who are exposed to infants, household contacts of newborns and early childhood workers) and consider recommending it for those in occupations at higher risk of infection in epidemics, for example, teachers and health care personnel besides those exposed to infants.
- Develop other initiatives to reduce hospitalisation rates in young children of Pacific and Other ethnicities and those living in the most deprived neighbourhoods.

Introduction[1]

Pertussis is an acute bacterial infection of the respiratory tract caused by *Bordetella pertussis*. The disease is highly transmissible in households and healthcare settings and is most often severe in young infants, in whom prolonged periods of apnoea may result in anoxic encephalopathy, seizures and death. The most common complications of pertussis are secondary infections, such as otitis media and pneumonia, and the physical sequelae of paroxysmal bouts of coughing.

Infants aged less than 3 months have the highest rates of notification and hospitalisation, but overall in New Zealand most infection occurs in older siblings, adolescents and adults. Māori and Pacific infants have the highest hospital admission rates and New Zealand infants have 3-6 times higher rates of admissions than in Australia, the UK and the USA. Although the duration of vaccine effectiveness is problematic with waning immunity after 4-12 years in some children, delay in any of the three doses of the primary immunisation series is associated with a five-fold increased risk of an infant being hospitalised with pertussis. Eight deaths occurred in New Zealand between 1997 and 2013. Since August 2000 the acellular pertussis vaccine has been used in New Zealand.

Superimposed on an endemic background incidence, major epidemics occur every 2-5 years. Since pertussis was made notifiable in 1996, New Zealand has experienced three epidemics each lasting approximately two years with the most recent ending in 2013-14.

This report reviews in detail notification data from the five South Island District Health Boards (DHBs) (Nelson Marlborough, West Coast, Canterbury, South Canterbury, and Southern) from 2009 to the end of 2013 and includes the large majority of the cases notified during the recent epidemic. Data from 1997 to 2013 were analysed to evaluate the extent of the historical epidemics in the South Island.

Methods

Pertussis notification data[a] for the five South Island DHBs were provided from EpiSurv by the Institute of Environmental Science & Research (ESR).[2] Detailed data for the past five years (2009-2013) included age, sex, ethnicity, location, occupation, hospitalisation and immunisation status. Limited data only (but including location) was requested for 1997-2008 to review epidemic patterns.

[a] **Definitions of notified cases**

Under investigation - A case which has been notified but information is not yet available to classify it as probable or confirmed.

Suspect (in children under five 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 by isolation of *B. pertussis* or detection of *B. pertussis* nucleic acid, preferably from a nasopharyngeal swab, or is epidemiologically linked to a confirmed case.

Descriptive analyses summarising data for each DHB, Territorial Authority (TA, where appropriate) and for the South Island as a whole were conducted using SPSS (version 17.0, SPSS Inc. Chicago, IL, USA) and Epi Info (version 7.0, Centers for Disease Control and Prevention, Atlanta, GA, USA). Note, some analyses at TA level need to be interpreted with caution due to small numbers. Population count and ethnicity data were sourced from the 2013 New Zealand Census (Tables 1 and 4).

Table 1. Population size of South Island DHBs[‡]

Nelson Marlborough	West Coast	Canterbury	South Canterbury	Southern
137,007	32,148	482,178	55,623	297,420

[‡] Population count data sourced from the New Zealand Census (2013)

The map of pertussis notification rates by TA was generated using Map Machine (Community and Public Health, Canterbury DHB, 2014).

For estimating notification and hospitalisation rates for specific groups aged less than one year, the time span in weeks of each group was used as a proxy for population because the 2013 Census populations were not available at this level (Figures 12 and 13). The units are arbitrary and absolute values should not be compared to actual rates, although the shape of the distribution is still meaningful.

Notification rates for urban and rural populations were not able to be calculated because at the time this report was written Statistics New Zealand had yet to release those data from the 2013 Census. Only the percentages of notifications from urban and rural areas are reported (Table 18). For this analysis the Statistics New Zealand classification of urban and rural[3] was used to reduce the three urban and four rural categories to two, urban and rural.

Where a case stated multiple ethnicities, prioritised ethnicity was used to reclassify to one. The order of prioritisation was: Māori, Pacific, Asian, Other, European. "Other" includes responses for a number of small ethnic groups not including Māori, Pacific, Asian or European.

The occupation of each case (where stated and/or possible) was coded according to the Australian and New Zealand Standard Classification of Occupations (ANZSCO v1.2, Level 1 and Level 2).[4]

Incidence and Rates (1997-2013)

Notifications

From 2009 to 2013 there were 5616 pertussis notifications (confirmed 32.8%, probable 60.4% and suspected 6.8%) in the South Island, and from 1997 to 2013 there were 14670 notifications (confirmed 40.1%, probable 48%, suspected 8.8%, under investigation 0.9% and unknown 2.1%).

Regular pertussis epidemics occur every two to five years and in the South Island and since 1997 there have been three, in 1999-2002, 2004-2005, and 2011-2013/14. The expected 2008-2010 epidemic was unusually small (Figure 1) (see Epidemics and Outbreaks). Each region within the South Island experienced similar epidemic patterns with the greatest variations apparent in the smaller DHBs (Figure 1). This was particularly so for Nelson Marlborough and West Coast during the recent epidemic. Since 1997, Westland, Grey, Tasman, and Nelson City have experienced the highest average rates of pertussis, with Otago and Waimate experiencing the lowest rates (Figure 2).

Figures 3 and 4 show TA notification rates for 2009-2013 with a pronounced north-south gradient. This may be due to vaccination coverage differences (see Vaccination) since pertussis is an endemic disease regardless of ethnicity, climate or geographic location.[5] Figure 4 indicates that the burden of the recent epidemic was greater in the South Island than in the North Island.

Figure 1. Pertussis notification rates (1997-2013) per 100,000 population by month, annualised for the South Island and the South Island DHBs (Note: vertical axis scale different for each region)

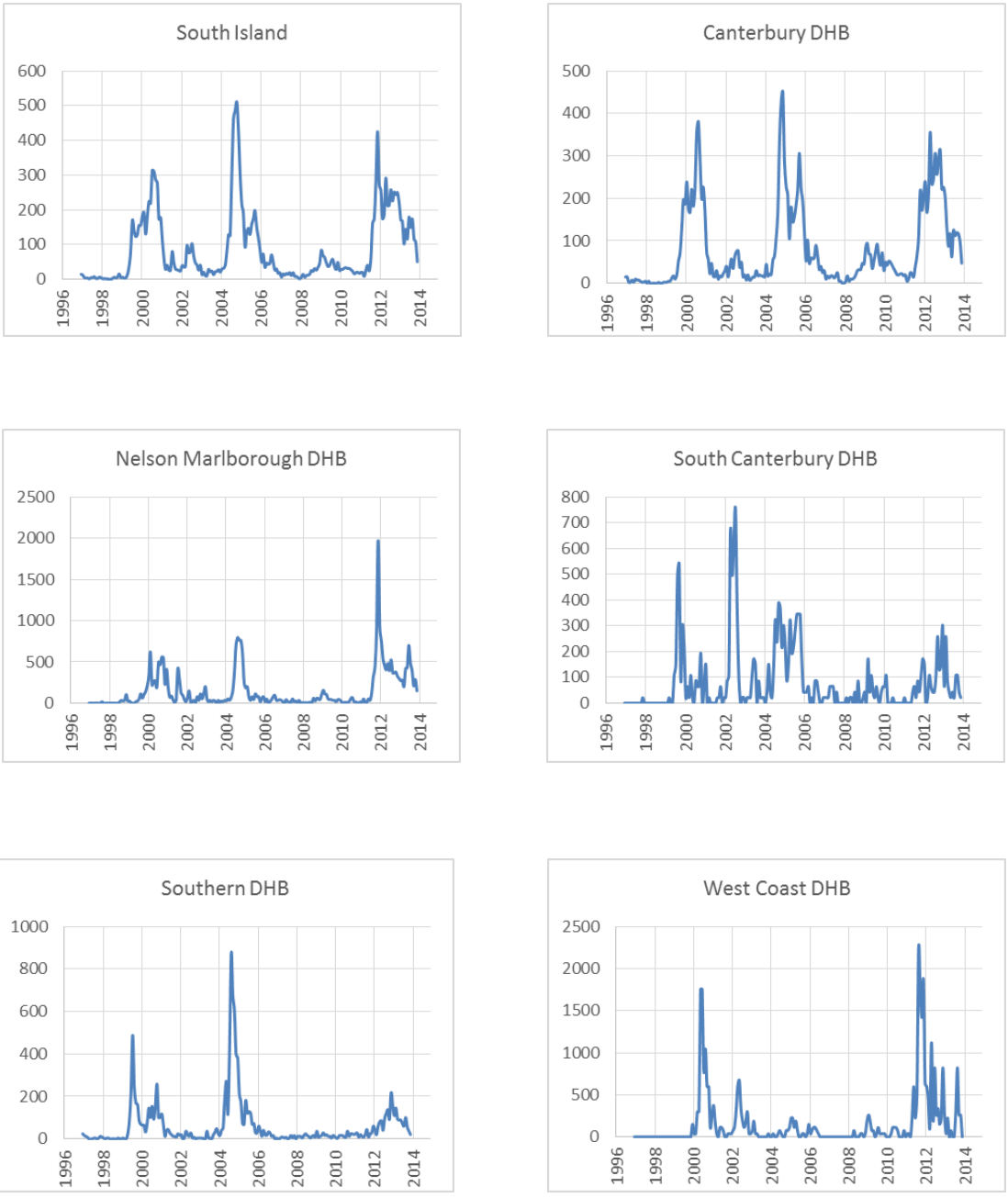


Figure 2. Average annual pertussis notification rates per 100,000 population for South Island TAs, 1997-2013

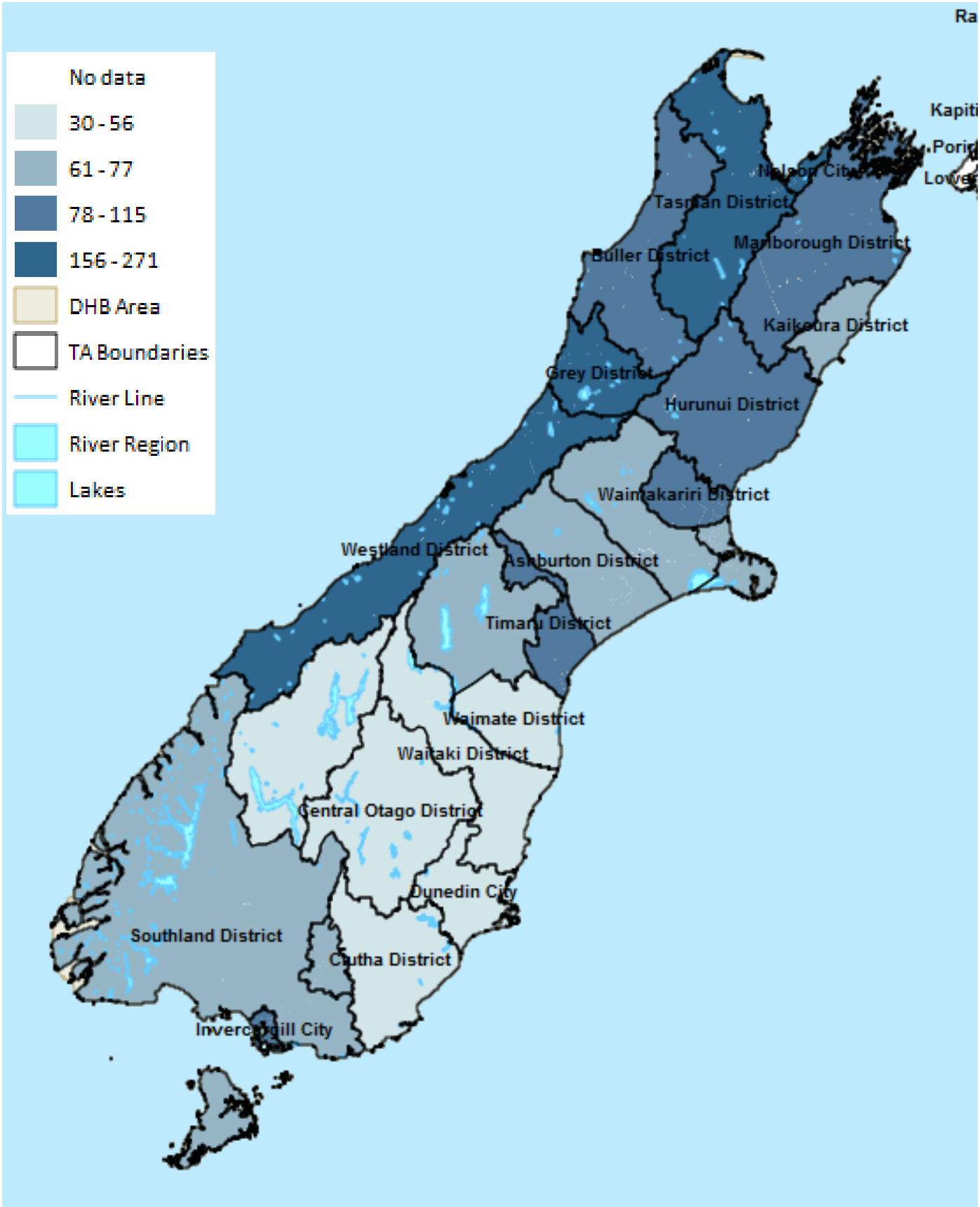


Figure 3. Average annual pertussis notification rates per 100,000 population for South Island TAs, 2009-2013

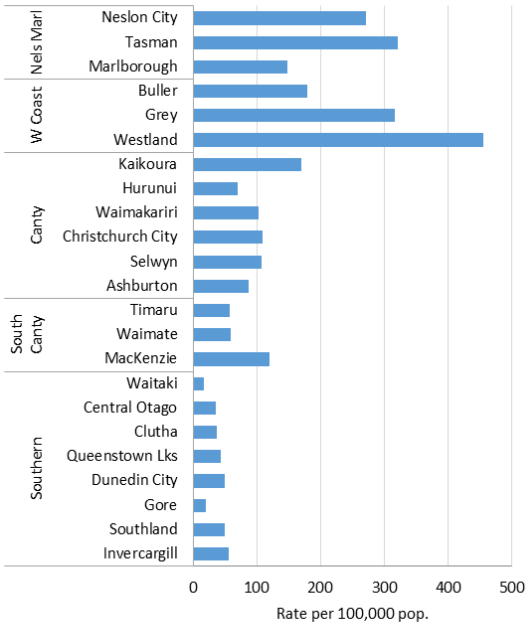
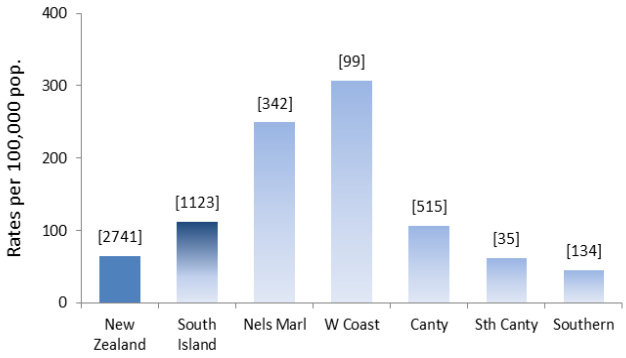


Figure 4. Average annual pertussis notification rates for South Island DHBs, 2009-2013 [average annual number of notifications]

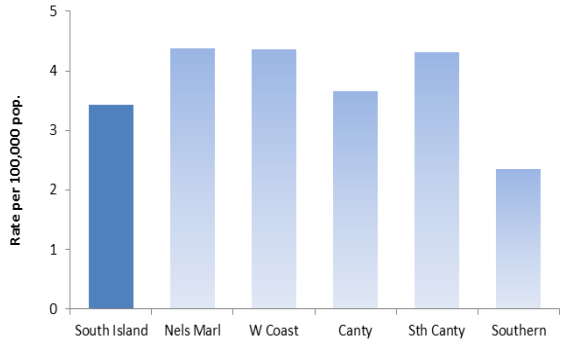


Hospitalisations

The differences between the DHBs in hospitalisation rates were markedly less than the differences in notification rates although those with the highest notification rates also tended to have the highest hospitalisation rates (Figures 4 and 5).

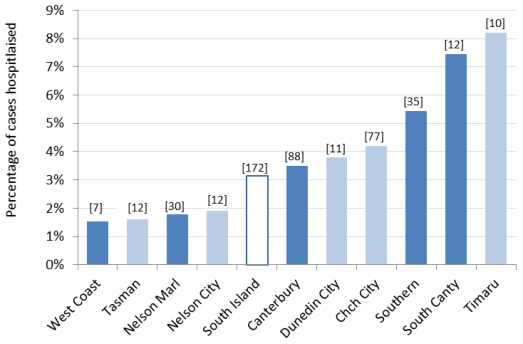
Overall 3.1 percent of notified cases were admitted to hospital in the South Island (Figure 6) although the percentage was markedly higher for young infants (see Demographic Characteristics [Age] and Figure 11). For many TAs there were too few cases for hospitalisation rates to be meaningful. Most admissions were in Nelson City (12), Tasman (12), Christchurch City (77) and Timaru (10), and for TAs with ten or more admissions, the percentage of notifications admitted was calculated (Figure 6). Districts and DHBs with a hospitalisation percentage greater than that of the South Island had either more admissions than expected, or possible 'under' notification of cases. Districts and DHBs with a lower hospitalisation percentage had either fewer admissions than expected or 'over' notification. 'Over' notification however, was perhaps less likely given that the large majority of notifications were either confirmed and probable cases.

Figure 5. Average annual hospitalisation rates* for South Island DHBs, 2009-2013



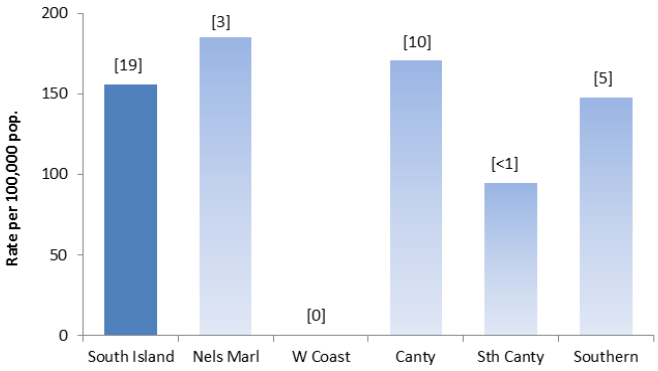
** Where hospitalisation status known*

Figure 6. Percentage of South Island pertussis notifications hospitalised,* by DHB and TA 2009-2013 [number of hospitalisations]**



*** TAs with 10 or more admissions*

Figure 7. Average annual hospitalisation* rates among infants less than 1 year of age for South Island DHBs, 2009-2013 [average annual number hospitalised]



** Where hospitalisation status known*

Hospitalisation rates for infants aged less than one year in West Coast (0 admissions) and South Canterbury (3 admissions) were relatively low compared with their overall hospitalisation rates (Figure 5 and 7). The cocooning strategy (see Epidemics and Outbreaks for an analysis of that programme) may have beneficially influenced these results although not fully accounting for them since South Canterbury and West Coast combined had only one admission of an infant (2 months of age) in the 12 months prior to the programme commencing.

Mortality

Eight deaths occurred in New Zealand between 1997 and 2013[6] including two 1 month old infants (one in Christchurch in 2012 and the other in Clutha in 2011).

Demographic Characteristics (1997/2009-2013)

Age

There was a change in the age distribution of notifications nationally with cases aged 30 years and over increasing from 23 percent in 1997 to 48 percent in 2013.[1] In Canterbury, West Coast, and South Canterbury this age group increased from 15 percent in 1997 to 60 percent in 2006 before decreasing to 49 percent in 2013 (Figure 8). For the South Island in 2013, 45 percent of notified cases were 30 years and over.

Figure 8. The annual percentage of notified pertussis cases aged 30 years and over in Canterbury, South Canterbury and West Coast, 1997-2013.

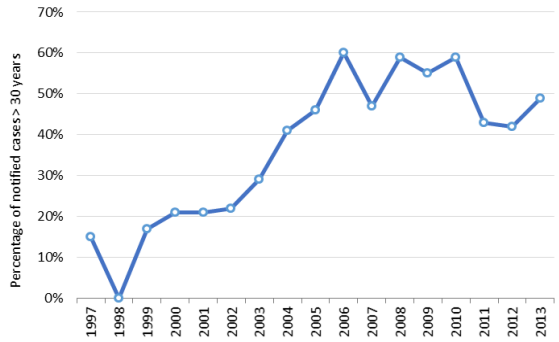
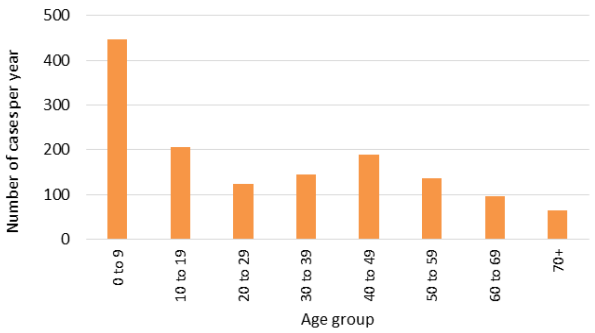


Figure 9. Average annual number of pertussis notifications for South Island DHBs, by age group, 2009-2013.



Figures 9-13 show incidence and hospitalisation data by age, particularly for those aged less than 12 months. Notification rates were highest in children aged between 5 months and 3 years and hospitalisation rates highest at 6 weeks to 2 months (Figures 10, 11). Sixty-nine percent of notified infants aged less than 3 months required admission (Figure 13).

The graphs show a sharp decline in hospitalisation for those over 3 months of age and highlight the importance of maternal vaccination in the latter stages of pregnancy. Although hospitalisation rates were highest in children aged less than 3 months, notifications were highest between 5 months and 3 years. For a woman who has two pregnancies in a relatively short space of time, the baby (aged between 6 weeks and 2 months, Figure 11) is likely to be at greatest risk of hospitalisation from the disease when the older sibling is at greatest risk of contracting it (aged between 5 months and 3 years, Figure 10).

Figure 10. Proxy* South Island pertussis notification rates, by age group, 2009 to 2013

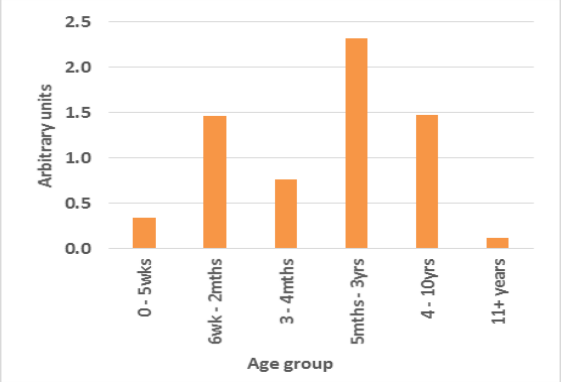


Figure 11. Proxy* South Island pertussis hospitalisation rates, by age group, 2009 to 2013

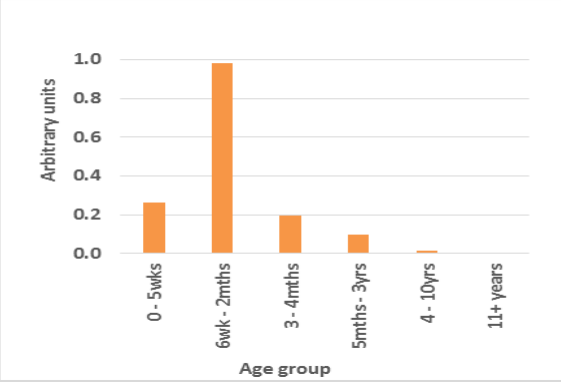


Figure 12. Average number of South Island pertussis hospitalisations per year, by age group, 2009 to 2013

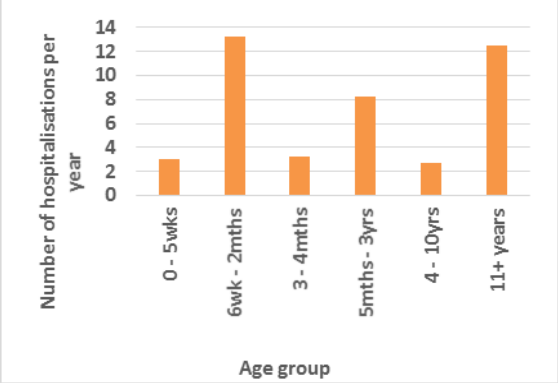
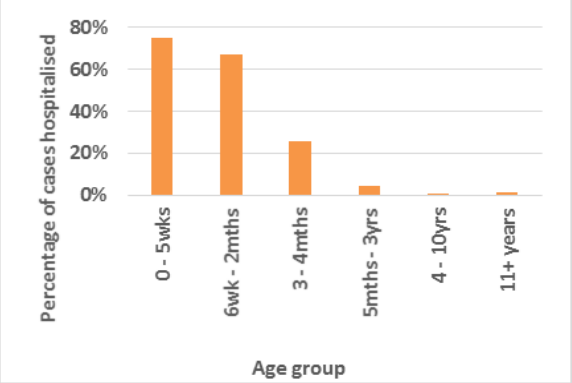


Figure 13. Percentage of hospitalised South Island notifications, by age group, 2009-2013



** See Methods*

Sex

Overall the notification rate for females was 1.3 times higher than for males, a figure consistent with other New Zealand data[7,8] although hospitalisation rates were the same. For children aged 0-4 years the female to male rates ratios for notification and hospitalisation were similar (Table 2).

Table 2. Notification and hospitalisation rates by sex for children aged 0-4 years and all ages, 2009 to 2013

	0-4 years		All ages	
	Male	Female	Male	Female
Number of notifications	518	574	2383	3233
Average annual notification rate per 100,000 population	326	380	96	127
Number hospitalised	54	60	84	88
Average annual hospitalisation rate per 100,000 population	34	40	3.4	3.4
Female:Male notification rate ratio	1.2		1.3	
Female:Male hospitalisation rate ratio	1.2		1.0	

Ethnicity

The pattern of notifications by ethnicity was similar for all DHBs with Europeans over represented (86.5%) (Tables 3 - 5). In South Canterbury 95 percent of notifications were European compared with 86 percent of the South Canterbury population. Asians however, were under represented comprising only 2 percent of notifications but 5 percent of the population. Rates for Māori and Pacific were equal, and twice that of Asians. Nationally between 2009 and 2013 Māori rates were 30 percent higher than rates among Pacific peoples and more than four times that of Asian peoples.[7]

The over representation of Europeans cannot be explained by lower immunisation rates and may be notification artefacts with persons of European ethnicity possibly presenting to their general practitioners more readily. The high immunisation coverage rates of Asians[8] may have resulted in less clinical disease.

Pacific and Other ethnicities had the highest percentages of notified cases that were hospitalised (12% and 13% respectively) and clearly the highest hospitalisation rates for children 0-9 years (Table 6 and 8). For children aged 0-9 years, European and Pacific had the highest notification rates (Table 7). The under representation of Māori in both the percentage of hospitalised cases (Table 6) and the hospitalisation rate for children 0-9 years (Table 8) is in contrast to national figures that show Māori have higher hospitalisation rates than European.[7]

Table 3. Ethnicity of South Island pertussis notifications by DHB, 2009-2013

District health board	Ethnicity (%)*					
	European	Māori	Pacific	Asian	Other	Unknown
Nelson Marlborough	87	9	1	3	0	1
West Coast	83	14	1	2	0	1
Canterbury	87	7	2	2	0	2
South Canterbury	95	4	0	1	0	0
Southern	87	8	2	2	1	1
All South Island DHBs	87	8	2	2	<1	1

** Prioritised ethnicity (see Methods)*

Table 4. Ethnicity of the South Island population‡

	Ethnicity*					
	European	Māori	Pacific	Asian	Other	Unknown
Percentage (%)	79.6	8.3	1.8	5.2	0.7	4.4

‡ Data sourced from the New Zealand Census (2013)
** Prioritised ethnicity*

Table 5. South Island pertussis notification rates per 100,000 population, by ethnicity, 2009-2013‡

	Ethnicity*				
	European	**Māori**	**Pacific**	**Asian**	**Other**
Notification rate	122	107	107	50	62

‡ *Population data sourced from the New Zealand Census (2013)*

** Prioritised ethnicity*

Table 6. South Island notifications hospitalised,* by ethnicity, 2009-2013

Ethnicity‡	Number of notifications	Number hospitalised	Number with known hospitalisation status	Percentage of notifications hospitalised (%)*
Asian	128	7	126	6
European	4859	132	4736	3
Māori	445	19	437	4
Pacific	94	11	93	12
Other	23	3	23	13
Unknown	67	0	60	0

**Notifications where hospitalised information known*

‡ *Prioritised ethnicity*

Table 7. South Island notification rates for children aged 0-9 years, by ethnicity, 2009-2013

Ethnicity*	Percentage of all notifications due to 0-9 year olds (%)	Average annual notification rate per 100,000 population
Asian	48	385
European	30	648
Māori	46	440
Pacific	49	518
Other	39	368
Unknown	10	63

** Prioritised ethnicity*

Table 8. South Island hospitalisation rates for children aged 0-9 years by ethnicity, 2009-2013

Ethnicity*	Number of 0-9 year olds hospitalised	Average annual hospitalisation rates per 100,000 population
Asian	7	44
European	88	39
Māori	18	38
Pacific	9	101
Other	2	82
Unknown	7	63

** Prioritised ethnicity*

Occupation

The greatest proportion of pertussis notifications were young people aged 16 years and under (41%) and not in the work force (Table 9). Almost one third of pertussis notifications were in paid employment (31%). Of the 1750 cases in paid employment, one quarter were professionals (Table 10). The next most common occupational categories among notifications were community and personal service workers, and clerical and administrative workers (both 14%).

These high incidence categories contain occupations that may be more likely to be exposed to people with pertussis – for example, teachers (8%), health professionals (6%), and carers and aides (6%) and it may be appropriate to recommend booster immunisations for these groups at the onset of an epidemic.

Table 9. Employment status by percentage of notified South Island pertussis cases, 2009-2013

Employment status (%)	District Health Board					
	Nelson Marlborough	West Coast	Canterbury	South Canterbury	Southern	South Island
In paid employment	30	32	30	38	37	31
Not in paid employment	63	57	52	52	50	56
Youth (≤16 years)	49	45	38	41	33	41
Retired	7	4	6	5	6	6
Not stated	6	11	18	10	13	13

Table 10. Occupations by percentage of notified South Island pertussis cases in paid employment, 2009-2013

Occupation % (n)	District Health Board					
	Nelson Marlborough	West Coast	Canterbury	South Canterbury	Southern	South Island
Professionals	27 (138)	19 (30)	27 (202)	17 (11)	23 (57)	25 (438)
Community & Personal Service	15 (78)	18 (29)	13 (95)	11 (7)	14 (35)	14 (244)
Clerical & Administrative	10 (53)	16 (25)	16 (122)	6 (4)	16 (40)	14 (244)
Managers	12 (60)	16 (25)	13 (98)	13 (8)	12 (29)	13 (220)
Technicians & Trades	10 (53)	11 (18)	14 (109)	11 (7)	11 (28)	12 (215)
Labourers	14 (74)	11 (17)	7 (56)	17 (11)	11 (27)	11 (185)

Neighbourhood Deprivation

The level of neighbourhood deprivation where notifications lived (NZDep2006) was available for 88.5% of notifications. South Island notification and hospitalisation rates were graphed by deprivation quintiles (Figure 14). There was a slight decrease in the notification rates for those living in neighbourhoods classified as quintiles 1 to 4 but a sharp drop for the most deprived. Although this pattern was not apparent in all DHBs, the most deprived neighbourhoods had the lowest notification rates in four of the five DHBs, the exception being West Coast. Canterbury and to a lesser extent Southern had consistent decreases in notifications from quintiles 1 to 5. As with ethnicity this may indicate a notification artefact possibly involving not just cost as a barrier to presentation. It has been shown in the UK that despite free visits to doctors, lower socio-economic groups use services less often in relation to need due to such factors as perception of illness severity, restrictions on available time limiting access to services, transportation, and communication once services are accessed.[9]

The trend for hospitalisation rates, however, was the reverse with the most deprived neighbourhoods (quintiles 4 and 5) having the highest rates. This has been reported in other New Zealand studies.[8,10] A study in Glasgow found that the risk of hospitalisation from pertussis in children living in deprived households was almost 10 times higher than in areas where households were not deprived.[11] Furthermore they found that overcrowding and unemployment were correlated with pertussis hospitalisation to a greater extent than vaccination rates.

Figure 14. South Island pertussis notification and hospitalisation rates, by neighbourhood deprivation index quintile, 2009-2013

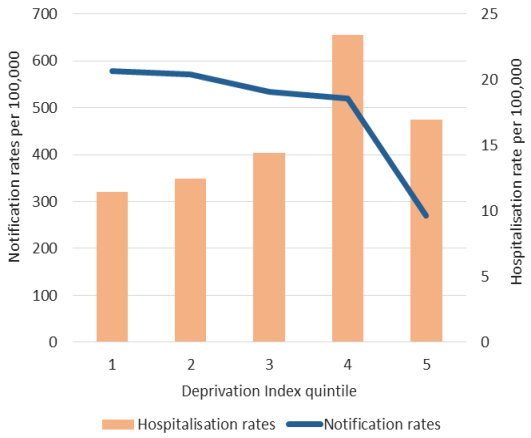
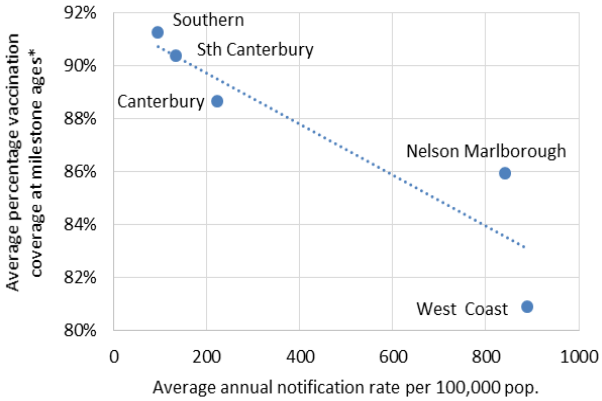


Figure 15. Inverse correlation between South Island DHB pertussis notification rates in children aged 0-9 years and vaccination coverage at milestone ages,* 2009-2013[7]



**12 months, 24 months and 5 years*

Vaccination Status

EpiSurv classifies any pertussis vaccination event as the case having been 'immunised'. For the South Island approximately 47 percent of cases had been vaccinated but for over one third of notifications the vaccination status was unknown (Table 11). The highest level of unknowns was in Canterbury (51.6%) and the lowest in Southern (19%). In 78 percent of cases reported to be vaccinated the number of doses they had received was unknown. Given that the average vaccination coverage (at 12 months, 24 months and 5 years) in the five DHBs was 81%-91%[12] many of the unknowns were probably vaccinated. There was an inverse association between vaccination coverage and notification rates for children 0-9 years (Figure 15). This finding is supported by the observation that small differences in coverage above 85% can result in large differences in pertussis prevalence.[13]

Table 11. Vaccination status of South Island pertussis notifications, 2009-2013

District Health Board	Pertussis immunisation status		
	Immunised (%)	Not immunised (%)	Unknown (%)
Nelson Marlborough	62	13	26
West Coast	50	15	36
Canterbury	34	14	52
South Canterbury	64	9	28
Southern	53	28	19
All South Island DHBs	47	15	38

Urban-Rural Location

There was no urban-rural analysis of notification rates apart from Table 17 because of the unavailability of that specific data from the 2013 Census (see Methods).

Outbreaks and Epidemics (1997-2013)

Outbreaks

Pertussis causes localised outbreaks and widespread epidemics. Household clusters however, are not recognised as outbreaks in EpiSurv.[14] In contrast to food poisoning outbreaks where the public health strategy is to identify risk exposures, find the source by epidemiologic and laboratory investigations, and prevent spread by remedial measures, cases and clusters of pertussis are followed up to identify contacts but usually not investigated further. Public health intervention, whether one or several related pertussis cases are notified, consists of advice about isolation, chemoprophylaxis, immunisation and education.

These differences meant that localised outbreaks in Canterbury, West Coast and South Canterbury were usually either not identified or not specifically coded in EpiSurv. This probably applied to Nelson Marlborough also as no outbreaks were coded there at all for 2009-2013. Analysis of outbreaks and clusters was therefore limited to:

1. a brief description of South Island outbreaks from 1997-2013 that were coded in EpiSurv, and
2. identifying household clusters from 1997-2013 in Canterbury, South Canterbury and West Coast.

An outbreak was defined as a discrete event coded as an outbreak in EpiSurv (epidemiologically linked cases) that was not a household cluster. However, without addresses for the Nelson Marlborough and Southern data, it was not possible to confirm that no household clusters were coded as outbreaks. Outbreaks usually involved members of families but three outbreaks were associated with either a preschool or school (Table 12).

A household cluster was defined as two or more cases with matching addresses that were temporally associated. The majority of household clusters had only two cases but accounted for 17 percent of cases in Canterbury, South Canterbury and West Coast (Table 13). Household clusters had a lower average number of cases (2.1) compared with outbreaks (4.7).

Table 12. Pertussis outbreaks coded in EpiSurv, 1997-2013

District Health Board	Number of coded outbreaks	Range of cases per outbreak	Total number of cases	Average number of cases per coded outbreak
Nelson Marlborough	0	-	0	-
West Coast	18	2-16	87	4.8
Canterbury	4	2-17	28	7.0
South Canterbury	0	-	0	-
Southern	15	3-6	58	3.9
All South Island DHBs	37	2-17	173	4.7

Table 13. Household clusters of pertussis in Canterbury, West Coast and South Canterbury DHBs (combined), 1997-2013

	All household clusters
Number of clusters	688
Number of cases	1424
Range of cases	2-6
Average number of cases	2.1
Median number of cases	2.0

Major Epidemics

Pertussis epidemics occur every 2-5 years as a result of immunity from immunisation waning after 4-12 years and 4-20 years following infection.[15] Three major epidemics occurred nationally between 1999 and 2013 and the notifications from 1997-2013 were reviewed to assess the extent of the epidemics in the South Island over that time (Figures 16 and 17).

Three major epidemics peaked in 2000, 2004-5, and 2011-12. Canterbury as expected on a population basis, had the most cases in every epidemic although in 2004, when the epidemic peaked in Southern, it recorded the most cases for that year. West Coast and Nelson Marlborough had the highest epidemic rates.

For the purpose of identifying the extent of the epidemics in each DHB, the onset of an epidemic was defined as the first of at least three consecutive months with an annualised notification rate of greater than or equal to 40 per 100,000 population (this was approximately two standard deviations above the mean for inter-epidemic months). The end of an epidemic was defined as the first of three consecutive months with fewer than 40 cases per 100,000 population per year. Between 1997 and 2013 in the South Island DHBs, on average 46 percent of months had epidemic levels of notifications (range 38-54%) (Table 14). The average duration of the most recent epidemic was 28.6 months (range 19-32 months) (Table 15).

Figure 16. Annual pertussis notifications in the South Island DHBs, 1997-2013

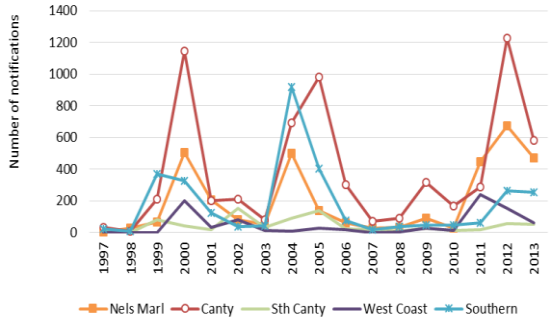


Figure 17. Annual rates of pertussis notifications in the South Island DHBS, 1997-2013

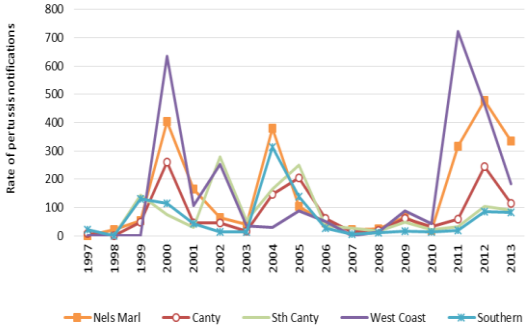


Table 14. Percentage of months with epidemic levels* of notifications by South Island DHB, 1997-2013

	District Health Board				
	Nelson Marlborough	West Coast	Canterbury	South Canterbury	Southern
Percentage of epidemic months (%)	54	40	50	46	38

** Annualised monthly notification rate of ≥ 40 per 100,000 population*

Table 15. The number of months with epidemic levels* of notifications by South Island DHB for the 2011-2013 epidemic

	District Health Board				
	Nelson Marlborough	West Coast	Canterbury	South Canterbury	Southern
Duration of epidemic (months)	31	31	32	30	19

** Annualised monthly notification rate of ≥ 40 per 100,000 population*

Table 16. Proportion of the population in each DHB affected by the major 2011-2013 epidemic

District Health Board	Notifications	Percentage (%)
Nelson Marlborough	1588	1.2
West Coast	447	1.4
Canterbury	2094	0.4
South Canterbury	102	0.2
Southern	510	0.2
All South Island DHBs	4741	0.5

Minor Epidemics

Figures 16 and 17 show that from 1997 to 2013 minor epidemics occurred in the years between the major epidemics in all DHBs except Southern. It is not known why Southern was an exception although their relatively high immunisation levels may have contributed to it (Figure 15) (see Vaccination Status).

To investigate whether there were any epidemiological differences between a minor and major epidemic, the details of notifications were analysed for the four DHBs that had minor epidemics in the peak year of 2009. Data from 2009 was compared with the peak year of 2012.

There were few notable epidemiological differences between a minor and major epidemic (Tables 17 and 18), a similar finding by Wall et al.[8] In 2012 the average age of notified cases was younger (26.3 years) compared with 2009 (32.3 years) a finding consistent with the decrease in the percent of notifications aged 30 years and over previously noted (Figure 8). In particular, the percentage of notifications in children aged 0-9 years increased from 22 percent to 35 percent and was apparent across all ethnicities (Table 19).

Table 17. Comparison of features between the minor epidemic in 2009 and the major epidemic in 2012 in the South Island

	2009 (minor epidemic)	2012 (major epidemic)
Number of cases	464	2111
Pertussis rate	67 per 100,000 population	300 per 100,000 population
Male : Female ratio	1 : 1.4	1 : 1.3
Age (average)	32.3 years	26.3 years

Table 18. Comparison of characteristics between the minor epidemic in 2009 and the major epidemic in 2012 in the South Island

Epidemic year	Percentage of notifications aged <1 year (%)	Percentage of notifications living in an urban area (%)	Percentage of notifications living in a rural area (%)	Percentage of notifications from each TA (%)*		
				Christchurch	Timaru	Tasman
2009	4.3	79.5	13	56%	6%	5%
2012	4.8	75.1	11	44%	2%	14%

**TAs with the greatest percentage differences in notifications*

Table 19. Percentage of notifications aged 0-9 years, by ethnicity, 2009 and 2012

Epidemic year	Ethnicity (%)*				
	European	Māori	Pacific	Asian	Total
2009	20	42	0	38	22
2012	32	52	53	48	35

** Prioritised ethnicity (see Methods)*

Cocooning Strategy

The 'cocooning' strategy is intended to protect infants from pertussis by ensuring those who have close contact with them are vaccinated against pertussis.[1] Free maternal pertussis vaccination (Boostrix) was introduced in West Coast in July 2011, Canterbury and South Canterbury in April 2012, and in Nelson Marlborough, Southern and nationally in January 2013[16,17] although the level of uptake was not available for this report. South Canterbury and West Coast implemented the strategy more comprehensively than the national programme by offering vaccination to all adults living in a household with an infant aged less than one year and not just to pregnant women. Figure 18 compares the relative levels of notifications for 2009-2013 of infants aged less than 3 months with all notifications.

There was a significant overall reduction of 41.7 percent (p=0.03) in the percentage of notifications due to infants aged less than 3 months in the 12 months following the commencement of the maternal Boostrix programmes compared with the previous 12 months for the South Island (Table 20). This reduction was almost entirely due to the results in Canterbury and Southern. In Canterbury the notifications among infants decreased by one despite the total number of pertussis notifications increasing 93 percent, while in Southern, notifications among infants decreased 83 percent compared with 33 percent for all pertussis notifications. South Canterbury, West Coast and Nelson Marlborough had a total of three notifications among infants aged less than 3 months pre-programme and that increased to eight in the 12 months after the programme commenced.

Figure 18. South Island pertussis notifications among infants aged <3 months compared with all notifications 2009-2013 (3-monthly moving averages), with timing of onset of the DHBs' maternal Boostrix programmes

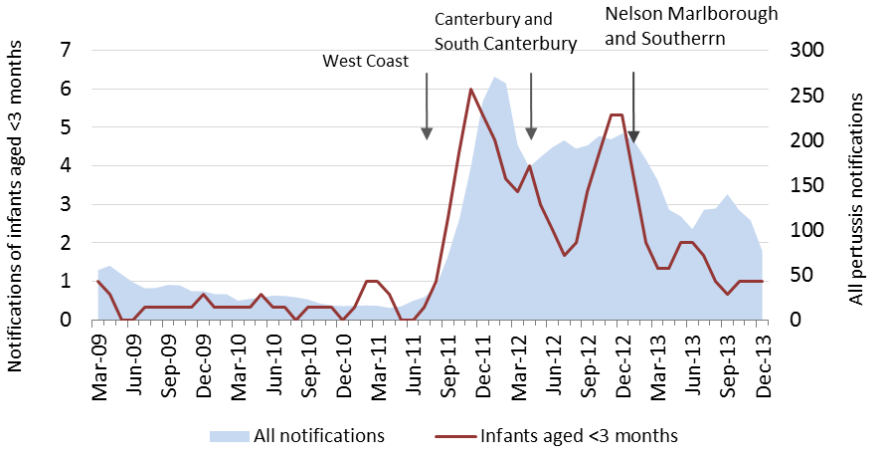


Table 20. Comparison of the percentage of pertussis notifications among infants aged less than 3 months in the 12 months post-commencement of the maternal Boostrix programme with the previous 12 months, in each DHB

District Health Board	Notifications 12 months pre-programme			Notifications 12 months post-programme				
	Aged <3 months (n)	All (n)	Percentage aged <3 months	Aged <3 months (n)	All (n)	Percentage aged <3 months	Change, post- compared with pre-programme	P value*
Nelson Marlborough	2	603	0.3%	5	457	1.1%	329.9%	0.15
West Coast	0	34	0.0%	2	313	0.6%	-	-
Canterbury	21	599	3.5%	20	1156	1.7%	49.3%	**0.03**
South Canterbury	1	33	3.0%	1	75	1.3%	44.0%	0.52
Southern	12	284	4.2%	2	220	0.9%	21.5%	**0.03**
All South Island DHBs	36	1553	2.3%	30	2221	1.4%	58.3%	**0.03**

** P value for Fisher's exact test of the difference between the 12 months pre- and post-programme*

Discussion

The epidemiology of pertussis in New Zealand has been described previously[1,8,11,18] and this report adds to the literature by reviewing South Island notification data. It also compares epidemic with non-epidemic cases, notification rates with vaccination coverage, and reviews the effect of the maternal Boostrix programme (cocooning strategy). While many of the findings parallel those of previous studies, the lower notification and hospitalisation rates for Maori compared with the rates for Maori nationally were a significant exception. The differences may have been due to better living conditions and vaccination coverage in the South Island.

The data quality was generally good apart from vaccination details which were often absent preventing certain analyses. A review of the epidemiology of pertussis in Waikato[8] also identified a lack of vaccination data and implemented new procedures subsequently to address the issue. This perhaps should be considered for South Island DHBs. Two analyses however, highlighted the impact vaccination possibly had on reducing pertussis incidence. One showed that notification rates in children 0-9 years were lowest in DHBs with the highest vaccination coverage and the other provided evidence that the maternal Boostrix programme reduced the expected number of notifications in infants most at risk because of age by 42%.

Pertussis is a major public health communicable disease issue largely because of the relative lack of effectiveness of the current vaccine in preventing disease and transmission particularly during the recurring epidemics. Until the vaccine is improved, it is important to promote on-time vaccination, increase coverage and uptake of booster doses by pregnant women and adults in at risk occupations, and possibly introduce a more inclusive cocooning strategy. Since 1997 pertussis incidence has been above epidemic levels for almost 50 percent of the time and vaccination should be considered a constant priority for the protection of the vulnerable, particularly infants, and not just during major epidemics.

References

1. Immunisation Handbook 2014, Pertussis, Chapter 14. Wellington: Ministry of Health. Available at: http://www.health.govt.nz/system/files/documents/publications/immunisation-handbook-may14-v4.pdf
2. EpiSurv is the national notifiable disease surveillance database operated by the Institute of Environmental Science & Research (ESR) on behalf of the Ministry of Health.
3. New Zealand: an urban/rural profile (2004), Statistics New Zealand (viewed online) http://www.stats.govt.nz/browse_for_stats/people_and _communities/ Geographic-areas/urban-rural-profile.aspx)
4. Occupation. Statistics New Zealand *[cited 15 July 2014]* available at: http://www.stats.govt.nz/methods/classifications-and-standards/classification-related-stats-standards/occupation.aspx
5. Heymann DL ed. Pertussis. In, Control of communicable diseases manual, 19th edition, American Public Health Association, 2011.
6. ESR, Notifiable and other diseases in New Zealand, Annual report, 2013. https://surv.esr.cri.nz/PDF_surveillance/AnnualRpt/AnnualSurv/2013/2013AnnualSurvRpt.pdf
7. ESR, Notifiable and other diseases in New Zealand, Annual reports, 2009 to 2013. https://surv.esr.cri.nz/surveillance/annual_surveillance.php
8. Wall R, Bell A, Theobald J. Pertussis (whooping cough) epidemiology in Waikato, New Zealand 2000-2009. NZ Med J 2011; 124(1331).
9. Dixon A, Le Grand J, Henderson J et al. Is the NHS equitable? A review of the evidence. LSE Health and Social Care Discussion Paper Number 11, The London School of Economics and Political Science, November 2003.
10. Blakely T, Mansoor O, Baker M. The 1996 pertussis epidemic in New Zealand: descriptive epidemiology. NZ Med J 1999; 112: 30-3.
11. Maclure A, Stewart GT. Admission of children to hospitals in Glasgow: relation to unemployment and other deprivation variables. Lancet 1984; 2(8404): 682-5.
12. National Immunisation Register Birth Cohort Childhood Immunisation Overview - Milestone Ages DHB, 2009, 2011 and 2013.
13. Grant C. Viewpoint: Controlling pertussis in New Zealand by improving our immunisation rate. NZ Med J 2000; 113: 228-30.
14. ESR, EpiSurv Support site, Manuals, Section C, Instructions for completing case report forms, OB-1 [revised Sep 2005].
15. Wendelboe AM, Van Rie A, Salmaso S, et al. Duration of immunity against pertussis after natural infection or vaccination. Pediatr Infect Dis J 2005; 24(5 Suppl): S58-61.
16. Hill L, South Island Immunisation Co-ordinator, personal communication.
17. Gilsenan B, West Coast Immunisation Co-ordinator, personal communication.
18. Grant C, Tan D, Pati A et al. A comparison of two pertussis epidemics in Auckland. NZ Med J 1997; 110: 182-4.