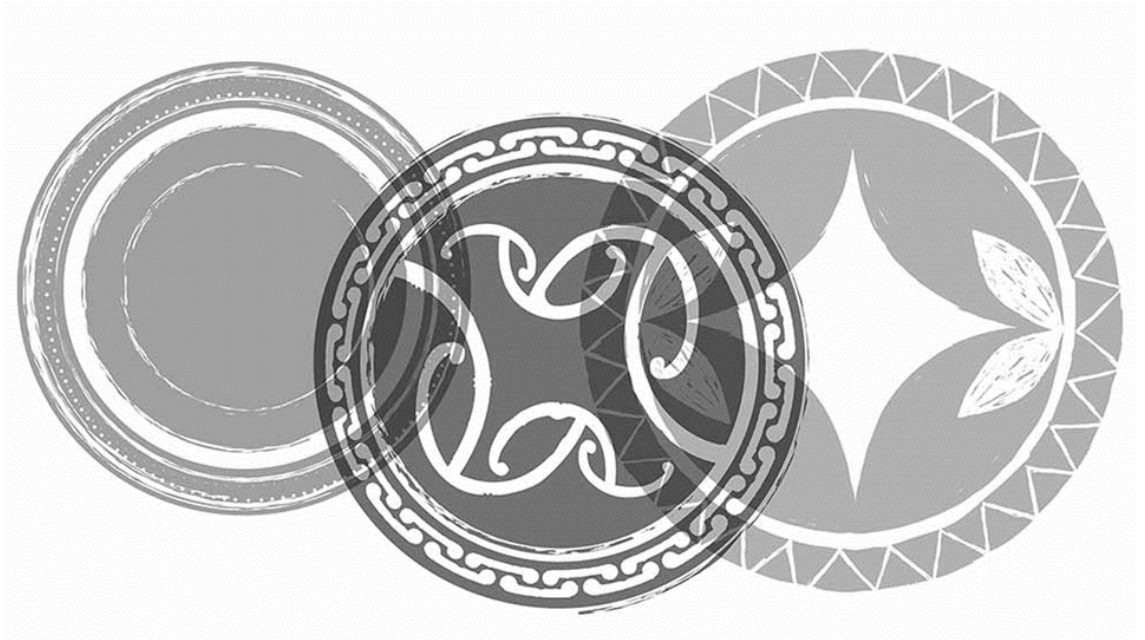


Pertussis Control Strategies 2015

A consistent approach for
New Zealand



Acknowledgements

The Ministry wishes to thank all participants for researching and critiquing international and national pertussis activities, with the view to making recommendations for the New Zealand environment.

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Contents

Acknowledgements	2
Abbreviations	iv
Introduction	1
Session 1: Pertussis disease burden and prevention strategies	2
Global epidemiology and effective international immunisation strategies	2
New Zealand pertussis epidemiology	6
New Zealand National Immunisation Schedule and pertussis strategies	8
Feedback from the World Health Organization Strategic Advisory Group of Experts on Immunisation, April 2015 meeting	10
Overview of different DHB strategies used during the epidemic	12
Session 2: Current New Zealand research	14
Factors affecting maternal vaccination	14
Pertussis vaccine safety in pregnancy	16
Audience research on attitudes and barriers to immunisation in pregnancy	17
Duration of vaccine effectiveness in New Zealand	18
Answers to the Workshop questions	21
Specific questions	21
Workshop discussions and working group summaries	22
Workshop conclusions and recommendations	23
Workshop conclusions	23
Recommendations	23
References	25
Attendees	27
Appendix: Working Group summary feedback	28
National Immunisation Schedule (Schedule): timing and doses	28
Improving vaccine coverage, timeliness and service delivery	30
Antenatal pertussis programme	31
Data, surveillance and reporting	32
Communications	34

Abbreviations

2P+1	two primary doses plus one booster dose schedule
3P+1	three primary doses plus one booster dose schedule
aP	acellular pertussis vaccine
DHB	district health board
DTaP	diphtheria-tetanus-acellular pertussis vaccine
DTwP	diphtheria-tetanus-whole cell pertussis vaccine
EPIC	Effectiveness of Pertussis Immunisation in Children Study
ESR	Institute of Environmental Science and Research
GP	general practitioner
IMAC	Immunisation Advisory Centre
NCIRS	National Centre for Immunisation Research and Surveillance (Australia)
NHI	National Health Index
NIR	National Immunisation Register
NMDS	National Minimum Dataset
NZDep	New Zealand Deprivation Index
PCR	polymerase chain reaction
PIPS	Pertussis in Pregnancy Study
PMS	Practice Management System
PTAC	Pharmacology and Therapeutics Advisory Committee
SAGE	Strategic Advisory Group of Experts on Immunization (WHO)
SBVS	school-based vaccination system
Tdap	tetanus and reduced antigen diphtheria-acellular pertussis vaccine
UK	United Kingdom
US	United States
VE	vaccine effectiveness
WHO	World Health Organization
wP	whole-cell pertussis vaccines

Introduction

Pertussis is a highly contagious bacterial respiratory disease characterised by a prolonged paroxysmal cough (whooping cough). The focus of pertussis immunisation and surveillance is to protect those most at risk from severe disease (those aged under one year).

A Pertussis Immunisation Strategy Workshop was held in July 2010 to agree on pertussis control priorities and recommendations in New Zealand for consideration by the Ministry of Health. The main recommendation was to ensure 95% of all infants in their first six months receive their scheduled vaccine doses on time. With the implementation of the immunisation health target in 2012, coverage of infants fully immunised by age eight months has increased from 83% to 93% for the three-month period ending 31 March 2015.

New Zealand experienced another major pertussis outbreak, peaking from August 2011 to December 2013 resulting in the hospitalisation of hundreds of infants aged under one year and the death of three unimmunised children, including two infants too young to be immunised.

In April 2015 the Ministry of Health held a workshop at the University of Auckland to bring together expertise and those with experience from this epidemic to discuss pertussis disease control strategies and a consistent approach for New Zealand. Gains have been made in the infant primary immunisation series, but pertussis is still a major public health issue. The Ministry of Health wanted to assess the available data and strategies with the aim of minimising the impact of future outbreaks on those most vulnerable.

The Ministry sought to answer the following questions at the workshop:

- How do we ensure that Māori, Pacific people, and people living in deprivation all have equitable access?
- How do we improve pregnancy immunisation uptake?
- Do we need to consider a cocooning strategy?
- Is the timing of the primary course correct at six weeks, three months and five months?
- Do we need an extra booster dose in the toddler years?
- Are the booster dose timings at four and eleven years appropriate?
- Are there any recommended changes for older children and adult boosters (eg. offer Tdap instead of Td in the adult schedule)?
- Is there a role for whole-cell pertussis (wP) on the New Zealand Schedule?
- Are we collecting data in the best possible way?

Key areas of focus and discussion for the workshop were: the timing of the National Immunisation Schedule vaccines, the use and delivery of maternal pertussis immunisation, improving immunisation coverage, timeliness and service delivery (in particular to reduce inequalities), evaluating data availability and pertussis-related surveillance, and assessing pertussis communication with health care professionals and the public.

The Ministry will use the recommendations from the Workshop to develop a consistent approach to pertussis control in New Zealand.

Session 1:

Pertussis disease burden and prevention strategies

Global epidemiology and effective international immunisation strategies

Peter McIntyre (NCRIS)

International trends

The burden of severe pertussis is a global issue. Young infants are the group most vulnerable to severe disease, hospitalisation and death, often before they receive primary immunisations and in families with the greatest socioeconomic deprivation. Older people are also at risk from severe disease.¹ In adolescents and adults, and for less severe disease, pertussis continues to be undiagnosed or unreported. Although reported pertussis reduced dramatically following the introduction of vaccine, the persistence of epidemic cycles strongly suggests that vaccines (both whole-cell and acellular) reduce the symptoms of infection without eliminating the circulation of *Bordetella pertussis*. The evidence for this has been added to recently by transmission data from an animal model in baboons.²

Currently, the only high-income countries without a toddler booster in their immunisation schedules are Australia, New Zealand, England and Wales. In England, during 2011/12, the rates of hospitalisation increased dramatically, reaching levels more comparable to those reported from Australia and New Zealand. This may in part reflect differences in diagnosis and coding, as reported mortality rates from pertussis in infants less than age three months have been similar in these countries over the last decade.

Despite relatively high and unchanging immunisation coverage, the number of young infant deaths from pertussis has remained relatively static over recent decades, although dramatically reduced from the pre-vaccine era. Deaths are concentrated among infants aged under two months who have received no vaccine doses. Various strategies are being evaluated worldwide to address this important residual immunity gap in high immunisation coverage countries.

The Australian experience

In the early 2000s Australia reported more pertussis cases than the US, this may have been the result of increased surveillance, compulsory reporting, and the use of serology and polymerase chain reaction (PCR) to detect pertussis infections (in 2008 reimbursement became available for PCR testing). It is unclear whether this increase was due to more cases or more cases being identified.

Waning of vaccine-acquired immunity against symptomatic pertussis appears to be more rapid among children who have received only acellular vaccine (DTaP) compared with schedules including all or some doses of whole-cell pertussis vaccine (DTwP). A 2011 study linking pertussis notifications and vaccine type recorded in a state-based register in Queensland showed that pertussis notification rates at ages 11 and 12 were 2.5 times higher in pre-adolescents who had received only DTaP, compared with those who had received only DTwP.³ Also, Australia removed a toddler booster (at age 18 months) in 2003, and during the 2009 epidemic pertussis notifications in three-year olds rose disproportionately. A national case control study demonstrated that the effectiveness of aP waned progressively from age two years, to be below 50% by four years.⁴

An important information gap for these excess toddler cases was their severity: data on this was not routinely collected, because cases were primarily notified based on positive PCR on throat swab. A study examining linked data in New South Wales from 2005 to 2008 provided some information. Using both hospitalisations and emergency department visits coded as pertussis and those linked in time to a pertussis notification, the study found that 7% of pertussis cases aged between two and five years were hospitalised and 27% attended emergency departments.⁵ Although being hospitalised with pertussis is a much lower proportion in immunised than among unimmunised or partially immunised children below age six months, it is appreciable. The immunisation status of these linked cases was unknown, but most are assumed to have received three doses.

Although ‘cocoon’ doses to the parents of young infants to protect against pertussis had been recommended in the *Australian Immunisation Handbook* since 2008, no funding was available. In 2009 an early response to the epidemic in New South Wales was to offer free boosters to close adult contacts of all infants less than 12 months old – probably the most widespread funded cocooning strategy implemented anywhere in the world. An evaluation of the strategy identified that a key risk factor for infant pertussis is large family size. After adjustment for this and a range of other confounders, it was estimated that the risk of severe pertussis was reduced by 51% when both parents were vaccinated more than four weeks prior to disease onset.⁶

However, to achieve its maximum effect, cocooning requires booster doses to all contacts, which is difficult to achieve, particularly if vaccine is not funded for extended family members. Are infected toddlers transmitting disease to their more vulnerable younger siblings? Recent Australian data on the presumptive source of transmission to young infants suggest that transmission from young siblings is more prevalent than from parents.⁷ This would mean that not just boosters for adults but toddler booster doses are likely to contribute to reduced exposure of young infants to pertussis. A toddler dose was deemed to be cost-effective and recommended for inclusion in the National Immunisation Programme by the Australian Pharmaceutical Benefits Advisory Committee in late 2014; it was announced in the May budget that the 18-month dose would be added to the funded national programme by the end of 2015.

Pertussis notifications are similar between ages 45 and 75 years, then the total number of hospitalisations increases steeply in the over-75-years age group.¹ Tdap boosters for adults at age 65 years may result in a reduction in the incidence of severe disease in this age group.

Maternal immunisation studies

Cocooning strategies are being superseded by antenatal vaccination in the third trimester of pregnancy. High levels of maternal antibodies passing transplacentally protect the infant from their birth. An observational study in the UK showed an approximately 50% reduction in pertussis cases in infants under age 13 weeks born to mothers who received Tdap during pregnancy.⁸ Maternal immunisation does not protect babies of mothers who have not been immunised during pregnancy (ie, there is no herd protection of other infants). Maternal immunisation is around 90% effective at reducing pertussis in the young infant when given in the first pregnancy, but to maintain this level of protection it is currently assumed that women require vaccination in each pregnancy. Infants of unimmunised mothers remain at risk due to transmission continuing in the general population. A UK case-control study showed that maternal vaccine effectiveness is 91–93% effective in infants aged under eight weeks; but notably during this study 10 to 20% of pertussis cases were born to immunised mothers.⁹ Evidence is emerging that there is variability in immune responses in adults to pertussis boosters, and therefore antibody levels transmitted to babies may vary, as suggested by preliminary data from studies of cord blood antibody levels in Israel.¹⁰

In the past, concerns in relation to vaccine safety have slowed uptake of maternal immunisation. More recently, a large UK cohort study shows good evidence that aP vaccines are safe to be given in pregnancy.¹¹ Safety research is ongoing in New Zealand (see below).

Neonatal vaccination

Neonatal vaccination is a potential alternative to immunising mothers during pregnancy. A pilot study conducted in Australia demonstrated significantly higher pertussis antibody levels by age two months in infants who received aP vaccine at birth and at one month, compared to controls. Levels remained higher at age six months.¹² Baboons have previously been shown to be protected against severe pertussis by either maternal or neonatal vaccine.¹³ Neonatal immunisation may be considered as a supplementary strategy for infants whose mothers were not immunised during pregnancy.

In the longer term, better pertussis vaccines are needed. New vaccines in the pipeline include a live attenuated intranasal vaccine, which has shown high efficacy against disease and transmission in mouse studies and has recently been trialled in a small phase 1 study in adults.

Summary: global epidemiology and effective international immunisation strategies

The aP vaccines are effective against severe disease, but waning of immunity is relatively rapid when the third dose is given at or under age six months, and is substantial over the next few years if no booster is given. One way to reduce the rapidity of waning may be to delay the third dose until 9 to 12 months, as two doses provide good short-term protection.

Available New Zealand-linked data could be used to investigate the effect of delayed doses. Even if a fourth dose in the second year of life is not deemed cost-effective for all children, it may be for those at higher risk of severe pertussis over the age of 12 months, such as infants with cardiorespiratory disease, especially post-prematurity.

Cocooning is imperfect, and at least some of the benefit found in the New South Wales cocooning study may actually be due to maternal antibody persisting in mothers immunised after a previous pregnancy.

Vaccination in the third trimester of pregnancy vaccination is approximately 90% effective at reducing young infant disease. In a routine immunisation context, a maternal dose could be considered the first dose of the primary series (passive immunisation to the infant) with similar aims of coverage to other infant doses.

New Zealand pertussis epidemiology

Tomasz Kiedrzyński (Ministry of Health)

Overview

In New Zealand, pertussis epidemics occur every three to five years. The peak period of the most recent outbreak was from August 2011 to December 2013. From 1 January 1998 up to 31 March 2015 EpiSurv disease notification data (including confirmed, probable, suspected cases and those still under investigation) and hospitalisation data from the National Minimum Dataset (NMDS) are closely correlated and clearly show outbreak years. Mortality data show pertussis disease fatalities of six infants between 2000 and 2011, and from 2012 to the first quarter of 2015 three pertussis deaths in unimmunised children were notified: two were aged under six weeks, and one was a three-year-old with chronic lung disease. Monthly numbers of pertussis cases from January 2012 to March 2015 show possible variability in reporting between DHBs.

The outbreak picture

In the middle of the 2012 outbreak the highest notification rates were in the youngest age groups, under-one-year olds in particular. A dip in notifications was seen in the 15–19 and 20–29 years age groups. Nearly half the cases (44%) in under-one-year-old infants were hospitalised compared with an average of 2% across all age groups. Of the cases aged over 70, 8% were hospitalised. A similar picture was seen after the peak of the 2014 outbreak. In general, Māori and Pacific infants aged under one year showed the highest proportions of hospitalisations.

National Immunisation Register (NIR) coverage and EpiSurv notification data were used to investigate vaccine coverage for the first series of three doses of pertussis-containing vaccine and incidence rates, including ethnicity and deprivation (NZDep). Coverage at age six months gradually improved from 67% in March 2011 to 78% in December 2013, and from 89% to 94% at age 12 months. Ethnicity and deprivation are both risk factor for timeliness of immunisations.

Disease burden

During the last outbreak, the Asian ethnic group had the lowest annual incidence rate in those aged under one year (226 per 100,000) and the highest immunisation coverage at age six months (88%); the New Zealand European incidence rate was 520 per 100,000 in those aged under one year, with a coverage of 81%. Pacific peoples had the highest incidence rates in under-one-year-olds (934 cases per 100,000) with a coverage rate of 73%, and Māori had the lowest coverage rate of 62%, with an incidence of 734 per 100,000 in under-one-year-olds.

Timeliness was improved during the outbreak, with coverage reaching 97% and 92% by 12 months of age in the Pacific and Māori groups, respectively. By December 2013 timeliness by ages 6 and 12 months had significantly improved for the most deprived (NZDep deciles 7–8 and NZDep deciles 9–10). DHB coverage during the outbreak varied between 60 and 84% at age six months and between 86 and 95% at age 12 months. As at December 2014, national immunisation coverage at age six months was 80%, and 94% at ages 8 and 12 months.

However, although immunisation coverage at ages 6, 8 and 12 months improved steadily and significantly in recent years, including in Pacific, Māori and the most deprived infants, and even reached 92% and over at age 12 months by December 2014, coverage at age six months in these population groups remains below 80%.

Introduction of maternal immunisation

Immunisation of pregnant women between 28 and 38 weeks' gestation was introduced in January 2013 as an epidemic control strategy because the most vulnerable infants are those too young to be immunised, and pertussis transmission from the mother is a significant risk factor. However, indications suggest that immunisation coverage in pregnancy is very low: currently coverage cannot be measured for pregnant women but it has been estimated at 13% based on eligible pertussis vaccine immunisation benefit claims for women of childbearing years (aged between 16 and 46 years).

New Zealand National Immunisation Schedule and pertussis strategies

Nikki Turner (IMAC)

Whole-cell pertussis vaccines first became available in New Zealand on request in 1945. In 1953 a combined pertussis-diphtheria vaccine became available. DTwP was introduced to the National Immunisation Schedule (the Schedule) in 1958, funded for those eligible from 1960 at ages three, four and five months. The six-week dose was introduced in 1984. Since 1996 the DTwP three-dose primary series has been offered at ages six weeks, three months and five months, with a booster at 15 months. In 2000 the pertussis-containing vaccine changed from DTwP to DTaP. Booster doses were added in 2002 and 2008 at ages 4 and 11, respectively. The booster dose at age 15 months was removed in 2006.

Currently the Schedule is focused on achieving optimal vaccine effectiveness with the current aP vaccines, but a better vaccine is needed to fully protect the most vulnerable. Current vaccines do not provide herd immunity. The wP vaccines, although more effective than the aP vaccines, are not now used in New Zealand due to their much higher reactogenicity.

There is some suggestion that hospitalisations have been declining since 2006, potentially due to improvements in vaccine coverage. Pertussis notification was introduced in 1997, and it appears that, as seen in Australia, the more cases you look for the more are found. Vaccine timeliness makes a big difference to the incidence of severe pertussis, and gains have been made in inequalities for the most deprived. According to the NIR, there is no gap in coverage at age four years between the highest and lowest NZDep indices.

The likelihood of being hospitalised is highest if the first or second primary series doses are delayed.¹⁴ Although the gap for being fully immunised has narrowed to around 2% for the most and least deprived an ethnicity gap of around 20% remains at age six months for the Māori and Pacific ethnicities. The Asian ethnicity has the best vaccine coverage and timeliness at age six months.

Service delivery: how much tighter should we go?

New Zealand is doing well in coverage and timeliness for the primary series. However, those most vulnerable to pertussis are infants under age four months, as seen from PICU hospitalisation data at Starship Hospital.¹ Tightening the timeliness of the age-five-months dose will not help protect this group. Timeliness of the earlier doses is crucial for protecting the youngest infants.

New Zealand Europeans have the highest coverage by age five years, but improvements in coverage are necessary for the age-four-years booster dose. There are currently no national coverage data available for the 11 years booster dose, as this age group is not part of the NIR birth cohort.

¹ Data courtesy of Dr Anusha Ganeshalignham, Intensivist, PICU Starship Children's Hospital.

In April 2012 Canterbury DHB offered a funded aP vaccine booster dose in pregnancy. The booster was recommended nationally in October 2012 and funded by PHARMAC from 1 January 2013 during a pertussis epidemic. However, uptake is low, and, as mentioned above, is estimated to be below 13%. PHARMAC removed the 'during epidemic' criterion on 1 August 2015.

Summary: New Zealand National Immunisation Schedule and pertussis strategies

Historically the childhood primary series was not well delivered, and although significant improvements have been made, inequities remain in terms of timeliness of delivery. Pushing harder for further improvements in timeliness is unlikely to reduce severe pertussis, as this mainly occurs in infants too young to have completed the primary course. Coverage for the age-four-years booster is not adequate (under 80%), and there is no coverage data available at age 11 years. Other strategies to prevent severe disease in young infants – such as immunisation of new mothers, health care workers and child care workers – have inconsistent or low coverage, and there is considerable variability between DHBs.

Funded boosters for pregnant women are available, but we do not know how well this is working.

There are two unanswered questions:

- How important is it to keep pushing the timeliness of delivery?
- How does maternal antibody interfere with the immune response of infants immunised at age six weeks? Interference has been shown at age eight weeks, but we do not know how much more interference there would be at six weeks or if this interference is clinically relevant.¹⁵

There are still equity gaps at six months of age, but making further gains would involve more resources and funding, bearing in mind that the most severe disease is in infants aged under four months.

Feedback from the World Health Organization Strategic Advisory Group of Experts on Immunisation, April 2015 meeting

Nikki Turner (WHO SAGE committee member)

There was a good discussion about pertussis at this Strategic Advisory Group of Experts on Immunisation (SAGE) meeting. Since October 2010 the WHO has recommended a three-dose pertussis primary series, with the first dose administered at age six weeks and subsequent doses given four to eight weeks apart. Booster doses are recommended for children aged between one and six years, preferably during the second year of life. Completion of this schedule is expected to ensure protection against pertussis for at least six years. Revised guidance in July 2014 recommended that, in countries in which fewer than five doses of pertussis-containing vaccines are used or affordable, wP vaccines should continue to be used. Countries using aP should consider an earlier booster in the second year of life (a toddler booster) in the case of resurgence of pertussis.¹⁶

Data from a systematic review of pertussis immunisation schedules, conducted by the SAGE Pertussis Subcommittee, were presented at the meeting. Globally there are 194 WHO member states, with 87 different immunisation schedules. Despite the range of schedules worldwide, they are providing a good level of control for severe pertussis, and a three-dose primary series ensures good coverage. Nine European countries follow a two-dose primary plus one booster (2P+1) schedule, as opposed to the three-dose primary plus one booster (3P+1) schedule used in other countries, including New Zealand. In the 2P+1 schedule, infants can be vaccinated at ages 6 and 14 weeks and given a booster between ages 9 and 12 months. Delivery of this Schedule can work effectively, but a delay in the second dose puts infants under age 12 months at risk.

During the pre-vaccine era deaths were predominantly in very young infants, particularly those aged under one year. However, in some countries there was a spread into the under-five-years age groups. In the UK, where coverage and timeliness are good, fewer pertussis cases have been seen since immunisation was introduced, but these cases are in young infants. In Kenya, where coverage and timeliness are poorer, fewer cases are seen but there is a wider spread of ages. This confirms that not just the schedule but coverage and timeliness are important in immunisation programmes.

Summary: analyses from the systematic reviews

The aP vaccines provide a good level of control for severe pertussis, and good individual protection is achieved in different countries using different primary schedules and formulations.

The age of initiation and length of intervals in the 3P schedules does not substantially affect immunogenicity (the quality of evidence is low to moderate).

When comparing the 3P schedule with the 2P+1 schedule:

- a systematic review found there was increased immunogenicity for 2P+1 but no evidence of increased clinical protection
- a randomised clinical trial comparing a 3P schedule with a 2P+1 schedule showed that 2P+1 provided better clinical protection from the third dose, but was unclear about a difference before the third dose – at an age of vulnerability for severe pertussis.

The overall conclusion, based on low-quality evidence, is that two versus three primary doses are likely to result in lower clinical protection and antibody titres until the third dose is given.

Modelling of schedules starting at age six weeks (to start as early as possible) concluded that if timeliness of delivery and coverage is very good, a 2P+1 schedule is effective.

However, in countries where there is the possibility of delay in the second dose, a 3P schedule would provide better protection.

Resurgence in pertussis has been observed in many countries, including New Zealand and Australia, several years after switching from wP to aP vaccines. It is unclear how this relates to the vaccines or booster doses. Direct comparison between these countries is prevented because they have different schedules and vaccine products. No serological impact was detected if booster doses were given at age 15 months versus 18 months.

Generally, pertussis vaccine is the main driver of different schedules, which focus on protecting infants from pertussis-related mortality. There is a lack of knowledge about the best schedules for diphtheria and tetanus. Evidence suggests – but this has not been proven – that a primary course of diphtheria vaccine provides long-term or life-long immunity, but it is not known how many doses of tetanus vaccine are required for lifelong protection. These vaccines will continue to be investigated by SAGE.

The SAGE committee recommended that each country:

- use its own epidemiology data to set an appropriate immunisation schedule
- continue to implement disease surveillance to monitor schedule effectiveness
- maintain the highest coverage possible.¹⁷

In New Zealand there is no compelling evidence at this stage that a 2P+1 schedule would be advantageous. The delay in the third dose may result in service delivery issues and problems for other antigen delivery, such as the Hib immunisation.

Overview of different DHB strategies used during the epidemic

During the 2011–2013 pertussis outbreak DHBs adopted different disease control strategies and improved immunisation service delivery. The strategies used by the Hawke's Bay and Nelson Marlborough DHBs are described below.

Hawke's Bay DHB

Caroline McElnay

Hawke's Bay DHB had been proactive in improving coverage for childhood immunisations prior to the pertussis outbreak. Despite 50% of babies being at higher risk from pertussis, particularly when considering the risk factors of particular ethnicities and levels of deprivation, few cases of pertussis were notified in this district. Childhood immunisation coverage in Hawke's Bay is consistently high: in the last quarter of 2014, coverage by age eight months was 96% for Māori, 100% for Pacific people and 98% for those in NZDep level 9–10 (most deprived).

The DHB uses data to enable a continuous quality improvement approach and has an agreed action plan and steering group in place. The district fosters close relationships between general practices, Māori providers and midwives, and encourages immunisation discussions across all health care providers. The DHB offers Tdap (Boostrix®) to all staff, and immunisation 'champions' provide education for and discuss immunisation with parents, child-care and health care professionals through training, advisory and outreach services. Specialist training is provided to groups such as midwives, special care baby units and paediatrics. Antenatal vaccinating clinics are run weekly to immunise pregnant women and to promote infant immunisation. Vaccinated mothers are more likely to immunise their infant on time. Overall, there is a strong awareness and lots of discussion opportunities for vaccination of children and mothers.

Nelson Marlborough DHB

Jill Sherwood

In contrast, Nelson Marlborough DHB was more reactive, as an outbreak response plan was needed to manage the increasing number of pertussis cases. Prior to the epidemic, the usual pertussis control practice was to promote immunisation in the media, update providers and ensure practice nurses were authorised vaccinators. To reduce transmission, letters were sent to the early childhood centres and schools of notified cases, and occasionally exclusion of unvaccinated children was required. Surveillance was time consuming: public health nurses followed up cases by interview, completed the case report manually which was then entered onto EpiSurv by administration staff. The medical health officer then checked the case status.

During the outbreak, additional strategies were adopted to manage the rapidly increasing number of cases. To improve disease control, reduce transmission and improve surveillance and communication, revised disease control measures were implemented. Laboratory confirmations were not performed for all cases since the burden of cost was on the DHB and laboratory confirmation was not going to alter the management of clinically confirmed cases. Public health nurses were trained to enter data onto EpiSurv, access Concerto for laboratory results and conduct systematic follow-up of notified cases to provide good quality data. Individual letters to schools were replaced by mass mail-outs to early childhood centres, Kōhunga Reos, schools and tertiary institutions as needed. Regular media updates were released and information for the

public was provided in community newspapers. Posters on vaccination and the risks adults posed to children were developed and distributed to general practice and community settings. Frontline staff were offered immunisation – this was funded for DHB staff and variably funded for staff working in general practice. At this time, vaccination was not funded for pregnant women and the DHB submitted a response to PHARMAC's proposal to make pregnant women eligible for funded pertussis immunisation. A resource pack was developed for pregnant women and sent to lead maternity carers, and media campaigns recommended maternal immunisation. Nelson Marlborough has a small Māori and low deprivation population, and the high number of cases may have been a reflection of the reporting bias and access to general practitioners. There was, however, a high level of vaccine declines and unvaccinated individuals in the Tasman region – the area where the outbreak began and with the most cases (peaking at 225 cases during December 2011). A higher proportion of children in this rural area were home-schooled compared with the national average. Those that attended school were more likely to get pertussis due to low immunisation rates. As the outbreak progressed good immunisation coverage was thought more effective than transmission strategies in controlling the epidemic. Improvements in vaccine education, coverage and timeliness were considered necessary to achieve this, and increased collaborative work within the health sector as well as cross sectorally was undertaken to this end.

Session 1: Questions and answers

Q: Since boosters in the second year of life only have an 80% efficacy, why are they being recommended?

A: The Australian study suggests there is a waning in immunity after age two years. This might be important for more vulnerable children over the age of one with comorbidities, and an 18-month

Q: Concerning the issue of hyporesponsiveness, so long as infants are not at risk, is circulating pertussis a good thing?

A: The aP vaccines are less reactive than wP, which encourages better coverage, but the number of antigens in aP is significantly fewer, so infants are primed only against those three to five antigens. Data from the US, where all adolescents were primed with aP, suggest the response to the adolescent aP booster is not very long lived because they were only primed to three antigens, resulting in less responsiveness later in life.

Session 2:

Current New Zealand research

Research projects are under way in New Zealand to consider the effectiveness of the pertussis immunisation schedule, attitudes influencing uptake and the safety of immunisation during pregnancy. Three maternal immunisation-related research projects, including the Pertussis in Pregnancy Study (PIPS) and the Effectiveness of Pertussis Immunisation in Children Study (EPIC), are described below.

Factors affecting maternal vaccination

Linda Hill (IMAC)

Although there are no specific data available for the uptake of Tdap during pregnancy, as mentioned previously, vaccine claims for eligible women aged between 16 and 46 years is approximately 13%. As part of my master's thesis¹⁸ I conducted a self-report survey during June and October 2013 in Canterbury DHB, the first DHB to offer funded maternal vaccine during late pregnancy. The survey evaluated factors affecting vaccine uptake as an extension of a larger study investigating vaccines in pregnancy.² The survey was conducted postpartum and therefore did not influence decisions on immunisations during pregnancy.

A total of 596 responses (29.8%) were received: 74% had received Tdap and 25.9% had declined. In comparison to 2011 census data, the participants were not representative of the population age groups and also under-represented the Māori population. In general, those mothers who accepted the vaccine desired to protect their baby (96%), followed health professional advice (84%), had an awareness of pertussis in the community (50%); 43% received the vaccine because it was funded. Those who did not accept the vaccine were either unaware of it (73%), had safety concerns around side-effects (68%) or were doubtful of the vaccine's effectiveness (56%).

Information encouraging immunisation was received primarily through midwives and GPs. Of those who had received discouraging information, 40% was through their GP. A similar number reported not receiving any discouraging information. Those who were not encouraged, or who were discouraged, by health providers were less likely to receive the vaccine. Of those respondents who were unaware of the vaccine, 56% said that they would have accepted it. Many of those who did not receive the vaccine had previously received it and were either told, or thought, that they did not need it again during their pregnancy.

² The Smart VIP study.

Summary: factors affecting maternal vaccination

Health care professionals' recommendations are strongly associated with vaccine uptake. These recommendations need to be clear and based on relevant, up-to-date information. Recommendations from this study are to:

- improve awareness and promote maternal vaccinations as routine, through a health target, GP education and a national campaign
- provide a funded GP visit additional to current antenatal care to offer Tdap and flu vaccines, and as an opportunity to discuss maternal and infant immunisations
- increase access to vaccine and promote key messages
- conduct further research into health professionals' attitudes and knowledge.

Pertussis vaccine safety in pregnancy

Helen Petousis-Harris (IMAC)

A major factor for encouraging more mothers to receive pertussis vaccine is the safety of the vaccine for the unborn child. Although there are no biologically plausible reasons why, or indeed any evidence that, inactivated vaccines would pose a risk, there have been few studies investigating the safety of vaccines during pregnancy. Vaccine manufacturers and developers would not enrol pregnant women in clinical trials, particularly pre-licensure. Pregnancy itself carries risks, and adverse outcomes do occur, which makes it challenging to assess vaccine safety. Globally, vaccines that are routinely recommended in pregnancy include: tetanus-diphtheria, influenza, inactivated polio, hepatitis B, hepatitis A, pneumococcal, meningococcal, and yellow fever (a live vaccine). No safety concerns have been raised by passive surveillance or clinical studies. Studies of aP vaccines in pregnancy have shown no adverse events associated with the vaccines, but the numbers in these controlled studies have generally been very small.

In New Zealand a large industry-funded study, the Pertussis in Pregnancy Study (PIPS), was initiated in 2013. There are three studies included in PIPS. Study 1 is a large, national data-linking study looking at all infants born during 2009 and 2013 and their mothers (n = 325,000), investigating multiple obstetric and birth outcomes and covering over 30,000 vaccine exposures. Results from this study are anticipated by early 2016. Data from the other two completed studies, PIPS 2 and PIPS 3 (encompassing SMART VIP), show that no serious adverse events were associated with the vaccine: of 793 pregnant women who received Tdap, 2% reported fever within 24 hours; other mild systemic events commonly associated with pregnancy, such as headache, fatigue, nausea, vomiting and myalgia/arthralgia were recorded (3.5%, 7.9%, 2.6% and 3%, respectively). Eight serious adverse events were observed during the four-week follow-up, including one infant death due to chromosomal abnormality: none of these were considered to be associated with the vaccine.¹⁹

In 2014, as mentioned previously, results from a large cohort study in the UK showed good evidence that aP vaccines are safe to be given in pregnancy. The study included over 6000 vaccinated pregnant women matched with a historical control of more than 18,000 unvaccinated pregnant women.⁸ A study conducted in California, which included 26,229 exposures out of 123,494 insured women, also found that receipt of Tdap during pregnancy was not associated with an increased risk of hypertensive disorders in pregnancy or preterm, or small-for-gestational-age births.²⁰ A systematic review by the SAGE pertussis subcommittee identified a need for surveillance, because there are currently no published reports outside the US of ongoing adverse events following immunisation (AEFI) surveillance systems that target pregnant women or offspring.

Summary: pertussis vaccine safety in pregnancy

Vaccines given to mothers do not pass to the infant – only the mother’s antibodies. There are no biologically plausible reasons why a mother or baby is placed at greater risk for vaccine-associated events, although empirical evidence of safety is currently lacking. Ongoing research supports the safety of vaccines for pregnant women and their babies, as demonstrated by the NZ PIPS studies 2 and 3.

Audience research on attitudes and barriers to immunisation in pregnancy

Sally Duckworth (Litmus Ltd)

A 2015 audience research study commissioned by the Ministry of Health investigated the barriers to immunisation in pregnancy across a range of DHBs, and ethnic and socioeconomic groups. Pregnant women, mothers with young infants and midwives were recruited.²¹ The study found that the feeling of vulnerability to and awareness of whooping cough is greatest when people have had personal experience of it or been informed about it through the media: they understand that it is serious for infants and trust the whooping cough vaccine to protect infants from infection. However, it is not generally understood that immunity weakens over time, so boosters are required for each pregnancy, and that the baby is not fully protected until they have received all primary immunisations.

Many of the women said they would immunise their infants but did not believe that you could immunise during pregnancy, or were fearful of not being able to see side-effects in their unborn baby. The newness of the campaign confused mothers, who had not been recommended vaccination during their previous pregnancies. Some mothers were fearful that the long-term impact was unknown. Throughout pregnancy women are told to be careful what they are putting in their body, and some felt uncomfortable about having a vaccine injected into them. The biggest motivation to immunise was to protect the unborn baby, particularly, for Māori and Pacific women, rather than themselves. New Zealand European (Pākehā) women were likely to wish to protect both themselves and their baby.

Midwives and other lead maternity carers are essential for imparting information: there is more trust of midwives than GPs in matters concerning pregnancy. Mothers whose midwife recommended vaccination were more likely to be immunised. Those whose midwife left the decision up to the individual were more likely to be uncertain and waver. Some midwives reported that they avoided disclosing the possibility of immunisation because they felt it was a controversial subject. Women would have preferred their lead maternity carers to vaccinate and found accessing vaccine through their GP an obstacle. Pākehā women were most likely to overcome logistical barriers.

Awareness of immunisation was lowest among Māori and Pacific women. Some women who had been pregnant previously felt that it was assumed they knew more than they did. Also, pamphlets tended to be unread by women from these ethnicities and younger women, especially as they felt overloaded with information during pregnancy. YouTube videos were viewed as alternatives to pamphlets.

Summary: attitudes and barriers to immunisation during pregnancy

The study found that to improve the uptake of antenatal vaccine, positive assurance is needed from midwives that the vaccine will protect the baby. Assurance needs to take the form of explaining that it is safe for the unborn baby when given in pregnancy specifically, not a generic message about the general safety of the vaccine. The fact that the vaccine is funded for the mother is an enabler. Significant barriers to uptake are a lack of accessible information and advice, and structural barriers to accessing services through general practice. Māori and Pacific pregnant women are particularly disadvantaged.

Duration of vaccine effectiveness in New Zealand

Sarah Radke (IMAC)

A case-control study, Effectiveness of Pertussis Immunisation in Children (EPIC), was conducted in 2015 by linking seven existing clinical and administrative data sets to evaluate the effectiveness and duration of protection provided by the National Immunisation Schedule against pertussis. The data were sourced from the National Immunisation Register (NIR), the National Minimum Dataset (NMDS), EpiSurv, school-based vaccination systems (SBVS), the National Health Index (NHI), Primary Health Organisation enrolment collection, and practice management systems (PMS).

There were two ages of interest – children aged six weeks to four years and children aged four to eight years enrolled on the NIR. Cases for children aged six weeks to four years included pertussis-related hospitalisations or pertussis notifications between 2006 and 2013. Cases for children aged four to eight years were limited to non-hospitalised pertussis notifications between 2006 and 2013. For every case, 20 controls were randomly sampled from children enrolled on the NIR and matched by age and DHB of residence. Demographic characteristics between cases and controls were compared using appropriate statistical tests. Vaccine effectiveness was calculated using multivariable conditional logistic regression and the formula $(1 - \text{Odds Ratio}) \times 100\%$. Sex, ethnicity and socioeconomic deprivation were examined as potential confounders. Various sensitivity analyses were performed to test the robustness of the study design.

For children aged six weeks to four years, significantly more reported cases were unvaccinated than matched controls (29% vs 12%, respectively; $p < 0.001$). Vaccine effectiveness increased from 41% after the first dose of the primary series, to 78% and 89% following the second and third doses, respectively, and maintained until the children's fourth birthday. Adjusting for confounders resulted in the vaccine effectiveness for the first dose dropping from 41% to 25% for the youngest infants (six weeks – two months), which was predominantly driven by differences in ethnicity between the vaccinated and the unvaccinated groups. No confounding was seen for the other ages and doses.

In children aged four to eight years, the difference in the proportions cases and controls who were immunised widened – 31% of non-hospitalised notified pertussis cases were unimmunised compared with 4% of the cohorts. Vaccine effectiveness following the primary series plus the first booster at age four years was 92% and was maintained until the children's eighth birthday. No evidence of confounding was seen.

Overall, the vaccine effectiveness following the primary series was approximately 84% (95% CI 82–86) and following the first booster dose increased slightly to 91% (95% CI 89–92). A series of sensitivity analyses did not change our primary finding that protection against pertussis disease was sustained through to children's fourth birthday following the primary series of vaccinations recommended by the National Immunisation Schedule.

In the first sensitivity analysis, the EpiSurv notification data were matched with the NMDS to examine differences between vaccine effectiveness and duration of protection for hospitalised and non-hospitalised notifications: a third of hospitalisations were not notified. The second sensitivity analysis limited cases to laboratory confirmed pertussis – approximately, half of the cases were laboratory confirmed. In the third sensitivity analysis, improved timeliness in recent birth cohorts was taken into account. The fourth sensitivity analysis reduced the wash-out period between vaccination and disease detection from 14 to seven days and again to zero days. To examine reporting behaviour of individual practices, controls were selected from the NIR and matched by general practice enrolment in addition to age and DHB of residence in the fifth sensitivity analysis. The final sensitivity analysis examined healthcare seeking behaviour by selecting controls from the matched case's general practice and randomly sampling from among children who had a non-cough visit within two weeks of the case disease date.

A strength of the EPIC study was utilising existing New Zealand health data. NHI numbers facilitated linking information across data sources at the individual level. Results could be reported separately for hospitalisations and notifications, and the validity of control sampling was verified. The electronic data linking methodology is timelier and less costly than traditional research methods that require prospective data collection. The ability to conduct a range of sensitivity analyses confirmed the robustness of the results.

A limitation of this and all observational studies is that there may be unmeasured residual confounding. The study was also limited to evaluating vaccine effectiveness in children less than age eight years because immunisation data for older children aggregated and available from a central source, such as the NIR is not yet available. Obtaining data for older children involves either waiting until 2017, when the children enrolled on the NIR age up, or extracting data from individual PMS, requiring additional funding and resources. Another limitation is that the results are not generalisable for all pertussis disease – because notifications are collected through passive surveillance, our analysis likely captures only cases at the severe end of the disease spectrum.

The New Zealand study was designed to be as similar as possible to the Australian study and the same vaccine (Infanrix-Hexa®) is used in both countries.²² The differences between the studies were in the schedules: the Australian primary series is given at ages 2, 4 and 6 months; and historically, Australia has had better vaccine coverage. As PCR testing is widespread in Australia, it is likely that milder pertussis cases were being detected and reported.

Summary: duration of vaccine effectiveness in New Zealand

The EPIC study data provides good evidence that the current National Immunisation Schedule protects against severe pertussis in infants and children. The pertussis vaccine provides moderate protection against severe disease after two doses and good protection after three doses. No evidence of waning immunity was shown following dose 3 up to age four years or following 3P+1 doses up to age seven years. Further investigations are required to investigate protection against mild disease and duration of protection in older children and adolescents, and to evaluate the effects of delays between doses 1 and 3.

Session 2: Questions, answers and observations

What is the role of the GP in antenatal care?

In Australia, hospitals have antenatal clinics (predominantly in rural areas) or mothers visit obstetricians (in cities). There is a lack of shared care and exposure of GPs to pregnant women. In New Zealand, lead maternity carers (frequently midwives) see pregnant women, and, as in Australia, there is usually not much contact with the GP during pregnancy. However, if the midwife and GP are in the same health care facility, it is possible to strengthen links.

Is a toddler booster dose needed since the data on vaccine effectiveness against severe disease is robust?

More studies are needed into coughs and mild disease. There are no data on whether the hospitalised pertussis cases are more likely to have pre-existing chronic diseases, although this information would be possible to obtain.

Answers to the Workshop questions

Specific questions

The Ministry asked the Workshop attendees to consider specific questions and the following replies were developed during the Workshop discussions.

How do we ensure that Māori, Pacific people and people living in deprivation all have equitable access?

To reduce severe disease we need to ensure excellent immunisation coverage is achieved for populations at the greatest risk from pertussis, particularly Māori, Pacific and low-income families, for whom the burden of disease is greatest. Inequity of access to information and care for these groups means that strategies need to be developed to address the inequity. Reducing the barriers to accessible information/advice and improving access to timely immunisation services must deliberately focus on Māori and Pacific infant and maternal immunisation coverage.

How do we improve pregnancy immunisation uptake?

By reviewing the evidence on maternal immunisation programmes and implementing an evidence-based, equity-focused programme with the goal of improving universal coverage.

Do we need to consider a cocooning strategy?

No. To achieve its maximum effect, cocooning requires booster doses to all contacts, which is difficult to achieve, particularly if vaccine is not funded for extended family members. Cocooning strategies are being superseded by antenatal vaccination in the third trimester of pregnancy.

Is the timing of the primary course correct at six weeks, three months and five months?

Yes. The current National Immunisation Schedule is working well to prevent severe pertussis in childhood. Even with an excellent schedule and good timeliness of delivery, there will still be high population circulation, hence the importance of a maternal immunisation strategy.

Do we need an extra booster dose in the toddler years?

No. The current National Immunisation Schedule is working well. The use of a pertussis booster in the second year of life currently appears not to be necessary in New Zealand. However, as for influenza and pneumococcal disease, a pertussis booster may benefit children at greater risk from respiratory disease, such as those with chronic disease and comorbidities. A second-year-of-life booster may protect these children from hospitalisation. Note: a toddler dose at age 18 months was deemed to be cost-effective in Australia and will be added to their national programme by the end of 2015.

Are the booster dose timings at 4 and 11 years appropriate?

Yes. The current National Immunisation Schedule is working well to prevent severe pertussis in childhood.

Are there any recommended changes for older children and adult boosters (eg, offer Tdap instead of Td in the adult schedule)?

Specific changes to the adult schedule were not discussed in depth at the Workshop. Tdap boosters for adults at age 65 years may result in a reduction in the incidence of severe disease among individuals in this age group. However, the role of pertussis-containing vaccines for prevention of pertussis in older people remains unclear. There is a significant burden of pertussis disease in older people, but the vaccine effectiveness of aP vaccine in this age group is unknown. Adult vaccination is not expected to offer any herd immunity.

Is there a role for whole-cell pertussis on the New Zealand Schedule?

No. The current National Immunisation Schedule is working well. The original reason for moving away from wP was due to its significant reactogenicity, and as this issue still remains it could affect confidence and infant uptake if it is introduced.

Are we collecting data in the best possible way?

New Zealand has many good sources available compared to other countries. A major asset is the NHI, which offers the potential to link data sets from various sources. Better use could be made of the existing data to provide a more complete picture of what is happening in New Zealand (ie, to describe pertussis epidemiology, immunity and those at greatest risk of pertussis, or severe pertussis).

Workshop discussions and working group summaries

The Workshop highlighted five key areas and related questions for further discussion. Workshop attendees were invited to discuss these areas in small groups. The five key areas were:

1. National Immunisation Schedule timing and doses
2. immunisation coverage, timeliness and service delivery
3. antenatal pertussis immunisation
4. data, surveillance and reporting
5. communications.

A summary of these working group discussions is attached in the Appendix.

Workshop conclusions and recommendations

Workshop conclusions

The major strategy for the National Immunisation Programme continues to be the protection of infants from severe pertussis disease. While the current National Immunisation Schedule is effective in preventing severe pertussis in childhood, the burden of severe disease mostly falls on infants younger than age two months, particularly those of Māori and Pacific ethnicity and those living in the most deprived areas. Individuals aged over 70 years are also at risk of hospitalisation due to pertussis.

Vaccine timeliness makes a big difference to the incidence of pertussis. There remains an equity gradient for on-time vaccination, and this means those at greatest risk of severe disease are the least well protected.

Future pertussis-related studies will help to answer the following questions:

- Do maternal antibodies interfere with the infant response to the age-six-weeks aP dose?
- What is the vaccine effectiveness of the aP vaccine in older people?
- Which group of children would benefit from a booster dose in their second year of life?

A better vaccine is needed to fully protect the most vulnerable, as current vaccines are not sufficiently effective to confer herd immunity with the current Schedule.

Recommendations

The recommendations developed by the Pertussis Control Strategies Workshop are as follows.

- The National Immunisation Schedule needs to be regularly reviewed by PHARMAC and the Ministry of Health.
- The Ministry of Health should review the evidence on maternal vaccination programmes and implement the necessary systems and processes in order to maximise their implementation and equity of coverage.
- A greater focus is needed on communication and education of the health sector and parents, to promote immunisation and improve coverage and timeliness, with a particular focus on maternal immunisation. (Refer to the working group summaries for suggested communication strategies.)
- Access to vaccines needs to be improved, particularly for pregnant women. This could involve enabling midwife vaccinators (eg, at DHB antenatal clinics, medical facilities or clinics adjacent to pharmacies) and other initiatives to improve coverage for pregnant women.
- PHARMAC should consider funding Tdap boosters at age 65 years to improve the pertussis burden among older people.

- The Tdap vaccine offered in pregnancy needs to be recorded on the NIR so that immunisation coverage in pregnant women can be monitored more accurately.
- A review of the disease notification process should be considered in order to improve completeness, accuracy and representativeness.
- Data sources need to be integrated and used more systematically to understand pertussis epidemiology, immunity and the impact on different population groups.

References

1. Liu BC, McIntyre P, Kaldor JM, et al. 2012. Pertussis in older adults: prospective study of risk factors and morbidity. *Clin Infect Dis* 55(11): 1450–6.
2. Warfel JM, Merkel TJ. 2014. The baboon model of pertussis: effective use and lessons for pertussis vaccines. *Expert Rev Vaccines* Oct; 13(10): 1241–5.
3. Sheridan SL, Ware RS, Grimwood K, et al. 2012. Number and order of whole cell pertussis vaccines in infancy and disease protection. *JAMA* 308(5): 454–61.
4. Quinn HE, Snelling TL, Macartney KK, et al. 2014. Duration of protection after first dose of acellular pertussis vaccine in infants. *Pediatrics* 133(3): e513–9.
5. McCallum LK, Liu B, McIntyre P, et al. 2014. Estimating the burden of pertussis in young children on hospitals and emergency departments: a study using linked routinely collected data. *Epidemiol Infect* 142(4): 695–705.
6. Quinn HE, Snelling TL, Habig A, et al. 2014. Parental Tdap boosters and infant pertussis: a case-control study. *Pediatrics* Oct; 134(4): 713–20.
7. Quinn HE. 2014. Pertussis control in Australia – the current state of play. *Commun Dis Intell Q Rep Sep* 38(3): E177–8.
8. Amirthalingam G, Andrews N, Campbell H, et al. 2014. Effectiveness of maternal pertussis vaccination in England: an observational study. *Lancet* 384(9953): 1521–8.
9. Dabrera G, Amirthalingam G, Andrews N, et al. 2015. A case-control study to estimate the effectiveness of maternal pertussis vaccination in protecting newborn infants in England and Wales, 2012–2013. *Clin Infect Dis* 60(3): 333–7.
10. Abu Raya B, Srugo I, Kessel A, et al. 2014. The effect of timing of maternal tetanus, diphtheria, and acellular pertussis (Tdap) immunization during pregnancy on newborn pertussis antibody levels – a prospective study. *Vaccine* 32(44): 5787–93.
11. Donegan K, King B, Bryan P. 2014. Safety of pertussis vaccination in pregnant women in UK: observational study. *BMJ* 349: g4219.
12. Wood N, McIntyre P, Marshall H, et al. 2010. Acellular pertussis vaccine at birth and one month induces antibody responses by two months of age. *Pediatr Infect Dis J* 29(3): 209–15.
13. Warfel JM, Zimmerman LI, Merkel TJ. 2014. Acellular pertussis vaccines protect against disease but fail to prevent infection and transmission in a nonhuman primate model. *Proc Natl Acad Sci* 111(2): 787–92.
14. Grant CC, Roberts M, Scragg R, et al. 2003. Delayed immunisation and risk of pertussis in infants: unmatched case-control study. *BMJ* 326(7394): 852–3.
15. Englund JA, Anderson EL, Reed GF, et al. 1995. The effect of maternal antibody on the serologic response and the incidence of adverse reactions after primary immunization with acellular and whole-cell pertussis vaccines combined with diphtheria and tetanus toxoids. *Pediatrics* 96(3 Pt 2): 580–4.
16. World Health Organization. 2014. Revised guidance on the choice of pertussis vaccines: July 2014. *Wkly Epidemiol Rec* [internet] 89(30): 337–44. Epub 25 July 2014. Available from: <http://www.who.int/wer/2013/wer8930.pdf>

17. World Health Organization. 2015. Meeting of the Strategic Advisory Group of Experts on Immunization, April 2015: conclusions and recommendations. *Weekly Epidemiology Record* 90(22): 261–80.
18. Hill L. 2015. *Factors Influencing Women's Decisions about Having the Pertussis Containing Vaccine during Pregnancy* [Masters of Health Science]. Christchurch, New Zealand: University of Otago.
19. Petousis-Harris H, Walls T, Radke S, et al. 2014. Safety of pertussis vaccine in pregnant women and their infants. Health Association of Australia, 14th Australian National Immunisation Conference, 17–19 June 2014; Melbourne, Australia.
20. Kharbanda EO, Vazquez-Benitez G, Lipkind HS, et al. 2014. Evaluation of the association of maternal pertussis vaccination with obstetric events and birth outcomes. *JAMA* 312(18): 1897–904.
21. Litmus Limited. 2015. *Immunisation for Pregnant Women: Audience research with pregnant women*. Wellington: Ministry of Health. Available from: <http://www.health.govt.nz/publication/immunisation-pregnant-women-audience-research-pregnant-women>
22. Quinn HE, Snelling TL, Macartney KK, et al. 2014. Duration of protection after first dose of acellular pertussis vaccine in infants. *Pediatrics* 133(3): e513–9.

Attendees

The Ministry of Health Workshop on Pertussis Control Strategies was attended by the following people.

Ministry of Health (Convenor)

Pat Tuohy (Chair)	Chief Advisor Child and Youth Health
Bryn Jones	Chief Advisor
Diana Murfitt	Senior Advisor – Immunisation
Rachel Webber	Senior Advisor – Immunisation
Bonnie Jones	Senior Advisor – Immunisation
Tomasz Kiedrzyński	Principal Advisor – Communicable Diseases
Ryan McLane	Senior Advisor – Communicable Diseases

National Centre for Immunisation Research & Surveillance – Australia

Peter McIntyre	Director
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PHARMAC

Nina Sawicki	Deputy Medical Director
Chris Chapman	Senior Therapeutic Group Manager

PHARMAC PTAC Immunisation Subcommittee

Gary Reynolds	General Practitioner
Stuart Dalziel	Paediatrician
Caroline McElnay	Public Health Medicine Specialist / Medical Officer of Health
Nikki Turner	IMAC Director
Tony Walls	Paediatrician / Infectious Diseases Specialist
Elizabeth Wilson	Paediatric Infectious Diseases Specialist

Immunisation Advisory Centre (IMAC) (Convenor)

Loretta Roberts	IMAC National Manager
Helen Petousis-Harris	Director of Immunisation Research and Vaccinology
Sarah Radke	Research Fellow – Epidemiologist
Mary Nowlan	Medical Writer
Theo Brandt	Communications Manager
Linda Hill	South Island Regional Immunisation Advisor

DHB attendees

Felicity Dumble	Medical Officer of Health – Waikato DHB
Bridget Lester	Project Specialist – Canterbury DHB Planning and Funding
Pip Anderson	Public Health Physician – Counties Manukau DHB

Medical Officers of Health representative

Michael Hale	Medical Officer of Health
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New Zealand College of Midwives representatives (NZCOM)

Alison Eddy	NZCOM Professional Advisor
Jo Watson	NZCOM

Institute of Environmental Science and Research (ESR)

Jill Sherwood	Public Health Physician
Aaron McLaughlin	Manager

Apologies: Rayoni Keith, Bronwen Pelvin (Ministry of Health); Emma Best, Dave Graham (DHBs); Tim Blackmore, Cameron Grant, Sean Hanna, David Murdoch, Patricia Priest, Karen Hoare (PTAC Immunisation Subcommittee); Sarah Ballard (NZCOM)

Appendix: Working Group summary feedback

National Immunisation Schedule (Schedule): timing and doses

1. The major strategy for the National Immunisation Programme is to protect infants from severe pertussis disease. Even with an excellent Schedule and good timeliness of delivery, there will still be high population circulation, hence the importance of the maternal vaccination strategy to protect very young infants.
2. Based on the results presented from the EPIC study, it appears that the current Schedule is working well, at least for more severe pertussis (hospitalised). We recommend *not changing the Schedule*, based on the current evidence: changing schedules is always challenging for parents and health care professionals.
3. The Schedule needs regular review: it was previously reviewed three-yearly, but currently it is unclear how it will be reviewed regularly. There is still some confusion and lack of clarity about the role of the Pharmacology and Therapeutics Advisory Committee (PTAC) Immunisation subcommittee with PHARMAC and the Ministry of Health. We recommend:
 - that PHARMAC and the Ministry of Health work together with the PTAC Immunisation Subcommittee to establish a regular review of the schedule
 - clarifying the role of the Subcommittee and its place as a technical advisory group to the Ministry of Health.
4. If wP-containing vaccines were used in a schedule, they would need to be used for the primary course and could not be used as boosters after a primary course of aP. The group recommended not considering wP vaccines on the Schedule because the current Schedule is working well (refer to the vaccine effectiveness results from the EPIC study). The original reason for moving away from wP was the significant reactogenicity of these vaccines, and because these issues still remain it could affect confidence and uptake of the infant schedule.
5. Maternal antibodies do interfere with wP responses in infants. There is still an unanswered question as to whether maternal antibody could interfere with the infant response to the age-six-weeks dose of aP vaccine. The UK data suggest this is not a big problem overall, but the question is still there, particularly with the New Zealand 3+1 (at four years of age) schedule.
6. The role of pertussis-containing vaccines for the prevention of pertussis in older people remains unclear. There is a significant burden of pertussis disease in older people, but the vaccine effectiveness of aP vaccine in this age group is unknown. There is currently only one small study published. There may be more data from Australia, which is planning on looking at the vaccine effectiveness in their older people who received the vaccine, based on their cocooning strategy.

7. There is likely to be a group of infants that are at higher risk than others from pertussis or from having more severe pertussis in their second year of life. Can we identify this group, and if we can, should we offer a booster dose in the second year of life to this group? Further research is needed here to identify this group. They may be the same, or similar, high-risk group as those who are at higher risk from pneumococcal disease and influenza.
8. The current health care worker recommendation is for 10-yearly boosters, but it is likely such workers can catch and transmit disease earlier than every 10 years. How frequently a repeat vaccination should be offered is unclear. There are data on baboons suggesting that: transmission can occur fairly early after a vaccination, wP is probably more effective than aP, and the only immunity is having pertussis disease. There is also significant individual variability. As a result, the data are still unclear. There is no clear, consistent, national funding for health care workers, and there should be.
9. Australian data are reporting that 70–80% of pertussis strains now in circulation are pertactin negative. However, US data and early Australian data suggest that this does not appear to be affecting vaccine effectiveness.
10. If the main purpose of the influenza vaccine is to protect infants, and there is less concern about severe influenza with pregnant women (except for pandemic influenza), then it may be a better strategy to offer influenza vaccine with the Tdap vaccine at 28–32 weeks' gestation. This is likely to have higher uptake. If a pregnant woman also has an underlying health condition making her at higher risk from influenza (refer to the influenza vaccine eligibility criteria), then she could be offered an extra influenza vaccine at the start of the influenza season.
11. There was discussion on whether there is any gain in adding aP to the Td as wound management. It was felt that because this is unlikely to reduce community circulation of pertussis, the only reason for this would be for individual protection.
12. The role of the adolescent dose can be summarised as follows.
 - a. It does reduce disease in adolescents.
 - b. It is probably useful in large families for reducing transmission to infants.
 - c. There are reasons for continuing this booster dose, but they are not strong.
 - d. It would be sensible programmatically to combine this dose with the delivery of the first human papillomavirus (HPV) vaccine.

Improving vaccine coverage, timeliness and service delivery

Antenatal coverage

Following is a selection of issues and suggestions for improvement.

- Current coverage based on claims data is estimated to be about 13 to 15 percent. This is inadequate.
- The initial stage should be to target areas where there is a higher risk and/or slower uptake of the infant primary course.
- Increase awareness and education within community and health professionals.
- Perception of safety is an issue and we need to develop more trust: monitor social media threads and respond to the 'gossip' and questions through YouTube and our websites.
- We need to get these vaccines on the NIR.
- Claims data might be useful in the short term, but there are differences between the accuracy of GP and DHB data.
- Lack of contact with GP in pregnancy may be a factor – provide a funded antenatal visit?
- Work off existing relationships – investigate midwives and pharmacy options.
- Supply stickers to midwives for notes.
- Add something in the *Your Pregnancy* book.

So far we have taken an appropriately cautious approach, but data on the safety and effectiveness of pertussis vaccine in pregnancy are becoming available in New Zealand. We have come from an emergency response and now we need to look at routine scheduling.

Infant immunisation

- The current schedule (3P+1) appears to be providing the correct number of doses.
- The timeliness of the second dose may be an important factor in protection, and awareness of its importance needs to be raised.
- Declines: IMAC is providing information and training on managing declines and how to have 'courageous conversations'.

Implementation

- Suggest piloting education to a specific region to test acceptability and operational issues.
- Get the right messages and respond to 'gossip' more visually (eg, through Facebook, videos, YouTube).
- Look at supporting practices to open later, or at weekends, for immunisation.
- Look at nurse claiming needs and funded practice nurse visits.
- Improve NIR coverage so that all immunisations are recorded for the whole of life. For the NIR to work best it needs to be accessible to all vaccine providers.

Antenatal pertussis programme

The working group made the recommendation that:

The Ministry of Health review the evidence on maternal vaccination programmes and implement the necessary systems and processes in order to maximise their implementation and equity of coverage.

Underpinning this review is the requirement for a decision to be made by PHARMAC regarding an ongoing recommendation for routine pertussis vaccination of pregnant women, and ongoing funding for this. This requires a review of the evidence relating to the cost-effectiveness of the programme and the experience in other countries regarding what is possible by way of coverage, and possibly consideration of a birth dose.

Other comments made during the group discussions mostly related to ideas or issues that need to be considered when designing such a programme, including:

- using a systems approach and ensuring integration and coordination of those systems
- funding streams to claim the immunisation benefit
- midwives vaccinating – clarify if this is covered by Section 88, or if midwives are eligible to claim an immunisation benefit
- cold chain management by lead maternity carers if vaccinating
- funded education and training for all health professionals involved in advocating for or delivering pertussis vaccination in pregnancy (eg, midwives, students, GPs)
- messaging systems between primary care and midwives
- focus on the three key messages for women as presented at the Workshop – use health education approaches that do not involve the use of pamphlets, and look at text messaging, YouTube clips, etc
- explore laboratory staff vaccinating – when pregnant women present for blood tests there may be the opportunity for vaccination
- consider opportunistic vaccination during ultrasound screening
- improve data collection on who is getting vaccinated – use the NIR and provide access for all vaccinators, and analyse data to ensure equity according to disease burden
- review the maternity services documentation as used by midwives to include prompts for pertussis and influenza vaccinations
- apparently GPs are seeing approximately 70% of pregnant women during the first trimester (quoted from claims data) – encourage those GPs/practices to recall women for pertussis vaccination, and link with midwifery data systems
- consider incentive schemes for women, to encourage vaccination
- consider funding a visit to the practice nurse during pregnancy – specifically for immunisation, but it is also an opportunity to discuss infant immunisations and engage with the practice
- provide support and encouragement for GPs for first-trimester consultation – set out expectation of what should be covered and what information is given to women, which would include vaccinations as well as looking after yourself, and discussion and prescriptions for folic acid or iodine.

Data, surveillance and reporting

General

Overall, the opinion of the group was that we should make better use of the existing data to have a more complete picture of what is happening in the population. New Zealand has many good data sources available compared to other countries, a major asset being the unique NHI identification, which offers great potential to link data sets from various sources and allows more accurate and meaningful analyses. This was also mentioned during some of the presentations earlier in the workshop.

The group discussions focused on the key existing data available, their more effective use, and the types of improvements required. Note: it is expected that the NIR will include the capacity to monitor pertussis immunisations in pregnancy this year, so this was not further discussed.

Notification data on EpiSurv

Pertussis notifications are expected to be carried out on suspicion by GPs and hospitals, and for laboratory positive cases by laboratories: it is a passive surveillance system. The purpose is to have a description of disease occurrence in the community and to evaluate the immunisation programme so that appropriate public health actions (including decisions) are carried out.

The main issues with notification are the representativeness (eg, public health units may have differing surveillance practices), completeness (missing data), accuracy (errors in data reported) and scope (some data that should be collected but are not) of the data. Completeness and accuracy are addressed in general by ESR processes, but some issues remain (eg, with timeliness and a lack of initiative to improve in this area). However, it was emphasised that the information on cases under age one year – the key targets for the pertussis immunisation programme – is expected to give a reasonably accurate picture of what happens in this age group.

It was also highlighted that the notification process should be made easier whenever possible – for GPs in particular.

NIR data

The main purpose of these data is to know the immunisation status of individuals and measure immunisation coverage for different population groups in order to take appropriate action when required. There are a number of problems with the NIR, including system accessibility (eg, no data on immunisations carried out outside the GP environment), the limited scope of the data, and a general lack of flexibility of the system. (Other working groups have also identified similar issues with the NIR.) NIR data may be complemented by data from GP claims for funded immunisations whenever possible and necessary.

PMS

It was highlighted that at the GP level, PMS may provide better interfaces with the existing data collection systems.

Hospitalisation data from the NMDS

Normally, hospitalisations for pertussis are expected to be notified. Not being subject to a notification bias, hospitalisations data from NMDS may provide better representativeness for the more severe (therefore hospitalised cases), and will usually have good completeness and reasonable accuracy, though hospitalisations have a limited data scope with regard to disease-specific information. This could, therefore, complement notification data for these cases. It was also highlighted that there may be a gap with regard to emergency department data, although emergency department pertussis cases are also supposed to be notified.

Laboratory data

Only positive cases are reported through direct laboratory notifications, and not all cases are tested, especially during outbreaks. Reporting of requests for pertussis testing could be useful if notifications were not carried out by GPs, but GPs (and clinicians in general) are still considered to be central to the notification process, and should be encouraged and supported to continue to be so. It would also lead to under-reporting if not all cases were tested.

Mortality data

Deaths are expected to be notified and reported through EpiSurv. The official mortality data are useful, but they suffer from a three-year delay owing to the validation requirements.

Recommendations

The following recommendations were made by the group.

- More systematic use of these data sources should be carried out to describe pertussis epidemiology, immunity and vulnerability in the different population groups (eg, through better data availability and with systematic reports), which would in turn help to achieve data completeness and accuracy and could overcome some representativeness issues. This should include better accessibility to raw NIR data in particular.
- There should be better integration of the above data (through the NHI) and the information provided from them. Systematic use of data should also improve data integration.
- Issues with completeness, accuracy and representativeness should be specifically addressed (eg, PMS to support timely notifications on suspicion, higher awareness and training of public health unit staff for data completeness and accuracy, notifications to be complemented by hospitalisation data, better flexibility and accessibility of NIR).
- The scope of the data (EpiSurv and NIR) should continue to be improved. This is an ongoing process carried out by ESR and the Ministry of Health.
- Some funding is required to implement the above activities.

The quality and meaningfulness of ethnicity information in general – in particular prioritised ethnicity – was also raised.

Communications

The audiences for communications were divided into two broad groups: health care professionals and pregnant women.

- Health care professionals included GPs, midwives, other lead maternity carers, mother-pēpe providers, practice nurses, antenatal educators, pharmacists and student health care providers.
- Pregnant women included those in the New Zealand European, Māori and Pacific ethnic groups, first-time mothers, and those with older children.

Each group needs different messages and tools.

- Health care professionals need detailed information supporting the safety and efficacy of pregnancy immunisation, and systems to bridge the gap between pregnancy care and general practice, where immunisation is usually provided. One suggestion was to set up a recall message when pregnant women first present at general practice, for immunisation at 28 weeks. Another was to include pregnancy immunisation within the published National Immunisation Schedule card in order to normalise it.
- Pregnant women need information to alert them to the recommendation that they can be immunised, and address any safety concerns they may have. This might include a poster, information in a Bounty pack, a video, content in *Your Pregnancy*, or emails to pregnancy lists. Women with large families may not be aware from earlier pregnancies of the current recommendations, and health care professionals may assume they have high level of awareness. First-time mothers may need lots of information from midwives, who have a limited amount of time to deliver it.

Inequality of access to information and care needs to be assumed, and strategies need to be developed to address this. Personal stories are a vivid way of communicating the importance of immunisation during pregnancy. An important message that resonated with pregnant women was that the vaccine doesn't cross the placenta to the baby, but the mother's protective antibodies do.