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Exploring the barriers and facilitators to implementation of maternal pertussis vaccination in Victoria, Australia

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Abstract

In response to ongoing pertussis epidemics, and infant deaths, a national recommendation for pertussis vaccination during pregnancy (maternal pertussis vaccination) was made in Australia in March 2015. However, based on coverage of maternal pertussis vaccination overseas and also of maternal influenza vaccination in Australia, there were concerns that coverage would be suboptimal. A national study of coverage shortly after the recommendation in 2015 suggested coverage of 46% with significant variation (27–63%) between states and territories.[1] The aim of this thesis was to understand the barriers to and facilitators of uptake of pertussis vaccination to inform implementation policy, with the ultimate goal of increasing coverage of maternal pertussis vaccination in Australia.

Chapter 1 reviews the literature including the factors associated with coverage of maternal vaccines in Australia and internationally. These are categorised into consumer-, healthcare provider- or systems-related.

The studies presented in Chapter 2 and Chapter 3 explore the consumer-related factors through three surveys of pregnant or post-partum women. They confirmed suboptimal coverage and highlighted (i) the health benefit messaging about maternal pertussis vaccination has not been as successfully conveyed to women from migrant and refugee backgrounds and Aboriginal women; (ii) the crucial role of healthcare providers as educators; and (iii) the significance women place on healthcare provider recommendation in their vaccine decision-making.

Chapters 4 and 5 present two surveys evaluating the healthcare provider–related factors associated with uptake. The national survey of maternity care providers presented in Chapter 4 demonstrated that while the majority of providers recommended pertussis vaccination in accordance with guidelines, a lack of knowledge of the guidelines, concerns about vaccine safety, and lack of confidence in their own knowledge about vaccination were barriers to recommendation. This study also highlighted that providing vaccination within routine pregnancy care would require an attitudinal shift by obstetricians and midwives to seeing themselves as

immunisers, supported by investment in the necessary vaccination infrastructure. The survey of pharmacists presented in Chapter 5 demonstrated a disparity in pharmacists' attitudes towards and provision of vaccination to pregnant women compared to other adults. With immunisation only recently added to their remit, pharmacists voiced a desire for further education and training.

Finally, with evidence that embedding vaccination within maternity services increases uptake, the study in Chapter 6 evaluated different models for delivering immunisation to pregnant women. A standing order for midwives to administer pertussis vaccination within maternity care clinics was compared with two other models – an onsite nurse-led immunisation service, and delivery by primary care. While coverage increased at all three sites, the most significant change (from 31% to 91%) was seen with implementation of a standing order, demonstrating the feasibility and effectiveness of this model.

In summary, this thesis identifies several barriers but more importantly strategies that could be implemented at the consumer, healthcare provider and systems levels to increase the suboptimal coverage of maternal pertussis vaccination in Australia. These findings could be used to inform future maternal vaccination implementation policy both in Australia and overseas.

Publications

The following peer-reviewed journal articles and research reports were published or submitted during PhD candidature.

PUBLICATIONS DURING ENROLMENT INCLUDED IN THESIS

Krishnaswamy S, Cheng AC, Wallace EM, Buttery J, Giles ML. Understanding the barriers to uptake of antenatal vaccination by women from culturally and linguistically diverse backgrounds: A cross-sectional study. *Human Vaccines & Immunotherapeutics*, 2018;14(7):1591–98.

Krishnaswamy S, Thalpawila S, Halliday M, Wallace EM, Buttery J, Giles ML. Uptake of maternal vaccinations by Indigenous women in Central Australia. *Australian and New Zealand Journal of Public Health,* 2018 42(3):321.

Krishnaswamy S, Wallace EM, Cheng AC, Buttery J, Giles ML. Protecting newborns from pertussis: The role of partner vaccination in the era of maternal immunization. *European Journal of Obstetrics, Gynecology and Reproductive Biology,* 2017 216:159–163.

Krishnaswamy S, Wallace EM, Buttery J, Giles ML. A study comparing the practice of Australian maternity care providers in relation to maternal immunisation. *Australian and New Zealand Journal of Obstetrics and Gynaecology*, submitted March 2018.

Krishnaswamy S, Suen B, Wallace EM, Buttery J, Giles ML. A survey of pharmacists' attitudes and practices regarding pharmacist-administered vaccination in Australia. *Journal of Pharmacy Practice and Research*, submitted June 2018.

Krishnaswamy S, Wallace EM, Buttery J, Giles ML. Strategies to implement maternal vaccination: A comparison between standing orders for midwife delivery, a hospital based maternal immunisation service and primary care. *Vaccine,* 2018 36(13):1796–1800.

PUBLICATIONS DURING ENROLMENT NOT INCLUDED IN THESIS*

Krishnaswamy S, Wallace EM, Buttery J, Giles ML. Antenatal pertussis vaccination: Are we implementing best evidence into practice? *Australian and New Zealand Journal of Obstetrics and Gynaecology,* 2016 56(6):552–555.

Naidu MA, **Krishnaswamy S,** Wallace EM, Giles ML. Pregnant women's attitudes toward antenatal pertussis vaccination. *Australian and New Zealand Journal of Obstetrics and Gynaecology,* 2017 57(2):235.

Giles ML, **Krishnaswamy S**, Wallace EM. Maternal Immunisation: What have been the gains? Where are the gaps? What does the future hold? *F1000 Faculty Reviews*, submitted June 2018.

*These papers are included as appendices.

Thesis including published works declaration

I hereby declare that this thesis contains no material which has been accepted for the award of any other degree or diploma at any university or equivalent institution and that, to the best of my knowledge and belief, this thesis contains no material previously published or written by another person, except where due reference is made in the text of the thesis.

This thesis includes four original papers published in peer-reviewed journals and two submitted publications. The core theme of the thesis is the barriers and facilitators to implementation of maternal pertussis vaccination in Australia. The ideas, development and writing up of all the papers in the thesis were the principal responsibility of myself, the student, working within the Department of Obstetrics and Gynaecology under the supervision of Associate Professor Michelle Giles.

The inclusion of co-authors reflects the fact that the work came from active collaboration between researchers and acknowledges input into team-based research.

I have not renumbered sections of submitted or published papers in order to generate a consistent presentation within the thesis.

In the case of chapters 2 through 6 my contributions to the work involved are shown in the table on the following page.

The undersigned hereby certify that the above declaration correctly reflects the nature and extent of the student's and co-authors' contributions to this work. In instances where I am not the responsible author I have consulted with the responsible author to agree on the respective contributions of the authors.

Student's signature: [redacted] **Date:** 9.7.18

Main supervisor's signature: [redacted] **Date:** 9.7.18

Authorship contributions

Thesis chapter	Publication	Status	Nature and % of student contribution	Co-author name(s); nature and % of co-author contribution	Co-author is Monash student
2	Understanding the barriers to uptake of antenatal vaccination by women from culturally and linguistically diverse backgrounds: A cross-sectional study	Published	70%. Concept, survey design, data collection, analysis, preparation of manuscript	Cheng AC 5% Wallace EM 5% Buttery J 5% Giles ML 15%	No No No No
2	Uptake of maternal vaccinations by Indigenous women in Central Australia	Published	75%. Concept, survey design, data analysis, preparation of manuscript	Thalpawila S 5% Halliday M 2.5% Wallace EM 2.5% Buttery J 2.5% Giles ML 12.5%	No No No No No
3	Protecting newborns from pertussis: The role of partner vaccination in the era of maternal immunization	Published	70%. Concept, survey design, data collection, data analysis, preparation of manuscript	Wallace EM 5% Cheng AC 5% Buttery J 5% Giles ML 15%	No No No No
4	A study comparing the practice of Australian maternity care providers in relation to maternal immunisation	Revisions under review	70%. Concept, survey design, data collection, data analysis, preparation of manuscript	Wallace EM 5% Buttery J 5% Giles, ML 20%	No No No
5	A survey of pharmacists' attitudes and practices regarding pharmacist-administered vaccination in Australia	Submitted	60%. Concept, survey design, data collection, data analysis, preparation of manuscript	Suen B 10% Wallace 5% Buttery J 5% Giles ML 20%	No No No No
6	Strategies to implement maternal vaccination: A comparison between standing orders for midwife delivery, a hospital based maternal immunisation service and primary care	Published	70%. Concept, data collection, data analysis, preparation of manuscript	Wallace EM 5% Buttery J 5% Giles ML 20%	No No No

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Contents

Definitions

Coverage: proportion of target population who received vaccination in the designated period (in this context the target population is pregnant women, partners of pregnant women or other household or family contacts)

Uptake: the taking up of vaccine by an individual (in this context pregnant women, partners of pregnant women or other household or family contacts)

Chapter 1: Introduction and literature review

1.1 Background

Despite more than 90% of children in Australia receiving the primary series of childhood vaccinations for pertussis, there has been a resurgence of pertussis notifications in the last decade.[2-4] A similar trend has been observed in many high income countries and has been attributed to increased testing, more sensitive diagnostic methods, changes to the childhood immunisation schedule with removal of booster doses, and more rapid waning of immunity following the programmatic change from vaccination with whole cell to acellular pertussis vaccine.[5,6] In Australia, the primary series of childhood pertussis vaccinations are at six to eight weeks, four months and six months of age.[7] Infants less than six months of age are more likely to be hospitalised and suffer higher morbidity and mortality from pertussis infection as they have not acquired full immunity from this primary series of childhood vaccinations.[8,9] In this age group, as many as two-thirds of infected infants may require hospitalisation and nearly one in 100 die.[5,7]

Immunising women against pertussis during pregnancy (maternal pertussis vaccination) boosts levels of maternal pertussis-specific IgG antibodies which can then be transferred across the placenta to the foetus. These maternally-derived antibodies provide the infant with short-term passive immunity from birth until they develop active immunity in response to their primary vaccination series.[10] If children do not receive a primary series of childhood vaccinations, they are unable to replace maternally-derived antibodies as they wane, leaving the child at risk of severe pertussis infection. Maternal immunisation also affords protection to the infant through transfer of IgA antibodies in breastmilk.[11,12] Although the highest levels of IgA to pertussis toxin have been reported in colostrum, pertussis-specific IgA has been detected for up to eight weeks in breast milk.[11]

In response to large and sustained pertussis epidemics and several deaths in very young infants, many countries have introduced maternal pertussis vaccination programs since 2011.[13-20] The United Kingdom (UK) and Argentina rapidly achieved

coverage of 60% and 67% within the first year.[21,22] But while such population level data is crucial, several studies, such as that by McAuslane et al., have highlighted the variability amongst different populations, with coverage ranging between 31% and 79% in their study in the UK.[23] Likewise, in the United States (US), New Zealand and Ireland, reported coverage has varied significantly from as low as 6% up to 82%.[24-31]

In Australia, maternal pertussis vaccination has been recommended since March 2015.[7] At this time, maternal influenza vaccine had been recommended in Australia for five years but coverage in most studies was only 40–50%.[32-34] While coverage data was not available immediately for pertussis, a national study soon suggested coverage of approximately 46% with variation between 27% and 63% between states and territories.[1]

Preventing pertussis-associated morbidity and mortality, particularly in infants less than three to six months of age is an important public health objective in Australia.[7] With maternal pertussis vaccination demonstrated to be the most effective strategy to achieve this, suboptimal and inconsistent uptake by pregnant women needs to be better understood.[9] This thesis attempts to both identify the factors contributing to low uptake and suggest strategies to address these at the consumer, healthcare provider and systems levels.

This first chapter presents a review of the literature.

1.1.1 Bordetella pertussis

Spread by aerosol, pertussis is a highly contagious bacterial infection with every case infecting an average of five other people in a susceptible community, and up to 90% of susceptible household contacts.[35] Immunity after infection is short-lived and re-infection can occur.

1.1.2 Clinical manifestations and epidemiology

As in other adults, pertussis infection in pregnant women can cause significant morbidity with a prolonged tussive illness, post-tussive emesis and rib fractures. Pregnant women are not at higher risk nor is infection more severe than in other

adults. As outlined above, the burden of severe disease is in infants less than six months of age, who have a 20-fold increased risk of infection.[5] Infection in this age group is frequently complicated by apnoea and pneumonia, and in rare circumstances by seizures, encephalopathy and death.[5]

In Australia, notification rates are highest (52.5 per 100 000 population) in the 5–9 year old age group closely followed by 0–4 year olds (39 per 100 000 population).[8] However, during the most recent epidemic between 2008 and 2011, the highest notification rates were seen in infants aged 0–5 months of age.[4] Hospitalisation rates amongst infants less than six months of age was 258 per 100 000 compared to 4 per 100 000 overall.[4] As is seen globally, almost all deaths occurred in infants less than eight weeks of age who were too young to have received their first dose of pertussis vaccine.[4]

1.1.3 Vaccination strategies to reduce the burden of infant pertussis

The three-dose primary series of combined diphtheria-tetanus-acellular pertussis (pertussis) vaccinations at six to eight weeks, four months and six months of age is highly effective at preventing pertussis.[2,7] However, a single dose confers only partial protection, rendering infants less than four months of age particularly vulnerable to infection.[7]

Three approaches to reducing this risk in very young infants have been explored: neonatal immunisation, cocooning and maternal immunisation. The rationale, effectiveness and challenges associated with each of these strategies is detailed below and summarised in Table 1.

Neonatal immunisation

Neonatal immunisation involves administration of an additional dose of pertussis vaccine shortly after birth. This directly increases immunity of the infant and confers partial protection against all possible sources of pertussis. However, currently acellular pertussis vaccines are only licensed for use from six weeks of age,[7] and even with a birth dose of vaccine infants would be incompletely protected until a second

vaccine dose is administered at six to eight weeks of age. Given that more than 90% of all pertussis mortality occurs in the 0–3 month age group, neonatal immunisation does not provide rapid enough immunity to adequately protect very young infants who are most at risk.

Another potential concern is that the high antibody levels stimulated by the birth dose might attenuate the immunological response to the primary childhood schedule (called "blunting"). Another potential concern is that the high antibody levels stimulated by the birth dose might attenuate the immunological response to the primary childhood schedule (called "blunting").[36] Studies of neonatal doses of acellular pertussis vaccine have yielded mixed results.[36-39] Halasa and colleagues compared immune responses in 50 neonates who received either hepatitis B vaccine alone or hepatitis B vaccine and an acellular pertussis vaccine at birth followed by routine childhood vaccinations. They reported reduced antibody responses to diphtheria and three of four pertussis antigens in their follow up to 18 months of age.[36] Wood et al. compared two additional doses of acellular pertussis vaccine (at birth and one month of age) with routine pertussis vaccination (three doses at 2, 4 and 6 months of age). Antibody responses were higher at two months of age in those infants who had received two doses compared to one or no doses without reducing subsequent pertussis antibody response after the primary series. Similar to Halasa, they also noted reduced responses to other antigens, in this case hepatitis B and H.influenzae type b at eight months of age in those who had received either one or two doses of neonatal pertussis vaccine.[37] In the largest study of 121 neonates, Knuf et al. compared antibody titres in neonates receiving hepatitis B vaccine alone or with an acellular pertussis vaccine at birth. Those who received a neonatal dose had earlier pertussis antibody responses but by seven months of age, titres were similar. They again noted a reduced response to other antigens, in this case diphtheria and hepatitis B antigens.[38] The same group subsequently examined responses after the 12–18 month booster and again demonstrated no blunting of pertussis responses but noted interference with hepatitis B, H.influenzae type b and diphtheria responses.[39]

Further research is required to establish the possible immunological effects of neonatal pertussis vaccination. Immunological blunting and interference is also a

potential concern with maternal immunisation and is discussed in more detail in Section 1.2.1, "Placental transfer of maternal antibodies".

Cocooning

Cocooning involves vaccination of parents and close contacts of the newborn. The aim is to boost immunity of all those in contact with the newborn, thereby reducing their risk of infection and in so doing reducing the potential for the infant to be exposed to pertussis. In response to the pertussis epidemic, cocooning was introduced in Victoria, Australia, in 2009, with a funded program for parents and vaccination of other close contacts encouraged but not funded.[40] The cocooning program in Victoria recommended that women be vaccinated post-partum and that their partners who had not received a pertussis vaccine in the preceding 10 years also be vaccinated, ideally during the pregnancy or otherwise post-partum.[40] Rowe et al. evaluated the effectiveness of the parental component of this program, reporting an adjusted vaccine effectiveness of 64% (95% CI 58–92%) in preventing pertussis in infants less than 12 months of age.[41] Similarly, Quinn et al. reported vaccine effectiveness of 51% (95% CI 10–73%) in preventing laboratory-confirmed influenza in infants less than four months of age.[42]

However, there are two main challenges in implementing cocooning strategies.

(i) Vaccination of parents in the immediate post-partum period

As antibodies do not rise until one to two weeks following vaccination, even vaccinated parents may be susceptible to infection during this interim period and can in turn infect their newborn. While studies assessing the coverage of cocooning in Victoria suggested parental coverage in the order of 50–80%, the timing of these vaccinations was of particular concern.[43,44] Rowe et al. reported that only 25% of fathers were vaccinated during the pregnancy, and only two-thirds of mothers and 29% of fathers were vaccinated within the first two weeks post-partum. Furthermore, 28% of fathers were vaccinated up to as late as eight weeks post-partum.[43] Vaccinating women and their partners in the immediate post-partum period is challenging given that most admissions for childbirth are short, parents have myriad

demands during this time and there are frequently administrative barriers to maternity hospitals providing vaccination to non-hospital patients (e.g. the other parent).[44] The delay in parental vaccination with cocooning highlights that in reality a significant proportion of infants are unlikely to be adequately protected by this strategy in the critical first few weeks of life.

(ii) The number of potential sources of infection and achieving a complete cocoon

A source of infection can only be identified in 40–50% of infant infections.[45-48] When a source can be identified, studies suggest parents account for 40–60% of infant pertussis cases.[46-51] In addition to their parents, studies have demonstrated that newborns have on average an additional two to three close contacts.[52-54] In addition to these identifiable contacts, there are numerous incidental contacts presumed to contribute to the more than 50% of cases where a source cannot be identified. There are obvious logistic difficulties in providing vaccination (usually through a variety of different providers) for the large number of contacts of newborn babies to achieve a complete cocoon. Highlighting this, three studies, one in Switzerland and two in the US, reported that only 32–50% of newborns' close contacts were up to date with vaccination.[52-54] These same studies demonstrated that complete cocooning occurred for only 7–26% of newborns.[53,54] While Australian studies have reported high uptake by parents, they have not reported on completeness of the cocoon.[42-44]

Maternal immunisation

Pertussis vaccination during pregnancy elicits the same antibody responses as in non-pregnant women, resulting in significantly higher maternal antibody levels than in women who are not vaccinated in pregnancy.[55-57] Transfer of these maternal antibodies across the placenta provides passive immunity to the newborn. Maternal pertussis vaccination is highly effective, and in evaluation of maternal pertussis programs has been reported to reduce laboratory-confirmed pertussis infections by more than 90% and pertussis-associated deaths by 95% in infants less than three months of age.[58-62] Maternal pertussis vaccination has been embraced in many jurisdictions with the view to conferring short-term protection to infants from all possible sources from birth.[13-20] Given the superior effectiveness of maternal

immunisation over both neonatal immunisation and cocooning, this is the preferred strategy in most resource-rich settings.[13-20]

Table 1: Comparison of vaccination strategies to reduce pertussis in infants

	Benefits	Disadvantages
Neonatal immunisation	• Protects infant from all sources of infection • Minimal extra resources required to implement vaccination program	• Adequate protection only achieved from second dose at 6–8 weeks of age • Extra injection for newborn • Possibly poor responses to subsequent vaccines (i.e. blunting)
Cocooning	• No extra injections for infant • Boosts maternal immunity to pertussis • Boosts immunity of adults in community to pertussis	• Infant still vulnerable in first 1–2 weeks after vaccination • Doesn't protect infant from sources other than vaccinated contacts • Large number of people requiring vaccination • Difficult to achieve complete cocoon • Resource intensive to achieve complete cocoon
Maternal vaccination	• Protects infant from all sources of infection • No extra injections for infant • Boosts maternal immunity to pertussis	• May require extra healthcare provider visits if vaccination not incorporated into maternity services • Possibly poor responses to subsequent vaccines (i.e. blunting)

The remainder of this chapter focuses on the principles of maternal immunisation followed by the evidence for its efficacy and safety. Lastly, the data on the barriers and facilitators of uptake are presented.

1.2 Maternal vaccination

The dual benefits of maternal vaccination for mother and child have long been recognised. The World Health Organization (WHO) called for elimination of maternal and neonatal tetanus in 1988 and one component of the elimination strategy was routine immunisation of pregnant women with tetanus toxoid.[63]

In 2012, The WHO Strategic Advisory Group of Experts on Immunization recommended pregnant women as the most important risk group for inactivated seasonal influenza vaccination, based on data suggesting that infection with pandemic influenza virus during pregnancy was associated with greater risk of severe infection, hospitalisation and death.[64] Since this time, in addition to the maternal benefits, the foetal and neonatal benefits of maternal influenza vaccination have been recognised.[65-69] These include decreased stillbirth, preterm birth and low birth weight, reduction in laboratory-confirmed influenza, acute respiratory infections / influenza-like illness, and hospitalisations for influenza-like illness in infants less than six months of age.[65-69]

Pertussis vaccine is the latest vaccine to have been recommended for pregnant women in many high and middle income countries.[13-20] Maternal vaccinations to reduce the burden of infant disease from respiratory syncytial virus and early-onset group B streptococcus infection are also in development.

1.2.1 Placental transfer of maternal antibodies

It has been demonstrated that pregnant women mount a similar immune response to pertussis vaccine to non-pregnant women.[55,70] Pertussis-specific IgG levels peak one to two weeks following vaccination.[12] Maternal IgG then crosses the placenta via active and passive transport mechanisms providing the newborn with short-term passive immunity. Active transport of maternal IgG commences from 13 weeks gestation and increases throughout pregnancy such that the majority of IgG transfer occurs in the last four weeks of pregnancy.[71,72] The longer the duration between maternal vaccination and delivery the greater the potential for antibody transfer. This

is important as infants born preterm may not derive as much benefit from maternal vaccination as there is less time for antibody transfer.

To afford protection to the neonate through transplacental antibody transfer, a pregnant woman must have adequate circulating levels of pertussis-specific IgG herself. However, immunity rapidly wanes after acellular pertussis vaccination.[5,6] Low levels of pertussis-specific IgG have been demonstrated in pregnant women.[73-75] Shakib and colleagues reported that only 17 of 81 (21%) pregnant women, mostly with unknown maternal pertussis immunisation status, had antibody levels considered to be protective against infection.[73] Likewise amongst 90 pregnant women in Thailand, only 43% of mothers had adequate levels.[74] In both these studies only a quarter of infants were born with antibody levels considered protective against infection.[73,74] Thus, without a booster dose during pregnancy, most pregnant women are unlikely to have sufficient circulating levels of pertussis-IgG to provide protection to their infant.[10,73,76,77]

After establishing that vaccination during pregnancy is required to boost maternal antibody levels, the next question is how often these booster doses are required. Leuridan et al. vaccinated 24 women between successive pregnancies.[78] The booster dose and subsequent delivery were an average of 13 months apart and although higher than pre-vaccination levels, antibodies to pertussis toxin had decayed significantly in that time.[78] Supporting these findings, Abu Raya and colleagues administered a booster dose of acellular vaccine to pregnant women in the second half of pregnancy and reported significant decline in antibody titres within 9–15 months.[77] These studies informed the decision to recommend pertussis vaccination during each pregnancy regardless of how closely spaced.[7,13,21]

One potential concern with maternal vaccination is that the high level of maternally-derived pertussis-specific antibodies may dampen the infant's own immune responses to subsequent pertussis vaccines, termed blunting. Blunting has been demonstrated following the primary series of childhood vaccinations in several small trials using acellular pertussis vaccine in pregnancy.[55,57,79-81] However, this effect does not appear to persist after subsequent booster doses.[55,57,82] The clinical significance of these attenuated responses remains unclear as there has not been an increase in incidence

of infection in older infants (as might be expected with poorer immune response to vaccination) in countries such as the UK, where maternal vaccination has been implemented for some years.[83]

1.2.2 Optimal timing of maternal vaccination

Maternal pertussis vaccination is administered primarily to protect the infant from birth until the primary vaccination series. As already discussed, this requires adequate maternal antibody levels for transplacental transfer. However, this strategy also requires sufficient time for antibody transfer to occur prior to delivery, and the persistence of maternally-derived antibodies until childhood vaccination commences at six to eight weeks of age. The half-life of maternally-derived IgG to pertussis toxin in infants is reported to be 37–47 days.[84,85]

Healy and colleagues studied 105 pregnant women who had been vaccinated in the preceding two years (median of 13 months prior), of whom 14 were vaccinated during the first trimester of the current pregnancy, and five later in the current pregnancy.[10] Cord blood antibody levels were similarly low in women vaccinated early in pregnancy or prior to pregnancy. They subsequently estimated infant titres at two months of age. By their estimates only 40% of infants whose mothers were vaccinated prior to pregnancy would be expected to have detectable IgG levels at two months of age. In comparison, they estimated that two of the three infants born to mothers vaccinated after 20 weeks would have detectable antibody levels at two months of age.[10]

Thereafter studies examining the optimal timing of maternal pertussis vaccination focused on third trimester vaccination.[20,55,75,86-88] Munoz et al. examined immunological responses after vaccination between 30 and 32 weeks gestation and demonstrated high antibody titres at delivery that persisted until two months of age.[55] Two subsequent studies investigated early versus late third trimester vaccination.[86,87] In the first study, Abu Raya and colleagues reported higher geometric mean titres of IgG to pertussis toxin in women vaccinated between 27 and 30^{+6} weeks compared to those vaccinated either between 31 and 36 weeks or after 36 weeks gestation.[86] Naidu et al. likewise demonstrated higher cord blood antibody levels in infants of mothers

vaccinated between 28 and 32 weeks compared to mothers vaccinated between 33 and 36 weeks.[87] They demonstrated higher cord blood antibody levels in women vaccinated between 27 and 30^{+6} and 28–32 weeks than in those vaccinated after 31–33 weeks gestation.[86,87] These two studies did not measure subsequent infant antibody levels, but with higher levels at birth and assuming similar kinetics of antibody decay, protective levels at two months of age would be expected.

Subsequently, the largest study to date was a non-inferiority study of 122 women vaccinated in the second and 213 women vaccinated in the third trimester.[20] They reported higher rates of seropositivity in cord blood of infants whose mothers were vaccinated in the second rather than third trimester (adjusted odds ratio 3.7, 95% CI 2.2–6.5). Findings remained significantly higher when the 32% of women who were vaccinated within two weeks of delivery were excluded. Again with modelling they reported that all infants would be expected to have protective levels of anti-pertussis toxin antibodies out to three months of age.[20] While these findings have not been replicated, there is some biological plausibility to the superior efficacy of second trimester vaccination as the longer delay between vaccination and delivery allows for greater cumulative antibody transfer.

Other studies have reported no difference by gestation at the time of vaccination.[75,88] There are a few reasons for the different findings amongst these studies: (i) different cord blood and infant antibody titres were used as a correlate of protection, ranging from 5 IU/ml to 50 IU/ml and estimates of persistence of maternally-derived antibodies will vary depending on which cut off is used; (ii) not all studies used the same brand of vaccine although most used just one within each trial; and (iii) while most studies were conducted prior to introduction of maternal vaccination programs, they did not account for timing since previous pertussis booster or pre-vaccination maternal antibody levels, both of which could potentially affect subsequent titres.

Summary of timing studies

While the optimal timing of maternal vaccination is yet to be definitively determined, there are some potential advantages to second rather than third trimester vaccination. In Australia, 9% of babies are born before 37 weeks gestation, and almost 1% before

32 weeks gestation.[89] Second trimester vaccination is likely to provide these babies with greater protection than that afforded by third trimester vaccination. In addition, reflected in the UK experience and as will be discussed in Section 1.3.2 on the coverage of maternal vaccination programs, an advantage of expanding the recommended immunisation window to include second trimester vaccination is the increased number of opportunities to immunise, and thereby increased vaccine uptake.[21]

1.2.3 The effectiveness of maternal pertussis vaccination

Pertussis infection

Various studies conducted in the UK, US and Spain have now demonstrated more than 90% effectiveness of maternal pertussis vaccination in preventing laboratory-confirmed pertussis in infants less than two to three months of age.[58-62] Furthermore, Amirthalingam et al. utilised UK vaccination and notification data to demonstrate that vaccine effectiveness against laboratory-confirmed pertussis in infants was only 43% when maternal vaccination occurred within one week of delivery compared to 91% effectiveness when administered earlier.[59]

Two studies have reported on vaccine effectiveness by trimester of maternal vaccination.[90,91] Winter et al. found that vaccination at 27–36 weeks was more effective in preventing laboratory-confirmed pertussis in infants less than two months of age than second trimester vaccination.[90] Although not statistically significant, supporting the findings of the immunological studies presented previously, they found greater vaccine effectiveness with vaccination between 27 and 31 weeks compared to after 31 weeks.[90] Skoff and colleagues also looked at vaccine effectiveness in relation to timing of maternal vaccination.[91] Their study combined first and second trimester vaccination but reported greater effectiveness with third trimester compared to earlier vaccination (78% compared to 64%).[91] The result was not statistically significant but the study was underpowered for this endpoint. In addition, unlike the other efficacy studies, their definition of pertussis cases was not limited to laboratory-confirmed cases.[91]

Hospitalisation and death

In terms of disease severity, three studies have reported reduced risk of hospitalisation, shorter hospital length of stay and fewer intensive care unit admissions in infants whose mothers were vaccinated at any time during pregnancy.[91-93] In terms of effectiveness by timing of maternal vaccination, Skoff et al. reported 91% vaccine effectiveness against pertussis-related hospitalisation regardless of whether women were vaccinated during first and second trimester or during the third trimester.[91] National data from the UK after three years of their maternal pertussis program has demonstrated 95% vaccine effectiveness against infant deaths.[59]

Preterm infants

Specifically examining vaccine effectiveness for preterm infants, Byrne et al. surveyed a national hospital admission database in the UK.[93] Preterm infants were over-represented in pertussis hospitalisations and this increased following introduction of the maternal pertussis vaccination program. The authors hypothesised that the program was effective in decreasing pertussis in full-term infants but not in preterm infants due to the more limited duration of transplacental transfer for preterm infants. Their study was conducted prior to revision of the UK guidelines to commence vaccination from 16 weeks and the authors anticipate that similar reduction may be seen for preterm infants following this recommendation.[93]

1.2.4 Safety

Maternal pertussis programs were introduced as a public health response to a pertussis epidemic.[83,94] This decision was based largely on the known safety of other inactivated vaccines during pregnancy as data on the safety of acellular pertussis vaccines was limited at that time.[94] However, with high coverage in the UK in particular but also with widespread implementation in the US, it was possible to rapidly accumulate safety data in terms of acute adverse events following vaccination, but also obstetric and foetal/infant outcomes.[95-99] While much of the data was not published at the time of introducing maternal pertussis vaccination in Australia, data

is now available from active and passive surveillance systems such as the Vaccine Adverse Events Reporting System (VAERS), Vaccine Safety Datalink project (VSD) and the UK Clinical Practice Research Datalink, as well as from clinical trials of maternal vaccination.

Adverse events following immunisation

An adverse event following immunization (AEFI) is any untoward medical occurrence which follows immunisation and importantly does not have to be caused by the vaccine. In the setting of maternal vaccination, AEFIs can refer to immediate adverse events in pregnant women (such as fever or limb pain) as well as adverse effects on the developing foetus, and adverse pregnancy outcomes.

AEFIs affecting the pregnant woman

There have been six published studies (one randomised controlled trial, two retrospective cohort and three prospective cohort studies) where one of the primary aims was to examine AEFIs affecting the pregnant woman rather than her offspring following maternal pertussis vaccination.[55,96,99-102]

The earliest is also the only randomised controlled trial.[55] Thirty-three women were vaccinated using the brand Adacel and safety was one of the primary outcomes. Using a seven-day diary to record AEFIs, they reported local pain in 78%, erythema in 9%, and induration/swelling in 9% of vaccinated women. AEFI rates were similar in pregnant and non-pregnant women.[55]

Kharbanda et al. retrospectively compared VSD data on medically attended AEFIs in 53 885 vaccinated (at any gestation) and 109 253 matched unvaccinated pregnant women between 2007 and 2013.[96] Again the Adacel brand of pertussis vaccine was the predominant brand used. They found no increase in medically attended AEFIs within three days of vaccination, and no increase in any neurological, thrombotic or cardiac events or proteinuria or gestational diabetes in women. They did note an increase in medical attendance for fever with an adjusted incident rate ratio of 5.4 (95% CI 2.1–13.9) but the actual rates of fever were still very low in the vaccinated group (2.8 per 10 000 compared to < 1 per 10 000 in unvaccinated group).[96]

Three large prospective observational studies of adverse events following third trimester vaccination have been published.[100-102] Fever was uncommon in all three studies (< 2%). The first study was conducted at two centres in New Zealand.[101] Similar to the rates observed in the randomised controlled trial, of 793 women vaccinated using the brand Boostrix, 79% reported mild-moderate pain at the injection site, 6% erythema and 8% swelling.[101] In the second study of 737 women in the US, 67% reported at least one AEFI.[100] However, in the largest study, of more than 5000 women in Western Australia, with three quarters vaccinated with Adacel and 25% with Boostrix, only 5–7% of women reported local reactions.[102] There were three main methodological differences that may explain some of the variation in these rates. Firstly, sample size was much larger in the Australian study and therefore this may be a more accurate representation of event rates. Secondly, different brands of pertussis and influenza vaccines were used and the proportion who received both vaccines differed. While no difference in event rates by brand has been reported previously, it may be that certain combinations of pertussis and influenza vaccines are more reactogenic than others. And lastly, and the factor most likely to account for the differences between studies, the two international studies provided women with AEFI information at the time of vaccination and collected events prospectively with more intensive follow up. Adverse event reporting in the Australian study required responding to three individual text messages. They received complete information from 88% of women reporting an AEFI. The authors themselves note from their previous work that there is evidence that AEFIs, particularly injection site reactions, may be significantly under-reported by SMS compared to phone interviews (risk ratio 0.41, 95% CI 0.29–0.59).[103]

(i) AEFIs in pregnant women with contemporaneous administration of influenza vaccine

As influenza vaccine is also recommended during pregnancy, four large cohort studies have examined rates of AEFIs with concurrent pertussis and influenza vaccination.[98,100-102] Of the three prospective studies on safety reported in the previous section, one reported fever and systemic effects to be more common amongst those who received concomitant trivalent influenza vaccine.[101] However the

other two, as well as a large retrospective cohort study of 36 844 women in the US, did not find a significant difference.[100,102,98]

(ii) AEFIs in pregnant women with repeated tetanus vaccination

It has been suggested previously that severe local reactions may be more common with shortened intervals between tetanus vaccine doses.[104] Regan and colleagues compared AEFIs in 70 women with recorded diphtheria-tetanus-acellular pertussis vaccination three years earlier to 2693 with no record of previous vaccination.[102] Women who had received a vaccine three years earlier were more likely to report an AEFI than those who had a longer interval between vaccinations (19% vs 11%, p = 0.04) predominantly because of an increase in local reactions (11% vs 6%, p = 0.06) and myalgia (3% vs 0.6%, p = 0.07). They were also more likely to consult a general practitioner (GP) for their AEFI (4% vs 1%, p = 0.03).[102] However, in a much larger cohort of 29 155 women in the US, Sukumaran and colleagues reported no difference in medically attended fever and local reactions between those vaccinated in the preceding two years, compared with two to five years earlier, or more than five years earlier.[97]

AEFIs affecting obstetric outcomes

Most adverse obstetric outcomes apart from preterm birth are rare and therefore large sample sizes are required to detect any effect of vaccination.

Fourteen studies have reported on preterm birth.[55,95,97-99,101,105-112] The smallest was a randomised controlled trial of 33 women vaccinated between 30 and 32 weeks[55] and the largest a retrospective cohort from an insurance database in the US of more than one million women vaccinated at any gestation.[99] None found an increase in preterm birth and three reported decreased preterm birth when vaccination occurred after 27 weeks as per the US recommendations.[99,105,109]

Three retrospective cohorts with 809 women in total have not demonstrated increased risk for spontaneous abortion.[110-112] In five of six observational studies of more than 28 000 women, no difference in stillbirth was noted.[95,101,108,109,111] The other study was a retrospective review of reports to the VAERS database. They noted

an increase in proportion of reports being due to stillbirth, increasing from 1.5% (2/132 reports) between 2005 and 2010 to 2.8% (11/392 reports) between 2011 and 2015 following the recommendation for maternal pertussis vaccination in the US. However, the authors note that this represents only a small absolute increase and has not been borne out in the larger observational studies.[106] Five cohorts of nearly 10 000 women have not demonstrated a significant increase in congenital anomalies.[107-110,112]

Kharbanda and colleagues in their retrospective cohort of 123 494 pregnant women from two VSD sites in California unexpectedly found a statistically significant increase in chorioamnionitis (6% in vaccinated women vs 5.5% in unvaccinated, adjusted relative risk 1.2, 95% CI 1.1–1.3) although this risk was lower in the subgroup vaccinated at 27–36 weeks (adjusted relative risk 1.1, 95% CI 1.0–1.2).[105] The same group subsequently examined data from seven VSD sites in the US and confirmed this finding (adjusted relative risk 1.2, 95% CI 1.2–1.3),[113] as did Layton et al. using a different insurance claims database in the US (relative risk 1.1, 95% CI 1.1–1.15).[99] Importantly, while these studies demonstrated increased relative risk, the absolute risk increase was small. Two smaller studies have not confirmed this association.[106,107] More work is needed to further explore any potential association, however, there are several factors that cast doubts: (i) there is no known biological explanation for the association; (ii) the diagnosis of chorioamnionitis could not always be substantiated on chart review; and (iii) in none of the studies was there increased rates of the complications of chorioamnionitis (preterm birth, transient tachypnea of newborn, sepsis or pneumonia).

Munoz et al. also reported on infant outcomes in their small randomised controlled trial of 33 women vaccinated between 30 and 32 weeks.[55] Unsurprisingly, given the small sample size and vaccination late in pregnancy, there were no serious adverse outcomes such as foetal death or congenital anomalies.[55] There have been four retrospective studies of more than 30 000 women from the US and UK and a prospective study of 403 women in New Zealand that have reported no difference in low birth weight infants with maternal pertussis vaccination.[95,98,107,108,112]

Five retrospective cohorts with more than 150 000 women in total have reported no increased risk for small for gestational age[97,98,105,107,112] and one study of 7378 women reported a decrease (10% compared to 15%, p = 0.03).[109] There have been six retrospective studies of more than 10 000 women and one prospective cohort study of 400 women that have each demonstrated no increased risk for congenital anomalies.[106-112]

There has been one systematic review of 21 studies on the safety of maternal pertussis vaccination.[114] This did not find any increase in AEFIs or adverse maternal and neonatal outcomes. Point estimates were 0.5–1.5 for preterm birth, 0.4–0.85 for stillbirth, 0.2–1.0 for neonatal death, 0.65–1.0 for small for gestational age, 0.8–1.2 for low birth weight, and 0.2–0.9 for congenital anomalies.[114]

1.3 Current recommendations and coverage

In the last decade, in response to widespread pertussis outbreaks and neonatal and infant deaths, many high-income countries have introduced maternal pertussis programs.[7,13-20] This section focuses on the recommendations and varied success in implementation of these programs.

1.3.1 Recommendations

International guidelines

In 2011, the US was the first country to recommended pertussis vaccination in the third trimester of pregnancy for women who had not received a booster dose in the preceding five years.[13] One year later, the recommendation was revised and remains the current guideline recommending vaccination between 27 and 36 weeks in every pregnancy regardless of previous doses.[13] The UK implemented their maternal pertussis program in October 2012.[14] In April 2016, based on the studies of timing of maternal vaccination presented earlier, guidelines were updated to recommend vaccination from 16 weeks gestation to increase the available window of opportunity for vaccination and with the possibility of increased efficacy and benefits for preterm infants.[21]

Several countries have subsequently followed suit but with varying recommendations regarding timing. These include Argentina (after 20 weeks),[15] Belgium (between 24 and 32 weeks),[16] Canada and Spain (between 27 and 32 weeks),[17,18] New Zealand (between 28 and 38 weeks)[19] and Switzerland (second or third trimester).[20]

Australian guidelines

Prior to March 2015, Australian guidelines recommended a booster dose of an acellular pertussis–containing vaccine either pre-pregnancy or as soon as possible after delivery and ideally prior to hospital discharge.[7] A dose during the third trimester was mentioned as an alternative strategy. In addition, the guideline clarified that booster doses for subsequent pregnancies were only recommended if five years or more would elapse between a previous dose and the expected date of delivery.[7]

Guidelines were revised in March 2015 to recommend an acellular pertussis–containing vaccine as a single dose during the third trimester of each pregnancy and ideally between 28 and 32 weeks.[7] This recommendation is currently funded in all states and territories of Australia, and maternal pertussis vaccination should now be considered standard of care.

1.3.2 Coverage

International experience

One of the challenges of monitoring coverage of maternal vaccination is that national immunisation registers do not exist in all countries and where they do, pregnancy status may not be captured. Therefore estimates of coverage have been derived from insurance databases, state or region-specific registers and research settings. Coverage of maternal pertussis vaccination has been quite variable. Countries that achieved rapid coverage include the UK, where coverage peaked at 78% within the first year and was subsequently sustained between 50% and 60%.[59] After the expansion of the immunisation window in April 2016, coverage increased to greater than 70%.[21] Similar to the UK, Argentina achieved high coverage of 50% within the first year increasing to 67% in the second year.[22] Studies from Belgium also indicate high

coverage, starting at 46% within the first year and increasing to 64–69% within three years.[16,115,116]

However, programs have not universally been so successful. Four years following recommendations in New Zealand, one study suggested coverage was only 44%.[28] In Israel, one study reported coverage of 52%.[117] Two studies in Ireland have reported coverage between 31% and 53%.[31,118] There are nine reports from the US on coverage of maternal pertussis vaccination.[24-27,96,119-122] Prior to the Advisory Committee on Immunization Practices recommendation for vaccination in every pregnancy regardless of previous vaccination status, coverage was 10–20%.[96,119-122] Subsequent to that recommendation in October 2012, coverage has gradually increased to greater than 50%, although there is considerable variability across the country with reported rates as low as 6% and as high as 82%.[24-26,119,121,122]

Coverage in Australia

Similar to internationally, there is not a national system in Australia for recording vaccination during pregnancy so estimates rely on data obtained from state-based platforms and from clinical studies.

The first estimate available and the largest dataset to date comes from the national FluMUM study.[1,123] Of 2755 women in the study in 2015, 46% had received a pertussis vaccine during pregnancy. This varied between states and territories with the lowest coverage in New South Wales (27%) and highest in Western Australia (63%).[123] As has been reported internationally, coverage in this cohort increased with time, reaching 74% in the third quarter of 2015.[123] Subsequently, coverage has been reported from four other studies.[34,124-126] The first, conducted shortly after the recommendation in 2015, reported coverage of 22% amongst women in the Northern Territory although by the end of 2015 coverage approached 40%.[34] In the second study, amongst 100 Aboriginal and Torres Strait Islander women in Western Australia also conducted in 2015, coverage was 63%.[125] The third and largest of these studies reported coverage of 82% amongst 406 women across four public hospital antenatal clinics in three states (Victoria, Western Australia and South Australia) in 2015–16.[124]

The final study, published only in abstract to date, reported 67% coverage amongst women receiving antenatal care in a public hospital in New South Wales in 2016.[126]

Despite what appears to be reasonable (albeit varied) coverage in Australia, even in areas with the highest coverage, nearly 30% of babies may be born to mothers with insufficient antibody levels to protect them during the critical first few months of life. Understanding the factors that are contributing to this variability in coverage in a country where healthcare and vaccines are free is central to improving coverage and also guiding implementation of future maternal vaccination programs.

1.4 Factors that influence uptake of maternal pertussis vaccination

A literature review was published in 2015 of the factors influencing uptake of maternal vaccination globally.[127] Almost all of the studies (113/155, 73%) focused on the influenza vaccine and of these, 73/113 (65%) were conducted in North America.[127] Another review published in 2016 focused specifically on the factors influencing healthcare provider recommendation and pregnant women's' uptake of maternal vaccination.[128] Again the majority pertained to influenza vaccine (47/64) but 10 studies of maternal pertussis vaccination were included. And again most studies were conducted in the US (37/47).[128]

With respect to what is known about the factors influencing uptake of maternal pertussis vaccine in the Australian context, there have been two published studies, one conducted in the Northern Territory and the other amongst Aboriginal and Torres Strait Islander women in Western Australia).[34,125] The barriers and facilitators of uptake of maternal pertussis vaccination have therefore largely been inferred from what was learned from implementation of maternal influenza vaccination.[32,33,129-136] Some of these factors may also be applicable to maternal pertussis vaccination but others are likely to be specific to influenza. Likewise, barriers to post-partum pertussis vaccination, which have also been reported in Australia,[43,132,137-139] cannot necessarily be extrapolated to an antenatal strategy.

The remainder of the literature review summarises the available data on the barriers and facilitators of uptake of maternal pertussis vaccination both internationally and in Australia. These can be divided into three categories: (i) consumer (pregnant women)-related; (ii) healthcare provider–related; and (iii) systems-related; and are summarised in Table 2 below and discussed in more detail in sections 1.4.1 – 1.4.3.

1.4.1 Consumer-related factors

This section reviews data from 26 studies of pregnant women's attitudes and uptake of maternal pertussis vaccination internationally.[16,23-31,115-121,140-148] Studies were not included if maternal vaccination was not recommended in that country at the time of the study. Ten of the 27 studies were conducted in the US,[24-27,119-121,140,145,146] five in the UK,[23,141-143,148] three in each of New Zealand,[28,29,147] Ireland,[30,31,118] and Belgium,[16,115,116] and one in each of Canada[144] and Israel.[117] The majority were interviews or surveys (16),[16,23,27,29-31,115-117,120,140-144,147] and retrospective cohort studies or audits (7),[24,26,28,119,145,146,148] and the remaining were a randomised controlled trial,[25] a prospective cohort study,[118] and a study based on modelling.[121]

The evidence from these international studies is discussed first, followed by the available data from the five Australian studies of consumer attitudes to maternal pertussis vaccination.[34,123-126] Otherwise, reference is made to data from Australian studies of influenza vaccination or post-partum pertussis vaccination as appropriate.

Table 2: Summary of factors associated with uptake of maternal vaccines

	International (antenatal pertussis)	Australia (antenatal pertussis)	Australia (influenza, post-partum pertussis)
Consumer-related	Demographics	Demographics	Demographics
	age[23,28,119,121,145-147]	age	age
	parity[16,116,119]	parity	parity[132]
	socioeconomic status[16,147,148]	socioeconomic status	socioeconomic status
	education[16,116]	education	education[136]
	ethnicity[23,24,115,117,120,127,143,145,147,148]	ethnicity	ethnicity
	primary language	primary language	primary language[132,137]
	Perception of disease severity or risk[25,29,117,120,143]	Perception of disease severity or risk	Perception of disease severity or risk[123,129,130,134,136,139]
	Awareness of recommendation[25,147]	Awareness of recommendation	Awareness of recommendation[44]
	Beliefs about vaccine efficacy[29,116,117,144]	Beliefs about vaccine efficacy	Beliefs about vaccine efficacy[44,130,135]
	Beliefs about vaccine safety[16,29,115,116,118,120,128,147]	Beliefs about vaccine safety[125]	Beliefs about vaccine safety[44,123,130,131,133-135]
	Healthcare provider recommendation[25,26,29-31,115,143,147]	Healthcare provider recommendation[125]	Healthcare provider recommendation[32,33,130,132-139,149]
	Access to vaccination[27,29,147]	Access to vaccination[124]	Access to vaccination[44,132,134,135]
Healthcare provider–related	Personal vaccination status[150]	Personal vaccination status	Personal vaccination status[129]
	Awareness of recommendation[16,151,152]	Awareness of recommendation	Awareness of recommendation
	Beliefs about vaccine safety[128,151,153-155]	Beliefs about vaccine safety	Beliefs about vaccine safety[157]
	Beliefs about their role in vaccination[154-156]	Beliefs about their role in vaccination	Beliefs about their role in vaccination[158]
Systems-related	Education of consumers[25,159]	Education of consumers	Education of consumers[33]
	Education and training of healthcare providers[150,151,153,154]	Education and training of healthcare providers	Education and training of healthcare providers[33]
	Integration of vaccination policy and procedures into maternity care[128,160,161]	Integration of vaccination policy and procedures into maternity care	Integration of vaccination policy and procedures into maternity care[158]
	Provision of vaccination within maternity services[162,163]	Provision of vaccination within maternity services	Provision of vaccination within maternity services[134,135,137]

Demographics

Sixteen studies have reported on the association between demographic factors and uptake of maternal pertussis vaccine.[16,23,24,26,28,115-117,119-121,143,145-148] Age greater than 25 years is the demographic factor most frequently reported to be associated with higher uptake.[23,28,119,121,145-147] Three studies have reported increased uptake amongst primiparous women.[16,116,119] Two reported greater uptake in women of higher socioeconomic status,[16,148] but conversely one in women of lower socioeconomic status.[147] Higher educational level has also been associated with greater uptake in two studies.[16,116] Previous receipt of influenza vaccine or receipt during the current pregnancy has also been reported to be associated with uptake of pertussis vaccine in three studies.[24,26,120]

In Wilson's review of uptake of maternal vaccines globally, only 46/155 (30%) included studies mentioned ethnicity.[127] Sixty percent (27/46) reported lower uptake amongst women from ethnic minorities, 17% (8/46) higher uptake, and 24% (11/46) found no difference.[127] Of the studies of maternal pertussis vaccination published since that time, three US studies have reported that African American women are less likely to report receiving pertussis vaccination during pregnancy than white women.[24,120,145] Donaldson and colleagues surveyed 200 ethnically diverse women in the UK.[143] Again they demonstrated lower uptake of pertussis vaccination among black compared to white women (19% vs 29.5%) and uptake varied by up to 15% between ethnic groups.[143] Being of an ethnic minority was also associated with reduced uptake of maternal pertussis vaccine in two other studies in the UK,[23,148] and also studies in Belgium,[115] New Zealand[147] and Israel.[117] International studies have predominantly surveyed Hispanic and African American women which does not reflect the cultural diversity of Australia, which has a much larger Asian population.

Two Australian studies have explored the association between demographics and uptake of maternal pertussis vaccine.[34,125] Neither found any of the demographics reported internationally to be associated with uptake. The only factor reported to be significant amongst the Aboriginal and Torres Strait Islanders living in Western Australia in Lotter's study, was living in a rural region (odds ratio 3.1, 95% CI 1.2–

7.6).[125] However, these findings may not be generalisable to non-Aboriginal women and those living in more populated and urban states.

Twelve studies have reported on maternal attitudes to influenza vaccination during pregnancy in Australia.[33,129-136,138,139,149] One reported that primiparous women were more likely[132] and other that more highly educated women were more likely to report influenza vaccination.[136] The remainder either did not analyse uptake according to demographic factors[33,131,133,138,139,149] or found no association.[129,130,134,135]

Several Australian studies of either maternal influenza or post-partum pertussis vaccination have surveyed women from migrant backgrounds.[33,44,129,130,132-134,137,138] Lu, Maher and Wiley did not find any difference in uptake of influenza vaccine by ethnicity.[129,130,134] Wong reported no difference for influenza vaccine but women whose first language was not English were significantly less likely to receive pertussis vaccine in accordance with the cocooning guidelines at the time (adjusted risk ratio 0.2, 95% CI 0.1–0.7).[132] This was also demonstrated in a study of 1080 post-partum women in Sydney where those who spoke English as a first language were 50% more likely to receive a pertussis vaccine post-partum (odds ratio 1.5, 95% CI 1.1–2.0).[137] The other studies while including women from migrant backgrounds did not report on uptake by ethnicity or primary language.[33,44,133,138]

Knowledge of disease

Women's perceptions about their baby's risk of pertussis[25,29,117,143] as well as the severity of infecton[117,120] have been reported to affect their decision to receive pertussis vaccination.

In Australia this has been reported in relation to maternal influenza vaccination with women who perceived themselves to be at high risk of infection[123,129,136,139] and perceived that influenza can be severe in pregnancy[123,130,134] more inclined to vaccination.

During the cocooning era, awareness of pertussis among women in Australia was reported to be more than 90% and therefore awareness of the disease is unlikely to be a barrier to uptake of the vaccine during pregnancy.[44,132,137]

Knowledge of vaccine

Belief in the effectiveness of maternal pertussis vaccination to reduce infant infection has been associated with vaccine uptake internationally[29,116,117,144] and was in fact the strongest predictor of uptake in one study.[117]

Belief that pertussis vaccination during pregnancy is safe has also been associated with vaccination in multiple studies.[29,116,118,120,147] The review by Macdougall et al. found concerns about safety to be the most commonly reported barrier.[128] However, the proportion of women who express concerns about vaccine safety varies considerably between studies. Two studies from Belgium reported that safety concerns were rarely the reason for non-vaccination (in just 3–5% of women).[16,115] Similarly, Gauld reported that very few women in their study in New Zealand raised significant concerns about safety.[147] However, amongst 113 Irish women, concern about safety was the most common reason for non-vaccination, reported by 41% of those who did not receive vaccination, and belief in the safety of the vaccine was significantly associated with uptake.[118]

In the absence of Australian data on women's beliefs about the effectiveness of antenatal pertussis vaccination, attitudes to post-partum pertussis vaccination may provide some insight. Only one study has reported on this.[44] In Donnan's study in 2010, 65% of women believed the vaccine was effective in preventing pertussis.[44] Likewise, although the same cannot necessarily be assumed for pertussis, Taksdal et al. reported that women who believed maternal influenza vaccination would protect their infant from influenza were nearly four times more likely to receive influenza vaccine than those who did not (adjusted odds ratio 3.8, 95% CI 1.2–12.4).[135] Maher and colleagues also found belief in the effectiveness of influenza vaccination to be associated with uptake but in relation to preventing influenza in themselves rather than their baby.[130]

In terms of beliefs about the safety of pertussis vaccine among women in Australia, one study has been published.[125] Lotter et al. reported that 26% of unvaccinated women cited safety concerns as their reason for non-vaccination in their 2015 study.[125] This proportion is lower than in the studies of influenza vaccination shortly

after it was introduced in 2010 where 40–60% of women reported declining vaccination because of safety concerns.[131,133] Whether Lotter et al.'s finding for maternal pertussis vaccine reflects a growing belief in the safety of maternal vaccination in general, or whether women believe the pertussis vaccine is safer than influenza vaccine, is unclear, and further data is required to determine if safety concerns will decrease with time as appeared to be the case with influenza vaccine. Regardless, the importance of confidence in vaccine safety as a driver of maternal vaccination in Australia is illustrated in Taksdal's study, where belief in the safety of maternal influenza vaccine was the strongest predictor of uptake, with an adjusted odds ratio of 21.6 (95% CI 2.85–163.8).[135]

Lack of healthcare provider recommendation

Healthcare provider recommendation is the most consistently reported factor driving maternal pertussis vaccination in international studies.[25,29-31,115,143,147] Healthcare provider recommendation was associated with 3.5-fold increased odds (95% CI 1.6–7.8) of being vaccinated in an Irish study[30] and was cited by 79–84% of women in studies from the UK and New Zealand as a reason for receiving vaccination.[29,143] Conversely, a lack of healthcare provider recommendation is frequently cited by women as reason for not receiving vaccination during pregnancy,[16,25,26,31,115,116,142,143,147] suggesting women are not reluctant to be vaccinated but rely on their healthcare provider to advise of what is required during pregnancy. A lack of healthcare provider recommendation is cited by up to 50% of unvaccinated women in some studies.[16,25,142]

One Australian study has reported on the influence of healthcare provider recommendation on uptake of maternal pertussis vaccine.[125] In interviews with 400 Aboriginal and Torres Strait Islander women in Western Australia, women who had received a recommendation by their healthcare provider were 13 times more likely (odds ratio 13.3, 95% CI 4.6–38.0) to receive the vaccine.[125] The significance of healthcare provider recommendation has also been borne out in numerous studies of Australian women's reasons for both maternal influenza,[32,33,125,130,132-136,139,149] and post-partum pertussis vaccination.[132,137-139] The strength of this association is

demonstrated in three studies where women were between seven and 42 times more likely to receive either influenza vaccination or post-partum pertussis vaccination if they had received a healthcare recommendation.[130,134,138]

Access to vaccines

Surveys of women from the US and New Zealand have suggested that limited access to vaccination services within maternity care is a barrier to uptake.[27,29,147] In a study by Hill et al. in New Zealand, of the women who had been vaccinated, 43% reported the fact that the vaccine was free and available as one of the reasons they received it.[29] In the same study, 22% of those who had not been vaccinated reported it was due to the inconvenience of attending another practice to access it.[29]

In terms of Australian data, in a recent study by Danchin et al., the most commonly reported barrier to uptake of maternal pertussis vaccination was not having access to vaccines in the antenatal clinic, although this was only reported by 12% of women.[124] Similarly, two studies have reported access as a barrier to uptake of post-partum pertussis vaccine but were again reported by only a small proportion of unvaccinated women (7%, 17%).[44,132] In a qualitative study of more than 100 women in New South Wales, Wiley and colleagues noted that women perceived vaccination as just one of many things that needed to be considered during pregnancy.[164]

1.4.2 Healthcare provider–related factors

Despite the importance of healthcare provider recommendation in women's decision-making about maternal vaccination less research has focused on understanding the barriers and facilitators of healthcare provider recommendation and provision of vaccination than of consumer-related attitudes towards maternal vaccination.

Nine studies of healthcare provider attitudes and practice with regards to maternal pertussis vaccination are included in this review of the international literature.[16,150-155,165,166] All but two also explored attitudes to influenza vaccine.[16,150-152,154,155,165] Four of the nine studies were conducted in the US,[151,155,165,166] while each of the remaining five were conducted in different countries. The majority surveyed a combination of provider groups with three comparing obstetricians, GPs or midwives without

combining these groups or including other provider groups such as hospital doctors, health assistants or nurses.[16,154,155] In total, seven surveys of obstetricians,[16,151,152,154,155,165,166] five of GPs[16,151-153,155] and four of midwives[16,150,154,155] are included in this review.

As there have only been three Australian studies published on healthcare provider attitudes and practice, these are discussed individually at the end of this section on healthcare provider–related factors.

Rates of healthcare provider recommendation

When examining rates of healthcare provider recommendation, it is important to consider that studies rely on providers' self-reporting of routine practice and may therefore overestimate provider recommendation. Supporting this, studies that have examined women and provider attitudes simultaneously have found that more healthcare providers report recommending maternal vaccinations than women recall receiving a recommendation.[129,151,167]

Five international studies of maternal pertussis vaccination have described providers' self-reported rates of recommendation.[16,151,153-155] In all but one study, obstetricians and GPs reported high rates of recommendation (78–100%).[16,151,154,155] The exception was a study of 109 GPs in Ireland where only 54% reported routinely recommending pertussis vaccination.[153] Notably in this study a larger proportion of GPs had safety concerns than reported in other studies.[153] In two of the three studies comparing provider groups, midwives were less likely to report recommending maternal pertussis vaccination (24% and 42%).[16,155] However, in the third study in Spain, 98% of midwives reported recommending pertussis vaccination according to guidelines compared to 96% of obstetricians.[154]

The following section presents an overview of the factors reported to influence healthcare provider recommendation of maternal pertussis vaccine.

Awareness of pertussis recommendations

Most studies have demonstrated high awareness of pertussis recommendations amongst maternity care providers.[16,150-152,154,155] The same three studies that examined rates of pertussis recommendation by provider group, also examined awareness of pertussis guidelines.[16,154,155] Again the Belgian and American studies found midwives were less likely to be aware of pertussis recommendations (70% and 24%) than obstetricians (100% and 97%) or GPs (92% and 100%) while the Spanish study found no difference (98.5% recommendation overall).[16,154,155]

While being aware of guidelines does not necessarily translate into recommendation,[16,152] in their study of 133 obstetric providers predominantly in private practice in the US, Bonville et al. found that knowledge of the guideline was the factor most strongly associated with recommendation (odds ratio 23.3, 95% CI 4.6–118.9).[151]

Concerns about safety

Personal beliefs about the safety of vaccination during pregnancy may also influence a healthcare provider's likelihood of recommending it. While several studies have reported on maternity care provider beliefs,[150,151,153-155,165] only few have examined whether these safety concerns affect either recommendation[153,154] or provision of vaccination.[151,155]

Three studies among different provider groups in different countries suggest that concerns about safety may vary considerably.[150,151,153] In Bonville's study in the US only 13% of providers did not believe "pertussis vaccine is safe for pregnant women", however this is substantially higher than the 3% of providers who had concerns about influenza vaccine.[151] In contrast, Vishram et al. found that midwives were equally concerned about the safety of pertussis and influenza vaccines but the rate was still relatively low (9%).[150] However, the final study of 109 GPs in Ireland in 2015–16 reported that 44% had concerns about the safety of pertussis vacciation.[153]

Two studies have examined whether safety concerns are associated with provider recommendation of pertussis vaccine.[153,154] Vilca and colleagues surveyed 194

midwives and obstetricians in Spain in 2014.[154] The most commonly reported barrier to recommending vaccination was concern about adverse events (31/121, 26%) with 31% of midwives and 10% of obstetricians who did not recommend pertussis vaccine expressing this concern.[154] In O'Connell's survey of Irish GPs, those with concerns about the short- and long-term safety of the vaccine, concerns that the vaccine was not licensed for use in pregnancy, or those who felt women might associate any adverse pregnancy outcome with the vaccine, were less likely to recommend it.[153] These GPs accounted for 81% of those who did not recommend vaccination.[153]

Personal vaccination status

Two studies have reported an association between providers being personally vaccinated against influenza and them recommending influenza vaccination for their pregnant patients.[151,154] Providers who reported annual influenza vaccination were nearly four times more likely (adjusted odds ratio 3.7, 95% CI 1.3–13.2) to recommend influenza vaccine to pregnant patients in Vilca's study in Spain and eight times more likely (odds ratio 8.4, 95% CI 1.5–45.4) in Bonville's study in the US.[151,154]

Unlike for influenza vaccine most studies have not asked providers about their personal pertussis vaccination status. The only study to have done so is a Belgian study which reported no association between personal pertussis vaccination status and recommendation.[16] One other study has reported on the association between personal influenza vaccination status and recommendation of pertussis vaccine.[150] This study of midwives in the UK found that midwives who had received influenza vaccination themselves were more likely to recommend both influenza (odds ratio 1.7, 95% CI 1.7–2.3) and pertussis (odds ratio 1.7, 95% CI 1.3–2.9) vaccines.[150]

Vaccination not perceived as their role

Models of maternity care vary significantly between different countries and may be provided by a range of healthcare providers including GPs, obstetricians and midwives. This may lead to some uncertainty about whose role it is to discuss, recommend and provide vaccination.

Unlike for GPs, immunisation has not traditionally been considered part of the core skill set of obstetricians or midwives. Ishola and colleagues surveyed midwives in the UK in 2011 and found that while 76% agreed they should advise women on vaccination only 28% wanted to be immunisers with the remaining 82% believing GPs should have that role.[156] Likewise in a study of all three provider groups (obstetricians, midwives and GPs) in the US in 2011, 29% believed it was not their role to provide vaccines.[155] However, in a more recent survey of obstetricians and midwives in Spain in 2014, 82% of obstetricians and 70% of midwives believed they should provide vaccinations for women.[154]

Australian studies of maternity care providers

Given that the recommendation for pertussis vaccination is relatively recent, there have not been any Australian studies published of provider attitudes to maternal pertussis vaccination. However, some insights may be gained from the studies of maternity care provider attitudes to maternal influenza vaccination. The three published studies are discussed below.[129,157,158]

The first study, conducted in 2011, was a survey of 36 obstetricians and 60 midwives at a single tertiary obstetric centre in Melbourne.[129] Eighty-one percent of obstetricians and 68% of midwives reported recommending influenza vaccination to pregnant women, with those who had been vaccinated themselves twice as likely to recommend the vaccine (relative risk 2.0, 95% CI 1.3–3.0).[129]

The second was a qualitative study of 17 GPs in Sydney in 2012.[157] The majority were aware of the guidelines and two-thirds reported recommending influenza vaccine to pregnant women. Providers who perceived influenza as a severe disease in pregnancy, who were confident in their own vaccine knowledge, including regarding the safety of the vaccine, and who placed trust in the health department's endorsement of the vaccine, were more likely to recommend the vaccine. However, more than half of the GPs had safety concerns, and those who did were more likely to view vaccination as a woman's personal choice rather than making a strong recommendation themselves.[157]

The third study was again qualitative and surveyed 15 obstetricians, midwives and GPs working in a tertiary maternity centre in South Australia in 2012.[158] The majority of providers were aware of the recommendation for influenza vaccination but the recommendation for cocooning was not as well known, particularly amongst midwives. Healthcare provider recommendation was reported as "inconsistent". Unlike the previous study, providers did not report safety concerns. Rather, their attitude towards both vaccines was shaped by their professional experience of severe influenza in their pregnant patients, and their own experience of pertussis infection. However, as in the study above, the endorsement by the health department gave them confidence to recommend vaccination. Providers also reported that when multiple providers are involved it is unclear who has responsibility for vaccination.[158]

Given the recommendation for pertussis and possibility of further maternal vaccinations in the future, further studies are required to assess provider attitudes to maternal vaccination in Australia. The available data suggests that improving uptake of maternal vaccination requires obstetricians and midwives to be reassured of the safety and effectiveness of maternal pertussis vaccination, and to perceive themselves as immunisers.

1.4.3 Systems-related factors

Unlike the previous two sections, in this part of the review the majority of data comes from research into strategies to improve uptake of maternal influenza vaccination as very little has been published in relation to maternal pertussis vaccine.

Three review articles including two systematic reviews have looked at various interventions to increase uptake of maternal vaccination.[128,160,168] The most recent systematic review by Bisset, published in 2018, examined strategies to improve uptake of maternal vaccination in high-income countries with a view to informing improvements in the implementation strategy in the UK.[160] Twenty-two studies were included, nine of which were randomised controlled trials and 13 observational studies. Eighteen of the 22 studies related to influenza vaccination and all four studies of pertussis were conducted in the US. Seven of the 13 observational studies assessed multi-modal interventions and so the effectiveness of any individual strategy was

difficult to establish. While none of the studies were determined to be of high quality, the strategies that were demonstrated to be effective included provision of education for healthcare providers and women, including reminders or alerts within antenatal records, and systems to enable midwife administration of vaccination within antenatal services. Text messages sent to women with educational messaging and to serve as a reminder were not found to be effective in three randomised controlled trials.[160]

Providing education for women

As outlined in the previous section, women's' lack of knowledge about influenza and pertussis, and concerns about the safety and efficacy of the vaccines are common barriers to uptake of maternal vaccines. Educating women and their communities is therefore an important step to overcoming these barriers.

Studies using different educational tools have had mixed results. Of four studies of written educational materials,[159,169-171] two were associated with increased uptake of maternal influenza vaccination.[169,171] Furthermore, in the randomised controlled trial using educational pamphlets by Meharry et al., in addition to increased uptake of influenza vaccination, women also better understood the benefit for their baby and the intervention reduced the time healthcare providers required to counsel women about vaccination.[169] Five studies have utilised text messages to provide education and reminders about influenza vaccine.[172-176] The four randomised controlled trials demonstrated no significant effect on uptake,[172,173,175,176] but the most recent study, published in 2017, using an opt-in model, was associated with an up to three-fold increase in uptake of influenza vaccine.[174] Neither of the two randomised controlled trials of video messaging increased uptake,[25,177] but in one trial messaging did affect health beliefs.[177] O'Leary et al. demonstrated no effect on uptake of either influenza or pertussis vaccine with use of interactive social media embedded in a website.[178]

Women have reported that they obtain information about maternal vaccines from a variety of sources apart from their healthcare providers.[83,140,141,143,179] These include informal networks, radio, television, the internet and social media.[83,140,141,143,179] Facebook sites such as "Light for Riley", about the death of an infant in Western

Australia from pertussis, which has more than 100 000 followers, highlights the reach of social media.[180] A study by Ellingson et al. in the US specifically explored women's preferences for receiving information about maternal vaccines. They reported that more than 50% of women used the Centers for Disease Control or pregnancy-related websites, however, preferences for how women received information varied by ethnicity, age and education.[140] Demonstrating these different preferences, in contrast to Ellingson's study population, a qualitative study by Wiley et al. of 132 Australian women found that women preferred to receive information about maternal influenza vaccination from the "system" (i.e. healthcare providers, their healthcare institution or health department) rather than from the internet.[164]

These studies highlight that a one size fits all approach to educating pregnant women is unlikely to have broad enough reach to improve uptake on its own.

Providing education to healthcare providers

As outlined in the previous section, if providers are aware of recommendations, believe they are endorsed by appropriate health authorities, and are reassured of the safety and efficacy of maternal vaccination, they are more likely to recommend vaccination.

Feeling inadequately trained in immunisation has been reported by healthcare providers as a barrier to recommending and providing vaccination.[154,156] A study of midwives in London in 2011 found that only a quarter felt well-prepared to discuss influenza vaccination with pregnant women.[156] Another study of UK midwives in 2015 reported that only 38% had undergone immunisation training but those who had were more confident advising women about vaccination.[150] Studies of obstetricians also suggest that those who are more knowledgeable about the vaccines are more likely to recommend and provide vaccination.[150,151,153,154] Unlike for GPs, immunisation has not been a core component of midwifery or obstetric practice. It has been suggested that midwifery and obstetric training should be reviewed to include competency in immunisation, and that more concerted efforts are needed to provide training and education to these two target groups.[128,156]

One of the challenges with guideline and practice change is communicating these changes to the target healthcare provider groups. Professional bodies have a role in endorsing and disseminating guidelines and education, providing training and communicating practice changes. The American College of Obstetricians and Gynecologists has put together many useful resources to assist obstetricians in discussing and providing vaccination.[181,182] Likewise, the Royal College of Midwives has been actively engaged with Public Health England to provide immunisation training in the UK.[83] In a study by Webb et al. in South Australia, the guidelines and resources used by maternity care providers frequently did not contain information about vaccination recommendations, and the information that was provided varied between resources.[158] Furthermore, the recommended resource for vaccination in Australia, the "Australian Immunisation Handbook", was perceived by maternity care providers more as a resource for information on childhood immunisation than maternal vaccination.[158] The same study by Webb et al. also reported unequal dissemination of information by health authorities to be an issue.[158] GPs in that study reported receiving updates from public health authorities about maternal vaccination but the same information was not received by maternity care providers working in hospital settings.[158] It is important that all providers involved in the discussion and delivery of maternal immunisation have access to consistent, evidence-based resources that address the current guidelines, vaccine safety and efficacy in particular.

Integrating vaccination policy and procedures into routine maternity care

Evidence suggests that maternal vaccination programs are more likely to be successful if vaccination is integrated into routine pregnancy care.[128,158,160,181] This encompasses incorporation into national and local policies, hospital protocols, documentation in pregnancy records, and use of alerts and immunisation registers. Webb and colleagues surveyed maternity care providers in South Australia.[158] They reported that the most significant barrier to maternal vaccination was that it had not been incorporated into routine maternity care.[158] They noted that for rhesus (D) immunoglobulin and post-partum rubella vaccination the policies, procedures and documentation were embedded in maternity care resources and guidelines and

therefore were considered standard of care, which in turn facilitated high compliance.[158]

Although becoming less common in Australia, many maternity care services still use paper-based antenatal records. The national antenatal record includes a field for influenza but not pertussis vaccination and it has been left to individual services whether they modify this record to include a place for documenting pertussis immunisation.[158] The pregnancy record should ideally have capacity for documentation of when vaccination has been discussed, information provided and finally when vaccination has been given. In addition, the post-partum section of the pregnancy record should also have a reminder for providers to confirm maternal vaccination status so the cocooning strategy can be discussed and offered to mothers who were not vaccinated against pertussis during pregnancy.

Prompts exist within antenatal records to remind providers to discuss breastfeeding, smoking cessation, and check rubella and anti-D status.[158] With paper-based antenatal records there is no automated way of including a prompt to remind providers about maternal vaccinations. However, one study that incorporated a reminder placed into the paper medical chart had two important outcomes: firstly, coverage increased from 15% to 52%; and secondly, the difference in uptake between women from differing cultural and linguistic backgrounds disappeared so that all women had equivalent uptake.[183] In the era of electronic health records capacity for automation make alerts or reminders an even more attractive strategy to increase coverage of maternal vaccination. Two studies have demonstrated increased coverage (one of influenza and the other pertussis) with electronic alerts.[161,184]

In addition to traditional immunisation providers, maternity care providers and pharmacists are now also vaccinating pregnant women in many countries.[147,185,186] Communication of vaccination status between providers is therefore becoming increasingly complex and highlights the importance of all providers having access to centralised immunisation registers.[128] In Australia, GPs and pharmacists have access to the Australian Immunisation Register (AIR) but obstetricians and midwives do not. In addition, electronic health information systems used in maternity care are not currently linked with the AIR. Thus maternity care providers cannot easily assess and

record vaccination history in this central repository, nor is it a requirement for them to do so. If integration of vaccination within routine maternity care is to be encouraged then access to the AIR and compatibility of health information systems needs to be considered.

Providing vaccination onsite

As primary providers of population-level vaccination in many countries, GPs are well versed in discussing immunisation and often have a well-established capacity to store and administer vaccines in their clinics.[83,158] The relative success of the maternal pertussis program in the UK has at least in part been attributed to the fact that antenatal care is generally provided by GPs and women can therefore obtain vaccinations during routine care from their antenatal care provider.[83] However, in Australia and the US, midwives or obstetricians are often the only healthcare providers women consult during pregnancy. As has been previously presented, for these women the additional step of consulting an additional provider to get vaccinated is an unnecessary barrier.[27,29,124,147]

Studies have demonstrated increased coverage with use of an immunisation nurse within antenatal clinics,[135,187] and a standing order for midwife administration of vaccination without the need for a doctor's review and prescription.[162,163] Each service needs to assess which model meets their requirements within financial and resource limitations, but endeavours should be made wherever possible.

The US Advisory Committee on Immunization Practices has recommended the use of standing orders to improve immunisation rates for more than a decade and the American College of Obstetricians and Gynecologists has endorsed this.[181,188] Ogburn and colleagues were the first to report the benefit of using standing orders to increase coverage of maternal influenza vaccination.[162] This was a retrospective study conducted over three influenza seasons (2002–2005) in a university-affiliated women's health clinic in the US. In the 2003–2004 influenza season they conducted education sessions for maternity care providers and made influenza vaccine available within the clinic with a protocol for nurses to screen pregnant women for the vaccine. Coverage of influenza vaccination during pregnancy was ascertained from review of a

random selection of patient records and increased from 0.5% in 2002–2003 to 3%. In the subsequent influenza season they introduced standing orders and coverage increased to 37%.[162] The authors note that US guidelines were revised in 2004 to recommend influenza vaccination at any gestation and this simplification of vaccination recommendations may have contributed in part to improved coverage. Regardless, the study highlights education and availability of vaccine without protocols and procedures for administration are unlikely to be successful.[162]

Subsequently, three studies in the US and one in Canada, all conducted when cocooning was the recommended strategy, demonstrated significant improvements in coverage of post-partum pertussis vaccine with use of standing orders (from 75% to 91%, 0% to 69%, 5% to 47% and 55% to 73%).[53,189-191] In one study that included a control hospital (vaccination at provider's discretion), vaccination rates increased from 0% to 69% where standing orders were introduced and remained 0% at the control hospital.[189] It is important to note that all of these studies included education of healthcare providers at the time of introducing standing orders and while this may be a confounder, the improvements are nonetheless impressive. These studies are good examples of standing order interventions to increase compliance with recommendations in the maternity setting; however, the challenges to vaccinating women in the postnatal setting are different to antenatally and therefore studies in the antenatal setting are needed.

Several Australian studies have also reported improved coverage of maternal influenza or post-partum pertussis vaccination with onsite vaccination.[134,135,137] Wiley et al. reported influenza vaccine coverage of 46% when vaccination was available onsite compared to 27% overall in their cohort.[134] In another study, women were nearly three times more likely to receive influenza vaccine when onsite vaccination was offered at their antenatal care facility compared to those who had to get the vaccine elsewhere (adjusted odds ratio 2.7, 95% CI 1.1–6.9).[135] Finally, in the setting of the cocooning strategy, Hayles et al. reported that coverage increased from 23% to 70% with provision of pertussis vaccine on the maternity ward prior to discharge.[137]

1.5 Summary

While the safety and efficacy of maternal pertussis vaccination has been demonstrated, specific questions remain about the optimal timing of vaccination, and the safety of repeated vaccinations. Given the variability in vaccine coverage but also in consumer-related, healthcare-related and systems-related barriers in different contexts, Australian data is required to inform local programs. The limited data available from Australia suggests coverage of maternal pertussis vaccination is higher than influenza vaccination, however, there appears to be significant variability. There is also limited Australian data on pregnant women's and maternity care providers' attitudes to and knowledge of pertussis vaccination during pregnancy, and of the barriers to provision of pertussis vaccination within maternity services.

This thesis seeks to understand the barriers and facilitators of uptake of maternal pertussis vaccination at the consumer, healthcare provider and systems levels in Victoria, Australia. Six studies were conducted to achieve this aim, three exploring consumer-related factors, two healthcare-related factors, and one examining different models of immunisation service delivery. The remainder of this chapter outlines the hypotheses and aims of these six studies.

1.6 Hypotheses and aims

Hypotheses

Consumer-related

1. Uptake of pertussis vaccination during pregnancy is affected by a woman's demographics, health literacy, and knowledge of the indications for and safety of pertussis vaccine
2. Healthcare provider recommendation is the most influential factor in vaccine uptake
3. Partners of pregnant women are less likely to be vaccinated as part of a cocooning strategy when pregnant women receive pertussis vaccination during pregnancy

Healthcare provider–related

1. Healthcare provider recommendation is influenced by awareness of guidelines, and personal beliefs about the safety and efficacy of maternal vaccination
2. There is a lack of clarity about whose role it is to discuss and recommend vaccination to pregnant women when multiple providers are involved in their care
3. Vaccination has been more widely incorporated into public hospital maternity care services than by obstetricians in private rooms
4. Pharmacists perceive benefits to providing vaccination onsite to clients
5. Pharmacists are less comfortable providing vaccine advice and administering vaccines to pregnant women than to non-pregnant adults

Systems-related

1. Onsite vaccination either through an immunisation service or standing orders improves uptake as vaccination can be delivered at the time of recommendation
2. A standing order model facilitating midwife administration of pertussis vaccine is well accepted, and improves uptake

Aims

Consumer-related

1. To assess uptake of pertussis vaccination during pregnancy and explore the facilitators of and barriers to uptake including in women from migrant and refugee backgrounds and Aboriginal and Torres Strait Islander women
2. To assess uptake of partner pertussis vaccination as part of the funded program in Victoria
3. To assess the theoretical risk for pertussis in newborns at the time of discharge from hospital based on pertussis vaccination uptake of household contacts

Healthcare provider–related

1. To examine the attitude, knowledge and practice of obstetricians, midwives and GPs and to explore differences between these groups with regards to maternal vaccination

2. To identify gaps related to division of responsibility for maternal vaccination
3. To identify barriers to recommending and providing vaccination within maternity care settings
4. To assess the attitudes, knowledge and practice of pharmacists with regards to vaccination and in particular maternal vaccination
5. To identify barriers to provision of vaccination services by pharmacists in Australia

Systems-related

1. To trial a standing order for midwife-led delivery of pertussis vaccine and compare with a walk-in immunisation service and delivery by primary care
2. To increase uptake of maternal pertussis vaccination

Chapter 2: Consumer uptake, attitude and knowledge of maternal vaccination

2.1 Introduction

In 2016, the Australian Immunisation Register, a whole of life immunisation register, was introduced, however it does not capture pregnancy status and therefore is currently of limited utility to measure coverage of maternal vaccinations. Therefore estimates of coverage have been obtained from state-based perinatal data collection registers and research settings. The available data suggests that coverage of influenza vaccination during pregnancy varies between 17% and 62%,[32-34,125,149] and pertussis 40% and 82%.[34,123-126]

Studies have demonstrated that women's attitudes towards vaccination have a significant impact on uptake of maternal influenza and pertussis vaccines internationally.[116-118,120,144,192] Likewise, the consumer-related barriers and facilitators of uptake of maternal influenza vaccination by women in Australia have been extensively reported.[32,33,129,130,132,133,135,136,139,164] However, they have not been studied in relation to maternal pertussis vaccination and whether these same factors have contributed to the suboptimal and highly variable coverage of maternal pertussis vaccination in Australia is unknown. Evaluating the coverage of the maternal pertussis program in Victoria and examining the barriers and facilitators of uptake was one aim of this thesis.

In 2016, one-third of Australians were born overseas. Studies suggest that women from migrant and refugee backgrounds may have poor maternal health compared to women born in Australia, and may also present later for antenatal care.[193,194] In addition, women not fluent in English have often been excluded from research on maternal vaccination in Australia.[32,43,137,139] Aboriginal and Torres Strait Islander women are another group who experience disparities in many health outcomes including maternal and neonatal outcomes.[194] In a report titled "Australia's health 2016" maternal mortality among Aboriginal and Torres Strait Islander women was twice that of other Australian women and their babies were more likely to be born

preterm.[194] Aboriginal and Torres Strait Islander peoples make up 2.8% of the Australian population and while the majority live in urban centres,[195] they are still poorly represented in studies conducted in urban hospital settings. Therefore, understanding the specific barriers to uptake of maternal vaccinations in these two groups of women was another aim of this research.

An extensive literature review is presented in Chapter 1 and is therefore not repeated in this chapter. However, below is a summary to highlight the knowledge gaps with regards to consumer-related barriers to maternal vaccination in Australia.

Studies of consumer-related factors associated with uptake of maternal vaccinations in Australia

The consumer-related factors associated with uptake of maternal pertussis vaccination in Australia had not been reported at the commencement of this thesis. Since this time, two studies have examined associations between consumer demographics, attitude, and knowledge and uptake of maternal pertussis vaccination.[34,125] One was a study of all women birthing in the Northern Territory and the other of Aboriginal women in Western Australia. In both studies uptake varied by geographical location but not by any other consumer-related factors.[34,125] The generalisability of these studies to more urban, populous and multicultural settings in Australia is uncertain.

In terms of maternal influenza vaccination, the consumer-related factors in Australian studies have been similar to those reported internationally. The barriers have included lack of healthcare provider recommendation, perception of being at low risk of acquiring influenza infection, lack of concern about the severity of influenza during pregnancy, concerns about vaccine safety, and access to vaccination.[32,33,129,130,132,134-136] Healthcare provider recommendation has consistently been demonstrated to be the strongest driver of vaccine uptake.[33,130,132,134,136]

(i) Studies specifically in women from migrant and refugee backgrounds

No Australian studies have reported on uptake of antenatal pertussis vaccination by ethnicity. None of the four studies that have reported on uptake of antenatal influenza

vaccination found any difference in uptake of influenza vaccine by ethnicity,[129,130,132,134] however the two studies of post-partum pertussis vaccination reported that women who spoke English as a first language were more likely than those who did not, to receive post-partum pertussis vaccination in accordance with the guidelines at the time.[132,137] All of these studies reported uptake as the primary outcome rather than examining differences in attitude, knowledge or the influence of healthcare factors such as provider recommendation. Addressing these knowledge gaps informed the first study in this chapter, "*Understanding the barriers to uptake of antenatal vaccination by women from culturally and linguistically diverse backgrounds: A cross-sectional study.*"

(ii) Studies in Aboriginal and Torres Strait Islander women

At the commencement of this thesis, one study had been published on uptake of maternal vaccination (influenza only) by Aboriginal and Torres Strait Islander women.[149] This pilot study of 53 Aboriginal and Torres Strait Islander women in Queensland reported maternal influenza coverage of 17%.[149] Almost all women had knowledge of influenza vaccine, and 49% knew it was recommended in pregnancy but only 40% recalled a healthcare provider recommendation for vaccination. Uptake was higher (22%) among women who received a recommendation. Less than a third of women believed vaccination would prevent them or their baby acquiring influenza.[149]

Since commencing the thesis, three further studies of uptake of maternal vaccination (influenza and pertussis) among Aboriginal and Torres Strait Islander women have been published.[34,125,196] The first was conducted from 2006 to 2011 in the Northern Territory, and reported that coverage of influenza vaccination increased from 2.2% prior to the recommendation for maternal influenza vaccination to 41% in the intra-pandemic period.[196] This study also assessed self-reported vaccination status, which was found to be a poor predictor of vaccination status (compared to the Northern Territory Immunisation Register) prior to the pandemic in 2009 but a reliable predictor in the intra-pandemic period.[196]

The second study comprising 1304 Aboriginal and Torres Strait Islander and 2034 non-Aboriginal women birthing in the Northern Territory in 2015, reported coverage

of influenza vaccination of 64% among Aboriginal and Torres Strait Islander women compared with 23% in non-Aboriginal women ($p < 0.001$).[34] In this study, coverage varied significantly by geographical location. The authors of this study also examined pertussis coverage (22%), which did not vary by Aboriginality but again varied geographically.[34] This study was conducted shortly after the recommendation for pertussis vaccination in Australia, and coverage did improve over the course of the year to approach 40%.[34] These findings highlight that access to healthcare and the systems for delivering maternal vaccinations are likely to affect uptake independent of Aboriginality.

The final study by Lotter and colleagues interviewed 100 Aboriginal and Torres Strait Islander women in Western Australia again in 2015.[125] Two-thirds of women recalled a healthcare provider recommendation for both vaccines and the same number reported receiving both vaccines. Living remotely was associated with increased uptake of both vaccines but the strongest association was with receiving a healthcare provider recommendation (odds ratio 13.3, 95% CI 4.6–37.9 for pertussis and odds ratio 15.6, 95% CI 4.9–49.5 for influenza). Similar to studies in non-Aboriginal women, the most common reason for vaccination was to protect the baby (reported by 95% of vaccinated women for pertussis and 97% for influenza), and lack of healthcare provider recommendation was the most common reason for non-vaccination (reported by 35% of unvaccinated women for pertussis and 49% for influenza).[125]

The second study in this chapter, "*Uptake of maternal vaccinations by Indigenous women in Central Australia",* addresses some of the remaining knowledge gaps regarding maternal vaccination in Aboriginal women, including (i) What is the current coverage of pertussis and influenza vaccines among Aboriginal women in Central Australia and has this changed since the published studies from 2015? (ii) Has the validity of self-reported influenza vaccination status remained high since the pandemic?

2.2 Hypotheses and aims

Hypotheses

1. Uptake of pertussis vaccination during pregnancy is affected by a woman's awareness of recommendations, and belief in the safety of the vaccine
2. Uptake of maternal vaccinations is likely to be lower among women from refugee and migrant backgrounds due to poor health literacy and systemic barriers to accessing culturally appropriate healthcare
3. Uptake of maternal vaccinations is likely to be lower among Aboriginal and Torres Strait Islander women due to poor health literacy and systemic barriers to accessing culturally appropriate healthcare
4. Healthcare provider recommendation is the most influential factor in vaccine uptake
5. Self-reported uptake of maternal vaccines among Aboriginal and Torres Strait Islander women is not a reliable estimate

Aims

1. To assess uptake of pertussis vaccination during pregnancy
2. To examine attitude and knowledge of maternal immunisation in pregnant women including women from migrant and refugee backgrounds
3. To examine uptake, attitude and knowledge of maternal immunisation in Aboriginal and Torres Strait Islander women in Central Australia
4. To examine the influence of healthcare provider recommendation in women's decision-making around maternal vaccinations
5. To assess validity of self-reported vaccination status amongst Aboriginal and Torres Strait Islander women compared to the Northern Territory Immunisation Register

2.3 Methods

Understanding the barriers to uptake of antenatal vaccination by women from culturally and linguistically diverse backgrounds: A cross-sectional study

This study was conducted at Monash Health, Melbourne, Australia. Monash Health is the largest hospital network and largest provider of maternity services in the state of Victoria, providing maternity services to approximately 10 000 women annually across three hospitals. Monash Health services a community where more than 50% of residents are born overseas, predominantly from Asia, Sub-Saharan Africa and increasingly Central Asia and the Middle East.[197] All three hospitals are part of the same department and covered by the same maternity care policies and the same schedule of antenatal visits determined by the model of care. All three hospitals provide general practitioner- or midwife-led care for low risk pregnancies. In addition, high risk pregnancies can be managed at two of the three hospitals (hospitals A and B) provided by obstetrician-led care. The largest maternity service (hospital A) is a tertiary obstetric referral centre with an onsite immunisation service. The second hospital (hospital B) provides primary and secondary level maternity care to a large migrant and refugee population with approximately 2500–3000 deliveries per annum. During the course of this study a standing order for midwife administration of pertussis vaccination within the antenatal clinic was introduced. The third hospital (hospital C) provides primary and secondary level maternity care for approximately 2000–3000 women each year and women are primarily referred to their GP for vaccination.

A questionnaire examining maternal uptake, attitudes and knowledge of both influenza and pertussis vaccines was developed. The questionnaire is included in Appendix 4. The questionnaire was subsequently translated into the three most common languages (Dari, Vietnamese, Mandarin) for which interpreting services are utilised within maternity care services at Monash Health. Interpreters were also engaged when available. The questionnaire was available in electronic form using the SurveyMonkey platform or in paper copy.

Women attending for antenatal care at the three maternity care sites of Monash Health were invited to complete the questionnaire either online on an iPad or in paper copy while awaiting their antenatal appointment after verbal consent was obtained. Questionnaires completed in hard copy were subsequently entered onto SurveyMonkey by the principal researcher or the research midwife.

Questionnaire data was extracted from SurveyMonkey for statistical analysis, which was performed using Stata for Windows 14.2 (College Station, Texas). Differences between proportions was determined using Fisher's exact or Pearson chi-square tests. Standard logistic regression models were used with vaccination status as the independent variable. Initially, univariate models were used to explore the association between patient factors and vaccination status. Variables for the multivariate model were selected on the basis of the plausibility of their relationship to vaccination status and their relationship to the primary research question of the relationship between demographics, knowledge and healthcare provider recommendation of vaccination and uptake. Stepwise selection processes were not used in line with conventional statistical practice. Statistical significance was defined as $p < 0.05$.

Ethics approval for this study was obtained from the Monash Health Human Research Ethics Committee Low Risk Review panel and the Monash University Human Research Ethics Committee.

Uptake of maternal vaccinations by Indigenous women in Central Australia

This study was conducted in Alice Springs, Northern Territory, Australia. Alice Springs is the largest town in a region of more than 900 000 square kilometres known as Central Australia. While Aboriginal and Torres Strait Islander people constitute 2.8% of the population in Australia overall, more than 25% of the population of the Northern Territory identify as Aboriginal.[198] Alice Springs itself has a population of approximately 40 000 and is surrounded by communities of between 50 and 1000 people usually living on ancestral lands and where Aboriginal people comprise 90% of the population.[199]

In Central Australia, women may receive antenatal care either in their community from midwives and/or remote area nurses, or in the towns of Alice Springs or Tennant Creek through hospital-based maternity services, shared care general practitioners, midwifery group practices or Aboriginal Community Controlled Health Organisations. However, almost all women deliver in Alice Springs Hospital and it was therefore more practical to survey women post-partum on the maternity ward. The Northern Territory unlike the rest of Australia has had a whole of life immunisation register since 1991 and this enabled comparison of self-reported and documented vaccination status.[200] While not mandatory, immunisation providers are encouraged to enter all vaccination administered to any adult or child in the Northern Territory. Immunisations delivered in primary care are directly exported to the register. Those given by other providers must be manually entered onto the register which usually occurs within two to three weeks (personal communication).

A questionnaire examining uptake, attitudes and knowledge of both influenza and pertussis vaccines was developed. The questionnaire is included in Appendix 5.

Women admitted on the maternity ward following delivery of a healthy infant were invited to participate. Women were included if they had a sufficient level of verbal English language fluency to provide informed consent and complete the survey as judged by the researcher and an independent person who witnessed the consent process. The questionnaires were not administered with an interpreter or an Aboriginal Health Worker. The researcher completed the questionnaire in hard copy and the questionnaires were subsequently entered onto SurveyMonkey by the principal researcher or research midwife. In addition, permission was sought to access each woman's vaccination history in the Northern Territory Immunisation Register. This was completed by the same researcher administering the survey. While pregnancy status is not recorded in the register, whether vaccination occurred during pregnancy was able to be determined by knowledge of gestational age at delivery.

Questionnaire data was extracted from SurveyMonkey. Statistical analysis was performed using IBM SPSS Statistics version 22.0 (Armonk, New York). Differences between proportions was determined using Fisher's exact or Pearson chi-square tests. Univariable logistic regression was used to determine factors associated with uptake

of vaccines. Statistical significance was defined as $p < 0.05$. Cohen's kappa coefficient was used to correlate accuracy of self-report with the immunisation register.

Ethics approval for this study was obtained from the Central Australian Human Research and Ethics Committee.

2.4 Findings

The two published papers are included at the end of this chapter where the results are presented in detail. The key findings are outlined below.

Understanding the barriers to uptake of antenatal vaccination by women from culturally and linguistically diverse backgrounds: A cross-sectional study

- Women born overseas were less likely to have heard of pertussis vaccine, believe pertussis vaccine to be safe during pregnancy, and recall a healthcare provider recommendation for pertussis vaccine.
- There was no difference in uptake of pertussis or influenza vaccines between women born in Australia or overseas.
- Healthcare provider recommendation was the only factor associated with uptake of both vaccines on multivariable analysis, with women who received a recommendation 10 times more likely to receive pertussis and 30 times more likely to receive influenza vaccine.

Uptake of maternal vaccinations by Indigenous women in Central Australia

- Uptake of influenza and pertussis vaccines among Aboriginal women was higher than in earlier studies and comparable to studies in non-Aboriginal women living in Australia.
- Contrary to studies in non-Aboriginal women living in Australia, awareness and uptake of pertussis vaccination was lower than influenza vaccination.
- Self-reported vaccination status significantly underestimated uptake of both vaccines as recorded in the Northern Territory Immunisation Register.

In both studies the most commonly reported motivation for vaccination was to protect the baby and lack of healthcare provider recommendation was the most commonly cited reason for non-vaccination. These studies highlight the crucial role of healthcare providers in recommending and discussing vaccination with pregnant women and demonstrated that when women from migrant and refugee backgrounds are aware of vaccine recommendations and are reassured of the safety, uptake is high.

2.5 Limitations

Understanding the barriers to uptake of antenatal vaccination by women from culturally and linguistically diverse backgrounds: A cross-sectional study

- This was a single centre study in a metropolitan university-affiliated healthcare network, women were well-educated and 50% were employed and therefore results may not be generalisable to other contexts even within Australia.
- Women from a diverse range of countries of birth were surveyed but therefore only a small number from any individual country were represented. This makes it difficult to make inferences about each country.
- We were unable to confirm self-reported uptake due to the large number of immunisation providers and lack of a state-wide immunisation register at the time of the study.
- Given that women of all gestations were surveyed, we included intention to be vaccinated, which may not equate with actually receiving vaccine and thereby may overestimate uptake.
- Although it is recommended that maternal vaccination is discussed at the first antenatal visit and therefore all women apart from those attending their first visit should have heard of the pertussis vaccine, this education may not always occur. By including women who were less than 28 weeks in the analysis of questions about having heard of or having received a recommendation for the pertussis vaccine, this may have biased the results to appear that fewer women have received education or a recommendation for the vaccine.

Uptake of maternal vaccinations by Indigenous women in Central Australia

- The major limitation was the small sample size, and the study therefore being underpowered to detect factors associated with uptake on multivariable analysis.
- This was a single-centre study with a high proportion of women from remote communities and speaking an Aboriginal language as their first language. Therefore our findings may not be generalisable to Aboriginal and Torres Strait Islander women from other Aboriginal groups, and living in urban settings.
- While all efforts were made to ensure women had sufficient English language proficiency to provide informed consent and understand the questionnaire, use of interpreters or Aboriginal Health Workers may have improved some women's understanding and therefore quality of data.
- Information on women who declined participation was not collected and therefore could any differences in attitudes between these groups could not be examined.
- The NT Immunisation Register requires immunisation providers to report vaccinations to the registry and therefore uptake may have been underestimated if women were vaccinated interstate, through their workplace, or were not reported to the registry. There can also at times be a two to three week delay in entry of data onto the registry from some providers which may have led to an underestimate of vaccine coverage.

2.6 Implications

We have found evidence to explain some of the factors behind suboptimal coverage of maternal pertussis vaccination. Both of these studies suggest women from these culturally and linguistically diverse backgrounds were less aware of pertussis vaccine than influenza but were accepting of both vaccines when recommended by their healthcare provider. Strategies to raise awareness of maternal pertussis recommendations amongst women from migrant and refugee and Aboriginal and Torres Strait Islander backgrounds need to be explored. Furthermore, discussions between women and their healthcare providers need to occur throughout pregnancy, be socioculturally appropriate, and allow women time and opportunities to discuss their specific concerns. As such a strong motivating factor, understanding the barriers

to healthcare provider recommendation is critical to improving uptake of maternal vaccination and is explored in Chapter 4.

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RESEARCH PAPER

Understanding the barriers to uptake of antenatal vaccination by women from culturally and linguistically diverse backgrounds: A cross-sectional study

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ABSTRACT

The role of maternal vaccination in reducing neonatal morbidity and mortality is expanding but uptake remains suboptimal. While the barriers to uptake have been well described, women from minority groups have not been well represented in previous studies. In this study we examine the facilitators and barriers to uptake of antenatal vaccination by women from culturally and linguistically diverse backgrounds in Melbourne, Australia. 537 women attending antenatal care completed a survey; 69% were born overseas. 63% had or intended to receive pertussis vaccine and 57% had or intended to receive influenza vaccine during their pregnancy. On multivariable analysis, predictors of uptake of pertussis vaccine were healthcare provider recommendation (OR 10, 95% CI 5–21, $p < 0.001$) and belief maternal pertussis vaccination is safe (OR 36, 95% CI 18–70, $p < 0.001$). For influenza vaccine, predictors of uptake were previous receipt of influenza vaccine (OR 8, 95% CI 5–15, $p < 0.001$) and healthcare provider recommendation (OR 30, 95% CI 16–56, $p < 0.001$). Lack of healthcare provider recommendation was the main reason for non-vaccination (17/46, 37%). While most women were aware of and intended to receive recommended vaccinations, recently arrived migrant women (resident in Australia for less than two years) were less likely to be aware of pertussis vaccine (15/22, 68% vs 452/513, 88%, p = 0.01) and less likely to believe it to be safe during pregnancy (4/22, 18% vs 299/514, 58%, $p < 0.001$). This highlights the important role of healthcare providers in recommending and educating women, particularly newly arrived migrant women, in their decisions about vaccination during pregnancy.

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Introduction

Vaccination of pregnant women to protect their newborns from infectious diseases is not a new strategy. Tetanus vaccination has been recommended to eliminate maternal and neonatal tetanus for more than 30 years.[1] The potential benefit of a maternal immunisation strategy has subsequently been recognised for other infections such as Bordetella pertussis and influenza virus, and in the future may include Group B streptococcus and respiratory syncytial virus.[2]

In recent years, maternal pertussis and influenza vaccination have been widely implemented in high-income countries. Pertussis vaccination during pregnancy using the adult combined diphtheria-tetanus-acellular pertussis vaccine (dTPa) has been demonstrated to reduce pertussis infections by 91% in infants less than three months of age,[3,4] and maternal influenza vaccination to reduce laboratory-confirmed influenza by two thirds in infants under six months of age.[5] In Australia, influenza vaccine has been funded for all pregnant women during the influenza season, irrespective of gestation, since 2010. Government funded maternal pertussis vaccination has been more recently introduced, with Victoria (the jurisdiction where this study took place) introducing this in 2015. National guidelines recommend maternal pertussis vaccination between 28 and 32 weeks in each pregnancy.[6]

Despite evidence supporting the effectiveness and safety of pertussis and influenza vaccination during pregnancy, uptake varies considerably with reported rates of 14–75% in the United States (US),[7-9] 30–60% in the United Kingdom (UK),[3,10-12] and 26–70% in series from Australia.[13-15]

Understanding the barriers and facilitators that contribute to such variability in uptake is central to implementing a successful and effective vaccination program. Most studies on women's attitudes toward maternal vaccination pertain to influenza vaccine given the recommendation for pertussis is more recent. In addition, women who did not converse or read in the dominant language have frequently been excluded from published studies. Of minority groups, the experiences of Black and Hispanic women in the US and UK have been described[11,16,17] but pertinent to the Australian context, the experiences of women from Asia and recently arrived migrants and refugees are not as well understood. In this study we aim to address these knowledge gaps by surveying women attending

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for pregnancy care in a public healthcare network known to service a culturally diverse population.

Results

Between September and December 2016, 537 surveys were completed. 370/537 (69%) women were born overseas from 62 different countries. The majority (275/370, 74%) of overseas-born women were from Asia; 161/370 (43.5%) from South Asia, 64/370 (17%) from Southeast Asia, 45/370 (12%) from East Asia. 31/370 (8%) women were born in New Zealand and the Pacific Islands and the remaining 69/370 overseas-born women hailed from various other regions. The most common countries of birth were India (71/537, 13%), Afghanistan (54/537, 10%), China (38/537, 7%), Vietnam (26/537, 5%), and New Zealand (18/537, 3%). The majority (209/370, 57%) of overseas-born women had lived in Australia for more than five years but 138/370 (37%) had resided in Australia for 2–5 years and 22/370 (6%) for less than 2 years. Eleven (2%) of women identified as Aboriginal or Torres Strait Islander.

342/537 (64%) of women spoke a language other than English (LOTE) at home with the most common languages being Dari, Mandarin, Punjabi, Vietnamese, Hindi, Khmer and Malayalam. These top seven languages accounted for 53% (180/342) of women speaking a LOTE. While only seven women (2%) elected to use translated surveys, one quarter (85/335) completed the survey using an interpreter.

Table 1 presents demographic and pregnancy characteristics of women by whether they were Australian- or overseas-born. Women born overseas tended to be older and more likely to have a university qualification. There was no difference however in employment status. In terms of the current pregnancy, Australian- and overseas-born women did not differ in terms of gravidity or gestation at the time of completing the survey (mean 29 weeks, SD 7). However there was a significant difference in the number of antenatal visits Australian-born and overseas-born women had prior to completing the survey. Of 167 Australian-born women 142 (85%) had had at least two prior visits, 17 (10%) 1–2 prior visits, and 8 (5%) no prior visits. In the 370 overseas-born women, 291 (79%) had had at least 2 prior visits, 74 (20%) 1–2 visits, and 5 (1%) none (p = 0.002).

Knowledge of antenatal vaccines

Overseas born women were significantly less likely to have heard of dTpa than Australian-born women (86% vs 93%, $p < 0.001$) (Table 1). Furthermore there was marked variation when explored by region of birth. Women from Cambodia (5/10, 50%), Pakistan (5/13, 38.5%), Sudan (4/12, 33%), and Afghanistan (16/54, 30%) were the least likely to have heard of dTpa. Women were significantly more likely to have heard of dTPa if they were older than 25 years (p = 0.004), spoke English as their first language ($p < 0.001$), had lived in Australia for more than two years (p = 0.01), if they had completed

Table 1. Participant characteristics.

Characteristic	Overall n = 537	Australian-born n = 167 (31%)	Overseas-born n = 370 (69%)	p-value
Age				0.02
<25 years	142 (26)	56 (33.5)	86 (23)	
>25 years	395 (74)	111 (66.5)	284 (77)	
Language other than English at home	342 (64)	17 (10)	325 (88)	<0.001
Highest formal education completed				<0.001
Primary school or below	93 (17)	21 (13)	73 (20)	
Secondary School	149 (28)	71 (42.5)	78 (21)	
TAFE[a] (Diploma, Certificate etc.)	87 (16)	38 (23)	49 (13)	
University qualification (Undergraduate/ Postgraduate)	207 (38.5)	37 (22)	170 (46)	
Employment				0.39
Employed	267 (50)	90 (54)	177 (48)	
Not employed	249 (46)	72 (43)	177 (48)	
Student	21 (4)	5 (3)	16 (4)	
Primigravid	224 (42)	66 (39.5)	158 (43)	0.50
Gestation				1.00
<13 weeks	13 (2)	4 (2)	9 (2)	
13–27 weeks	171 (32)	53 (32)	118 (32)	
≥28 weeks	353 (66)	110 (66)	243 (66)	
Heard of dTpa[a]	467 (87)	161 (96)	306 (83)	<0.001
Heard of IIV[a] (n = 499)	486 (97)	157 (99)	329 (96.5)	0.07
Previous dTpa	183 (34)	91 (54.5)	92 (25)	<0.001
Previous IIV (n = 494)	260 (53)	86 (55)	174 (52)	0.56
HCP[a] recommended dTpa	372 (69)	127 (76)	245 (66)	0.03
HCP recommendation IIV (n = 492)	321 (65)	107 (69)	214 (63.5)	0.26
Belief dTpa is safe during pregnancy	304 (57)	109 (65)	195 (53)	0.01

[a]Abbreviations used.
TAFE: Technical and Further Education (TAFE) institutions provide mainly vocational training in Australia.
dTpa: Pertussis-containing vaccine (diphtheria, tetanus and acellular pertussis).
IIV: Inactivated influenza vaccine.
HCP: Healthcare provider.

more than primary school education ($p < 0.001$), were employed ($p < 0.001$), and were multiparous ($p = 0.006$). Awareness of influenza vaccine (IIV) was greater and did not differ by any of the variables examined. (Table 2)

Women derived knowledge of antenatal vaccines from a variety of sources. They reported hearing about vaccines from midwives (56% for dTpa and 45.5% for IIV) and general practitioners (44.5% for dTpa and 68.5% for IIV) more than obstetricians (24% for dTpa and 14% for IIV). Compared to IIV, more women reported hearing about dTpa through posters and information displayed in antenatal clinics (18% vs 4%), public health messages (18% vs 8%), within social circles (37% vs 27%) and on the internet (16% vs 6%). Conversely more women were aware of IIV through their workplace (12% vs 2%).

Despite recalling a recommendation from an obstetrician less often, more than a third of women (196/537, 36.5%) placed most trust in their obstetrician for vaccine advice. 30% reported trusting GPs most for vaccine advice, and 28.5% their midwife. Women reported less trust in the internet (0.4%) and family and friends (1%) compared to their maternity care providers.

Approximately 40% of women were unsure whether antenatal dTpa was safe for themselves or their baby. Factors associated with belief that maternal dTpa is safe for themselves of their baby were: age greater than 25 years (61% vs 46%, $p = 0.003$), being Australian-born (65% vs 53%, $p = 0.008$), residence in Australia longer than two years (90% vs 71%, $p = 0.02$), speaking English at home (64% vs 52%, $p = 0.01$), more than primary school education (61% vs 36%, $p < 0.001$), being employed (66% vs 47%, $p < 0.001$), having heard of (65% vs 0%, $p < 0.001$) or received dTpa previously (85% vs 8%, $p < 0.001$) and receiving a healthcare provider (HCP) recommendation for dTpa (76% vs 13%, $p < 0.001$).

Uptake

Overall 339/537 (63%) of women reported having already received or intention to receive dTpa during their pregnancy. Of the 204 women beyond 32 weeks gestation, 124 (61%) had

Table 2. Knowledge of maternal vaccines.

Factor	Heard of dTpa[a] n (%)		Heard of IIV[a] n (%)	
Age		p = 0.002		p = NS[a]
Less than 25 years	113/142 (80)		125/129 (97)	
Greater than 25 years	354/393 (90)		361/370 (98)	
Country of Birth		p<0.001		p = NS
Australia	161/167 (96)		157/158 (99)	
Other	306/368 (83)		329/341 (96.5)	
Region of Birth		p<0.001		p = NS
Australia	161/167 (96)		157/158 (99)	
East Asia	40/45 (89)		40/41 (98)	
Southeast Asia	56/64 (87.5)		59/60 (98)	
South Asia	125/159 (79)		145/150 (97)	
New Zealand + Pacific Islands	28/31 (90)		27/28 (96)	
Other	57/69 (83)		58/62 (93.5)	
Years resident in Australia		p = 0.01		p = NS
Less than 2 years	15/22 (68)		18/20 (90)	
More than 2 years	452/513 (88)		467/478 (98)	
First language		p<0.001		p = NS
English	188/195 (96)		183/185 (99)	
Other	279/342 (82)		303/314 (96.5)	
Education completed		p = 0.001		p = NS
Primary school	70/93 (75)		79/82 (96)	
Secondary school	134/149 (90)		135/141 (96)	
TAFE[a]	80/86 (93)		79/80 (99)	
University	183/207 (88)		193/196 (98.5)	
Employment		p<0.001		p = NS
Employed	251/267 (94)		248/253 (98)	
Not employed	200/247 (81)		217/225 (96)	
Student	16/21 (76)		21/21 (100)	
Gravida		p = 0.006		p = NS
Primgravid	184/223 (82.5)		203/207 (98)	
Multigravid	283/312 (91)		283/292 (97)	
Gestation		p = NS		p = NS
Less than 13 weeks	10/13 (77)		12/13 (92)	
13-27 weeks	142/170 (83.5)		159/164 (97)	
Greater than 27 weeks	315/352 (89.5)		315/322 (98)	
Number of prior antenatal visits		p = 0.01		p = NS
None	10/12 (83)		12/12 (100)	
1-2 visits	71/91 (78)		83/86 (96.5)	
More than 2	386/432 (89)		391/401 (97.5)	

[a]Abbreviations used.
dTpa: Pertussis-containing vaccine (diphtheria, tetanus and acellular pertussis).
IIV: Inactivated influenza vaccine.
NS: Not significant.
TAFE: Technical and Further Education (TAFE) institutions provide mainly vocational training in Australia.

been vaccinated against pertussis. A further 22/80 (27.5%) intended to be vaccinated prior to delivery of whom three were already 38 weeks gestation.

On univariable analysis, factors associated with uptake (already or intended) of dTpa included age greater than 25 years, birth in regions other than Southern Asia, if overseas born living in Australia more than five years, speaking English as first language, completing more than primary school education, and being employed. In addition having heard of, previous receipt of, receiving a HCP recommendation for and believing dTpa is safe during pregnancy were significantly associated with uptake. On multivariable analysis, uptake of dTpa was significantly and strongly associated with receiving a HCP recommendation (OR 10, 95% CI 5–21, $p < 0.001$) and belief that the vaccine is safe during pregnancy (OR 36, 95% CI 18–71, $p < 0.001$). (Table 3)

Table 3. Univariable and multivariable analyses of uptake of maternal pertussis and influenza vaccines.

	Uptake of dTpa[a]				Uptake of IIV[a]			
	Univariable analysis		Multivariable analysis		Univariable analysis		Multivariable analysis	
Factor	OR (95% CI)	p-value	OR (95%CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value
Age								
Less than 25 years	Ref				Ref			
Greater than 25 years	2.0 (1.4–3.0)	<0.001	1.7 (0.8–3.4)	0.17	1.4 (1.0–2.2)	0.08	0.7 (0.4–1.3)	0.30
Country Of Birth								0.35
Australia	Ref				Ref			
Other	0.7 (0.5–1.0)	0.07			1.2 (0.8–1.8)	0.34		
Region Of Birth								
Australia	Ref				Ref			
East Asia	1.8 (0.8–4.0)	0.15			1.6 (0.8–3.4)	0.17		
SE Asia	0.7 (0.4–1.2)	0.17			1.2 (0.7–2.2)	0.56		
South Asia	0.5 (0.3–0.8)	0.002			1.1 (0.7–1.8)	0.57		
NZ + Pacific Islands	0.9 (0.4–2.2)	0.90			1.5 (0.7–3.6)	0.31		
Other	0.8 (0.5–1.5)	0.59			1.0 (0.6–1.9)	0.96		
Years in Australia for overseas born women								
Born in Australia	Ref				Ref			
Less than 2 years	0.2 (0.1–0.5)	0.001	1.9 (0.4–9.6)	0.43	0.7 (0.3–1.8)	0.50	1.3 (0.3–5.5)	0.69
2–5 years	0.5 (0.3–0.8)	0.002	1.5 (0.5–4.6)	0.53	0.8 (0.5–1.3)	0.40	0.9 (0.3–2.1)	0.75
More than 5 years	1.0 (0.6–1.5)	0.82	2.2 (0.8–6.0)	0.11	1.5 (1.0–2.4)	0.05	1.7 (0.7–3.7)	0.22
First language								
English	Ref				Ref			
Other	0.6 (0.4–0.9)	0.006	0.5 (0.2–1.3)	0.14	1.0 (0.7–1.4)	1.0	1.4 (0.6–3.1)	0.40
Education completed								
University	Ref				Ref			
Primary school	0.4 (0.2–0.6)	<0.001	0.7 (0.3–1.8)	0.50	0.2 (0.1–0.4)	<0.001	0.4 (0.2–0.9)	0.02
Secondary school	0.8 (0.5–1.3)	0.34	0.6 (0.3–1.4)	0.26	0.6 (0.4–0.9)	0.02	0.7 (0.4–1.3)	0.27
TAFE[a]	1.1 (0.6–1.9)	0.80	0.7 (0.3–1.8)	0.50	0.6 (0.3–0.9)	0.03	0.4 (0.2–0.8)	0.013
Employment								
Employed	Ref				Ref			
Not employed	0.5 (0.3–0.7)	<0.001			0.7 (0.5–1.0)	0.05		
Student	0.4 (0.2–1.1)	0.07			0.9 (0.3–2.2)	0.78		
Parity								
Nulliparous	Ref				Ref			
Multiparous	1.4 (1.0–2.0)	0.06			0.9 (0.6–1.2)	0.44		
Gestation								
More than 27 weeks	Ref				Ref			
Less than 13 weeks	0.3 (0.1–1.0)	0.06		0.58	0.4 (0.1–1.2)	0.10		
13–27 weeks	0.8 (0.5–1.2)	0.25		0.14	0.6 (0.4–0.8)	0.004		
Antenatal visits								
None	Ref				Ref			
1–2 visits	1.3 (0.4–4.2)	0.65			1.6 (0.4–5.6)	0.49		
More than 2	1.5 (0.5–4.6)	0.46			3.0 (0.9–10.4)	0.07		
Heard of dTpa / IIV								
No	Ref				Ref		Ref	
Yes	25.4 (10.7–60.1)	<0.001	0.7 (0.2–2.2)	0.56	16.8 (2.2–130.6)	0.007	3.1 (0.2–79.4)	0.50
Previous dTpa / IIV								
No	Ref		Ref		Ref		Ref	
Yes	2.9 (1.9–4.3)	<0.001	1.2 (0.6–2.3)	0.63	3.9 (2.7–5.7)	<0.001	8.3 (4.6–15.0)	<0.001
HCP[a] recommended								
No	Ref		Ref		Ref		Ref	
Yes	24.9 (15.3–40.7)	<0.001	9.9 (4.6–21.3)	<0.001	16.2 (10.1–25.9)	<0.001	29.6 (15.8–55.6)	<0.001
dTpa is safe for me / my baby					N/A	N/A	N/A	N/A
No	Ref		Ref					
Yes	70.5 (38.5–129.3)	<0.001	35.8 (18.1–70.5)	<0.001				

[a]Abbreviations used.
dTpa: Pertussis-containing vaccine (diphtheria, tetanus and acellular pertussis).
IIV: Inactivated influenza vaccine.
HCP: Healthcare provider.
TAFE: Technical and Further Education (TAFE) institutions provide mainly vocational training in Australia.

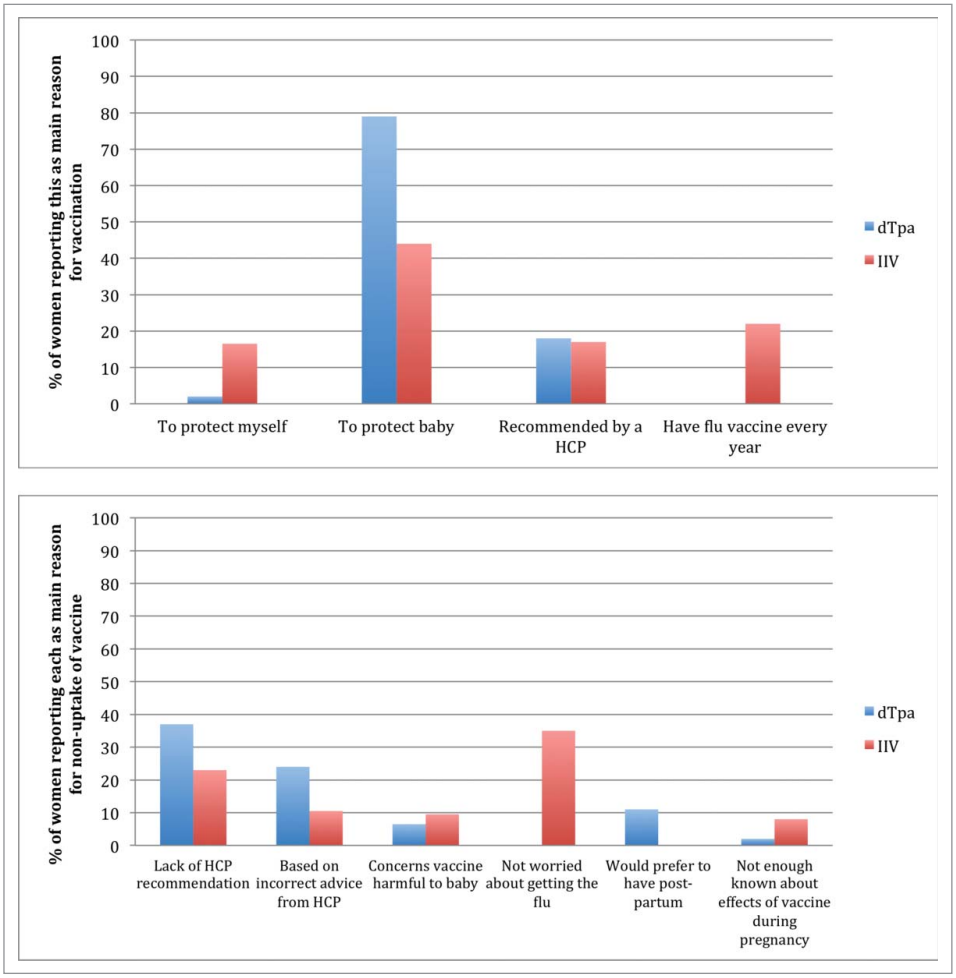

Figure 1. Reasons for vaccination/ non-vaccination
Abbreviations: dTpa: Pertussis-containing vaccine (diphtheria, tetanus and acellular pertussis) IIV: Inactivated influenza vaccine HCP: Healthcare provider.

The survey commenced at the end of the 2016 influenza season in the southern hemisphere. 279/489 (57%) of women reported receiving an IIV during their current pregnancy. None of the women in the first trimester reported receiving an IIV, 63/159 (40%) in the second trimester and 189/317 (60%) in the third trimester.

On univariable analysis, factors associated with uptake of IIV were living in Australia for more than five years (if overseas-born), university education, being in the third trimester of pregnancy, and having heard of, previously received or reporting a HCP recommendation for IIV. On multivariable analysis university education, previous receipt of IIV and a HCP recommendation for IIV remained significantly associated with uptake. (Table 3)

Reasons for vaccination/ non-vaccination

Vaccination to protect their baby was the most common motivation reported by women for both vaccines (Fig. 1).

The primary reason cited for not intending dTpa vaccination was lack of HCP recommendation by 17/46 (37%) of these women. Women born overseas were significantly less likely to recall a HCP recommendation for dTpa than Australian-born women. (Table 1) 25/537 (5%) of women reported that a HCP advised them not to have dTpa during pregnancy; 19/25 (76%) of women by a GP, and three each by a midwife or obstetrician. Among women not vaccinated against influenza, lack of concern about contracting influenza infection during pregnancy was reported by 33/95 (35%) and lack of HCP recommendation by 22/95 (23%). (Fig. 1)

A proportion of women were declining vaccines based on inaccurate advice from their HCP: 11/46 (24%) for dTpa and 10/95 (10.5%) for IIV. (Fig. 1) Women in this category reported receiving advice to have pertussis vaccine post-partum rather than antenatally, that they retained adequate immune responses from previous vaccination, that it was too late in pregnancy for the vaccine to be administered or that the vaccination was not safe during pregnancy.

Discussion

We examined the attitudes to and knowledge of maternal vaccination of a large number of ethnically diverse women in an urban Australian setting. 70% of women surveyed were overseas-born, predominantly from Asia, representing the largest study published to date of pregnant women's attitudes to antenatal vaccination from this region. The key findings were (1) the majority of women had heard of both pertussis and influenza vaccines but women from culturally and linguistically diverse (CALD) backgrounds were less likely to be aware of and more

likely to have concerns about the safety of dTpa in pregnancy; (2) a third of women did not recall receiving a HCP recommendation for either dTpa or IIV during their pregnancy and HCP recommendation was significantly less likely to be recalled by women born overseas; (3) a significant proportion of women declining vaccination appeared to be doing so based on incorrect advice from their HCP (4) Uptake of dTpa and IIV did not differ between Australian-born or women from CALD backgrounds but remains suboptimal. On multivariable analysis factors significantly associated with uptake of dTpa were HCP recommendation and belief in the safety of the vaccine during pregnancy and for IIV, HCP recommendation and previous receipt of IIV.

While most women in our study were aware of influenza and pertussis vaccines, this varied considerably amongst ethnic groups (30% in women from Afghanistan compared with 93% in women from East Asia). This highlights that women from CALD backgrounds should not be regarded as a homogenous entity and consideration for the education and health literacy of each woman is important.

Two in five women overall but half of overseas-born women did not believe antenatal dTpa was safe for themselves or their baby. In addition, women resident in Australia for less than two years were less likely to believe in the safety of dTpa during pregnancy. Numerous studies have found an association between belief in the safety of vaccination during pregnancy and uptake.[2,17,18] HCP play a crucial role in addressing safety. Our study suggests this may be of particular importance for women who have more recently arrived from overseas countries and may therefore not have had access to information about the safety of maternal vaccination previously. Maternal vaccination in low- and middle- income countries focuses on tetanus and sometimes influenza but pertussis is rarely included in antenatal guidelines. This may account for less awareness and belief in safety of dTpa amongst women from these countries even if they have received pregnancy care in their country of origin previously.

As has been reported previously, women place trust in their HCP to provide information on vaccination during pregnancy but one third of women did not recall any HCP recommendation for either vaccine. Women from CALD backgrounds were even less likely to recall a recommendation. More than 80% of both Australian- and overseas-born women had had at least two antenatal appointments prior to completing the survey and therefore lack of contact or time with HCP was not likely to have contributed significantly to this. While recall bias and difficulties with language may contribute to these findings, they nevertheless suggest room for improvement as HCP recommendation has consistently been demonstrated to be a key driver of vaccine uptake.[11,16,19-21] It is incumbent on HCP to engage women from CALD backgrounds in timely, evidence-based, and culturally appropriate discussions about indications for, and safety of vaccines during their routine pregnancy care.

Also concerning was the number of women who reported declining vaccination based on incorrect advice from their HCP. This study commenced six months after the change to maternal dTpa recommendations and as described not all HCP were fully across the changes. HCP concern about safety of antenatal vaccination may also have contributed to inappropriate recommendation. While it is the duty of each HCP to keep abreast of guidelines, this also highlights the challenges faced by health departments in disseminating new information to such a diverse range of HCP.

Uptake of maternal vaccination amongst CALD women may be hampered by lack of familiarity with health services, language barriers and lack of interpreters, and competing priorities particularly for those who have only recently arrived.[22] Standing orders for vaccination within pregnancy care settings have been demonstrated to increase uptake[23-25] and may be particularly useful for CALD women. By enabling vaccination during routine pregnancy care, standing orders would negate women having to navigate multiple healthcare services. In addition, given that intepreters are already engaged for the antenatal appointment, they could then also be utilised in the discussion and to consent women for vaccination by their antenatal care provider.

The strengths of our study are the large sample size and inclusion of women from a diverse range of backgrounds. Most studies published to date pertain to Black or Hispanic[11,16,17] women who do not make up a large proportion of the population in Australia. Our survey captures the experience of women from Asia and Sub-Saharan Africa, which has been missing from the narrative until now. As women had access to a funded vaccination program cost could be excluded as a barrier. In addition by surveying women antenatally rather than post-partum the results are less likely to be influenced by recall bias.

There are several limitations of the study that need to be acknowledged. This was a study in a metropolitan university-affiliated healthcare network, women were relatively well educated and 50% were employed and therefore results may not be generalisable to other contexts. While we surveyed women from a large number of countries, this meant that there was only a small number to make inferences about each country. We were unable to confirm self-reported uptake due to the large number of immunisation providers and lack of a statewide immunisation register at the time of the study. Finally, given that women of all gestations were surveyed, we included intention to be vaccinated, which may not equate with actually receiving vaccine and thereby may overestimate uptake.

Women from CALD backgrounds have been under-represented in maternal immunisation research to date. This study, conducted in a resource rich setting, focused primarily on these women's attitudes towards and uptake of maternal vaccines, without confounding by cost or access to vaccine. While in our study there was no difference in uptake, women born overseas, whose first language was not English and who had migrated less than two years earlier were less likely to have heard of pertussis-containing vaccines and were less likely to receive a HCP recommendation for vaccination. They were also more likely to have concerns about safety. Given HCP recommendation has consistently been demonstrated to be the most important factor contributing to uptake, and concerns about safety consistently reported as a barrier to uptake, new approaches to these areas with a focus on CALD women needs to be addressed.

Patients and methods

We recruited a convenience sample of pregnant women attending for antenatal care at Monash Health, Melbourne, Australia between September and December 2016. Monash Health is the largest public hospital network in Melbourne, providing maternity care to over 10 000 women per year across three hospitals. In Australia pregnant women are eligible for government-funded dTpa and IIV removing cost as a barrier to uptake.

All women attending for antenatal care were eligible. Researchers approached them in the waiting room and they were invited to complete an online or paper-based survey prior to their antenatal clinic appointment. The survey included information on demographics, pregnancy, attitudes towards and pregnancy care provider recommendation of whooping cough and flu vaccines during their pregnancy. The primary outcome of interest was uptake (already occurred or intended) of both vaccines. Secondary outcomes of interest were awareness of the vaccines and beliefs about safety of dTpa during pregnancy. The survey was translated into Dari, Vietnamese and Mandarin, the three most common languages requiring use of interpreting services in our antenatal clinics. Women whose first language was not English were able to complete one of the translated surveys where applicable or offered the use of an interpreter when available.

Statistical analysis was performed using Stata for Windows 14.2 (College Station, Texas). Differences between proportions was determined using Fisher's exact or Pearson chi-square tests. Logistic regression models were used to determine factors associated with uptake of vaccines. Independent variables were included if they answered the study question about the relationship between awareness of vaccines and uptake. Statistical significance was defined as $p < 0.05$.

Details of ethics approval

The study was approved by Monash Health and Monash University Human Research Ethics Committees on 26th July 2016 (Ref: 16254L) and 5th September (Ref: 0840).

Disclosure of potential conflicts of interest

SK received a Glaxo Smith Kline Small Project Grant for this research. The remaining authors report no conflicts of interest.

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Uptake of maternal vaccinations by Indigenous women in Central Australia

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Despite evidence supporting the effectiveness and safety of both pertussis (dTpa) and influenza (IIV) vaccines during pregnancy, uptake remains suboptimal.[1] In the Northern Territory (NT), IIV uptake improved from 2.2%, prior to the 2009 H1N1 pandemic, to 41% during pandemic.[2] More recently, Overton reported IIV uptake of 64% and dTpa of 22% among Indigenous women.[3] Uptake of dTpa was lower compared with studies in non-Indigenous Australian women. In this study, we surveyed Indigenous women in Central Australia to evaluate uptake of dTpa two years following maternal dTpa recommendations in Australia. Self-reported uptake was correlated with the NT Immunisation register to assess the validity of self-report.

We surveyed women admitted to the maternity unit at Alice Springs after delivery of a healthy newborn between November 2016 and April 2017. The survey collected demographics, women's attitudes and knowledge of antenatal vaccines and vaccination status. Women living in Alice Springs and Tennant Creek were considered town-resident, and outside these remotely resident. Self-reported vaccination status was compared to that recorded in the NT Immunisation register, an all-ages immunisation register used since 1991. Women who received IIV within the influenza season, but prior to the pregnancy itself, were considered to have received 'antenatal' vaccination as they would not be re-vaccinated during pregnancy.

Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS; IBM Corporation. IBM SPSS Statistics for Windows, Version 22.0. Armonk, New York: IBM Corp, Released 2013). The study received approval from the Central Australian Human Research and Ethics Committee.

Surveys were completed by 85% (47/55) of women approached. The mean age was 25 years (SD 5). A total of 53% (25/47) of women spoke an Aboriginal language at home; 36% (9/25) of whom spoke Arrente. Seventy per cent of participants (33/47) lived in remote communities; 55% (26/47) were high school educated but 40% had completed only primary school education. One-quarter of women were employed, and 34% (16/47) of women were primigravid. Only 11% (5/47) identified a doctor as their main maternity care provider, reflecting the predominance of women living in remote communities receiving midwife (22/47, 47%) or remote area nurse-led care (19/47, 40%).

More women were aware of IIV than dTpa: 44/47 (94%) compared to 26/47 (55%). Self-reported uptake of IIV was 49% (23/47) and of dTpa was 28% (13/47). Forty-seven per cent (22/47) of women surveyed were unsure if they had received dTpa and 32% (15/47) IIV during pregnancy. More women received IIV and dTpa according to the immunisation register; 70% (32/46) IIV and 50% (23/46) dTpa. A significant proportion of women who reported vaccination during pregnancy were vaccinated post-partum (9% for IIV, 23% for dTpa). More than half of women who were unsure of their vaccination status received maternal vaccination.

Almost all women reported dTpa vaccination to protect themselves or their baby; whereas, half of women reporting IIV did so because of healthcare provider (HCP) recommendation. The most common reason cited for non-vaccination was lack of HCP recommendation or advice from a HCP to be vaccinated post-partum.

Our main findings are: 1) awareness and uptake of influenza vaccine was greater than pertussis vaccine; 2) self-reported vaccination status underestimated vaccine coverage; 3) the public health message of maternal vaccination for maternal and neonatal protection against pertussis has been well understood; and 4) lack of HCP recommendation is the predominant reason reported for non-vaccination.

Uptake of IIV in our study was similar to that reported by Overton;[3] however, uptake of dTpa was substantially higher (50% vs 27%). Our study was conducted 18 months following the recommendation of maternal dTpa in Australia and, as has been seen with IIV, uptake has increased with the passage of time. As in previous studies of Indigenous women, uptake of IIV is higher than dTpa, probably due to greater familiarity with IIV among Indigenous women, in whom annual IIV is recommended from 15 years of age.

Self-report significantly underestimated vaccine coverage, although more so for dTpa than IIV, likely reflecting greater awareness of IIV and therefore more accurate self-report.

Our study also highlights the importance of an all-ages immunisation register such as the Adult Immunisation Register (AIR), which has recently been introduced nationally. The register was particularly useful for women who were unsure, which led to underestimating vaccine coverage. With increasing interest in maternal vaccination, the ability to corroborate vaccination history through AIR will be invaluable.

Our study adds to reports emphasising the importance of HCP recommendation in women's decision making around vaccination.[4,5]

Encouragingly, uptake of both maternal IIV and dTpa are higher in our study than reported among Indigenous women previously. While uptake of IIV is comparable to non-Indigenous Australian women, there is much room for improvement for dTpa. HCP recommendation is likely to be the most influential strategy and HCP should therefore be equipped with the evidence, recommendations and support to provide maternal vaccination in a culturally sensitive way. Streamlining reporting to immunisation registers will be important in ensuring these tools provide robust measures of vaccine coverage in the future.

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Chapter 3: The role of the cocooning strategy to protect newborns in the setting of a maternal pertussis vaccination program

3.1 Introduction

In the studies presented in Chapter 2, coverage of maternal pertussis vaccination was 50% among Aboriginal women in Central Australia and 63% among women in a culturally diverse cohort in Melbourne.[201,202] As a result, 37–50% of infants in these cohorts may not have acquired adequate immunity from their mothers to protect them from pertussis. Furthermore, even in situations where maternal vaccination has occurred, it may not adequately protect the newborn if there has been insufficient time between vaccination and birth to allow for placental transfer of antibodies.[20,58] This may be the case for babies born prematurely or when maternal vaccination has occurred within two weeks of delivery. Adjunctive strategies are required to protect newborns not protected by maternal vaccination.

Cocooning, or vaccination of all the regular contacts of a newborn (including the mother in the post-partum period), was the recommended strategy for protecting newborns from pertussis in Australia prior to 2015.[40] However, as outlined in Chapter 1, cocooning is inferior to maternal vaccination. It is less effective, more difficult to implement and does not protect the infant from all possible sources of infection.[41,42,54] Two Australian studies[41,42] suggest that even when both parents are vaccinated cocooning is only 51–64% effective in preventing pertussis compared to greater than 90% effectiveness[59-62] of maternal vaccination. In addition, achieving a complete cocoon (vaccination of all regular contacts of the newborn) is challenging.[52-54] Transmission of pertussis occurs from asymptomatic as well as symptomatic contacts so limiting exposure to unwell contacts is unlikely to eliminate risk. A further limitation to the cocooning approach is that household contacts account for up to two-thirds of infant infections with the remainder thought to be due to incidental contacts who are not covered with a cocooning strategy.[48] Highlighting the challenge of achieving a complete cocoon, a study from Basel, Switzerland found that in only 7% of

884 newborns was the cocoon complete (defined as all close contacts having received a dose of pertussis-containing vaccine in the preceding 10 years).[54]

With the change to a maternal vaccination strategy in Australia in 2015, the benefit of continuing the cocooning strategy was questioned. All states and territories in Australia ceased funding a cocooning strategy apart from Victoria, where this research was conducted. In this context, the study in this chapter, *"Protecting newborns from pertussis: The role of partner vaccination in the era of maternal immunization",* sought to answer the following two questions:

1. Will partners of pregnant women continue to be vaccinated at the high rates observed as part of the cocooning strategy in the setting of national recommendations for a maternal vaccination strategy?
2. Do consumers and healthcare providers understand the role of cocooning as an adjunct to maternal vaccination?

3.2 Hypotheses and aims

Hypotheses

1. Partners of pregnant women are less likely to be vaccinated as part of a cocooning strategy when pregnant women receive pertussis vaccination during pregnancy

Aims

1. To assess uptake of maternal pertussis vaccination during pregnancy
2. To assess uptake of partner pertussis vaccination as part of the funded program in Victoria
3. To assess the theoretical risk for pertussis in newborns at the time of discharge from hospital based on pertussis vaccination uptake of household contacts

3.3 Methods

In Victoria, 30% of births occur in private hospitals. To examine the experience of women receiving both public and private antenatal care, the study was conducted in one public hospital network (Monash Health) and two private hospitals (Frances Perry House and Jessie McPherson Private Hospital) in Melbourne, Victoria. Maternity and immunisation services at Monash Health have been described in Section 2.3 in Chapter 2. Jessie McPherson Private Hospital manages approximately 1000 deliveries per annum and Frances Perry House approximately 3600 deliveries per annum. These hospitals were selected as private hospitals with and without access to an onsite immunisation service respectively.

A questionnaire was developed to assess (i) vaccination status of the newborn's mother, her partner, and any other household or close contacts of the newborn; (ii) where maternal and partner vaccination was administered; and (iii) whether household or close contacts were usually resident in Australia or overseas. No identifying information was collected. The questionnaire is provided in Appendix 6.

The study was conducted between August and December 2016. After verbal consent was obtained, the survey was administered to post-partum women or their partners on the maternity ward at any of the participating hospitals following delivery of a healthy newborn. Women with insufficient verbal English to consent were excluded. The survey was completed electronically on an iPad using the SurveyMonkey platform.

Questionnaire data was extracted from SurveyMonkey for analysis. Statistical analysis was performed using IBM SPSS Statistics for Windows version 22.0 (Armonk, New York) and Stata for Windows 14.2 (College Station, Texas). Categorical variables were compared with chi-squared or Fischer's exact test. The relationship between influenza and pertussis vaccination was assessed using the kappa statistic. Logistic regression models were used to determine factors associated with vaccination status in mothers, partners, and other contacts of newborns.

Ethics approval for this study was obtained from the Monash Health Human Research and Ethics Committee Low Risk Review Panel, which also oversees ethics approvals for Jessie McPherson Private Hospital, the Monash University Human Research and Ethics Committee and the Medical Advisory Committee at Frances Perry House.

3.4 Findings

The published paper *"Protecting newborns from pertussis: The role of partner vaccination in the era of maternal immunization"* is included at the end of this chapter. The results are presented in detail in the paper, but the key findings are outlined here:

- Uptake of parental vaccination was in keeping with rates reported in Australia prior to the recommendation for maternal pertussis vaccination in 2015.
- When maternal pertussis vaccination did not occur, there were low rates of vaccination of the newborn's other close contacts, particularly carers usually resident overseas.

The study highlights the vulnerability of infants whose mothers are not vaccinated during pregnancy with nearly a quarter of newborns discharged to a household where neither parent reported vaccination according to recommendations. These are the infants that would derive most benefit from a cocooning strategy, but this message does not appear to have been well understood by parents.

3.5 Implications

Concerted efforts to increase uptake of maternal pertussis vaccination should continue as this is the most effective strategy to prevent pertussis infection in infants. However, there remains a role for the cocooning strategy for preterm infants, for infants whose mothers were vaccinated within two weeks of delivery or who did not receive vaccination during pregnancy. While the focus of this study was uptake of partner vaccination, vaccination of unvaccinated mothers in the post-partum period is an important part of the cocooning strategy. Conversations between maternity care providers and pregnant women should be tailored to each woman's individual circumstances and therefore need to be continued post-partum. For infants born

preterm or whose mothers were not vaccinated or vaccinated within two weeks of delivery, the immunisation history of parents and all close contacts of the infant should be ascertained, and post-partum vaccination facilitated where required. With improved coverage of maternal vaccination, cocooning will play a less significant role but in the meantime this study highlights that it is an important adjunctive strategy in protecting newborns from pertussis.

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Full length article

Protecting newborns from pertussis: The role of partner vaccination in the era of maternal immunization

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ABSTRACT

Objective(s): While antenatal vaccination is the most effective strategy to reduce newborn pertussis infection and its associated morbidity and mortality, uptake has consistently been reported to be suboptimal. "Cocooning" or vaccination of the close contacts of newborns therefore remains an important strategy for protecting newborns when maternal vaccination has not occurred or with insufficient time for antibody transfer. This study assesses the uptake of pertussis vaccination by parents and close contacts of newborns providing insight into the vulnerability of newborns to pertussis upon discharge from hospital to their primary carers.

Study design: The study was conducted at three public and two private hospitals in Melbourne, Australia. A survey was administered to 689 women and/or their partners admitted on maternity wards of participating hospitals after delivery of a healthy newborn between August and December 2016. The main outcomes measured were reported vaccination rates and factors associated with uptake of pertussis vaccination. Kappa statistic and logistic regression were used to determine factors associated with vaccination.

Results: 70% of women and 66% of partners reported pertussis vaccination according to national recommendations. Significantly 22% of newborns were discharged to a household where neither parent reported vaccination. Compared to when maternal vaccination did occur, in families where it didn't there were low rates of vaccination of partners (83% vs 26%) and other carers, particularly carers usually resident overseas (76% vs 18.5%).

Conclusion(s): While the majority of mothers and partners reported pertussis vaccination in accordance with recommended guidelines, concerningly nearly a quarter of newborns were discharged to a home where neither parent was vaccinated. When maternal vaccination did not occur, rates of vaccination of the other close contacts was poor. Educating women to encourage vaccination of partners and carers particularly those coming from overseas, prior to their arrival is an important consideration when maternal immunization does not occur. Cocooning remains an important approach to protect newborns of mothers vaccinated late or not vaccinated in pregnancy.

Introduction

The World Health Organisation estimates there are 50 million infections and 300, 000 thousand deaths from pertussis annually [1]. Like many infectious diseases the highest burden of disease and mortality is in resource-poor countries where vaccine coverage may not be as high and diagnostics and treatment not as available. Even in countries such as Australia with high

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childhood vaccination coverage there are epidemics every five years and there have been record numbers of notifications in the last decade [2,3].

Pertussis is a respiratory infection with disproportionately high morbidity and mortality in infants less than six months of age who are too young to have obtained full protective immunity through a primary series of vaccination. As many as two-thirds of infected babies may require hospitalisation [4] and in babies less than 6 months old nearly 1 in 100 die [2]. Infants are rarely the primary source of infection in a household. When a source is identified, parents account for 40–60% of infant infections [5–9].

Given the persistently high incidence of early childhood infections, multiple approaches to reducing risk to newborns have been explored. These include "cocooning," which targets vaccination of parents and close contacts of the newborn. Studies have demonstrated the challenges of this strategy reporting incomplete cocooning in 93% of families [10] and vaccination of both parents in only 56% of families [11].

Maternal immunisation provides passive immunity to the newborn by transfer of maternal antibodies across the placenta. It is highly effective, reducing pertussis infections by 91% and deaths by 95% in infants less than three months of age. [12–15] Maternal pertussis vaccination has been recommended in the United Kingdom and United States since 2011–12 [16,17] and in Australia since 2015 [2].

The efficacy of antenatal vaccination depends on uptake by pregnant women. Reported uptake has been variable: 50–70% in the UK [12,14], as low as 14% in the US, [18–20] and 26–74% in Australia [21,22]. Even in areas with the highest uptake, at least 30% of babies may be born with insufficient antibodies to afford protection during the critical first few months of life.

Newborns may also be susceptible if their mother declines vaccination during pregnancy, or if there is insufficient time for antibody transfer post vaccination as with vaccination within two weeks of delivery. In Australia, 9% of babies are born before 37 weeks gestation, and almost 1% before 32 weeks gestation [23]. Optimal timing of maternal vaccination is at least 10 weeks prior to delivery, a timeframe that is often not obvious for those born unexpectedly preterm [24–27]. These newborns would benefit from concerted efforts to vaccinate the contacts around them.

In this era of antenatal vaccination the benefits of cocooning may have been forgotten. This study evaluates the uptake of pertussis vaccination by partners of pregnant women and other contacts of the newborn in accordance with the program in Victoria, Australia which includes free vaccine for partners of pregnant women if they have not been vaccinated in the last 10 years.

Materials and methods

The study was conducted from August to December 2016 at one public hospital network and two private hospitals in Melbourne, Australia. The public hospital network provides maternity services to approximately 10 000 women annually across three separate hospitals. Public hospital A is a tertiary obstetric referral centre with an onsite immunisation service providing free vaccination to all patients eligible through government funded programs including pregnant women and their eligible partners. Public hospital B provides primary and secondary level maternity care to a large migrant and refugee population with approximately 2500 deliveries per annum. During the course of the study standing orders for midwife administration of antenatal pertussis vaccination within the antenatal clinic were introduced. Public hospital C provides primary and secondary level maternity care for approximately 2000 women each year. Private Hospital A (approximately 1000 deliveries per annum) and private hospital B (approximately 3600 deliveries per annum) were selected as private hospitals with and without onsite access to an immunisation service respectively.

Women and their partners admitted to a maternity ward following delivery of a healthy newborn in the abovementioned hospitals were invited to complete a questionnaire about their vaccination status, where vaccination was administered, and the vaccination status of household members and others who would play a significant caring role for the newborn. Partners and other contacts were considered appropriately vaccinated as per the national guidelines if they had received a pertussis-containing vaccine during the pregnancy or in the preceding 10 years [2].

Categorical variables were compared with chi-squared or Fischer's exact test. The relationship between influenza and pertussis vaccination was assessed using the kappa statistic. Logistic regression models were used to determine factors associated with vaccination status in mothers, partners, and other contacts of newborns. Individual hospital and presence of an immunisation service were included in the logistic regression of vaccination status in the mother. Clustering between hospitals was accounted for using the robust Huber White sandwich estimator for standard error. For partners and other contacts, factors of interest were included a priori (with no variable selection

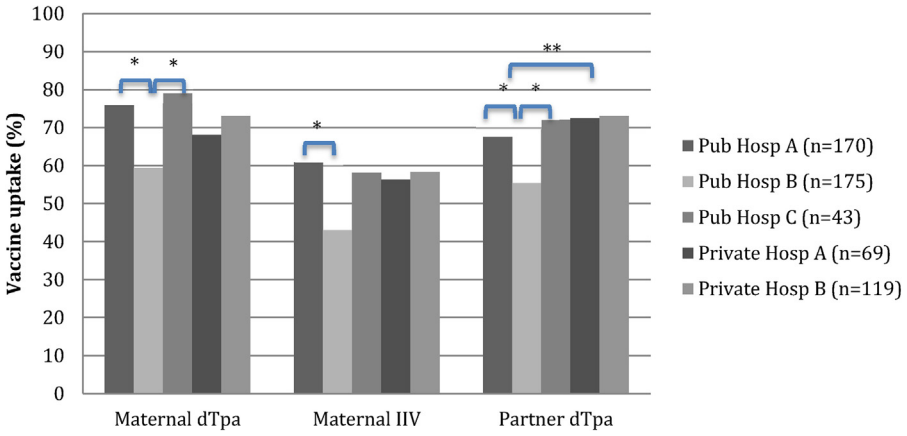

Fig. 1. Recruitment and uptake by hospital (%).
Number of participants and uptake rate of pertussis and influenza vaccination by pregnant women and pertussis vaccination by partners per hospital
*Significant difference between the public hospitals ($p < 0.05$)
*Significant difference for public versus private overall ($p < 0.05$)

procedure) and included type of family member (partner, grandparent, sibling, other), overseas residence of family member, and maternal vaccination status.

Ethics approval was obtained from the research ethics committee for the public hospital network and private hospital A and the Medical Advisory Committee for private hospital B.

Results

689 of 704 (98%) partners or women approached agreed to participate in the study. Of the 15 who declined, nine did so due to language barriers, three provided no reason, two did not believe in vaccination in general, and one had visitors. Overall, 501 surveys were completed from public hospitals and 188 from private hospitals (Fig. 1).

Vaccination in mothers

70% (479/689) of women reported vaccination against pertussis and 55% (365/689) against influenza during their pregnancy ($p < 0.001$). There was no significant difference between women receiving private or public care for either vaccine (71% vs 70%, $p = 0.6$ for pertussis and 58% vs 54%, $p = 0.5$ for influenza).

The proportion of women reporting vaccination against pertussis and influenza did however vary significantly by hospitals within the public hospital network (Fisher's exact, $p = 0.02$ and 0.01, respectively). When compared to public hospital B women at public hospitals A and C had higher odds of vaccination against pertussis (OR 2.2, 95% CI: 1.4–3.5, $p = 0.001$ and OR 2.5 95% CI 1.1–5.6, $p = 0.02$ respectively). Uptake was only statistically different for influenza between public hospital A and B (OR 2.1, 95% CI: 1.3, 3.2, $p = 0.001$) (Fig. 1).

Our study suggests a moderate association (kappa statistic 0.47) between women reporting pertussis and influenza vaccination. A higher proportion (71%, 328/459) of women who reported vaccination against pertussis also reported influenza vaccination compared to 18% (37/202) for women not vaccinated against pertussis.

Vaccination in partners

48% (333/689) of partners received a pertussis-containing vaccine during the pregnancy and 66% (452/689) were vaccinated according to current recommendations in Australia (booster dose within 10 years).

Unlike for women, there was a significant difference in proportion of partners appropriately vaccinated between public (63%, 315/501) and private hospitals (73%, 137/188, $p = 0.02$). Partner vaccination rates differed significantly between the three public hospitals following the same distribution as for pregnant women: 68% (115/170) vaccinated according to guidelines in public hospital A, 55% (97/175) at public hospital B, and 72% (31/43) at public hospital C (Fig. 1).

There was a moderate correlation (kappa statistic 0.55) between pregnant women and their partner being vaccinated. 83% (398/479) of partners were vaccinated if the woman was vaccinated during pregnancy, compared to only 26% (53/207) of partners of women not vaccinated antenatally. Unfortunately, nearly a quarter of newborns (22%, 154/689) were discharged to a household where neither parent was vaccinated according to current recommendations.

Site of immunisation

Nearly two thirds (64%, 82/129) of vaccinated mothers at public hospital A utilised the onsite immunisation service. In contrast, at public hospital C (most geographically distant from the immunisation service), all 34 mothers were vaccinated by general practitioners (GP).

Prior to the introduction of standing orders at public hospital B 85% (58/68) of pregnant women were vaccinated by GPs. Within three months of its introduction 33% of pregnant women were vaccinated at the antenatal clinic.

While 72% (34/47) of mothers at private hospital A were vaccinated by GPs, nearly a quarter (10/47, 21%) utilised the immunisation service within the geographically co-located public hospital. Interestingly, 8% (7/85) of women at private hospital B were vaccinated in their obstetrician's rooms suggesting incorporation of immunisation by some private obstetricians.

The overwhelming majority (95%, 249/263) of partners were vaccinated by GPs.

Other contacts

Three quarters (526/689, 76%) of newborns were discharged to a home with at least one additional household member or carer other than their parents; a grandparent in 49% (336/689), sibling in 42% (293/689), and other contact in 9% (63/689).

67% of the carers/household contacts reported vaccination as recommended in the national guidelines but this decreased to 53% (336/632) when only adult contacts were considered.

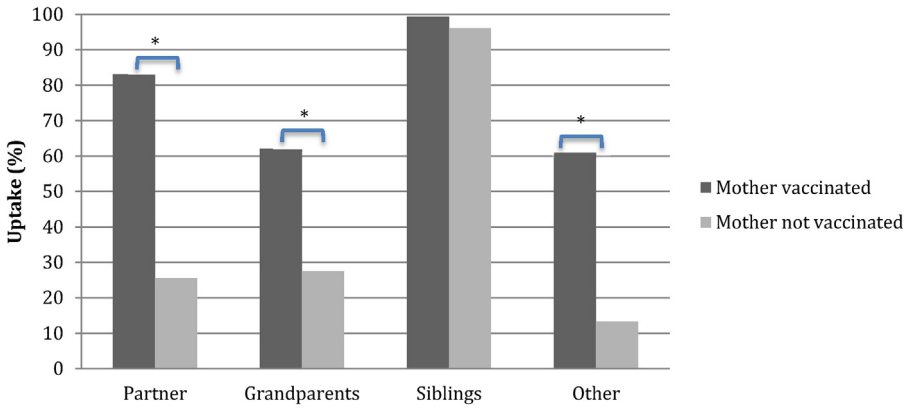

Fig. 2. Uptake by contacts according to mother's vaccination status.
Comparison of uptake of pertussis vaccine by partners and other contacts of the newborn based on the pregnant woman's vaccination status
*Significant Odds Ratio- Partner: OR 14.3 (9.6–21.2), Grandparents: OR 4.3 (2.8–6.5), Other: OR 10.2 (2.0–51.1)

Grandparents of newborns born in private hospitals were more likely to report vaccination than those in public, but siblings across both health systems had very high rates of up to date vaccination as reported by their parents. As demonstrated with partners, the other contacts were more likely to report vaccination if the mother was vaccinated (Fig. 2). On logistic regression, adjusting for type of family member, and residency status the odds of a family member being vaccinated was 10 times higher if the mother was vaccinated (OR 10.5, 95% CI 5.5, 20.1, $p < 0.01$)

37% of adult contacts came from overseas to care for the newborn. On logistic regression, the odds of reporting vaccination was 94% lower in overseas-resident contacts (OR 0.06, 95% CI 0.04–0.11, $p < 0.01$)(Fig. 3).

Comment

The main findings from our study are (1) two thirds of pregnant women and partners report vaccination according to guidelines, (2) onsite immunisation is well utilised if available (3) there are low rates of vaccination of contacts of newborns when maternal vaccination does not occur and (4) adult carers from overseas are less likely to be vaccinated than those resident in Australia.

70% of women reported pertussis vaccination during pregnancy. This is higher than most international studies [28–30] but consistent with recent data from other states in Australia [21]. As has been reported previously [21,31], uptake of influenza vaccination was lower than pertussis (55% vs 69.5%). In our study women who reported pertussis vaccination were more likely to also be vaccinated against influenza.

We demonstrated that women utilise onsite immunisation services when available which may reflect a preference for avoiding additional healthcare appointments with the attendant cost, time and travel commitment. This was particularly evident with the introduction of standing orders at Public Hospital B with uptake increasing from 57% to 65% and vaccination at the clinic from 0 to 33% within three months.

Regardless of uptake, there are several groups of newborns, particularly those whose mothers were vaccinated within two weeks of delivering for whom maternal vaccination may provide inadequate protection and where cocooning continues to be an important preventive strategy. Various studies have examined partner uptake as part of a cocooning strategy. While uptake was suboptimal (17%–61%), the timing of parental vaccination was of particular concern [10,11,32]. Many parents were not vaccinated prior to discharge from hospital and up to 20% were vaccinated more than two months post-partum [10,11,33]. This is clearly too late to provide protection to the newborn in the critical first months of life.

To the best of our knowledge this is the first study to specifically examine partner vaccination since the introduction of maternal vaccination. With two thirds of partners and mothers reporting vaccination our study affirms most parents recognise the importance of vaccination to protect the newborn. However it also demonstrates parents' understanding around vaccination recommendations is limited. Unlike Steiner who reported no correlation between women and partners acceptance of vaccine [32], in our study partners were more likely to be vaccinated when maternal vaccination occurred. However it is newborns of women not vaccinated during pregnancy that would derive most benefit from their other contacts being vaccinated. Public health efforts need to engage women not vaccinated during the recommended interval during pregnancy and ensure their partners are vaccinated.

Partners of women receiving private antenatal care were more likely to be vaccinated than those receiving public care, possibly because more women in private care were vaccinated by GPs where their partner could be vaccinated contemporaneously. Conversely, vaccination of partners within maternity services is often not possible due to administrative barriers. Alternative delivery models within maternity services, and pharmacist-delivered vaccination should be explored to minimise barriers, maximise uptake and facilitate concurrent vaccination of women and their partners during the pregnancy to provide a more effective cocoon for newborns from birth.

A novel and significant finding in our study is that more than a third of adult contacts came from overseas to assist with care of the newborn, reflecting the large migrant and refugee population of the public hospital network. Only 18.5% of grandparents from overseas were appropriately vaccinated compared to 76% of those living locally. Susceptibility due to un- or incompletely vaccinated carers from overseas warrants more discussion with pregnant women as they plan caring responsibilities for the post-partum period.

One of the strengths of our study is measurement of actual rather than intended uptake. Competing time pressures, priorities, and difficulty accessing immunisation providers are just a few reasons for non-vaccination despite an intention to do so [11]. This highlights that uptake cannot be predicted by attitudes alone. Another strength was surveying parents prior to discharge, thereby reflecting the potential risk for newborns as they enter the community. In addition the large sample size, low numbers

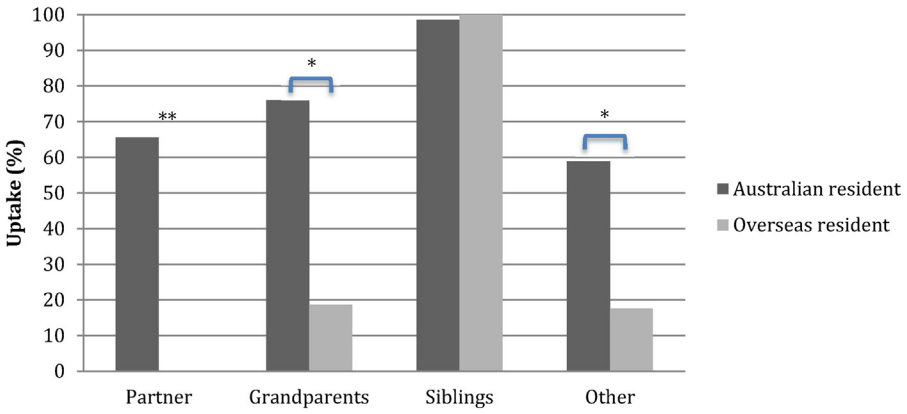

Fig. 3. Uptake of pertussis vaccine by Australian vs overseas residence.
Comparison of uptake by contacts of the newborn based on usual country of residence (Australia vs other)
*Significant Odds Ratio- Grandparents: OR 13.9 (8.9–21.5), Other: OR 6.7 (1.6–27.6)
** Partners were not questioned about usual country of residence

declining participation, and inclusion of public and private patients from hospitals with and without an immunisation service enables our results to be generalised to most obstetric care settings.

We acknowledge several limitations of this work. Self-reported vaccination status could not be confirmed given the variety of immunisation providers. Timing of vaccination was not collected and therefore protective efficacy of reported vaccination cannot be assumed. However, a large number of partners reported vaccination along with their partner and therefore likely early in the third trimester. The other limitation in terms of generalisability is the issue of cost. This study was undertaken in a state with a funded program for partner vaccination and thus the high uptake reported may not be reflected in other jurisdictions. Funded partner programs in the era of maternal vaccination need to be considered particularly where uptake of maternal vaccination is poor.

While antenatal vaccination is the most effective strategy to reduce newborn pertussis infections, this study highlights the continued importance of cocooning strategies for newborns who will not derive benefit from maternal pertussis vaccination because their mothers were not vaccinated during pregnancy or because of delivery at a time when the vaccination may not be maximally effective. Antenatal care providers should continue to promote antenatal vaccination but should tailor their discussions to encourage vaccination of partners and contacts of the newborn particularly those coming from overseas when maternal immunisation does not occur.

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Chapter 4: Attitude, knowledge and practice of maternity care providers in Australia to maternal vaccination

4.1 Introduction

In Australia, women may receive maternity care through one of several different models. A maternity services review by the Australian Government Department of Health published in 2009 found that 93% of women receive antenatal care through one of the following four models: (i) private maternity care – through an obstetrician or a general practitioner (GP) with subspecialty obstetric qualification (GP obstetrician) with intrapartum and post-partum care provided by the same practitioner; (ii) public hospital clinic care – antenatal care delivered entirely though public hospital antenatal clinics; (iii) shared maternity care – where the majority of antenatal care is provided by a GP with visits to the hospital at the latter part of pregnancy including intrapartum care in a public hospital; and (iv) combined maternity care – shared care without public hospital antenatal care.[203]

Regardless of which healthcare providers are involved in a woman's pregnancy care, they can play three important roles in terms of maternal vaccination: (i) providing information and answering women's questions; (ii) recommending vaccinations; and (iii) administering vaccinations to women within the maternity care setting (if possible). However, as was described in Chapter 1, healthcare provider knowledge of guidelines, the diseases and the vaccines, as well as their perception of their role in vaccination have been demonstrated to affect the likelihood of them recommending and providing maternal vaccination. In Australia, obstetricians, general practitioners and midwives must all be registered with and have continuing professional development approved annually by the Australian Health Practitioners Regulation Agency (AHPRA). AHPRA does not require any members of three provider groups to undergo immunisation training to maintain registration or as part of continuing professional development. Access to immunisation education and training varies significantly between the groups and is coordinated through each professional body.

Presented below is a summary of the data presented in Chapter 1, to highlight the knowledge gaps with regards to healthcare provider–related barriers to maternal vaccination in Australia.

Studies of healthcare provider–related factors associated with uptake of maternal vaccinations in Australia

Only three studies had been published on the attitude and practice of Australian healthcare providers to maternal vaccination prior to commencing this thesis.[129,157,158] All related to influenza vaccination alone.

Two were small qualitative studies both conducted in 2012.[157,158] They reported high awareness of the guidelines for influenza vaccination during pregnancy and that recommendation was influenced by the provider's perception of pregnant women's risk of disease. However, rates of provider recommendation and concerns about safety were variable.[157,158] In the study by Webb et al. providers felt that it was unclear who had responsibility for the different aspects of vaccination, and that the barriers primarily pertained to lack of incorporation of vaccination into routine maternity care policies and procedures.[158]

The third and largest study was a survey of 36 obstetricians and 60 midwives at a single tertiary obstetric institution in Melbourne in 2011 (six months following the recommendation for influenza vaccination).[129] This study found that nearly three quarters of providers reported recommending influenza vaccination to pregnant women. Providers who had personally been vaccinated against influenza were twice as likely to recommend it. They did not find any differences in attitude or practice between midwives and obstetricians.[129]

All three studies were small, surveyed providers from a single region, relied on self-report, and were conducted prior to the recommendation for maternal pertussis vaccination. The manuscript titled *"A study comparing the practice of Australian maternity care providers in relation to maternal immunisation"* was designed to address three key knowledge gaps regarding the healthcare provider–related barriers to uptake of maternal vaccination in Australia:

1. It is unknown if maternity care providers in Australia are aware of the pertussis guideline introduced in 2015
2. There is a paucity of Australian-specific data on maternity care provider attitude, knowledge and practice with regards to maternal pertussis vaccination
3. There is ambiguity about who obstetricians, midwives and GPs perceive is responsible for discussing and administering vaccinations to pregnant women

4.2 Hypotheses and aims

Hypotheses

1. Healthcare provider recommendation is influenced by awareness of guidelines, and personal beliefs about the safety and efficacy of maternal vaccination
2. There is a lack of clarity about whose role it is to discuss and recommend vaccination to pregnant women when multiple providers are involved in their care
3. In terms of recommending vaccination, midwives are more hesitant with greater concerns about safety and less confidence in their own vaccine knowledge
4. GPs are more comfortable than obstetricians and midwives in administering vaccinations to pregnant women
5. Vaccination has been more widely incorporated into public hospital maternity care services than by obstetricians in private rooms

Aims

1. To examine the attitude, knowledge and practice of obstetricians, midwives and GPs with regards to maternal vaccination
2. To explore differences in attitude and practice between different provider groups
3. To identify gaps related to division of responsibility for maternal vaccination
4. To identify barriers to recommending and providing vaccination within maternity care settings

4.3 Methods

A questionnaire was developed with input from members of each provider group and piloted at two maternal immunisation forums. The final questionnaire collected information on (i) personal and practice demographics; (ii) knowledge about vaccinations in pregnancy; (iii) current practice of recommending and providing vaccinations; (iv) barriers to implementing vaccination services; and (v) beliefs about each provider group's role in discussing and administering vaccinations. The questionnaire was available through the SurveyMonkey platform and is included in Appendix 7.

The study was conducted between September and November 2016. Members of each target group were emailed by their professional bodies with an invitation to participate in the study and a link to the online survey. All Fellows, Trainees and Diplomates of the Royal Australian and New Zealand College of Obstetricians and Gynaecologists (RANZCOG) were invited to participate via an email from the College. A follow up email was sent six weeks later. Midwives received invitations via the Australian College of Midwives email newsletter over two consecutive months. Due to a limited number of responses from midwives, midwives at Monash Health were subsequently recruited in person during education sessions and team meetings. GPs were recruited via primary health network email newsletters.

Questions using a Likert scale were collapsed for statistical analysis. "Strongly agree" and "agree" were categorised as "agree." "Strongly disagree" and "disagree" were categorised as "disagree" with the third category "neither agree or disagree", designated "neutral." Statistical analysis was performed using IBM SPSS Statistics version 23.0 (Armonk, New York). Fisher's exact or Pearson chi-square tests were used for subgroup analyses. Binary logistic regression was used to determine factors associated with recommending according to guidelines and providing vaccines. Statistical significance was defined as $p < 0.05$.

Ethics approval was obtained from the Monash Health Human Research and Ethics Committee Low Risk Review Panel, and Monash University Human Research and Ethics Committee. The Continuing Professional Development Committee of RANZCOG

also approved the survey and credited it for one professional development point for Self-Education.

4.4 Findings

The manuscript for this study, "*A study comparing the practice of Australian maternity care providers in relation to maternal immunisation",* is included at the end of this chapter and provides detailed results. The key findings are outlined below:

- Despite high awareness of the 2015 recommendation, one in five providers did not recommend maternal pertussis vaccine according to guidelines. We found that providers who were not vaccinated themselves, who lacked confidence in their knowledge of pertussis vaccine, who were unsure of the safety of maternal pertussis vaccination and who were not aware of the recommendation for maternal pertussis vaccination were less likely to recommend it appropriately.
- Midwives had more concerns about the safety of maternal pertussis vaccine than obstetricians and general practitioners.
- Obstetricians and midwives perceived discussing vaccinations as their responsibility but GPs as responsible for administering maternal vaccinations.
- Barriers to embedding vaccination within maternity care included concern about capacity to store vaccines onsite, and capacity to integrate vaccination into workflow.

4.5 Limitations

- Response rates from provider groups other than obstetricians were limited. In particular, the oversampling of midwives from our institution limits the generalisability of findings for this particular group as the results may be a reflection of the practice of our institution rather than that practised nationally.
- The limited small number of midwives, particularly from states other than Victoria, limited the analysis of providers by state/territory and therefore the ability to interpret and generalise results nationally.
- Respondents reported high rates of personal vaccination. This may reflect that they are more supportive of vaccination and may not represent the views of

providers who do not themselves get vaccinated. While not affecting the internal validity of our findings, the study may overestimate the proportion of providers who routinely recommend and provide maternal vaccination.

- Providers may have overestimated how frequently they recommend vaccination as previous studies surveying women and healthcare providers simultaneously have found that more providers report recommending vaccinations than women recall receiving them.

4.6 Implications

This was the first nationwide survey of maternal vaccination amongst all three maternity provider groups in Australia. Most maternity care providers were aware of and recommended vaccinations in accordance with guidelines. This study also provides some clarity about perceived division of responsibility. While all providers perceived discussing vaccination as an important component of providing maternity care, the vast majority believed the actual administration of vaccines to be the remit of the GP. This has implications for implementation policy highlighting an important gap between the evidence that suggests integration within antenatal care service delivery improves uptake, and the findings in this study that those working within these settings do not see vaccination as their primary responsibility.

A STUDY COMPARING THE PRACTICE OF AUSTRALIAN MATERNITY CARE PROVIDERS IN RELATION TO MATERNAL IMMUNISATION

Abstract

Background: Women's decisions regarding vaccination during pregnancy are heavily influenced by maternity care provider (MCP) recommendation. Understanding why MCPs may not recommend vaccination is central to improving vaccination rates.

Aims: To examine the knowledge, attitudes and practice of Australian MCPs to maternal vaccination.

Methods: We surveyed obstetricians, midwives and general practitioners (GPs) between September and November 2016. Providers were asked about their knowledge and current practice, and about their perceived roles in discussing and administering maternal vaccinations.

Results: 870 surveys were completed. Each MCP group believed they had the primary responsibility for discussing vaccinations but all groups perceived GPs as primarily responsible for administering vaccines. More midwives had concerns about safety (21/129, 16%) than obstetricians (9/359, 3%) and GPs (7/326, 2%) ($p<0.001$). Overall, 83% of MCP recommended pertussis vaccination (dTpa) and 78% influenza vaccination (IIV) according to guidelines, with no differences between groups. Overall 77% provided dTpa onsite (GPs 99%, midwives 70%, obstetricians 60%, $p<0.001$) and 71% provided IIV (GPs 99%, midwives 48%, obstetricians 54%, $p<0.001$). Factors associated with recommending vaccination in accordance with guidelines and providing vaccination onsite were similar across groups; personal history of vaccination, confidence in vaccine knowledge, and awareness of recommendations for and belief in the safety of maternal dTpa.

Conclusions: Among MCPs, the rates of recommending and providing maternal vaccination were higher than reported previously. Further improvements might be expected with increased awareness of guidelines, further education around vaccine safety, and by changing perceptions of the role of obstetricians and midwives in providing maternal vaccinations.

Introduction

Maternal vaccination has been recommended by the World Health Organization to eliminate maternal and neonatal tetanus since the 1990s.[1] Likewise the benefit of vaccination to prevent severe influenza in pregnant women has been recognised since the 1960s but came to the forefront of public health efforts in association with the influenza pandemic in 2009. In addition to the direct benefits to the mother, maternal vaccination with an inactivated influenza vaccine (IIV) also prevents influenza and febrile respiratory illness in infants.[2-4] Maternal vaccination with a diphtheria-tetanus-acellular pertussis vaccine (dTpa) reduces pertussis in infants by more than 90%,[5, 6] and has been recommended in several countries including the United Kingdom (UK), United States (US), Belgium, New Zealand, Argentina, and Australia.

Despite the recommendation for, and demonstrated effectiveness and safety of maternal dTpa and IIV, uptake varies considerably. For example, reported rates for pertussis vary from 14–64% in the US[7,8], 30–60% in the UK,[9-11] and 27–70% in Australia.[12-13] Barriers to uptake can be categorised as consumer-, healthcare provider- or system- related. Examples of these barriers include lack of consumer and healthcare provider (HCP) awareness of recommendations, consumer and HCP concerns about vaccine safety and efficacy during pregnancy, lack of HCP recommendation, access to vaccines, failure to incorporate vaccination into routine pregnancy care, and, in some jurisdictions, cost.[14-17] Of these, the most consistent reason women report for not being vaccinated is lack of HCP recommendation.[15,18, 19]

In Australia despite national recommendations, and access to free vaccine and healthcare, the uptake of maternal vaccinations varies between jurisdictions.[12] Pregnancy care may be provided through private or public hospitals, by obstetricians,

midwives, general practitioners (GPs) with an obstetric qualification or a combination of these (shared care). Other than a study by Maertens et al. in Belgium,[20] studies have not looked at these different maternity care provider (MCP) groups within the same setting. The aims of this study were to: explore attitudes and practice; identify gaps related to division of responsibility; and ascertain the roles different MCPs believe they have in provision of maternal vaccination.

Methods

A questionnaire was developed by the researchers based on review of the published literature with input from members of each target group; GPs, midwives and obstetricians. It was piloted amongst a convenience sample of these target groups at two maternal immunisation forums. The final online questionnaire collected demographic information, and included questions on knowledge, perceived roles in discussing and administering vaccines, current practice and perceived barriers to provision of maternal vaccination.

An email describing the project and containing a link to the questionnaire was distributed to MCPs through their professional bodies between September and November 2016 as follows:

- Australian fellows, trainees and diplomates of The Royal Australian and New Zealand College of Obstetricians (RANZCOG)
- Members of the Australian College of Midwives
- Shared care providers through several primary healthcare networks.

While all members of these groups could complete the survey, only those currently providing maternity care were included in the analysis. In addition, a convenience sample of midwives at a single institution (Monash Health) were invited to complete the survey to increase response rate by this provider group. Midwives were invited to participate from antenatal clinics, and during team meetings and education sessions. Hard copy surveys and the link to the electronic survey were provided and the midwife running each of the meetings or sessions subsequently returned any completed surveys to the researcher.

RANZCOG Fellows could claim 1 professional development point in Self-Education for completion of the survey.

Descriptive statistical analysis was performed using IBM SPSS Statistics Version 23.0. The significance of differences between subgroups were determined using Fisher's exact or Pearson chi-square tests. Statistical significance was defined as $p<0.05$. Binary logistic regression was used to determine factors associated with recommending according to guidelines and providing vaccines.

The study was approved by the Monash Health and Monash University Human Research and Ethics Committees.

Results

894 responses to the electronic mailout were received and an additional 80 midwives were recruited at Monash Health. Response rates were 25% (435/1741) for obstetricians, 10% (45/466) for obstetric trainees, 12% for GPs (346/2944), and 3% (135/5000) for midwives. Fifty surveys were excluded due to missing data and 54 as they were completed by HCP not currently providing pregnancy care. Accordingly, 870 surveys were included in the analysis (367 obstetricians, 45 obstetric trainees, 328 GPs, and 130 midwives).

Demographics

Responses were received from all jurisdictions in Australia although more Victorians were recruited because recruitment of GPs also occurred through Victorian primary healthcare networks and additional midwives at Monash Health. Participant demographics are presented in Table 1. Midwives were less likely to report ever receiving IIV themselves than obstetricians, obstetric trainees and GPs ($p=0.001$) but there was no difference in personal dTpa status. (Table 1)

Of 359 obstetricians, 153 (43%) reported working predominantly in private rooms, of whom 65 (42%) also worked in a public hospital. Fifty percent (96/194) of the obstetricians who worked at least some of the time in private practice had a midwife or practice nurse in their rooms.

Knowledge and beliefs: vaccination during pregnancy

Midwives were more likely to be concerned about vaccine safety (21/129, 16%) than obstetricians (9/359, 3%), GPs (7/326, 2%) or obstetric trainees (0/43) ($p<0.001$). All MCP groups were most concerned that we do not fully understand the effects of dTpa given in every pregnancy; 30/129 (23%) midwives, 45/359 (13%) obstetricians, 33/326 (10%) GPs and 4/43 (9%) obstetric trainees ($p<0.001$).

Most MCPs agreed that influenza is a severe disease in pregnancy (794/848, 94%) and that IIV poses less risk to pregnant women than influenza infection (802/848, 95%). Only 290/848 (34%) were aware of the benefits of IIV in preventing respiratory illness in infants. Knowledge did not vary by MCP group.

Most respondents were aware of the national guidelines to recommend dTpa in the third trimester of every pregnancy (770/852, 90%). There were no differences by years of practice or work in private or public systems.

Overall 760/870 (87%) MCPs felt sufficiently knowledgeable to advise pregnant women about dTpa and 769/848 (91%) about IIV. GPs and obstetricians were more confident advising about dTpa (311/328, 95% and 324/367, 88%) and IIV (311/321, 97% and 337/356, 95%) than obstetric trainees (31/43, 72% and 33/42, 79%) or midwives (94/130, 72% and 88/129, 68%) ($p<0.001$).

Current practice: vaccination as part of routine pregnancy care

MCPs were asked if they routinely take a vaccination history as part of antenatal care. Overall 672/861 (78%) reported routinely taking a vaccination history. This varied by role. GPs were more likely to routinely include a vaccination history (290/325, 89%) than midwives (93/126, 74%), obstetricians (262/367, 71%), or obstetric trainees (27/43, 63%) ($p<0.001$). Obstetricians working primarily in private practice were more likely to routinely take a vaccination history (119/152, 78%) than those working primarily in public clinics (138/206, 67%) ($p=0.02$).

Responsibility for discussing vaccination

MCP were asked who they believe has the main responsibility for discussing vaccinations with pregnant women. Overall, 396/870 (46%) of respondents believed

it was primarily the GP's role, 261/870 (30%) the obstetrician's role, and 101/870 (12%) the midwife's. The majority of each MCP group believed it to be primarily their role to discuss vaccinations; more than half of obstetricians (188/369, 51%), 225/328 (69%) GPs and 51/130 (39%) midwives. Only 9/130 (7%) midwives felt that discussing vaccinations with pregnant women was the primary responsibility of the obstetrician. A higher proportion of obstetricians working primarily in private practice 107/153 (70%) believed discussing vaccinations to be their primary responsibility compared to 75/206 (36%) in public practice ($p<0.001$). (Table 2)

Responsibility for administering vaccination

The majority of each MCP group believed it to be the GP's role to administer vaccinations (63% overall; 73% of GPs, 61% of obstetricians, 51% of obstetric trainees, and 50% of midwives). (Table 3).

Responsibility for administering vaccinations was less clearly delineated amongst obstetricians working in public clinics. Of those working primarily in private practice 117/153 (77%) believed vaccination to be the GP's role compared to 105/206 (51%) in public ($p<0.001$). Nearly a quarter (48/206, 23%) of obstetricians in public practice believed it to be the midwife's role.

Recommendation according to guidelines

Overall 711/862 (83%) MCP reported recommending dTpa in line with national guidelines, however 88/856 (10%) recommended dTpa in the third trimester only if women hadn't received a booster in the preceding five years (the recommendation prior to March 2015). There was no difference by MCP group.

For IIV, 632/815 (78%) MCP reported recommending IIV to pregnant women according to current recommendations (during the influenza season regardless of gestation) while 171/803 (21%) did not recommend IIV during the first trimester. Again there was no difference between MCP groups.

Factors associated with recommending dTpa and IIV according to current guidelines were personal history of vaccination, and confidence in their vaccine knowledge, irrespective of MCP group. In addition, for dTpa, awareness of guidelines and belief in

the safety of dTpa during pregnancy were associated with recommending according to guidelines. (Table 3)

Provision of vaccination services during pregnancy

Overall 666/870 (77%) MCP indicated they provide dTpa and 602/848 (71%) IIV at their place of work. GPs were significantly more likely to provide dTpa and IIV than obstetricians or midwives. Obstetricians were more likely to provide vaccination if their primary practice was a public hospital clinic or if they had a nurse or midwife in their private rooms. MCPs who had personally received IIV and dTpa previously, and felt that they had enough information to confidently advise pregnant women on vaccination, were more likely to provide both dTpa and IIV. MCP who were aware of and recommended dTpa in accordance with national guidelines were also more likely to provide vaccination services. (Table 4)

Barriers to provision of vaccination services

Overall 511/870 (59%) MCP reported they administer dTpa to pregnant women and did not perceive any barriers to provision of the service. Amongst the remaining 359 respondents, the following barriers were identified; lack of clarity around vaccination roles when multiple providers are involved (119/359, 33%), lack of capacity to store vaccines on site (101/359, 28%), lack of time (55/359, 15%), inability to manage severe adverse reactions onsite (41/359, 11%), and not having a practice nurse or midwife in their rooms (36/359, 10%). Thirty-one (9%) wanted more information to facilitate their decision-making, and 17/359 (5%) were worried about liability issues.

Discussion

In this nationwide survey of Australian MCPs we found that all practitioner groups had reasonable knowledge of the national recommendations and of the benefits of maternal vaccination. Most reported that discussing vaccination with pregnant women was part of their professional role. However, one in four practitioners did not recommend dTpa and one in five did not recommend IIV in accordance with national guidelines. Similar to previous studies we found that being vaccinated themselves, feeling adequately informed, belief in the safety of vaccines, and being aware of

recommendations were associated with increased likelihood of recommending according to guidelines.[14,15,21]

The majority of MCPs agreed that dTpa is of benefit to mother and infant. The safety of administering dTpa in *every* pregnancy was the primary safety concern particularly amongst midwives. This contrasts with earlier studies where MCP expressed more widespread concerns about the safety of vaccinations during pregnancy.[14,22,23] Midwives are often the first HCP a woman consults during pregnancy. Addressing the safety concerns of midwives and increasing their confidence in vaccination may further increase the number of midwives recommending vaccination to pregnant women.

MCPs recognised the maternal benefits of IIV but the benefit in preventing influenza and other febrile respiratory illnesses in infants did not appear to be well appreciated. Women have consistently reported protecting their baby as their primary motivation for maternal vaccination.[24,25] In contrast to dTpa, IIV has mostly been promoted for maternal benefit. The benefit of maternal IIV for infants is therefore an important message for MCPs to communicate if uptake is to be improved. In 2017, health departments targeted this message to both MCPs and pregnant women.[26]

This study helps to provide some clarity around roles and may also reflect changing MCP attitudes. Compared to earlier studies, all groups perceived discussing vaccination as part of their role.[17,27] However, administering vaccinations was viewed as the primary responsibility of GPs. An understanding of these expectations is important for development of health policy. As primary providers of population level vaccination, GPs have a well-established capacity to store and administer vaccines. However, in Australia and the US, midwives and obstetricians are often the primary or only HCP women consult during their pregnancy. It has been suggested that embedding vaccination into routine pregnancy care and providing vaccination at the time of HCP recommendation increases uptake.[17,19,28] When not provided onsite, the additional step of women making an appointment and attending an additional provider is a barrier to vaccination. In our previous work, uptake of dTpa increased from 39% to 91% after implementation of standing orders for midwife administration within pregnancy care clinics.[28] Many of the MCP we surveyed have adopted onsite

vaccination, with 61% of obstetricians and 70% of midwives reporting dTpa to be available to pregnant women at their place of work. IIV was less commonly provided and this disparity warrants further research as it was beyond the scope of the current study. This study highlights that for onsite vaccination to be more widely implemented, MCP need to perceive administration as their responsibility and barriers to storing vaccines on site need to be overcome.

Strengths and limitations

This is the first nationwide survey that directly compares different MCPs' knowledge of national guidelines, attitude and clinical practice in regards to administering vaccination to pregnant women in Australia. The strengths of our study include the large sample size and all three MCP groups completing the same survey allowing for direct comparison. However there are limitations that need to be acknowledged. Response rates from MCP groups other than obstetricians were limited. In particular the oversampling of midwives from our institution limits the generalisability of findings for this particular group as the results may be a reflection of the practice of our institution rather than that practiced nationally. In addition, respondents reported high rates of personal vaccination. This may reflect that they are more supportive of vaccination and may not represent the views of MCP who do not themselves get vaccinated. While not affecting the internal validity of our findings, the study may overestimate the proportion of providers who routinely recommend and provide maternal vaccination. Finally, MCP may have overestimated how frequently they recommend vaccination as previous studies surveying women and HCP simultaneously have found that more HCP report recommending vaccinations than women recall receiving them.[14,29]

Conclusion

Rates of recommending and providing maternal vaccination were higher than reported previously. To increase MCP recommendation further, addressing knowledge gaps about timing, frequency and safety of maternal vaccines and keeping providers updated on guidelines will be important. Further work is required to change obstetrician and midwife perception of administration of maternal vaccines as their role in conjunction with providing the infrastructure to support vaccination within pregnancy care settings.

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Table 1: Demographics

	n (%)
Professional category (n = 924)	
Obstetrician	369 (40)
Obstetric trained but not providing antenatal care	22 (2)
Obstetric trainee	43 (5)
Midwife	130 (14)
GP† – shared care or GP obstetrician	295 (32)
GP – not providing shared care	33 (4)
Other	32 (4)

	Total (n = 870)	Obstetricians/ trainees (n = 412)	Midwives (n = 130)	GPs (n = 328)	p
Age					< 0.001
Less than 35 years	182 (21)	91 (21)	46 (36)	45 (14)	
35–55 years	431 (50)	209 (51)	59 (46)	163 (50)	
More than 55 years	250 (29)	110 (27)	24 (19)	116 (36)	
Country of birth					< 0.001
Australia	602 (69)	256 (62)	108 (83)	238 (73)	
Other	268 (31)	156 (38)	22 (17)	90 (27)	
Country of training					< 0.001
Australia	776 (89)	347 (84)	118 (91)	311 (95)	
Other	94 (11)	65 (16)	12 (9)	17 (5)	
State/Territory of practice					< 0.001
Australian Capital Territory	15 (2)	6 (1.5)	1 (1)	8 (2)	
New South Wales	179 (21)	109 (27)	12 (9)	58 (18)	
Northern Territory	11 (1)	3 (1)	1 (1)	7 (2)	
Queensland	173 (20)	90 (22)	16 (12)	67 (20)	
South Australia	69 (8)	34 (8)	3 (2)	32 (10)	
Tasmania	18 (2)	11 (3)	2 (1.5)	5 (1.5)	
Victoria	329 (38)	116 (28)	94 (72)	119 (36)	
Western Australia	76 (9)	43 (10)	1 (1)	32 (10)	
Years providing pregnancy care					< 0.001
0–5 years	155 (18)	63 (15)	48 (38)	44 (14)	
5–10 years	154 (18)	93 (23)	16 (13)	45 (14)	
10–15 years	106 (12)	58 (14)	14 (11)	34 (10)	
More than 15 years	448 (52)	195 (48)	49 (39)	204 (62)	
Personal vaccination status					
Influenza vaccine ever	831 (96)	396 (96)	116 (89)	319 (97)	0.001
Pertussis vaccine in last 10 years	766 (88)	358 (87)	118 (91)	290 (88)	NS

† GP: General practitioner

Table 2: Each MCP† group's attitudes on roles in discussing and administering vaccination

MCP group's opinion	Who they believe has the primary responsibility to DISCUSS n (%)			Who they believe has the primary responsibility to ADMINISTER n (%)		
	Obstetrician	**Midwife**	**GP**	**Obstetrician**	**Midwife**	**GP**
Obstetricians (n = 369)	188 (51)	29 (8)	120 (33)	44 (12)	61 (17)	225 (61)
Midwives (n = 130)	9 (7)	51 (39)	37 (29)	2 (2)	25 (19)	65 (50)
General practitioners (n = 328)	49 (15)	15 (5)	225 (69)	25 (8)	23 (7)	239 (73)
Obstetric trainees (n = 43)	15 (35)	6 (14)	14 (33)	2 (5)	13 (30)	22 (51)

† MCP: Maternity care provider

Table 3: Univariable analysis of factors associated with recommending dTpa† and IIV† according to guidelines

	dTpa		IIV	
	OR (95% CI)	**p**	**OR (95% CI)**	**p**
MCP† role				
GP†	ref		ref	
Obstetrician	0.8 (0.6–1.2)	0.3	0.9 (0.6–1.3)	0.7
Midwife	0.7 (0.4–1.1)	0.7	1.1 (0.6–1.9)	0.7
Country of training				
Australia	ref	< 0.001	ref	0.07
Other	0.4 (0.3–0.6)		0.6 (0.4–1.0)	
Years providing pregnancy care				
0–5 years	ref		ref	
5–10 years	0.8 (0.4–1.5)	0.8	0.6 (0.3–1.1)	0.1
10–15 years	1.1 (0.5–2.2)	0.9	0.4 (0.2–0.8)	0.01
More than 15 years	0.6 (0.3–0.9)	0.02	0.3 (0.2–0.5)	< 0.001
Type of practice				
Public	ref	0.5	ref	0.6
Private	1.2 (0.7–1.9)		1.1 (0.7–1.8)	
Ever had influenza vaccine yourself				
No	ref	0.002	ref	0.01
Yes	2.8 (1.4–5.4)		2.7 (1.2–5.7)	
Had pertussis vaccine in last 10 years				
No	ref	< 0.001	ref	< 0.001
Yes	2.3 (1.5–3.7)		2.3 (1.5–3.6)	
Routinely take a vaccination history				
No	ref	0.01	ref	0.13
Yes	1.7 (1.2–2.5)		1.3 (–0.9–2.0)	
Do you feel confident you have enough information to advise pregnant women on dTpa/ IIV				
No	ref	< 0.001	ref	< 0.001
Yes	6.8 (4.5–10.4)		3.5 (2.0–6.1)	
Not enough is known about safety of dTpa in pregnancy				
Agree	ref	< 0.001	n/a	n/a
Disagree/Neutral	5.6 (2.9–10.9)			
Not enough is known about safety of dTpa in every pregnancy				
Agree	ref	< 0.001	n/a	n/a
Disagree/Neutral	4.0 (2.6–4.1)			
Awareness of change to dTpa guidelines in 2015				
No	ref	< 0.001	n/a	n/a
Yes	22 (12.9–37.6)			
Recommend IIV according to guidelines				
No	ref	< 0.001	n/a	n/a
Yes	3.1 (2.1–4.5)			
Recommend dTpa according to guidelines				
No	n/a	n/a	ref	< 0.001
Yes			3.1 (2.1–4.6)	

† Abbreviations: dTpa – Diphtheria-tetanus-acellular pertussis vaccine; IIV – Inactivated influenza vaccine; MCP – Maternity care provider; GP – General practitioner

Table 4: Univariable analysis of factors associated with providing vaccination services onsite

	Pertussis vaccine		Influenza vaccine	
	OR (95% CI)	**p**	**OR (95% CI)**	**p**
MCP† role				
GP†	ref		ref	
Obstetrician	0.02 (0.01–0.06)	< 0.001	0.2 (0.006–0.04)	< 0.001
Midwife	0.04 (0.01–0.4)	< 0.001	0.01 (0.004–0.03)	< 0.001
Years providing pregnancy care				
0–5 years	ref		ref	
5–10 years	1.2 (0.7–2.0)	0.6	1.9 (1.1–3.2)	0.02
10–15 years	0.6 (0.3–1.0)	0.07	0.7 (0.4–1.2)	0.2
More than 15 years	0.6 (0.4–0.97)	0.04	1.1 (0.7–1.6)	0.7
Type of practice				
Public	ref	< 0.001	ref	< 0.001
Private	0.2 (0.1–0.2)		0.4 (0.2–0.5)	
In private practice, do you have a practice nurse/midwife in your rooms?				
No	ref	< 0.001	ref	< 0.001
Yes	4.8 (3.1–7.3)		4.7 (3.0–7.2)	
Ever had influenza vaccine yourself				
No	ref	0.04	ref	0.04
Yes	2.0 (1.05–3.8)		1.9 (1.03–3.7)	
Had pertussis vaccine in last 10 years				
No	ref	< 0.001	ref	0.01
Yes	2.4(1.6–3.5)		1.7 (1.1–2.5)	
Do you feel confident you have enough information to advise pregnant women on dTpa†/ IIV†				
No	ref	< 0.001	ref	< 0.001
Yes	2.3 (1.6–3.4)		2.7 (1.7–4.2)	
Not enough is known about safety of dTpa in pregnancy				
Agree	ref	0.05	n/a	n/a
Disagree/ Neutral	1.9 (1.0–3.7)			
Awareness of change to dTpa guidelines in 2015				
No	ref	< 0.001	n/a	n/a
Yes	2.8 (1.8–4.2)			
Recommend dTpa according to guidelines				
No	ref	0.002	n/a	n/a
Yes	1.8 (1.3–2.6)			
Recommend IIV according to guidelines				
No	n/a	n/a	ref	0.2
Yes			1.3 (0.9–1.8)	

† Abbreviations: MCP – Maternity care provider; GP – General practitioner; dTpa – Diphtheria-tetanus-acellular pertussis vaccine; IIV – Inactivated influenza vaccine

Chapter 5: Increasing access through non-traditional immunisers

5.1 Introduction

Traditionally in Australia the majority of pregnant women have been vaccinated by their general practitioner (GP).[130,136] However, with efforts to improve coverage of influenza vaccination during pregnancy, and with the recommendation in 2015 of maternal pertussis vaccination, a large number of additional vaccines needed to be administered with few additional resources for delivery. With 305 377 births in Australia in 2015[204] and the number increasing each year, the capacity of existing immunisers has the potential to limit the success of maternal vaccination programs. In response, increasing the number and range of professionals trained and eligible to administer vaccines to pregnant women needed to be considered. Pharmacists are one such group.

Pharmacists have been providing vaccination to adults in the UK, Canada, US and New Zealand for up to 20 years.[205] International experience suggests the addition of pharmacists as immunisers increases uptake of adult vaccination[186,206] and that consumers both support and are satisfied with the service.[206,207]

Pharmacists are already highly regarded and highly accessible providers of preventative healthcare in Australia and therefore are well placed to provide vaccination services.[205] Pharmacists are also a particularly useful resource in rural and remote regions of Australia where access to GPs and maternity care providers can be limited. For pharmacists to be granted authority to administer vaccines in Australia, legislation had to be changed in each state and territory. Western Australia was the first Australian state to pass legislation enabling pharmacist-administered vaccination in December 2014.[185] In May 2016 Victoria became the last Australian state/territory to do so.[185] While pharmacists across Australia may now administer vaccinations, the scope of practice, training and credentialing requirements vary significantly between jurisdictions.[185] All permit influenza vaccination including for pregnant women while only some permit maternal pertussis vaccination.[185]

In studies of pharmacist-administered vaccination in Queensland and Western Australia, consumers valued the convenience and accessibility of the service, and pharmacists reported professional satisfaction.[205,208] However, there has been little published on provision of maternal vaccinations by pharmacists either in Australia or internationally.[209] Given that one of the driving forces for the change in legislation was providing increased access to maternal vaccinations, identifying any concerns or barriers specific to provision of maternal vaccination is important.

To address this gap in our understanding, the study *"A survey of pharmacists' attitudes and practices regarding pharmacist-administered vaccination in Australia"* explores the attitude, knowledge and practice of pharmacists in Australia with a focus on maternal vaccination.

5.2 Hypotheses and aims

Hypotheses

1. Pharmacists perceive benefits to providing vaccination onsite to clients
2. Pharmacists are less comfortable providing vaccine advice to pregnant women than to non-pregnant adults
3. Pharmacists are less comfortable administering vaccines to pregnant women than non-pregnant adults
4. Legislative requirements for provision of vaccination services in the pharmacy setting remain a barrier to pharmacists introducing vaccination services

Aims

1. To assess the attitude, knowledge and practice of pharmacists with regards to vaccination
2. To compare differences in pharmacists' attitude and knowledge of maternal vaccination to vaccination of non-pregnant adults
3. To identify barriers to provision of vaccination services by pharmacists in Australia

5.3 Methods

As the peak professional body for pharmacists nationally and provider of the majority of continuing professional development for pharmacists, the Pharmaceutical Society of Australia (PSA) was approached to collaborate on this study. With the input of the Victorian Branch Director and Senior Policy Officer, a questionnaire was developed using the online platform SurveyMonkey. The final questionnaire collected information on demographics, pharmacy characteristics, immunisation training undertaken, pharmacists' comfort with discussing and providing vaccines to pregnant women and other adults, and perceived benefits of and barriers to providing vaccination services. The questionnaire was piloted by a convenience sample of pharmacists to ensure it was well understood. The final questionnaire is included in Appendix 8.

The study was conducted between April and June 2017. An explanatory email with a link to the questionnaire was distributed to PSA members nationally via the email newsletter with three reminders sent. In-person recruitment was also undertaken at the PSA Victorian Pharmacy conference in April 2017. At the conference, participants could complete the survey online using an iPad, or in paper copy. The responses from the paper copy were manually transcribed onto SurveyMonkey by the principal researcher or research midwife. The study was also promoted at monthly PSA education sessions during the study period, and on the PSA and PSA Early Career Pharmacist Facebook pages. An invitation to participate was also distributed online through the Eastern Melbourne Primary Health Network email newsletter to approximately 300 pharmacies. This newsletter is not only available to pharmacists but also pharmacy assistants, and other pharmacy staff and therefore the denominator of pharmacists who receive this newsletter is unknown.

Questions using a Likert scale were collapsed for statistical analysis. Positive responses were combined (e.g. extremely important, very important and important combined into a category "important"). Statistical analysis was performed using IBM SPSS Statistics version 22.0 (Armonk, New York). Subgroup comparisons by state of practice, setting (urban compared to rural/remote), years of practice, and type and size of pharmacy were determined a priori. The significance of differences between

subgroups were determined using Fisher's exact or Pearson chi-square tests. Statistical significance was defined as $p < 0.05$.

Ethics approval was obtained from the Monash University Human Research and Ethics Committee.

5.4 Findings

The manuscript for this study, *"A survey of pharmacists' attitudes and practices regarding pharmacist-administered vaccination in Australia",* is included at the end of this chapter and provides detailed results. The key findings are outlined below:

- Three-quarters of pharmacists felt underequipped with their undergraduate training on vaccination.
- Pregnant women frequently ask pharmacists for advice about maternal vaccination; however, pharmacists were less comfortable discussing and administering vaccines to pregnant women than non-pregnant adults.
- Pharmacists perceive the legislative requirements pertaining to staffing and premises as well as managing anaphylaxis as the most significant barriers to providing vaccination services.

5.5 Implications

This is the first national study examining pharmacists' attitudes towards maternal vaccination in Australia. The study suggests that all pharmacists, regardless of whether they provide vaccination or not, would benefit from further immunisation education and training particularly around maternal vaccination. Simplifying the legislative requirements for providing vaccination services without compromising patient safety, along with uniform legislation across states and territories may encourage more pharmacists to implement vaccination services. The generalisability of the findings is limited by the small sample size and low response rate. Furthermore with a majority of respondents from Victoria the results may not reflect the heterogeneity in service provision given the different jurisdictional requirements. It is

nevertheless an important piece of work given the current impetus for pharmacists to provide vaccination services for pregnant women in Australia.

Pharmacist-delivered vaccination is one strategy to improve suboptimal rates of maternal vaccination in Australia. However, it still requires a pregnant woman to attend a healthcare provider independent of the site of her antenatal care, and, in some jurisdictions, incur additional costs with service and vaccine fees. Several studies have demonstrated greater uptake when vaccination is administered onsite within maternity care services.[135,162,187,210] The following chapter explores the impact of incorporating onsite vaccination into a maternity service.

A SURVEY OF PHARMACISTS' ATTITUDES AND PRACTICES REGARDING PHARMACIST-ADMINISTERED VACCINATION IN AUSTRALIA

Abstract

Background: The importance of adult vaccination including maternal vaccination is increasingly being recognised. Access to immunisation providers is one barrier to achieving high coverage of adult vaccinations. Utilising pharmacists as immunisers has improved uptake internationally but has only recently been introduced in Australia.

Aim: To examine the attitudes and practices of pharmacists in Australia with regards to vaccination, with a focus on maternal vaccination and barriers to implementation.

Methods: Survey of members of the Pharmaceutical Society of Australia and pharmacists in the Eastern Melbourne Primary Health Network.

Results: 156 responses were analysed. Twenty-seven percent (42/156) of respondents practiced in rural regions. Pharmacists working in rural regions were more likely to provide influenza vaccination than those in metropolitan areas (38/42 [91%] vs 80/112 [71%]; p=0.01). Three quarters (102/137, 74.5%) felt they had received inadequate education on vaccination during undergraduate training but 130/156 (83%) felt appropriately supported by their professional bodies to implement vaccination. Two thirds (88/137, 64%) had completed an immuniser training course and 103/146 (70.5%) had a trained pharmacist immuniser on staff. Maternal vaccination was less frequently provided (influenza 64/154 [42%]; pertussis 42/115 [37%]). Pharmacists felt less comfortable discussing (120/156 [77%] vs 136/156 [87%]; p=0.005) and administering (85/156 [55%] vs 119/156 [77%]; p<0.001) vaccinations to pregnant women than other adults. The majority (96/109, 89%) agreed the Australian immunisation register would be a useful tool for healthcare providers.

Conclusions: Pharmacists were less comfortable with maternal vaccination than other adult vaccination. Greater access to training may alleviate some of this hesitancy.

Keywords: Pharmacist; vaccination; immunisation; implementation; maternal vaccination; adult vaccination; Australia

Introduction

Childhood vaccination has been the focus of public health efforts against vaccine preventable diseases for decades.[1] However, in recent years the importance of adult vaccination has been increasingly recognised.[2] Vaccination against influenza, pneumococcus and herpes zoster for adults at high risk of these infections is recommended in many high income countries including Australia.[1] In addition, in the last decade, maternal vaccination (vaccination of women during pregnancy) against influenza, and more recently pertussis, has been recommended for both maternal and neonatal benefits.[1]

However, uptake of adult vaccinations both in Australia and internationally has been suboptimal.[2-4] In addition, despite evidence supporting the effectiveness and safety of maternal pertussis and influenza vaccines, uptake of these also varies considerably with reported rates of 6%–82% in the United States (US),[5-7] 30–60% in the United Kingdom (UK),[8,9] and 26–70% in Australia.[10-12] Barriers to uptake include lack of public and healthcare provider (HCP) awareness of the recommendations, consumers not being recommended to have the vaccines by their HCP, access to vaccines and immunisation providers and, in some jurisdictions, cost.[12-14]

Community pharmacists already provide a range of preventive healthcare advice. With extended opening hours and without need for appointments they are often more accessible and convenient than traditional medical services. Accordingly, community pharmacists are well placed to provide vaccination services. Over the last 20 years pharmacist-administered vaccination has been successfully adopted internationally including in the US, UK, Canada and New Zealand.[15]

Isenor et al. conducted a systematic review of the impact of pharmacists as immunisers. All 14 studies reported increased vaccination rates compared to provision by traditional immunisation providers only. Pooled analysis of the two randomised controlled trials including influenza, pneumococcal and herpes zoster vaccines found a 2.6-fold (95% CI 1.8–3.9) increase in vaccination rate when pharmacists were able to provide immunisations in addition to traditional providers.[16]

Between 2014 and 2016, all states and territories of Australia have introduced pharmacist-administered vaccination with Victoria being the last state to do so in May 2016.[17] However, regulations vary between jurisdictions.[17] Some are able to administer only influenza vaccination and others influenza, pertussis and measles, mumps and rubella vaccines.[17] In four states and territories pharmacy interns are able to administer vaccinations under the supervision of a pharmacist immuniser.[17] Access to National Immunisation Program (NIP) funded vaccines is only available to pharmacists in Victoria.[17] In other states and territories, eligible patients can receive NIP-funded vaccines free of charge through primary care (primary care provider may charge an appointment fee but the vaccine is free) but they must purchase the vaccine in addition to paying an administration or service fee if vaccinated by a pharmacist. In September 2016 a national all-age immunisation register (Australian Immunisation Register) was introduced in Australia to record all NIP and private vaccines administered.[1] Pharmacist immunisers in all states and territories are expected to contribute to this register.[18]

In the first Australian pilot of pharmacist-administered vaccination, the Queensland Pharmacist Immunisation Pilot, consumer satisfaction was well over 94%. Despite being eligible for free vaccination under the NIP, 20% of consumers elected to pay to use a pharmacy service for convenience. Almost 14% of those vaccinated had never received an influenza vaccine previously and 15% reported they would not have been vaccinated were it not for the pilot trial.[19] These findings were replicated more recently in Western Australia.[15]

To date there has been little published on pharmacists' attitudes and practice in relation to maternal vaccination.[20] Dolan et al. surveyed American pharmacist

immunisers in 2009–10 about influenza vaccine. They found that fewer pharmacists believed they had an important role in vaccinating pregnant women compared to other adults. Pharmacists' concerns pertained to vaccine safety, liability, and categorisation of influenza vaccine as category C during pregnancy.[20]

With the recent changes in legislation in Australia, pharmacists now have new and important health promotion and leadership roles in recommending and providing vaccination to their patients including pregnant women. With a paucity of Australian-specific data on pharmacist-administered vaccination and in particular provision of maternal vaccination, there is a need to understand the barriers and needs of pharmacists in this emerging area.

This study aims to explore the current attitude and practice of pharmacists to vaccination in Australia, the barriers to establishing pharmacist-administered vaccination services, and any differences in pharmacists' knowledge or attitude to vaccination of pregnant women compared with other populations.

Methods

A survey was developed by the researchers in collaboration with representatives from the Victorian branch of the Pharmaceutical Society of Australia (PSA), the peak national professional pharmacy organisation.[18] The survey consisted of multiple choice questions, open-ended questions and questions utilising a Likert-type scale. The survey was based on review of the published literature and piloted by a convenience sample of pharmacists. The final national survey was administered through an online platform (Survey Monkey) collecting demographic information and included questions on immunisation training, attitudes to vaccination including during pregnancy, and experience with providing vaccination services with an emphasis on perceived benefits and barriers.

Years of practice was categorised in five-year intervals up to 15 years, with a final category of more than 15 years. Four groups were used to categorise pharmacy type: franchised banner group, independent community pharmacy, private pharmacy group, and public hospital pharmacy. Pharmacies were defined as large (more than

three pharmacists on duty), medium (2–3 pharmacists on duty) or small (one pharmacist on duty).

The study was conducted between April and June 2017. An invitation to complete the survey was emailed through the national email newsletter to all PSA members nationally (approximately 14 000) in April 2017 with three further reminder emails between April and June 2017. In addition, attendees at the PSA Victoria monthly education and professional development sessions were advised of and provided the online link to the study. Researchers also recruited face to face at the PSA Victorian Pharmacy Conference in April 2017 (approximately 250 attendees). Surveys completed in hard copy at the conference were transcribed by the principal investigator onto the online platform. In May 2017, the questionnaire was promoted on the PSA and PSA Early Career Pharmacists Facebook pages (approximately 7000 followers). In addition, a link to the survey was included in the June 2017 email newsletter of the Eastern Melbourne Primary Health Network.

Descriptive statistical analysis was performed using IBM SPSS Statistics version 22.0 (Armonk, New York). Subgroup comparisons by state of practice, setting (urban compared to rural/ remote), years of practice, and type and size of pharmacy were determined a priori. Given the small number of respondents from jurisdictions other than Victoria, this subgroup analysis was not performed due to inadequate power to draw meaningful conclusions. The significance of differences between subgroups were determined using Fisher's exact or Pearson chi-square tests. Statistical significance was defined as $p<0.05$.

The study was approved by the Monash University Human Research Ethics Committee.

Results

169 completed surveys were returned (response rate 1%). Of these, 13 (8%) were excluded as the respondents indicated they were in non-clinical roles, leaving 156 responses for analysis. The majority of respondents worked in Victoria (102/156, 65%). The response rate amongst Victorian pharmacists was approximately 4% (102/3140).

Table 1 summarises the demographics of the respondents. Responses were received from all jurisdictions in Australia except for the Northern Territory, from pharmacists with a broad range of experience in a variety of settings. Demographics of respondents were compared with pharmacists registered with the Australian Health Practitioner Regulation Agency and Pharmacy Board of Australia, and immunisation training data with national PSA figures. New South Wales, Queensland, and Western Australia were underrepresented in our survey, but Tasmania, Australian Capital Territory and South Australia were proportionately represented. A greater proportion of our sample was immunisation trained than the general pharmacy population (64% in our sample compared to national average of 13% [personal communication Bill Suen]). Ten percent (15/146) of respondents worked in large pharmacies, 99/146 (68%) in mid-sized pharmacies and 32/146 (22%) in small pharmacies.

Immunisation services provided

Three-quarters of respondents (119/155, 77%) worked in pharmacies where influenza vaccination (IIV) was provided. Those practising in rural/ remote settings were more likely to provide IIV than those working in metropolitan/ urban pharmacies (38/42 [91%] vs 80/112 [71%]; p=0.01). Provision did not differ in any of the other subgroup analyses.

Pharmacists were frequently the sole immunisers at the pharmacy (85/118, 72%), however 18/118 (15%) employed nurse immunisers, and 9/118 (8%) used a combination of pharmacist and nurse immuniser. Only 2/118 (2%) respondents reported pharmacy interns supervised by the pharmacist administering immunisations.

Most pharmacies provided their immunisation service utilising a combination of appointment system and walk-ins (66/119, 55.5%). However, 12/119 (10%) required clients to make an appointment at all times, 21/119 (18%) vaccinated by appointment only during specified hours, and 17/119 (14%) provided vaccinations at any time without appointment.

Immunisation training

Three quarters (102/137, 75%) of pharmacists felt they had not received enough education on immunisation during their undergraduate pharmacy training. This did not vary significantly by when they trained. Importantly, 130/156 (83%) respondents reported feeling appropriately supported to provide immunisation services by their professional body.

Overall 88/135 (65%) of pharmacists reported completing an approved immuniser training course. Pharmacists working in rural/ remote settings were more likely to have completed a course than those practising in metropolitan settings (31/42 [74%] vs 59/113 [52%]; p=0.02). Those working in large pharmacies were also more likely to have undergone a training course (13/15, 87%) than those working in mid-sized (53/99, 54%) or small (16/32, 50%) pharmacies (p=0.04). There were no differences in any other subgroup analyses.

Nearly three quarters (103/146, 71%) of respondents reported having a trained pharmacist immuniser on staff. Rural/ remote pharmacists were more likely to report a trained immuniser pharmacist on staff (34/41, 83%) than those in metropolitan practice (68/104, 65%) (p=0.04). Otherwise there were no differences in subgroup analyses.

Attitudes to and barriers to providing pharmacy-based immunisation services

Pharmacists were asked to rate how important the potential benefits of pharmacist-administered vaccination were to them, and the significance of various factors as potential barriers to provision of immunisation services. The benefit to the public was more highly rated than their own professional or monetary benefits. In terms of barriers to providing the service, the most common barriers cited were the legislative requirements regarding premises and staffing and managing anaphylaxis. (Table 2)

Australian Immunisation Register (AIR)

Of those able to comment on their experience utilising the AIR, the vast majority (96/109, 89%) believed the AIR was a useful tool for healthcare providers to access an up to date vaccination history. A third (28/83, 34%) felt the requirement to contribute to the AIR was a barrier to providing immunisation services. Less than half (33/70, 47%) found registering as a user on AIR straightforward, 39/66 (59%) reported the administrative requirements of reporting to AIR onerous, and only 22/80 (28%) believed pharmacists were adequately reimbursed for contributing to AIR.

Vaccination during pregnancy

At the time of the study IIV could be administered by pharmacists in all states and territories but only Queensland, Victoria, Australian Capital Territory (ACT) and Northern Territory permitted pharmacists to administer the combined diphtheria-tetanus-acellular pertussis (subsequently referred to simply as pertussis) vaccine. Overall 64/154 (42%) reported IIV was administered to pregnant women at their pharmacy. Pertussis vaccine was equally offered in states where it was permitted (42/118, 36%)(p=0.3). Provision was highest amongst respondents from Queensland at 7/15 (47%), then Victoria at 35/100 (35%) while 0/3 from the ACT reported administering pertussis vaccine to pregnant women at their pharmacy.

Provision of maternal vaccination varied by pharmacy size. Pharmacists working in large pharmacies were more likely to provide both IIV and pertussis vaccines to pregnant women (10/15 [67%] for IIV and 9/15 [60%] for pertussis) than those working in medium (41/97 [42%] and 25/97 [26%]), and smaller pharmacies (9/32 [28%] and 5/32 [16%]) (p=0.04 and p=0.005 for IIV and pertussis respectively). In addition, providing pertussis vaccination was more likely to be reported by pharmacists working in public hospital pharmacies (6/10, 60%) than other types of pharmacies – 20/68 (29%) in franchised banner group pharmacies, 4/14 (29%) in private pharmacy groups, and 10/58 (17%) for independent community pharmacies (p=0.04).

A third (30/88, 34%) of those working in pharmacies that did not offer vaccination to pregnant women reported an intention to do so in the future. Nearly 80% (119/153, 78%) of respondents reported being asked for advice on maternal vaccination at least once a week. Respondents were also asked about their comfort discussing and administering vaccinations to various patient groups including pregnant women. They were less comfortable discussing and administering vaccinations to pregnant women than other adults including adults with comorbid conditions. (Table 3)

Discussion

To the best of our knowledge this is the first multi-jurisdictional survey of the attitudes and practices of both immuniser and non-immuniser pharmacists following the introduction of legislative changes permitting pharmacist-administered vaccination in Australia. As was reported in Hattingh's study in Western Australia,[15] we demonstrated that pharmacist-administered vaccination appears to have been more widely adopted in rural and remote regions. Pharmacists in our study rated the public health benefits as amongst the most important benefits of pharmacist-administered vaccination. Pharmacies can fulfil an important role in increasing access to immunisation particularly in rural and remote settings where access to primary healthcare services can be more limited than in metropolitan areas.

Pharmacists may also be particularly valuable in the setting of maternal vaccination as maternity care services are often not equipped to store or administer vaccinations on site.[21] Maternal vaccination has been recommended nationally but implemented and funded at a state and territory level. Pharmacist-administered vaccination has also been implemented on a state level. Overall 42% of pharmacists reported offering IIV and 37% pertussis vaccine to pregnant women. It is noteworthy that a third of those offering IIV specifically excluded pregnant women. As it stands, it may be challenging for pregnant women to know which pharmacies currently provide a service for them. Encouragingly, the study suggests that there is an intention to expand maternal vaccination services in the future and therefore greater consistency in service provision can be expected. In addition, consumer awareness of pharmacists as immunisers is likely to rise and further increase demand for the service.

Only three of the seven states and territories in Australia authorised pharmacists to administer pertussis vaccination at the time of the study. If one of the aims of pharmacist administered vaccination is to increase access and thereby uptake of maternal vaccination, the rationale for allowing pharmacists to vaccinate pregnant women against influenza but not pertussis needs to be reconsidered. There are also inconsistencies across states and territories with regards to training requirements, ongoing credentialing, the types of vaccinations able to be administered and whether pharmacy interns can administer vaccines.[20] Standardising regulations across the country would reduce confusion and provide pharmacists who work in multiple jurisdictions with greater clarity.

Pharmacists reported feeling underequipped by the current undergraduate pharmacy training on vaccination. While immunisation training requirements vary by state and territory, accredited immuniser training for registered pharmacists is only provided by the PSA or Pharmacy Guild of Australia. Furthermore, even if pharmacists do not personally administer vaccines, our study demonstrated that pregnant women frequently consult them for vaccination advice and therefore adequate training of all pharmacists in maternal vaccination is essential. Our respondents also reported being more uncomfortable administering vaccinations to pregnant women than other adults. This hesitancy needs to be further examined if pharmacists are to play a key role in delivering maternal immunisations. Encouragingly, efforts to integrate vaccination into pharmacy education are underway[22] and importantly the majority of pharmacists reported feeling supported by their professional bodies to establish vaccination services.

Pharmacists in our study identified many of the same barriers to implementation as reported by studies from the US and Canada including availability of pharmacy space, maintaining adequate staffing, keeping up to date with recommendations, legal liability and financial reimbursement.[23,24]

Australia has only recently adopted a national immunisation register encompassing children and adults[1] and hence our study was uniquely able to examine pharmacists' perceptions of the AIR. While pharmacists in our study recognised the importance of the AIR as an important tool to facilitate communication and collaborative care, their

frustrations with the registration process, inability to link AIR with their electronic dispensing systems, and inequitable access to remuneration between traditional immunisation providers and themselves are all issues that need to be addressed for the continued success of the program.

The strengths of our study include the inclusion of pharmacists with a breadth of experience and those practising in a diverse range of settings. However, there are some limitations that need to be acknowledged. The most significant limitation is the low response rate nationally. Due to the low response to the online survey we attempted to recruit pharmacists through a number of channels. The most effective was in person recruitment at the conference. The low response rate may signify that immunisation services are not a high priority for pharmacists in general and that those that responded may be more supportive of vaccination than the general pharmacist population. Supporting this presumption, 64% of our respondents had undergone an immuniser training program compared to the national average of 13% [personal communication Bill Suen]. Likewise a higher proportion of our sample reported immunisations being offered at their pharmacy (74% provided influenza vaccine) compared to data available from Victoria and Tasmania suggesting only 20% and 51% of pharmacies provided immunisation services [personal communication Bill Suen]. Both of these potential biases and the low response rate clearly limit the generalisability of our results. Nonetheless given that our study includes students and pharmacists from multiple jurisdictions, along with regional and metropolitan Australia, we believe our study provides insight into pharmacists' perspective in Australia.

Conclusion

Pharmacists are perceived as convenient, and accessible providers of healthcare in Australia. With suboptimal adult and maternal vaccination coverage in Australia, this innovative model is welcome to increase immunisation rates and thereby health outcomes particularly for adults at risk and pregnant women and their families. However greater focus may need to be given to pertussis vaccination, and education programs implemented to increase pharmacists comfort in responding to queries related to vaccination during pregnancy.

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Table 1: Demographics of respondents

Demographics (n = 156)	n (%)
Age (median, range)	33 years (19–74)
Australian-born	100 (64)
Completed pharmacy training in Australia	145 (93)
In which state/territory is your primary place of work	
Australian Capital Territory	3 (2)
New South Wales	15 (10)
Queensland	15 (10)
South Australia	10 (6)
Tasmania	3 (2)
Victoria	102 (65)
Western Australia	8 (5)
In what setting is your primary place of work	
Metropolitan / urban	113 (72)
Rural / remote	42 (27)
What is your primary professional role	
Pharmacy owner	27 (17)
Pharmacy manager	26 (17)
Employee pharmacist	82 (53)
Student	19 (12)
For how long have you been a practising pharmacist†	
0–5 years	42 (31)
6–10 years	28 (20)
11–15 years	20 (15)
More than 15 years	47 (34)
Which of the following best describes your primary place of work	
Franchised banner group	68 (44)
Independent community pharmacy	59 (38)
Private pharmacy group	14 (9)
Public hospital pharmacy	11 (7)

† 9 student responses were excluded from analysis for this question and therefore n = 137

Table 2: Pharmacists' perceptions of the benefits of and barriers to providing immunisation services

Please rate how important each of the following potential benefits of pharmacist-administered vaccination are to you	Important n (%)	Not important n (%)	No opinion n (%)
Increased access to immunisation	154 (99)	1 (0.6)	1 (0.6)
Convenience for clients	153 (98)	2 (1)	1 (0.6)
Public health benefit of increasing immunisation coverage	153 (98)	2 (1)	1 (0.6)
Expanding the role and professional image of pharmacists	149 (95.5)	6 (4)	1 (0.6)
Providing more holistic care	147 (94)	7 (4.5)	2 (1)
Professional satisfaction	147 (94)	8 (5)	1 (0.6)
Monetary gains	124 (79.5)	22 (14)	10 (6)

How significant do you feel each of the following potential barriers to providing immunisation services are at your primary place of work	Significant n (%)	Insignificant n (%)	Unsure n (%)
Meeting premises requirements	124 (79)	28 (18)	4 (3)
Meeting professional staffing requirements	128 (82)	25 (16)	3 (2)
Managing anaphylaxis	123 (79)	29 (19)	4 (3
Meeting demand for the service	114 (73)	38 (24)	4 (3)
Concerns about liability	113 (72)	38 (24)	5 (3)
Cost of training program	208 (67)	95 (30)	9 (3)
Time required to complete training program	86 (55)	66 (42)	4 (3)
Cost of professional development	112 (72)	40 (26)	4 (3)
Time required for professional development	98 (63)	52 (33)	6 (4)
Charging a fee for the service	91 (58)	61 (39)	4 (3)

Table 3: Comfort with discussing and administering vaccinations

How comfortable do you feel discussing the risks and benefits of vaccination when asked by the following customer groups?				
	Pregnant women	**Adults**	**Adults with chronic medical conditions**	**p-value**
Comfortable discussing	120/156 (77%)	136/156 (86%)		0.005
	Ref		123/156 (79%)	0.7

Please rate how comfortable you would be with administering vaccinations to each of the following customer groups				
	Pregnant women	**Adults**	**Adults with chronic medical conditions**	**p-value**
Comfortable administering	85/156 (55%)	119/156 (77%)		< 0.001
	Ref		101/156 (65%)	< 0.001

Chapter 6: Delivering vaccination services

6.1 Introduction

As outlined in Chapter 4, women in Australia may receive pregnancy care through a private obstetrician, a public hospital antenatal clinic or a combination of providers in various shared care models.[203] However, general practitioners (GPs) and local government immunisation services have traditionally been the main providers of vaccinations.[130,136] One of the potential problems with this separation of maternity and immunisation services, is that many women do not otherwise consult a GP during pregnancy care, and therefore obtaining vaccination requires an additional appointment with the attendant time and travel. While maternal vaccinations are fully funded for pregnant women in Australia, they may have to pay a fee for the GP consultation. Local government immunisation services also provide maternal vaccinations and do not charge a fee, but may require women to make an appointment and attend during specific immunisation sessions. Pharmacists have recently become an alternative immunisation provider in Australia.[185] As was demonstrated in the study presented in Chapter 5, not all pharmacists currently offer maternal vaccination services, so women wishing to access vaccination through their local pharmacy are dependent on the pharmacy having a trained pharmacist immuniser and offering the service. In addition, pharmacist-administered vaccination still requires that women attend an additional provider and pay a service fee.

One Australian study has reported that not being offered vaccines within the antenatal clinic was the most common barrier reported by women (32/290, 12%; 95% CI 8–16).[124] In addition, in a qualitative study of 15 obstetricians, midwives and GPs in South Australia in 2012, providers expressed concern that the process and cost of referring women to other providers was a barrier to uptake.[158]

Two Australian studies have demonstrated increased uptake of antenatal influenza and one of post-partum pertussis vaccination when vaccination is provided onsite.[134,135,137] Taksdal et al. reported that women who had access to onsite influenza vaccination were nearly three times as likely to receive it (adjusted odds ratio 2.8,

95% CI 1.1–6.9).[135] Likewise Wiley and colleagues found that uptake of influenza vaccine was significantly higher at a service with an immunisation nurse embedded within the clinic compared to those sites that did not have onsite vaccination (46% compared to 21% and 17%, p = 0.04).[134] Finally Hayles et al. reported that uptake of post-partum pertussis vaccine increased from 23% to 70% after the vaccine was made available for administration on the maternity ward.[137]

One barrier to midwives and nurses administering vaccinations is waiting for a review and prescription from a doctor. A standing order provides a legal written instruction for a registered nurse or midwife to assess a woman's suitability and administer medications or vaccines without the need for a prescription or review by a doctor. In Australia, standing orders have primarily been used for delivery of emergency medications, in rural and remote settings and in specified immunisation programs.[211] In the maternity care setting, standing orders have been used for a variety of conditions including management of pain and emesis in labour, post-partum haemorrhage, and for administration of Rhesus (D) immunoglobulin, intrapartum antibiotic prophylaxis to prevent early-onset neonatal group B streptococcus infection, Vitamin K, and neonatal hepatitis B vaccination.[212]

There have not been any studies specifically on use of standing orders for midwife administration of maternal vaccines in antenatal clinics in Australia. We trialled a standing order and compared this to two other models of delivery to try and address the low uptake of maternal pertussis vaccination at our institution. A study was conducted to assess the impact of this intervention and is presented in the publication attached at the end of this chapter, "*Strategies to implement maternal vaccination: A comparison between standing orders for midwife delivery, a hospital based maternal immunisation service and primary care.*"

6.2 Hypotheses and aims

Hypotheses

1. Onsite vaccination either through an immunisation service or use of a standing order improves uptake of maternal pertussis vaccination as vaccination can be delivered at the time of recommendation
2. A standing order model facilitating midwife administration of pertussis vaccine is well accepted and improves uptake

Aims

1. To trial a standing order for midwife-led delivery of pertussis vaccine and compare with a walk-in immunisation service and delivery by primary care
2. To increase uptake of maternal pertussis vaccination

6.3 Methods

Monash Health delivers maternity care across three geographically separate hospitals. The three hospitals are described in detail in Section 2.3. The largest, a tertiary obstetric referral centre, has an onsite, nurse-led, walk-in immunisation service which provides vaccination to all Monash Health patients including pregnant women. From our previous work we determined that the immunisation service was primarily used by women receiving maternity care at that site and very few women receiving maternity care at either of the other hospitals utilised this service.[213] At the other two hospitals, women had the option of obtaining vaccination from the immunisation service, or through primary care. In order to provide equitable access to onsite vaccination across the three maternity hospitals of Monash Health, a standing order model was proposed. A standing order for midwife administration of pertussis vaccine in the post-partum period already existed from the time when cocooning was the recommended strategy. This was revised to be consistent with national guidelines to preferentially recommend pertussis vaccination during pregnancy. The standing order authorised midwives to administer pertussis vaccine to pregnant women during the third trimester of pregnancy within maternity care clinics at Monash Health.[212]

Due to logistic issues, the standing order for antenatal pertussis vaccination was only introduced at one of the three hospitals during the study period. This created a temporary situation where women at each hospital were predominantly vaccinated through different models: through an onsite immunisation service at hospital A, by midwives within the clinic using the standing order at hospital B, and through primary care (usually their GP) at hospital C.

Uptake of pertussis vaccination by women at each of the sites was captured in the Birthing Outcome System (BOS), a state-wide perinatal database in which women's self-reported vaccination status is recorded. At the start of the study period the vaccination field was only able to be completed by midwives after delivery. During the course of the study, BOS was revised to enable midwives to complete this field during any antenatal visit. To assess the effect of this change independent of the effect of the standing order, a sub-study to determine the impact was conducted. Vaccinations administered at the immunisation service at hospital A are recorded in the electronic medical record and also an immunisation database. Women's vaccination status in these records were compared to that in BOS for a three-month period prior to the change and a further three-month period following.

A time series analysis of fortnightly uptake rates as measured by BOS was performed across all three hospitals from 1 September 2015 (13 months prior to the introduction of standing orders at hospital B) to 30 June 2017 (6 months following introduction of standing orders at hospital B). Statistical analysis was performed using IBM SPSS Statistics version 23.0 (Armonk, New York). Mann Whitney U tests were used to determine the significance of differences in uptake over time.

The study was assessed by Research Support Services at Monash Health as a Quality and Service Improvement Activity and was therefore exempt from full ethics committee review.

6.4 Findings

The publication *"Strategies to implement maternal vaccination: A comparison between standing orders for midwife delivery, a hospital based maternal immunisation service and primary care"* is included at the end of this chapter and provides detailed results. The key findings are outlined below:

- While uptake improved at all three hospitals over the study period, the greatest increase was seen at hospital B where standing orders were implemented.
- The impact of standing orders was consistent with the reported experience internationally.
- A standing order was demonstrated to be a feasible, acceptable and effective model to increase uptake of maternal vaccines within public hospital antenatal clinics in the Australian context.
- Contrary to what is reported in the literature, accessing a GP did not appear to be a barrier to uptake in our study with high uptake amongst women at hospital C who primarily received vaccination through primary care.
- Access to a dedicated onsite immunisation service did not lead to greater uptake than achieved through the other models.

6.5 Implications

This study was unique in contemporaneously examining uptake of antenatal pertussis vaccination using three different models of immunisation service delivery. It was also the first Australian study examining the effect of a standing order on uptake of maternal pertussis vaccination. Uptake improved markedly with introduction of the standing order underscoring the importance of providing timely, onsite vaccination whenever possible. The study also highlights that a diversity of immunisation models are needed in maternity care settings as all can achieve high coverage in the right setting. Multiple factors are thought to have contributed to the surprisingly low uptake at hospital A at the end of the study. Increased use of the immunisation service could be facilitated by enabling nurse immunisers to directly enter vaccination data into the perinatal data collection tool, with further education of healthcare providers to encourage recommendation, through secondment of an immunisation nurse from

the service to the antenatal clinic itself to reduce waiting times and inconvenience for patients and to enable the same interpreters used for the antenatal appointment to be used for the vaccination consent and administration process. Further work needs to be undertaken to understand the success of the primary care-led model at hospital C and how these successes may be replicated elsewhere. Ideally the barriers and wishes of providers and women specific to each maternity service should be assessed in determining the most appropriate model of immunisation service delivery for their setting.

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Strategies to implement maternal vaccination: A comparison between standing orders for midwife delivery, a hospital based maternal immunisation service and primary care

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ABSTRACT

Maternal vaccination is a safe and effective strategy to reduce maternal and neonatal morbidity and mortality from pertussis and influenza. However, despite recommendations for maternal vaccination since 2010, uptake remains suboptimal. Barriers to uptake have been studied widely and include lack of integration of vaccination into routine pregnancy care and access to vaccination services. Standing orders for administration of vaccines without the need for a physician review or prescription have been demonstrated to improve uptake as part of multi-model interventions to increase antenatal influenza and post-partum pertussis vaccination.

Monash Health is a university-affiliated, public healthcare network in Melbourne, Australia providing maternity services across three hospitals. In this study we compared three different immunisation models – an immunisation nurse-led immunisation service, standing orders for midwife-administered pertussis vaccination within pregnancy care clinics, and delivery by general practitioners in primary care. Uptake of maternal pertussis vaccine was measured as recorded in the state-wide perinatal data collection tool.

Uptake improved significantly at all three hospitals over the study period with the most significant change (39% to 91%, $p < .001$) noted at the hospital where standing orders were introduced.

Our study highlights the diversity of immunisation service models available in maternity care settings. We demonstrated significant improvement in uptake of maternal pertussis vaccination with introduction of midwife-administered vaccination but each maternity service should consider the model best suited to their needs.

1. Introduction

In recent years maternal immunisation has become an integral component of pregnancy care. Following the lead of the United Kingdom (UK) and the United States (US), many countries now recommend maternal influenza and pertussis vaccination during pregnancy. Both vaccines have been demonstrated to be highly efficacious in preventing maternal and neonatal morbidity and mortality [1–3].

However despite demonstrated efficacy and safety, uptake of these vaccines during pregnancy remains suboptimal. Barriers to uptake include failure to incorporate vaccination into routine pregnancy care, lack of healthcare provider (HCP) recommendation, concerns about safety, and access to vaccination services [4–6].

Numerous studies have highlighted the importance of HCP recommendation as an enabler of vaccination [7–10]. As providers of population level vaccination programs, primary care physicians are well versed in discussing immunisation and often have an established capacity to store and administer vaccines in their clinics. However, in Australia and the US, midwives or obstetricians are often the only HCP many pregnant women consult during pregnancy so the logistics of incorporating maternal vaccination into pregnancy care need to be considered. Barriers to maternity

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services providing vaccination include lack of the necessary infrastructure to support vaccination, lack of training and knowledge of maternity care providers regarding current recommendations, and concerns about liability and reimbursement [4,5].

Studies have also demonstrated that women's intention to be vaccinated does not necessarily equate with receipt of vaccination. Competing time pressures, priorities, and difficulty accessing immunisation providers are barriers to vaccination despite an intention to do so [11]. In a study of influenza vaccination in pregnancy, women were 2.7 (CI 1.1–6.9, p = .035) times more likely to be vaccinated if the vaccine was offered at their pregnancy care facility compared to those who had to get the vaccine elsewhere [7].

At some locations, further barriers to vaccine administration include a requirement for a prescription from a doctor and obtaining the vaccine from a pharmacy. Such barriers can be readily overcome by instituting standing orders for midwife administration of vaccines without the need for physician review or prescription. The US Advisory Committee on Immunisation Practices has recommended the use of standing orders to improve immunisation rates for more than a decade [12]. One community hospital in the US increased their post-partum pertussis vaccine uptake from 18% to 69% (p < .001) with introduction of standing orders [13]. Similarly, two other US hospitals implemented standing order models and reported increased vaccination rates to approximately 80% compared to only 20% overall in the US [14–16].

In this study we implemented standing orders for midwife administration of acellular pertussis-containing vaccine (dTpa) during the third trimester and report on the impact of this change. In addition, with three different immunisation models utilised within the same healthcare network, this study provides a unique opportunity to directly compare different immunisation models in the Australian context.

2. Materials and methods

Monash Health is the largest public healthcare network in Melbourne, Australia providing maternity care to over 10,000 women per year across three hospitals. Hospital A is a tertiary obstetric referral centre with an onsite immunisation service. Hospital B provides primary and secondary level maternity care to a large migrant and refugee population with approximately 3000 deliveries per annum. Hospital C provides primary and secondary level maternity care for approximately 3000 women each year.

All States and Territories in Australia fund dTpa for pregnant women. Women can access vaccination through primary care, local government immunisation services and in some states through pharmacies. In addition, at our institution pregnant women are offered free vaccination through a nurse-led immunisation service located at hospital A. Despite being available to all pregnant women of the health network, our earlier work suggests that the immunisation service is almost exclusively accessed by women receiving pregnancy care at hospital A [8]. This is most likely due to the geographic distance of both Hospital B and Hospital C from hospital A. Therefore, prior to this study women attending hospital A received their vaccination through the immunisation service, and women attending hospital B and hospital C were predominantly referred to their general practitioner (primary care) for vaccination.

To facilitate equitable access to onsite maternal vaccination across all three maternity services, and improve uptake, the existing standing order for post-partum administration of dTpa by midwives was expanded to include antepartum administration. The amendment was approved in June 2015. A standing order enables midwives to administer vaccination after obtaining informed consent from the woman, without the need for a prescription or order from a medical doctor. Standing orders were implemented at hospital B in October 2016, but had not yet been implemented at hospital C at the time of the study. As such we were able to compare three different models of immunisation service delivery- a dedicated immunisation nurse-led immunisation service (hospital A), standing orders for midwife administration within pregnancy care clinics (hospital B), and provision by primary care (hospital C). Education regarding standing orders was provided to maternity care staff at hospitals B and C in the week prior to and week following implementation of standing orders at hospital B.

Prior to hospital discharge pregnant women's self-reported receipt of antenatal pertussis and influenza vaccines is recorded by midwives as part of the Victorian Perinatal Data Collection in the Birthing Outcome System (BOS) database at all three maternity services. Prior to 17th January 2017 the antenatal vaccination field could only be completed post-partum. Since 17th January 2017 midwives have also been able to complete these fields during any antenatal visit.

The accuracy of BOS in capturing maternal vaccination was validated by comparing vaccination records from the immunisation service at hospital A with the subsequent entry on BOS. This was performed for women vaccinated between March and May 2016. This validation study was repeated for women vaccinated in February–April 2017 following the changes facilitating antepartum data entry to determine the effect of this change on the accuracy of the database.

A time series analysis of dTpa uptake as captured in BOS was performed to assess the impact of the introduction of standing orders at hospital B. Power calculations determined that a sample size of 500 women was needed in both pre- and post-implementation groups based on 90% power to detect a 10% difference in uptake. We estimated 20 vaccinations would be administered per week at hospital B and therefore required uptake data for 6 months post-implementation. Uptake was assessed in fortnights from 1st September 2015 to 30th June 2017 at all three hospital sites. This provided uptake rates for births 13 months prior to the introduction of standing orders and for eight months following with data during the month of implementation not included in the analysis. The post-implementation period was further divided to account for the delay between administration of dTpa at 28–32 weeks gestation and those women birthing. Thus the three periods of comparison were (1) Pre-implementation of standing orders: 1st September 2015–26th September 2016; (2) First three months post-implementation: 8th November 2016–30th January 2017; (3) Subsequent post-implementation period: 31st January 2017–3rd July 2017 (when women vaccinated using standing orders were likely to have birthed and therefore be entered into BOS).

Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS; IBM Corporation. IBM SPSS Statistics for Windows, Version 23.0. Armonk, New York: IBM Corp, Released 2013). The Mann Whitney *U* test was used to determine the significance of differences in uptake between periods 1 and 2 and 2 and 3 at each hospital. To evaluate the difference in accuracy of BOS a Pearson chi-squared test was performed. A p-value of less than .05 was deemed to be significant for all analyses. The study was approved by our institution's research support service as a Quality and Service Improvement project (5th May 2017, Ref RES-17-0000-248Q).

3. Results

3.1. Uptake

At hospital B uptake was recorded for 2848 deliveries over 56 weeks prior to implementation of standing orders and for 1766

deliveries over 34 weeks after the introduction of standing orders. The median number of deliveries (102, range 87–121) did not differ pre or post-implementation. Median uptake of antenatal dTpa increased significantly throughout the study period from a median of 39% (range 28–52%) prior to introducing standing orders, to 48% (range 42–63%) in the three months immediately post-implementation, and 91% (range 71–95%) in period three. (Table 1, Fig. 1).

Uptake at hospital A is presented in Table 1 and Fig. 1. As can be seen in Fig. 1 uptake improved in late 2015 and continued to improve significantly between periods 1 and 2 but then less so between periods 2 and 3.

At hospital C uptake steadily improved over the study period from a median of 65% (range 49–73) in period 1 to 88% (range 81–90) in period 3. (Table 1) Similar to hospital B a more marked increase in uptake is noted from February 2017 (Fig. 1).

The rates of women for whom vaccination status was unclear reduced substantially at hospital B from mid-January 2017. This change was not seen in hospital A or C (Fig. 1).

3.2. Changes to the perinatal data collection system

Prior to the change enabling antepartum entry of maternal vaccination 79% (377/480) of antenatal dTpa vaccinations given at the immunisation service were accurately recorded as such in BOS. There was no significant change following capability for antepartum entry with 83% (360/436) of antenatal vaccinations recorded accurately (p = .2).

4. Discussion

Our study is unique in examining three models of implementation of maternal vaccination contemporaneously. Uptake of dTpa increased significantly across all three hospitals during the study period. This was most notable at hospital B where since the introduction of standing orders uptake increased more than twofold.

4.1. Immunisation services

Women at hospital A were able to utilise a dedicated walk-in (no appointments) immunisation service providing government-funded dTpa. Despite the apparent convenience of an onsite immunisation service led by trained immunisation nurses, at the end of our study uptake at hospital A was the lowest of the three hospitals. Differences in patient demographics, HCP recommendation, lack of interpreting services and waiting time at the immunisation service could possibly have contributed to poor uptake despite the apparent benefits of this model.

4.2. Standing orders

The American College of Obstetrics and Gynaecology, US Community Preventive Services task force and US Advisory Committee on Immunisation Practices all recommend use of standing orders to improve uptake of maternal vaccination [12,17,18]. To the best of our knowledge, this is the first report of the impact of standing orders on uptake of antenatal dTpa within hospital-based maternity care settings. Post-implementation, more than 90% of pregnant women were vaccinated in hospital B which is significantly higher than the 40–70% reported nationally [19,20].

Hospital B services large migrant and refugee communities. Consolidation of healthcare delivery such as with standing orders may be particularly effective for women from culturally and linguistically diverse backgrounds, living in rural and remote areas, and for young mothers and those with complex social circumstances where vaccination on site and by healthcare providers with whom they have a pre-existing relationship may facilitate vaccination.

Enabling midwives to enter vaccination during pregnancy did not have a significant impact on the accuracy of recorded uptake in BOS except at hospital B where standing orders were introduced. Only midwives are able to enter vaccination history in BOS. With the change, midwives vaccinating women at hospital B could simultaneously enter the vaccinations reducing the number of women for whom vaccination status was unclear in BOS. At hospitals A and C midwives were reliant on women recalling their vaccination history which is therefore subject to recall bias. This improved accuracy may explain some but not all of the improved uptake seen at hospital B.

4.3. Primary-Care delivered vaccination

From our previous work we demonstrated that women at hospital C almost exclusively receive vaccination through primary care [8]. Contrary to previous reports, the time and cost of attending additional healthcare appointments for vaccination did not appear to be a significant barrier to receiving vaccinations in our study with women at hospital C having the highest reported uptake at the beginning and 88% at the end of our study.

4.4. Strengths and limitations

One of the strengths of our study was the introduction of standing orders alone. Previous studies have introduced multi-faceted interventions making analysis of the impact of individual components challenging [21–23]. In addition, the different models of delivery at the different hospital sites provided "control" groups against which to assess our intervention. Performing validation studies of our data collection system also enabled us to qualify the validity of our findings and ascertain the impact of the standing orders and the change to the data collection system independently.

Table 1
Uptake of dTpa over the study period.

Time period	Median% uptake (min, max)			p-value
	1	2	3	
Hospital A	55 (39,68)	65 (60,67)	68	.01
(immunisation service)			(59,74)	.23
Hospital B	39 (28,52)	48 (42,63)	91	.003
(standing orders)			(71,95)	.001
Hospital C	65 (49,73)	74 (68,81)	88	.002
(primary care)			(81,90)	.001

Time period 1: Pre-implementation of standing orders.
Time period 2: First 3 months following implementation of standing orders.
Time period 3: Subsequent period following implementation of standing orders.

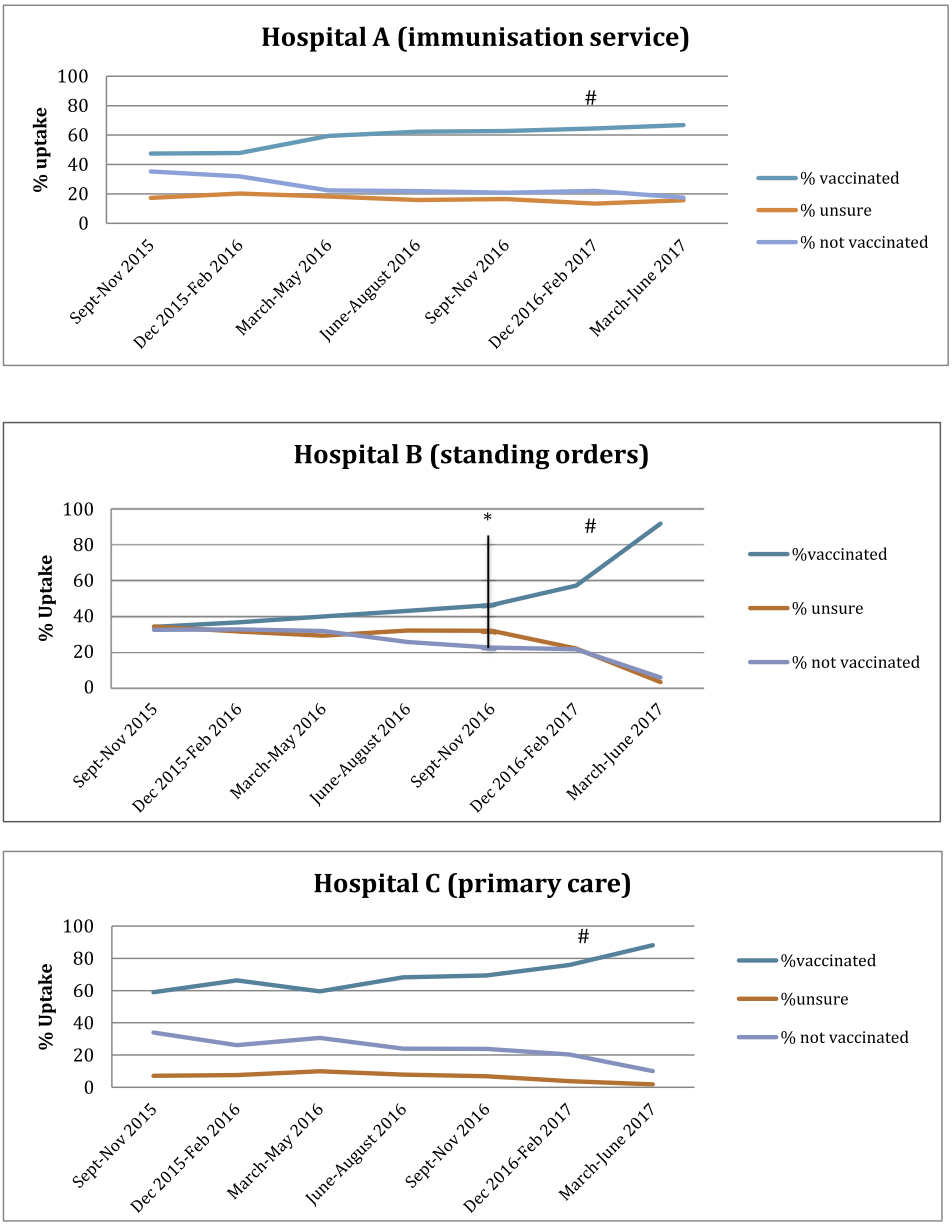

Fig. 1. Uptake of dTpa across hospitals. * Standing orders implemented at hospital B. # Antepartum entry of vaccination on BOS.

There are limitations of our study that need to be acknowledged. Vaccine uptake in BOS is based on women's self-report and therefore is subject to recall and observer bias. The increase in uptake at hospitals B and C coincided with a change in our recording system that reduced the potential for these biases and hence some of the change may be attributable to improved data collection. However uptake did not simultaneously increase in hospital A, and rates of women whose vaccination status was unclear did not change at hospital A or C suggesting that recall bias was not contributing to the changes seen. A second limitation is that we provided education sessions on standing orders prior to the planned introduction at hospitals B and C and this reinforcement of maternal vaccination may have contributed to improved uptake at these sites.

5. Conclusion

Maternal immunisation is the most effective strategy to reduce the burden of influenza and pertussis infection in infants. Given the diverse models of antenatal care, different methods of maternal immunisation delivery need to be considered. Hence, there is no "one size fits all" model for immunisation delivery in the pregnancy care setting. In some settings this may comprise a dedicated immunisation service, and in others the more traditional model of primary care. Both of these models in our study performed well. Our research importantly also demonstrated that introduction of standing orders for midwife administration of vaccines had the most significant impact on uptake and could be considered for any antenatal care model utilising midwife care.

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Disclosure of Interests

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Chapter 7: Integrated discussion and conclusion

While the potential benefit of maternal vaccination as a means of protecting newborns from infectious diseases has been recognised for more than 20 years, routine vaccination of pregnant women in Australia only galvanised the attention of maternity care providers and public health departments following the influenza pandemic in 2009. Ongoing pertussis epidemics, and in particular infant deaths, led to the recommendation for pertussis vaccination during pregnancy in Australia in March 2015. By this time, maternal pertussis vaccination had been routine in the US and UK for several years and robust evidence for the immunological effectiveness and safety was available but data on the impact of these programs was just emerging.

Experience with the introduction of maternal influenza vaccination in Australia in 2010 raised many questions for implementation of the maternal pertussis program; Was the poor coverage of maternal influenza vaccine specific to influenza or was it indicative of a general hesitancy about vaccination during pregnancy? Would the same factors that influenced uptake of influenza vaccine also be important for uptake of pertussis vaccine? What could we learn from successful implementation overseas and which of these strategies could be translated to the Australian context?

As has been described, after the introduction of maternal pertussis vaccination in Australia in 2015, coverage was suboptimal and varied significantly between jurisdictions. The aim of this thesis was to understand the consumer-, healthcare provider- and systems-related barriers to successful implementation of the maternal pertussis vaccination program in Victoria.

The three studies presented in chapters 2 and 3 provided new data and insights into consumer-driven factors. Women from migrant and refugee backgrounds as well as Aboriginal and Torres Strait Islander women were less aware of pertussis vaccine and its safety during pregnancy than Australian-born, non-Aboriginal women. Women who had concerns about the safety of pertussis vaccination during pregnancy were significantly less likely to receive the vaccine, as were those who had not received a recommendation from their healthcare provider. These studies highlight that more

needs to be done to convey important public health messages to all pregnant women, with specific provisions for women for whom English is not their first language. This needs to occur at the community level by public health departments, and at the individual consultation level by maternity care providers. Exploring women's preferences around communication strategies was beyond the scope of this work but is an important area for future research.

Two studies, presented in chapters 4 and 5, explored the healthcare provider-associated barriers to uptake of the maternal pertussis vaccination program. The first study, *"A study comparing the practice of Australian maternity care providers in relation to maternal immunisation",* was the first nationwide study of maternal vaccination and captured the current attitude and practice of a large number of providers from all states and territories of Australia. While providers were knowledgeable about the infant benefits of maternal pertussis vaccination, those who lacked knowledge about guidelines and vaccine safety were less likely to recommend pertussis vaccination. This could be addressed by providing further education around the guidelines, safety and efficacy of maternal pertussis vaccination. This would benefit all practitioner groups. Importantly, apart from midwives being more likely to have concerns about vaccine safety, there was no significant difference in attitudes or recommendation between provider groups. This is important as women expect and should receive the same care regardless of their main maternity care provider or model of maternity care. The third important finding was that despite feeling responsibility for discussing vaccination, obstetricians and midwives in this study did not perceive themselves as immunisers. This has significant implications for implementation policy which currently aims to increase provision of vaccination within routine pregnancy care. Providers reported a lack of clarity about whose role it is to administer vaccinations to pregnant women and a lack of organisational infrastructure to support vaccination within maternity care settings. Despite evidence to suggest that providing vaccination within maternity care increases uptake, this is unlikely to happen until obstetricians and midwives see themselves as having a role in administration of vaccines.

Two key barriers to pharmacist-administered maternal vaccination were highlighted by the study, *"A survey of pharmacists' attitudes and practices regarding pharmacist-administered vaccination in Australia",* presented in Chapter 5. The first was that pharmacists were less comfortable discussing and administering vaccinations to pregnant women than other adults. To alleviate this discomfort and equip pharmacists with the necessary knowledge and skills to provide maternal vaccination services, greater emphasis on immunisation in undergraduate pharmacy training and increased access to immunisation training for registered pharmacists is recommended. Many pharmacies that provided vaccination services to other adults, did not extend this service to pregnant women. Women should not be in a position where they attend a pharmacy for vaccination but are turned away, and part of the success of pharmacist-delivered vaccination will depend on how broadly it is adopted. The second barrier pertains to the legislative requirements for setting up an immunisation service as well as inconsistent vaccine administration rights and credentialing requirements between states and territories. These have the potential to limit the success of pharmacist-delivered vaccination to pregnant women. The discrepancy in pharmacists being able to administer influenza but not pertussis vaccine in some states and territories needs to be addressed. Increasing access to one but not both maternal vaccines is problematic as it sends a confusing message to consumers about the importance of pertussis vaccine, and it undermines the convenience and reliability of pharmacist-administered vaccination if consumers can get both vaccines at the same time through their general practitioner but not through their pharmacist.

The final study presented in Chapter 6 explored systemic strategies for increasing uptake of maternal vaccinations. It demonstrated that a standing order for midwife-administration of pertussis vaccine to women during their routine antenatal care is feasible and effective in increasing uptake in the Australian context. A standing order helps to dispel some of the uncertainty about provider roles and removes the obstacle of women having to attend an additional provider solely for the purpose of vaccination. Due to the success of the strategy and ease with which midwives were able to incorporate vaccination into their workflow, a standing order for maternal influenza vaccination is currently being considered at our institution.

The findings of this study on standing orders has broad applicability. It is a particularly attractive strategy for populations such as women from migrant and refugee backgrounds and women with complex social and emotional needs, where vaccination by a provider with whom women have a pre-existing relationship, may facilitate uptake. The key challenge in implementing standing orders is to streamline processes for ordering vaccines, monitoring cold chain, and documenting vaccination to minimise the additional workload on midwives and other staff. While this was a concern at the outset of this study, with strong midwife engagement in the initiative, these concerns did not prove to be a significant barrier to implementation. Nevertheless, the same model may not be feasible across all settings, nor may it be required in populations with high uptake utilising other immunisation service delivery models. Furthermore, with additional maternal vaccines in the pipeline such as against respiratory syncytial virus and group B streptococcus, the workforce implications do need to be considered.

Table 3: Summary of barriers to uptake of maternal pertussis vaccination

Consumer-related barriers	Healthcare provider–related barriers	Systems-related barriers
• Lack of healthcare provider recommendation • Uncertainty about safety of vaccine in pregnancy	• Unaware of current recommendations • Concerns about vaccine safety • Not perceiving themselves as responsible for immunisation • Pharmacists less comfortable discussing and administering vaccines to pregnant women than other adults	• Lack of infrastructure to support provision of vaccinations within maternity care • Legislative requirements for pharmacists to provide vaccination services

7.1 Areas for further research

Several areas for future research have been identified:

- Exploring the most effective methods to convey evidence-based health information to pregnant women, particularly those from culturally and linguistically diverse backgrounds and their preferred methods of receiving education about maternal vaccination.
- Understanding the optimal way to train vaccine providers. Maternal vaccines can now be administered by healthcare providers for whom immunisation is not their core business. It is important that training is tailored to the knowledge, experience and skillset of the different provider groups.
- Consideration and evaluation of the impact of an expanding repertoire of maternal vaccines. Health service and financial capacity to introduce additional vaccines such as against respiratory syncytial virus and group B streptococcus as well as the acceptability of these for women and healthcare providers will need to be assessed. Furthermore the impact of adding these vaccines to the current recommendations also needs to be considered.
- Determining the feasibility of instituting standing orders for influenza and pertussis vaccination in varied maternity care settings to improve uptake of both maternal vaccinations

7.2 Implications for practice and policy

While no aspirational targets for coverage of maternal pertussis vaccination have been set in Australia, coverage of 50–70% as demonstrated in these studies is suboptimal. The studies in this thesis identify several barriers to uptake. Several strategies to overcome these barriers are evident, and imminently translatable to clinical practice and public health policy. These include:

- Consumer education: Translation of available educational material into various languages, promotion of maternal vaccination using social media and other maternal health websites, and possibly education within community forums to

better communicate the benefits and safety of maternal pertussis vaccination to women from culturally and linguistically diverse backgrounds.

- Targeted education for maternity care providers: This should focus on the infant benefits and safety of maternal vaccination and would be likely to have the broadest reach if delivered through their respective professional bodies.
- Education for pharmacists: Training in maternal vaccination again through their professional bodies is desired by pharmacists and will potentially increase their comfort in discussing and providing maternal vaccinations.
- Promotion of pharmacists as immunisers: Promotion would increase both consumer and provider awareness of this new service, and any resulting increase in demand may encourage additional pharmacists to consider introducing the service.
- Incorporation of immunisation training into undergraduate and postgraduate training: This should be a module in undergraduate pharmacy training and also postgraduate obstetric and midwifery training.
- Integrating maternal vaccination into pregnancy care documentation: There should be capacity for documenting both influenza and pertussis vaccines in women's hand-held records, the pregnancy record and in immunisation registers. All maternity services should develop policies and protocols to prompt staff about maternal vaccination, and clearly delineate expectations of how women may obtain vaccination and responsibilities for providing vaccination.
- Greater cooperation between public health department immunisation branches and maternity services: Maternity services are unlikely to be aware of existing documents such as the National Vaccine Storage "Strive for Five" guidelines that clearly outline the requirements for maintaining cold chain.[214] Increasing the knowledge and accessibility of such resources, as well as provision of practical support, would aid providers in implementing onsite vaccination within maternity care.

7.3 Conclusion

There is now good clinical data for the effectiveness and safety of maternal pertussis vaccination. The studies in this thesis are among the first to provide estimates of uptake of maternal pertussis vaccination in Australia. Furthermore, this PhD includes the first Australian study of pharmacist attitudes to maternal vaccination, and the first to report on the impact of a standing order to increase uptake of maternal pertussis vaccination in Australia. The importance of healthcare provider recommendation as a driver of vaccine uptake cannot be overstated. This body of work highlights the importance of conveying targeted information about the safety and benefits of maternal vaccination in future public health messaging for both consumer and provider groups. Providing women with options for how they choose to receive healthcare education and targeting vaccine messaging to the needs of individual populations may be a more successful approach in the future. In addition, although limited by a small sample size, this work suggests possibly poor uptake of maternal vaccination services by pharmacists and identifies some of the barriers that could be addressed to increase this. Finally, this work provides real world evidence for the effectiveness of embedding vaccination within maternity care services through the use of a standing order to increase uptake of maternal vaccination.

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Appendix 1: Antenatal pertussis vaccination: Are we implementing best evidence into practice?

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Review Article

Antenatal pertussis vaccination: Are we implementing best evidence into practice?

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Maternal immunisation is the most effective strategy to reduce infant morbidity and mortality from pertussis infection, and is now standard of care in many countries, including Australia. However, uptake cannot be guaranteed unless the barriers to implementing programs locally are understood. Education and resources for antenatal care providers, embedding vaccination within antenatal care, and provision of culturally appropriate information for pregnant women are integral to a successful antenatal vaccination program.

Key words: maternal immunisation, pertussis, vaccine acceptance, vaccine attitudes, vaccines in pregnancy.

Introduction

Pertussis infection causes significant morbidity and mortality, particularly in children less than six months of age before they have received the protective immunological benefit of at least two doses of pertussis-containing vaccine. Up to two-thirds of infected babies require hospitalisation, and nearly one in 100 under six months of age die.[1] Sadly, for over two decades Australia has had the highest reported rates of pertussis in the world.[2]

Multiple approaches to reducing risk to newborns have been explored. Vaccination reduces the incidence of infection more than 20-fold, but at least two doses are required to confer protection.[1,2] 'Cocooning' was implemented in 2011–12 to reduce the 50–60% of infant infections acquired from parents. But achieving a complete cocoon is costly, resource- and time-intensive, and logistically challenging to implement.[3,4]

The Australian Immunisation Handbook was updated in March 2015 to recommend pertussis vaccination to pregnant women in the third trimester of every pregnancy regardless of prior vaccination history.[1] This was endorsed by the Royal Australian and New Zealand College of Obstetricians and Gynaecologists. All Australian states and territories have funded maternal vaccination programs since June 2015, initiatives that have seen vaccination uptake increase from 8% to 72%.[5]

This article reviews the evidence for maternal vaccination, identifies barriers to uptake and highlights areas for future research. A literature search was performed using key words and restricting manuscripts to English.

Antenatal Vaccination

Antenatal pertussis vaccination achieves two-for-one protection: of the pregnant woman who may be susceptible due to waning immunity, and of her baby through placental transfer of maternal antibodies.

Placental transfer of maternal antibodies

Active and passive transfer of maternal immunoglobulin G (IgG) across the placenta provides transient passive immunity to the newborn with fetal antibody titres rising two weeks after maternal vaccination. However, most pregnant women do not have adequate levels of

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anti-pertussis IgG for placental transfer to be effective and therefore require a booster dose during pregnancy.[6]

Does maternal vaccination reduce newborn pertussis infection?

Two major studies have reported the efficacy of maternal vaccination in preventing laboratory-confirmed pertussis in infants under three months of age to be 91–93%.[7,8]

What is the best time for maternal pertussis vaccination?

Longer latency between maternal vaccination and delivery may facilitate greater antibody transfer. Third trimester vaccination is effective but recent studies report significantly higher maternal and infant antibody levels with second trimester vaccination than with third.[3,6,9–11] However, vaccination prior to 20 weeks leads to waning antibody levels before infant vaccination at six weeks of age.[6] Other benefits of second trimester vaccination include protection for the 7% of babies born preterm who might have inadequate levels if vaccinated in third trimester, and a wider 'immunisation window' to aid implementation.

Are there concerns about maternal pertussis vaccination?

Blunting of infant immune responses

Based on studies of live vaccines (measles and oral polio) but also whole cell pertussis vaccine, high levels of maternally derived antibodies in the newborn may blunt the infant's own immune response to primary immunisation.[12]

Three recent studies reported lower antibody levels after a primary series of acellular pertussis-containing vaccines in infants of mothers vaccinated antenatally. However, there was no difference following the booster dose at 18 months of age (a dose that has been recently reintroduced in Australia), suggesting memory response may be unaffected.[3,9,13]

Reassuringly, this blunted response does not appear to be clinically significant, as there is no evidence of increasing pertussis infections in late infancy in the UK where there has been high antenatal immunisation coverage since 2012.

Is antenatal pertussis vaccination safe?

More than half a million pregnant women have received the vaccine. Cohort data from over 40 000 pregnant women identified no adverse birth outcomes or increase in medically attended adverse events following vaccination.[14,15] Using short message service (sms) surveillance following vaccination, one in ten antenatally vaccinated women in Western Australia reported an adverse reaction within a week of vaccination, predominantly local reactions, particularly if previous pertussis vaccination was recent (11% vs 6%) with few seeking medical attention for the same.[16]

Is repeated tetanus vaccination problematic?

Given guidelines recommend a pertussis-containing vaccine in every pregnancy, concerns have been raised about women having repeated tetanus vaccination. Linked vaccination and outcome data from 30 000 previously tetanus-vaccinated women who were subsequently vaccinated in pregnancy observed no difference in the rate of medically attended adverse events or adverse birth outcomes.[17]

Current Recommendations and Implementation

In 2015 the Global Pertussis Initiative recommended prioritisation of maternal vaccination to decrease pertussis-related infant mortality. Despite such recommendations, uptake has been variable, rapidly achieving 60% in the UK[11] but as low as 14% in some states in the USA.[4] Even within Australia, the FluMUM study reported variable uptake, from 26% to 62% in 2015.[5] Understanding the factors contributing to such variability is central to implementing a successful vaccination program.

Systems-related factors

Antenatal care is provided by a range of healthcare providers (HCPs) including general practitioners (GPs), obstetricians and midwives. Inevitably, this leads to uncertainty about whose role it is to discuss, recommend and provide vaccination. Traditionally, obstetricians' expertise has been high risk rather than routine pregnancy care and midwives have been educators though not required to administer vaccinations. GPs are well equipped to immunise out of hospital settings but do not have the same facilities to do so in hospital antenatal clinics. Delineation of each HCP's role would provide clarity for HCPs and women and ensure vaccination is not overlooked.

Knowledge and development of resources to support HCPs is important. While researchers and policy makers may reference the Australian Immunisation Handbook, antenatal HCPs who have not been familiar with immunisation until recently, may consult the hospital intranet or local guidelines. Provision of consistent, up to date, and easily accessible evidence-based guidelines to HCPs should be ensured.

Programs are more likely to be successful if vaccination becomes embedded in routine pregnancy care.[18] While currently not available in many pregnancy care settings, infrastructure to maintain and monitor cold chain and staff trained in immunisation are vital. Additionally, changes such as inclusion of antenatal pertussis in the

pregnancy record would serve as a prompt for discussion and administration of vaccine and aid evaluation of safety and effectiveness. Currently only the antenatal record in Queensland includes such reminders for pertussis.[18]

Healthcare provider factors

HCPs have differing knowledge, experience and comfort with discussing and providing vaccination to pregnant women. Vaccination being a relatively recent development, many antenatal HCPs do not traditionally see vaccination as within their remit. This needs a significant cultural shift for any vaccine program to be successful.

Midwives are frequently the first HCP a pregnant woman consults and are thereby well placed to advise women. A survey of midwives' attitudes to post-partum pertussis vaccination found midwives were less confident than hospital nurses and immunisation providers in providing vaccine advice, and were more likely to administer vaccine if they believed immunisation to be part of their job and could easily integrate it into their workload.[19] Researching attitudes to antenatal vaccination and equipping midwives with the necessary knowledge and support will be integral.

Obstetricians are significantly more likely to recommend vaccination if they have knowledge of national recommendations (odds ratio (OR): 23.33), routinely recommend influenza vaccine (OR: 12.5), are able to administer vaccines in their rooms (OR: 7.01) and receive influenza vaccine themselves (OR: 8.36).[4]

Consumer factors

The most common reasons pregnant women decline vaccination are lack of recommendation by HCPs, safety concerns and lack of awareness of vaccine recommendations.[18,20] Women are more inclined to have pertussis vaccination than influenza as they perceive pertussis vaccination as being for the benefit of their baby compared to influenza vaccine which they perceive as solely for their own benefit.[20] Women look to their HCP to provide evidence-based information and provision of such would overcome a number of these incorrect assumptions.

Women from culturally and linguistically diverse backgrounds and Aboriginal and Torres Strait Islanders (ATSI) have been underrepresented in research to date. In the FluMUM study only 34% of ATSI women were vaccinated against pertussis compared to 43% overall.[5] Achieving universal vaccination requires us to examine barriers and uptake in all groups, particularly those traditionally known to underutilise maternal services.

The impact of the media as a driver of vaccination cannot be underestimated.[20] Social media, with sites such as the Light for Riley Facebook page, has proven to be a powerful tool in disseminating personal stories in a much more accessible way than traditional information sources. Social media may play an even more important role in reaching groups with less healthcare engagement.

Lessons learned:
- Antenatal care provider recommendation is the strongest driver of vaccination
- Systemic changes to embed vaccination into routine pregnancy care are vital
- The role of social media and personal stories in influencing consumer attitudes cannot be underestimated

Priorities for future research:
- Studies on antenatal care provider and consumer barriers to uptake in the Australian context are needed
- Differences/needs of specific cultural groups and ATSI must be examined to achieve universal vaccination

Summary

Maternal immunisation has emerged as the most effective strategy to reduce the morbidity and mortality of newborn pertussis infection. While uptake has been more enthusiastic than for maternal influenza vaccine, challenges to implementation in Australia remain. It is imperative to incorporate vaccination into routine antenatal care and identify the unique barriers to uptake in Australia, particularly in culturally and linguistically diverse and ATSI women. Ongoing surveillance to rapidly detect any unexpected adverse outcomes at a population level will also be key to the success of current and future antenatal vaccination programs.

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Appendix 2: Pregnant women's attitudes toward antenatal pertussis vaccination

Naidu MA, **Krishnaswamy S,** Wallace EM, Giles ML. Pregnant women's attitudes toward antenatal pertussis vaccination. *Australian and New Zealand Journal of Obstetrics and Gynaecology,* 2017 57(2):235.

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LETTER TO THE EDITOR

Pregnant women's attitudes toward antenatal pertussis vaccination

In March 2015, national guidelines in Australia changed from recommending either antenatal or postnatal pertussis vaccination, to recommending antenatal vaccination to pregnant women in the third trimester of each pregnancy. Prior to this change, we examined women's attitudes to antenatal pertussis vaccination, given the historical poor uptake of antenatal influenza vaccine which had a reported uptake of 10.3–40.0% at the time.[1–3] Unlike the influenza vaccine, antenatal pertussis vaccination was being promoted for the protection of the newborn, rather than for the protection of the mother herself.

As part of a study looking at the optimal timing of administration of the maternal pertussis vaccine,[4] women were offered the acellular pertussis vaccine in the third trimester. Very few women approached to participate in the study declined the vaccine. At recruitment all 137 women on the study[4] were surveyed on their attitudes toward antenatal pertussis vaccination. Two questionnaires were excluded, as they were incomplete.

Therefore, 135 women completed the questionnaire on the reason for accepting or declining maternal pertussis vaccination. Women were asked to choose all reasons applicable to them, and then the one most important reason in their decision to accept or decline the pertussis vaccine. Of the women who completed the questionnaire the average age was 30.6 years. Approximately half (48.2%) of those surveyed were Australian born, 46.7% were nulliparous women.

Of the women who completed the questionnaire, 118/135 (87%) intended to accept the vaccine. There were no significant differences in demographics (age, country of birth, parity, main antenatal care provider and prior knowledge of pertussis vaccine) between those intending to accept or decline pertussis vaccination.

The study demonstrated that the majority of women (75.4%) who accepted the pertussis vaccine during pregnancy were recommended vaccination by their healthcare provider (HCP). In comparison, women who declined the vaccine during pregnancy were less likely to have been recommended by their HCP (41.2%). The most important reason women gave for accepting the vaccine was for the protection of their newborn (95.7%). The majority of women who declined the vaccine did so because they had a history of pertussis vaccination in the preceding five years (the recommended vaccination interval in 2014; 41.2%), had concerns of harm to their baby (29.4%) or had concerns about potential side effects of the vaccine (23.5%).

Of the 17 women who declined the pertussis vaccine during pregnancy and completed the questionnaire, 23.5% said they would not consider having the pertussis vaccine after their current pregnancy, 35.3% would have the vaccine after their current pregnancy, and 41.2% were not sure about getting the vaccine in the future.

The conclusions drawn from this study are that in order to optimise uptake of antenatal pertussis vaccination recommendations, public health messages should focus on the protection afforded to the newborn, but importantly also dispel concerns about vaccine safety in pregnancy given this was the main reason for declining vaccination. These messages are likely to be more influential if reinforced by healthcare professionals during regular antenatal visits.

CONFLICTS OF INTEREST

The authors report no conflict of interest.

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Appendix 3: Maternal Immunisation: What have been the gains? Where are the gaps? What does the future hold?

Giles ML, **Krishnaswamy S**, Wallace EM. Maternal Immunisation: What have been the gains? Where are the gaps? What does the future hold? *F1000 Faculty Reviews*, submitted June 2018.

MATERNAL IMMUNISATION: WHAT HAVE BEEN THE GAINS? WHERE ARE THE GAPS? WHAT DOES THE FUTURE HOLD?

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Abstract

Vaccination of pregnant women has enormous potential to protect not only mothers from vaccine preventable diseases but also her infant through the passive acquisition of protective antibodies before they are able to themselves acquire protection through active childhood immunisations. Maternal tetanus programs have been in place since 1989, and as of March 2018, only 14 countries in the world were still to reach maternal neonatal elimination status. This has saved hundreds of thousands of lives. Building on this success, influenza and pertussis containing vaccines have been recommended for pregnant women and introduced into programmes, albeit predominantly in resource rich settings. These have highlighted some important challenges when additional immunizations are introduced into the antenatal context. With new vaccine candidates on the horizon, such as respiratory syncytial virus (RSV) and Group B streptococcus (GBS), it is important that we learn from these experiences, identify the information gaps and close these to ensure safe and successful implementation of maternal vaccines in the future, particularly in low- and middle-income countries with a high burden of disease.

Main text

In 2015 the Sustainable Development Goals (SDG) were launched to replace the Millennium Development Goals previously set, in 2000, by the United Nations to guide the eradication of poverty, hunger, illiteracy, and disease (1). The third SDG is to ensure healthy lives and promote well-being for all, at all ages. An important target of this SDG is to end preventable deaths of newborns and children under five years of age by 2030. All countries should be aiming to reduce neonatal mortality to 12 per 1000 live births or lower and under-five mortality to 25 per 1000 live births or lower (2). If every country were to achieve these SDG targets for child survival by 2030 then 10 million more children will survive to age five. Half of these will be additional newborn babies surviving past one month of age.

In 2016, the worldwide mortality rate for children under five years of age was 41 per 1000 live births. This is half the worldwide rate in 1990 (3). The first 28 days of life is the most vulnerable period for children. In 2015 the global neonatal mortality rate was 19 per 1000 live births, a fall from 31 per 1000 live births in 2000. A leading cause of death of these children is infectious diseases, particularly pneumonia, sepsis and respiratory illness. Vaccination against infectious diseases has had a key role in improving child health. However, most childhood vaccinations start at six weeks of age and many diseases require more than one dose of vaccine to confer adequate protection. This leaves newborn infants vulnerable in their first months of life. Vaccination of the pregnant mother (maternal vaccination) has emerged as a potential strategy to reduce the morbidity and mortality of very young infants during this vulnerable period.

Maternal immunisation provides transient passive immunity to the newborn by the transplacental transfer of maternal IgG antibodies (Ab). This begins around 13 weeks gestation and increases throughout pregnancy such that the majority of Ab transfer occurs in the last trimester of pregnancy. Antibodies can also be transferred to newborns via breast milk. For example, IgA Ab to pertussis toxin is present in breast milk following maternal immunisation (4). Although the highest level has been

reported in colostrum, pertussis-specific IgA has been detected for eight weeks in breast milk (4).

The World Health Organization (WHO) and national policy makers recommend routine Tetanus and Influenza vaccination for pregnant women and, in specific settings, vaccination for Pertussis, Hepatitis (A and B), Yellow Fever, Meningococcus, Pneumococcus and Polio. In addition to these, new vaccines are on the horizon to address other causes of neonatal morbidity and mortality, such as Respiratory Syncytial Virus (RSV) and Group B Streptococcus (GBS). In this article we summarise the gains made thus far in maternal immunisation, the current gaps that remain, and the future goals and opportunities for maternal vaccination to improve maternal and child health.

What have been the gains?

One of the greatest success stories of maternal immunisation has been the effective elimination of maternal and neonatal tetanus through maternal vaccination. In 1988, the WHO estimated that 787,000 newborns died of neonatal tetanus, stimulating the 42nd World Health Assembly the following year to call for the elimination of neonatal tetanus by 1995. To achieve this, low resource countries have implemented maternal tetanus toxoid vaccination programs. By March 2018, while 14 countries are yet to reach maternal neonatal tetanus elimination status, there has been a 96% reduction in neonatal mortality from tetanus – over 750,000 lives saved – compared with the late 1980s (5). The majority of this gain has been achieved by maternal immunisation (5).

A more recent example of gains afforded by maternal immunisation relates to pertussis infection. Hospitalisation and infant mortality due to pertussis disproportionately affects children less than six months of age (6). This is likely because children require at least two doses of pertussis containing vaccine before they are adequately protected and, in most vaccination programs the first immunization is not given until two months of age. To address this, maternal immunisation has been recommended as a strategy in many resource rich countries including in the United States (US) since 2011, the United Kingdom (UK) since 2012 and Australia since 2015.

In 2012, in response to high rates of disease in infants under three months of age and an increase in pertussis-related deaths, the UK's Department of Health recommended a vaccination program including a pertussis containing vaccine for all women in the third trimester of pregnancy (7). Evaluation of the effectiveness of this program showed that it reduced pertussis infection in infants <8 weeks of age by 93% (8). Various studies conducted in the UK, US, and Spain have now confirmed more than 90% effectiveness of maternal pertussis vaccination in preventing laboratory-confirmed pertussis in infants less than 2–3 months of age (9-12). Vaccine effectiveness against infant death is estimated at 95% (9). Since introduction of the maternal pertussis immunization programme in the UK, there have been 16 infant deaths between 2013 and 2015, compared with 14 infant deaths in 2012. Of the 16 infants who died after introduction of the programme, 14/16 occurred in babies whose mothers were not vaccinated. Of the remaining two infants who died, the mother was vaccinated less than 10 days prior to delivery (9). This highlights a key implementation issue related to maternal immunisation; identifying the optimal timing of administration of maternal vaccine, to maximise transplacental passage of maternal antibodies. In relation to pertussis, research data supports the clinical findings cited above, that vaccination early in the third trimester, or even possibly in the second trimester, is most likely to achieve protective level of antibodies in the baby (13, 14).

Both tetanus and pertussis provide examples of how maternal immunisation programs, when successfully implemented, can prevent almost all vaccine-related disease in infants and in the case of tetanus, elimination.

Where are the gaps?

Despite the successes of tetanus and pertussis, many key gaps in the field of maternal immunisation remain. For example, influenza vaccination has been recommended for pregnant women since the 1960s (15). This is because influenza infection is associated with more severe disease in pregnant women. In 2012, The WHO Strategic Advisory Group for Experts on Immunization recommended pregnant women as the most important risk group to benefit from inactivated seasonal influenza vaccination (16). Despite this global recommendation, and evidence for efficacy in the prevention

of influenza in pregnant women and their babies, not all countries recommend or are able to implement maternal influenza vaccination programs. A review worldwide of national influenza immunisation policies, undertaken by the WHO and UNICEF, showed that, of the 115 WHO member states that had an influenza immunisation policy, less than half included pregnant women (17). Inclusion of pregnant women in a national policy was more likely in high or upper middle-income countries (28). This highlights an important challenge in maternal immunisation; how do we expand immunisation programmes beyond maternal tetanus in low- and middle-income countries to include additional vaccines with known benefits to pregnant women and the fetus? It is particularly challenging because in the world regions with the greatest burden of newborn deaths, Southern Asia and sub-Saharan Africa (18), less than half of all pregnant women have access to adequate pregnancy care (19).

Further, for the successful delivery of effective maternal vaccination programs, beyond strengthening of basic health services and skilled personnel, there are other factors that need to be considered before implementation of any new maternal vaccine, including knowledge of pathogen specific epidemiology, country-specific burden of disease data among pregnant women and their newborns, implementation costs, vaccine effectiveness and safety. Indeed, concerns of safety have been identified as a key barrier to vaccine uptake. Even in countries with a fully funded programme, uptake of influenza vaccine during pregnancy remains low (20-22). Concerns over safety are one of the most important factors contributing to this (23).

This is disappointing because in 2011, the WHO's Strategic Advisory Group of Experts on Immunization tasked the Global Advisory Committee on Vaccine Safety (GACVS) to review the evidence on safety of vaccinations in pregnant women. The Advisory Committee's report included the outcomes of maternal morbidity and mortality, miscarriage/stillbirth, prematurity, small size for gestational age and congenital anomalies. There was no evidence of any adverse outcome, maternal or perinatal (24). Since publication of the GACVS report, there have been five systematic reviews of influenza vaccine safety in pregnancy (25-29). All reviews concluded that there were no safety concerns for either mother or fetus associated with the use of influenza vaccines (25-29). This highlights an important gap in our understanding. Why do

women and healthcare providers still cite safety concerns as an important reason for not receiving influenza vaccine during pregnancy despite this evidence?

One reason may be related to the language and content of product information provided by influenza vaccine manufacturers. A review by Proveaux and colleagues reported on 96 separate influenza vaccines and found that 21% of these included language suggesting that official recommendations should be "considered". Half of the products suggested users consult a health care provider to determine whether the product should be given during pregnancy and only 10% suggested use during pregnancy (30). In addition, a subsequent study of 141 maternal health-care providers from 49 countries in all six WHO regions suggested that health-care providers perceive product information as contradicting WHO and national immunisation recommendations and that this could affect their decision to recommend the vaccine to pregnant women (31).

Importantly, not only has there been no safety signal identified in all the systematic reviews undertaken in relation to influenza vaccination during pregnancy, but there is actually data reported suggesting a statistically significant benefit to the newborn in terms of reduced preterm birth (32-35). This requires further evaluation as reducing preterm birth, particularly in low- and middle-income countries will contribute significantly to achieving the SDGs by 2030.

What does the future hold?

Respiratory syncytial virus (RSV) and Streptococcus agalactiae (group B streptococcus, GBS) are two important causes of neonatal morbidity and mortality that are attractive vaccine candidates for maternal immunisation programmes.

RSV is an important cause of lower respiratory tract illness in infants globally and is responsible for one third of deaths due to lower respiratory tract infection in children less than one year of age (36). Infants under six months of age are particularly susceptible and so, as is the case with tetanus, pertussis and influenza, maternal immunization may be an effective strategy to confer protection during this vulnerable period. Like with any maternal vaccine, the magnitude of benefit to the mother, fetus and newborn may differ. In evaluating a new maternal vaccine it is important to

measure the potential maternal benefit along with the benefit to the child.. The maternal effects of RSV infection during pregnancy are only just beginning to be understood. A recent publication by Chu et al. described the clinical presentation and birth outcomes of RSV infection in pregnancy in Nepal (37). Of the cases observed, 50% sought medical care, and of those infected during pregnancy, 29% delivered preterm births (37). In contrast, a recent publication from South Africa (38) did not report any association between maternal RSV infection and adverse pregnancy outcomes. Post-partum infection however, was associated with concurrent infection in 52% of infants (38).

Currently, an RSV vaccine candidate for pregnant women is undergoing a phase III clinical trial (www.clinicaltrials.gov). This trial investigators aim to recruit 8618 women and administer either vaccine or placebo in the third trimester of pregnancy. The primary outcome is RSV-proven lower respiratory tract infection with hypoxemia in the infant. Effectiveness and safety is yet to be established.

Future goals of a maternal program against RSV would be to prevent infant death and hospitalisation, prevent or reduce the severity of lower respiratory tract illness in young infants, reduce transmission in the household and community, reduce antibiotic usage for treatment of lower respiratory tract illness and potentially reduce maternal effects of RSV during pregnancy. The hope for the future is development of a safe and effective RSV vaccine, which will protect infants from severe disease. However, there are many important pieces of information required to fully understand the potential magnitude of benefit an RSV vaccine may offer. Importantly, RSV burden of disease data, particularly mortality and morbidity in low- and middle-income countries is essential and is currently lacking. In addition, successful implementation will only be possible if the vaccine is affordable and both healthcare providers and pregnant women understand the benefits and can be reassured in relation to the safety of the vaccine.

GBS is an important cause of neonatal sepsis and meningitis, especially in the first three months of life. In 2015, worldwide, an estimated 205,000 infants developed early onset disease and 11,400 infants had late onset disease. There were an estimated 90,000 deaths in infants less than three months of age and 33,000 cases of

invasive GBS disease in pregnant or post-partum women. It has been estimated that a maternal GBS vaccine with 80% efficacy and 90% coverage could prevent 107,000 stillbirths and infant deaths (39). More specifically, models have estimated that with a vaccine efficacy of 70%, and coverage equal to the proportion of pregnant women with≥4 antenatal visits, maternal GBS immunization would prevent one-third of GBS cases and deaths in Uganda and Nigeria, 42–43% in Guinea-Bissau, and 55–57% in Ghana (40).

The most common current strategy to reduce neonatal sepsis is screening for GBS in pregnant women and administration of intrapartum antibiotics to those who are colonized. It has been shown to reduce early onset neonatal GBS sepsis, but has no impact on late onset GBS infection (between 7 and 90 days of life). In addition, the strategy of screening and antibiotics is often challenging in settings where women infrequently attend for antenatal care, and where access to diagnostic testing and intravenous antibiotics during labour is limited. These challenges make a GBS vaccine approach appealing.

GBS candidate vaccines have been investigated in phase I and phase II clinical trials (41-45). These trials have used bivalent and trivalent vaccines (serotypes Ia, Ib and III). More recently vaccine manufacturers are focusing on pentavalent vaccines covering the five GBS serotypes which account for greater than 90% of invasive neonatal disease. An important data requirement with candidate maternal vaccines is information on effectiveness, particularly in low- and middle-income countries, utilizing clinical endpoints. This may be challenging with designing future GBS vaccine trials given the need for a large sample size to adequately power the study, and robust surveillance and diagnostic systems to adequately confirm endpoints. Nevertheless, establishing effectiveness and safety are essential prior to recommending any new maternal vaccine and must remain a priority as candidate GBS vaccines are developed.

What more needs to be done?

Maternal immunisation, although not a new concept, is gaining momentum as an important, safe and effective strategy to prevent infant morbidity and mortality, in addition to providing direct protection to the mother. Embracing this and applying the

principles learned from implementation of other maternal vaccines to other infectious diseases such as RSV and GBS holds enormous promise particularly in countries with the highest rate of childhood mortality. Maternal immunisation may contribute significantly to achieving the SDG target to end preventable deaths of newborns and children under five years of age by 2030. However, increased resources and effort need to be invested in understanding disease burden, particularly in low- and middle-income countries so the populations who stand to benefit the most from these strategies can be identified. Clearly vaccine effectiveness and safety data is crucial, however as has been seen with other maternal vaccinations, unless there is adequate education of women and healthcare providers, and consideration given to optimal implementation strategies, the maximal benefit from maternal vaccination programmes will not be achieved.

Abbreviations

SDG – Sustainable Development Goals

WHO – World Health Organization

RSV – Respiratory Syncytial Virus

GBS – Group B streptococcus

GACVS – Global Advisory Committee on Vaccine Safety

Disclosure

The authors declare that they have no disclosures.

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Appendix 4: Questionnaire for *"Understanding the barriers to uptake of antenatal vaccination by women from culturally and linguistically diverse backgrounds: A cross-sectional study"*

Examining the Attitudes and Knowledge of Antenatal Care Providers and Consumers to Antenatal Pertussis Vaccination- Consumer Survey

1. Introduction

This questionnaire is part of my PhD examining the attitudes of and advice givento pregnant women regarding vaccination in pregnancy, particularly in regards to flu (also called influenza) and whooping cough (also called pertussis). A separate survey is being conducted of healthcare providers.

Your participation is voluntary and anonymous and whether you choose to participate or not, will not impact your care. If you would like the assistance of an interpreter to discuss or complete the survey, please let the interpreter present during your antenatal clinic appointment know, and they can contact me through switchboard.

This project has been approved by Monash Health Human Research Ethics Committee. The questionnaire should take approximately 10minutes to complete. Once you have completed the survey please return it to me (I will be in the clinic waiting area until the clinic is finished).

Thank you for participating in this survey, and assisting in our understanding of vaccinations in pregnancy.

Dr. Sushena Krishnaswamy

2. About You

1. How old are you (in years)?

2. In which country were you born?

- ◯ Australia
- ◯ Other (please specify)

3. In what year did you come to Australia (year of birth if born in Australia)?

4. Do you identify as Aboriginal or Torres Strait Islander?

- ◯ Yes ◯ No

5. Do you primarily speak a language other than English at home?

- ◯ No
- ◯ Yes (please specify)

6. What is your current residency status in Australia?

- ◯ Australian citizen/ Permanent Resident
- ◯ On a visa with medicare entitlements
- ◯ On a visa without medicare entitlements
- ◯ I don't know
- ◯ Other (please specify)

3. About You

7. What is the highest level of formal education you have completed?

- ◯ Did not complete Primary School
- ◯ Primary School
- ◯ High school
- ◯ Undergraduate degree
- ◯ Post-graduate qualification (e.g.: Masters, PhD)
- ◯ Other e.g.: TAFE (please specify)

8. Which of the following categories best describes your current employment status?

- ◯ Employed, working full-time
- ◯ Employed, working part-time/ casual
- ◯ Employed, maternity leave
- ◯ Home duties
- ◯ Student
- ◯ Not employed
- ◯ Other (please specify)

4. About your pregnancy

9. How many weeks pregnant are you?

10. Before this pregnancy, how many times have you been pregnant?

0 1 2 More than 2

11. Where do you receive your antenatal care?

- Public hospital
- Private obstetrician
- Other (please specify)

12. Before today, how many antenatal visits have you attended during this pregnancy?

0 1 2 More than 2

13. Who is the main person you see for antenatal appointments?

- GP
- Obstetrician
- Midwife
- Other (please specify)

14. Who would you trust <u>the most</u> for advice about vaccines in pregnancy (tick one box only)?

- ◯ Obstetrician
- ◯ Midwife
- ◯ GP
- ◯ Friends/ family
- ◯ Internet
- ◯ Department of Health website
- ◯ Other (please specify)

5. Pertussis (whooping cough) vaccine

15. Have you heard of the pertussis (whooping cough) vaccine?

◯ Yes ◯ No ◯ Unsure ◯ Not answered

16. From who/ where did you hear about the whooping cough vaccine (tick all that apply)?

- ☐ I have not heard of the whooping cough vaccine
- ☐ Obstetrician
- ☐ Midwife
- ☐ GP
- ☐ Pharmacist
- ☐ Other (please specify)
- ☐ Friends/ family
- ☐ Public health campaign
- ☐ Internet
- ☐ Poster in antenatal clinic
- ☐ Not answered

17. Have you ever received a whooping cough vaccine prior to this pregnancy?

- ◯ No- I have never received one
- ◯ Yes- after my last pregnancy
- ◯ Yes- unrelated to pregnancy
- ◯ Not sure
- ◯ Not answered

6. Pertussis vaccination advice from your healthcare providers

18. In THIS pregnancy, have the following healthcare providers recommended the whooping cough vaccine to you (tick one response for each provider)?

	Yes	No	Haven't seen this health professional during my pregnancy	Not answered
Obstetrician	○	○	○	○
Midwife	○	○	○	○
GP	○	○	○	○
Pharmacist	○	○	○	○

19. When did the main person you see for antenatal care recommend you have the whooping cough vaccine?

- ○ No one has recommended the whooping cough vaccine to me
- ○ Anytime during pregnancy
- ○ In the third trimester
- ○ Between 28 and 32 weeks
- ○ During pregnancy but I'm not sure of the exact timing
- ○ After delivery (post-partum)
- ○ Not answered

20. In this pregnancy, has any healthcare provider advised you NOT to have the whooping cough vaccine during pregnancy?

- ○ No
- ○ Yes- Obstetrician
- ○ Yes- GP
- ○ Yes- Midwife
- ○ Not answered
- ○ Yes- other (please specify)

7. Pertussis vaccination in this pregnancy

21. Have you already been given the whooping cough vaccine during this pregnancy?

- ◯ Yes
- ◯ No

22. If you've had a whooping cough vaccine during this pregnancy, where did you get it?

- ◯ I have not had a whooping cough vaccine during this pregnancy
- ◯ Antenatal clinic
- ◯ Obstetricians private rooms
- ◯ GP clinic
- ◯ Monash Immunisation
- ◯ Local council Immunisation service
- ◯ Administered by a pharmacist
- ◯ Other (please specify)

23. If you have not had a whooping cough vaccine so far during this pregnancy, do you intend to?

- ◯ I've already had a whooping cough vaccine in this pregnancy
- ◯ Yes, before I deliver my baby
- ◯ No, I will after I deliver my baby
- ◯ No I do not intend to
- ◯ I am unsure

8. Pertussis vaccination in this pregnancy

24. If you have had, or intend to have the whooping cough vaccine, what is your MAIN reason for having it (tick one box only)?

- ○ I do NOT intend to have the whooping cough vaccine
- ○ I am unsure if I'll have the vaccine during pregnancy
- ○ I want to protect myself from whooping cough
- ○ I want to protect my baby from whooping cough
- ○ The vaccine was recommended by a healthcare provider
- ○ The vaccine was recommended by a public health campaign/ media
- ○ Other (please specify)

25. If you have not had, and do not intend to have the whooping cough vaccine during your pregnancy, what is your MAIN reason for not having it (tick one box only)?

- ○ I have had or intend to have the whooping cough vaccine during this pregnancy
- ○ I am unsure if I'll have the vaccine during pregnancy
- ○ It was not discussed or recommended to me by any of my healthcare providers
- ○ I would like more information before deciding
- ○ I would prefer to be vaccinated after delivering my baby
- ○ I have experienced side effects from whooping cough vaccine previously
- ○ I have experienced side effects from other vaccines previously
- ○ I am concerned the vaccine may be harmful to my baby
- ○ I do not believe in vaccinations in general
- ○ I do not think enough is known about whooping cough vaccine in pregnancy
- ○ I received the whooping cough vaccine after my last pregnancy so don't need it again
- ○ Other (please specify)

26. If you are unsure about having the whooping cough vaccine this pregnancy, why (tick one box only)?

- ○ I have had or intend to have the whooping cough vaccine during this pregnancy
- ○ I do NOT intend to have the whooping cough vaccine during this pregnancy
- ○ It was not discussed or recommended to me by any of my healthcare providers
- ○ I would like more information before deciding
- ○ I would prefer to be vaccinated after delivering my baby
- ○ I have experienced side effects from the whooping cough vaccine previously
- ○ I have experienced side effects from other vaccines previously
- ○ I am concerned the vaccine may be harmful to my baby
- ○ I do not think enough is known about whooping cough vaccine in pregnancy
- ○ Other (please specify)

9. Pertussis Vaccine

27. Please indicate your opinion regarding the following statements:

	Agree	Disagree	Unsure	Not answered
Whooping cough vaccine is recommended after delivery rather than during pregnancy	○	○	○	○
Having the whooping cough vaccine during pregnancy is safe for me	○	○	○	○
Having the whooping cough vaccine during pregnancy is safe for my baby	○	○	○	○
Not enough is known about the effects on my baby of pertussis vaccination while I'm pregnant	○	○	○	○

10. Flu vaccine

28. Have you heard of the flu vaccine?

◯ Yes ◯ No ◯ Unsure

29. From who/ where did you hear about the flu vaccine (tick all that apply)?

- ☐ I have not heard of the flu vaccine
- ☐ Obstetrician
- ☐ Midwife
- ☐ GP
- ☐ Pharmacist
- ☐ Other (please specify)
- ☐ Friends/ family
- ☐ Public health campaign
- ☐ Internet
- ☐ Poster in antenatal clinic

30. Have you ever received a flu vaccine prior to this pregnancy?

- ◯ No- I have never received one
- ◯ Yes- I had it in my last pregnancy
- ◯ Yes- In the past, unrelated to pregnancy
- ◯ Not sure

31. In THIS pregnancy, have any of the following healthcare providers recommended the flu vaccine to you?

	Yes	No	Haven't seen this health professional during my pregnancy	Not answered
Obstetrician	◯	◯	◯	◯
Midwife	◯	◯	◯	◯
GP	◯	◯	◯	◯
Pharmacist	◯	◯	◯	◯

11. Flu vaccination during this pregnancy

32. Have you already had a flu vaccine during this pregnancy?

- ◯ Yes
- ◯ No

33. If you have not had the flu vaccine during this pregnancy, do you intend to?

- ◯ I have already had the flu vaccine during this pregnancy
- ◯ Yes
- ◯ No
- ◯ Unsure

34. If you have already had a flu vaccine during this pregnancy, where did you get it?

- ◯ I have not had the flu vaccine this pregnancy
- ◯ Antenatal clinic
- ◯ Obstetricians private rooms
- ◯ GP clinic
- ◯ Monash Immunisation
- ◯ Local council immunisation service
- ◯ Administered by a pharmacist
- ◯ Other (please specify)

35. If you have had, or intend to have, the flu vaccine during this pregnancy, what is your MAIN reason for having it (tick one box only)?

- ◯ I do not intend to have the flu vaccine during this pregnancy
- ◯ I am unsure if I'll have the flu vaccine during this pregnancy
- ◯ I get the flu vaccine every year
- ◯ I want to protect myself from flu
- ◯ I want to protect my baby from flu
- ◯ The flu vaccine was recommended by a healthcare provider
- ◯ The flu vaccine was recommended by a public health campaign/ media
- ◯ Other (please specify)

36. If you have NOT had the flu vaccine during this pregnancy, and do not intend to, what is your MAIN reason for not having it (tick one box only)?

- ◯ I have already had or intend to have the flu vaccine during this pregnancy
- ◯ I am unsure if I'll have the flu vaccine during this pregnancy
- ◯ None of my healthcare providers have discussed or recommended flu vaccine to me
- ◯ I would like more information before deciding
- ◯ I am not worried about getting the flu
- ◯ I have experienced side effects from flu vaccine previously
- ◯ I have experienced side effects from other vaccines previously
- ◯ I am concerned the vaccine may be harmful to my baby
- ◯ I do not believe in vaccinations in general
- ◯ I do not think enough is known about flu vaccine in pregnancy
- ◯ Other (please specify)

37. If you are unsure about having the flu vaccine this pregnancy, why (tick one box only)?

- ○ I have already had or intend to have the flu vaccine during this pregnancy
- ○ I do not intend to have the flu vaccine during this pregnancy
- ○ None of my healthcare providers have discussed or recommended flu vaccine to me
- ○ I would like more information before deciding
- ○ I am not worried about getting the flu
- ○ I have experienced side effects from flu vaccine previously
- ○ I have experienced side effects from other vaccines previously
- ○ I am concerned the vaccine may be harmful to my baby
- ○ I do not think enough is known about flu vaccine in pregnancy
- ○ Other (please specify)

38. An interpreter was used in completing this survey

- ○ Yes
- ○ No

Appendix 5: Questionnaire for *"Uptake of maternal vaccinations by Indigenous women in Central Australia"*

Antenatal Pertussis Vaccination- Aboriginal and Torres Strait Islander women

1. Introduction

This survey is looking at what Indigenous women think about being vaccinated in pregnancy.

Your participation is voluntary and whether you choose to do the survey or not will not affect your care at Alice Springs Hospital. We will not collect any information that can identify you from this survey. We will help you complete the survey, but we can also get an Aboriginal Liaison Officer to help us.

This project has been approved by Central Australian Human Research Ethics Committee. The questionnaire should take approximately 10minutes to complete.

Thank you for participating in this survey, and assisting in our understanding of vaccinations in pregnancy.

Dr. Sushena Krishnaswamy

2. About You

*** 1. How old are you (in years)?**

*** 2. Do you mainly speak a language other than English at home?**

- ○ No
- ○ Yes (please specify)

*** 3. Do you live in town or on community?**

- ○ In a town/ city
- ○ In a remote community

*** 4. What is the highest level of formal education you have completed?**

- ○ Did not Complete Primary School
- ○ Primary School
- ○ High school
- ○ Undergraduate degree
- ○ Post-graduate qualification (e.g.: Masters, PhD)
- ○ Other (please specify)

*** 5. Which of the following categories best describes your current employment status?**

- ◯ Employed, working full-time
- ◯ Employed, working part-time/ casual
- ◯ Employed, maternity leave
- ◯ Home duties
- ◯ Student
- ◯ Not employed
- ◯ Other (please specify)

3. About your pregnancy

*** 6. Before this pregnancy, how many times have you been pregnant?**

- ◯ 0
- ◯ 1
- ◯ 2
- ◯ More than 2

7. Who was the main person you saw for care during your pregnancy?

- ◯ Obstetrician
- ◯ Midwife
- ◯ Remote area nurse (in community clinic)
- ◯ Other (please specify)

4. Whooping cough vaccine

*** 8. Have you heard of the whooping cough vaccine?**

- ◯ Yes
- ◯ No
- ◯ Unsure

*** 9. Did you have a whooping cough vaccine during your pregnancy?**

- ◯ I haven't had a whooping cough vaccine in this pregnancy
- ◯ Yes, during the pregnancy
- ◯ No, after the baby was born
- ◯ I don't know

5. Whooping cough vaccine in this pregnancy

*** 10. If you had a whooping cough vaccine in this pregnancy, where did you get it?**

- ○ I did not have a whooping cough vaccine during this pregnancy
- ○ I don't know if I had a whooping cough vaccine during this pregnancy
- ○ Aboriginal Health Organisation
- ○ Community clinic
- ○ GP clinic
- ○ Hospital
- ○ Other (please specify)

*** 11. If you had the whooping cough vaccine in this pregnancy, what was the MAIN reason you had it (tick one box only)?**

- ○ I did not have a whooping cough vaccine during this pregnancy
- ○ I don't know if I had the whooping cough vaccine during this pregnancy
- ○ I wanted to protect myself from whooping cough
- ○ I wanted to protect my baby from whooping cough
- ○ My doctors told me I should
- ○ It was recommended by a public health campaign/ media
- ○ Other (please specify)

*** 12. If you did NOT have the whooping cough vaccine in this pregnancy, what was your MAIN reason for not having it (tick one box only)?**

- ○ I had a whooping cough vaccine during pregnancy
- ○ I'm not sure if I had a whooping cough vaccine during pregnancy
- ○ It was not discussed/ recommended to me
- ○ I wanted more information before deciding
- ○ I preferred to be vaccinated after delivering my baby
- ○ I've had side effects from vaccines before so was worried
- ○ I was concerned the vaccine may hurt my baby
- ○ I don't believe in vaccinations in general
- ○ I don't think enough is known about pertussis vaccine in pregnancy
- ○ I had it after my last pregnancy so don't need it again
- ○ Other (please specify)

6. Flu vaccine

*** 13. Have you heard of the flu vaccine?**

- ◯ Yes ◯ No ◯ Unsure

*** 14. Did you have a flu vaccine during this pregnancy?**

- ◯ Yes ◯ No ◯ Unsure

*** 15. If you had a flu vaccine during this pregnancy, where did you get it?**

- ◯ I didn't have the flu vaccine during this pregnancy
- ◯ I don't know if I had the flu vaccine this pregnancy
- ◯ Aboriginal Health Organisation
- ◯ Community clinic
- ◯ GP clinic
- ◯ Hospital
- ◯ Other (please specify)

*** 16. If you had the flu vaccine during this pregnancy, what was your MAIN reason for having it (tick one box only)?**

- ◯ I didn't have the flu vaccine during this pregnancy
- ◯ I don't know if I had the flu vaccine during this pregnancy
- ◯ I get the flu vaccine every year
- ◯ I wanted to protect myself from flu
- ◯ I wanted to protect my baby from flu
- ◯ My doctors told me I should
- ◯ It was recommended by a public health campaign/ media
- ◯ Other (please specify)

*** 17. If you did NOT have the flu vaccine during this pregnancy what was your MAIN reason for not having it (tick one box only)?**

- ◯ I had the flu vaccine during my pregnancy
- ◯ I don't know if I had the flu vaccine during my pregnancy
- ◯ No one told me about it
- ◯ I would like more information before deciding
- ◯ I have had side effects from vaccines before so I am worried
- ◯ I am concerned the vaccine may hurt my baby
- ◯ I don't believe in vaccination in general
- ◯ I don't think enough is known about the flu vaccine in pregnancy
- ◯ Other (please specify)

18. Would you be happy for us to check your flu and pertussis vaccines on the NT vaccination register?

- ◯ Yes
- ◯ No

19. NT Immunisation Register

	Antenatal	Postnatal	Not had it
Pertussis vaccine	◯	◯	◯
Flu vaccine	◯	◯	◯

Other (please specify)

Appendix 6: Questionnaire for *"Protecting newborns from pertussis: The role of partner vaccination in the era of maternal immunization"*

MonashHealth

Examining the Uptake of Antenatal Pertussis Vaccination - Partner Study v.2

* 1. Did your partner receive a pertussis (whooping cough) vaccine during her pregnancy?

- Yes
- No
- I dont know

* 2. Where did she have it?

- She did not get the vaccine during pregnancy
- Antenatal clinic (public)
- Private obstetrician's rooms
- GP
- Monash immunisation service
- Local council immunisation service
- I don't know
- Other (please specify)

* 3. Did your partner receive a flu vaccine during her pregnancy?

- Yes
- No
- I don't know

* 4. Were you vaccinated against pertussis during your partner's current pregnancy?

- ◯ Yes, I had the vaccine while my partner was pregnant
- ◯ No, I didn't have the vaccine in this pregnancy because i have had it in the last 10 years
- ◯ No, I have not had the vaccine

* 5. Where were you vaccinated?

- ◯ I have not had the pertussis vaccine in the last 40 weeks
- ◯ Antenatal clinic
- ◯ Private obstetrician's rooms
- ◯ GP
- ◯ Monash immunisation services
- ◯ Other (please specify)

6. Who else will live in your home or provide significant care for your baby?

- ☐ Parents (baby's grandparents)
- ☐ Dependent children
- ☐ No one
- ☐ Other (please specify)

7. Of the other people in you household or those providing significant care for your baby, who has had the pertussis vaccine during your partners pregnancy?

	N/A (not living with me/ providing care)	No (has had vaccine in the last ten years)	No (not in current pregnancy)	Yes	I don't know
Maternal grandmother	◯	◯	◯	◯	◯
Maternal grandfather	◯	◯	◯	◯	◯
Paternal grandmother	◯	◯	◯	◯	◯
Paternal grandfather	◯	◯	◯	◯	◯
Siblings	◯	◯	◯	◯	◯
Other (please specify)	◯	◯	◯	◯	◯

8. Of the other people in your household or those providing significant care for your baby, who has come from overseas?

	Yes	No	N/A (not living with me/ providing care)
Maternal grandmother	◯	◯	◯
Maternal grandfather	◯	◯	◯
Paternal grandmother	◯	◯	◯
Paternal grandfather	◯	◯	◯
Siblings	◯	◯	◯
Other (please specify)	◯	◯	◯

9. In what type of postanatal ward is your partner staying?

- ◯ Public
- ◯ Private

Appendix 7: Questionnaire for *"A study comparing the practice of Australian maternity care providers in relation to maternal immunisation"*

MONASH University

Examining the Attitudes and Knowledge of Antenatal Care Providers and Consumers to Antenatal Pertussis Vaccination- Healthcare Provider Survey RANZCOG

Introduction

This questionnaire is part of a PhD examining the attitudes of antenatal care providers and advice given to pregnant women regarding vaccination in pregnancy. A separate survey is being administered to pregnant women to examine their attitudes.

Participation is voluntary and anonymous. The questionnaire should take approximately 10minutes to complete.

The project has been approved by the Monash Health Human Research Ethics Committee, and for email distribution by the Royal Australian and New Zealand College of Obstetricians and Gynaecologists, Australian College of Midwives and South Eastern Health Providers Association.

Thank you for participating in this survey.

A/Prof Michelle Giles and Dr. Sushena Krishnaswamy
Department of Obstetrics and Gynaecology, Monash University

MONASH University

Examining the Attitudes and Knowledge of Antenatal Care Providers and Consumers to Antenatal Pertussis Vaccination- Healthcare Provider Survey RANZCOG

Demographics

1. What is your primary professional role (tick one box only)?

- ○ Obstetrician
- ○ GP (regularly undertake shared care)
- ○ GP (care up to 20 weeks gestation but not usually beyond)
- ○ Midwife
- ○ Immunisation Nurse
- ○ Maternal Child Health Nurse
- ○ Other (please specify)

2. How old are you (in years)?

3. In which country were you born?

- ○ Australia
- ○ Other (please specify)

MONASH University

Examining the Attitudes and Knowledge of Antenatal Care Providers and Consumers to Antenatal Pertussis Vaccination- Healthcare Provider Survey RANZCOG

Practice demographics

4. In which country did you complete your post-graduate medical/ midwifery/ nursing training?

- ○ Australia
- ○ Other (please specify)

5. In which State/ Territory do you currently practice?

- ○ Australian Capital Territory
- ○ New South Wales
- ○ Northern Territory
- ○ Queensland
- ○ South Australia
- ○ Tasmania
- ○ Victoria
- ○ Western Australia

6. For how long have you been a practising healthcare professional?

- ○ 0-5 years
- ○ 5-10 years
- ○ 10-15 years
- ○ More than 15 years

7. If you provide care/ advice to pregnant women, for how long have you been doing this?

- ◯ I do not provide care/ advice to pregnant women
- ◯ 0-5 years
- ◯ 5-10 years
- ◯ 10-15 years
- ◯ More than 15 years

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Examining the Attitudes and Knowledge of Antenatal Care Providers and Consumers to Antenatal Pertussis Vaccination- Healthcare Provider Survey RANZCOG

Practice demographics

8. Where do you provide most of your antenatal care (tick one box only)?

- ○ I do not provide care/ advice to pregnant women
- ○ Public hospital antenatal clinic
- ○ Private rooms (O & G specialist)
- ○ General Practice/ Community Health Centre
- ○ Other (please specify)

9. Do you provide antenatal care in a public hospital even if it is not your primary place of work?

- ○ I do not provide care/ advice to pregnant women
- ○ My primary place of work is a public hospital
- ○ Yes
- ○ No

10. If you are a doctor working in a private practice/ community health centre, do you have a midwife/ practice nurse in your rooms?

- ○ Yes
- ○ No
- ○ I am not a doctor
- ○ I do not work in a private practice/ community health centre

MONASH University

Examining the Attitudes and Knowledge of Antenatal Care Providers and Consumers to Antenatal Pertussis Vaccination- Healthcare Provider Survey RANZCOG

Your vaccination status

11. Have you ever been immunised against influenza?

◯ Yes ◯ No

12. Have you received a pertussis-containing vaccine in the last 10 years?

◯ Yes ◯ No ◯ Unsure

MONASH University

Examining the Attitudes and Knowledge of Antenatal Care Providers and Consumers to Antenatal Pertussis Vaccination- Healthcare Provider Survey RANZCOG

Vaccination in your practice

13. How often do you include a vaccination history as part of your pre-pregnancy or antenatal history?

- ◯ I do not provide care/ advice to pregnant women
- ◯ Always
- ◯ Usually
- ◯ Sometimes
- ◯ Rarely
- ◯ Never

14. Who do you believe has the main responsibility for DISCUSSING vaccinations with pregnant women (tick one box only)?

- ◯ The woman's usual GP
- ◯ Obstetrician
- ◯ Midwife
- ◯ Pharmacist
- ◯ Other (please specify)

15. Who do you believe has the main responsibility for ADMINISTERING vaccinations to pregnant women (tick one box only)?

- ◯ The woman's usual GP
- ◯ Obstetrician
- ◯ Midwife
- ◯ Department of Health
- ◯ Pharmacist
- ◯ Other (please specify)

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Examining the Attitudes and Knowledge of Antenatal Care Providers and Consumers to Antenatal Pertussis Vaccination- Healthcare Provider Survey RANZCOG

Vaccination during pregnancy

16. Which of the following vaccinations are safe to give in pregnancy (tick one box for each vaccine)?

	Yes	No	Unsure
Hepatitis A	◯	◯	◯
Hepatitis B	◯	◯	◯
Measles, Mumps, Rubella	◯	◯	◯
Pneumococcal	◯	◯	◯
Typhoid	◯	◯	◯
Varicella	◯	◯	◯

17. Do you feel you have been provided enough information to be confident to offer pregnant women advice about pertussis vaccination during pregnancy?

◯ Yes ◯ No ◯ Unsure

MONASH University

Examining the Attitudes and Knowledge of Antenatal Care Providers and Consumers to Antenatal Pertussis Vaccination- Healthcare Provider Survey RANZCOG

Antenatal pertussis vaccination- your practice

18. Is pertussis vaccination provided to pregnant women at your primary place of work?

◯ Yes ◯ No

19. If pertussis vaccination is provided to pregnant women at your primary place of work, who administers it (tick all that apply)?

- ☐ Pertussis vaccine is not provided at my place of work
- ☐ Practice nurse
- ☐ Midwife
- ☐ Obstetrician
- ☐ GP
- ☐ Immunisation service
- ☐ Pharmacist
- ☐ Other (please specify)

20. What issues (if any) do you perceive as barriers to the provision of pertussis vaccine to pregnant women at your primary place of work (tick all that apply)?

- [ ] Pertussis vaccine is offered at my place of work and there are no apparent barriers
- [ ] There is a lack of clarity about whose role it is to vaccinate pregnant women when multiple providers are involved
- [ ] I do not have time
- [ ] I do not have a practice nurse or midwife
- [ ] I am worried about the liability issues if something goes wrong
- [ ] I do not have the capacity to store vaccines on site
- [ ] I do not have the facilities/ equipment to manage severe adverse reactions
- [ ] I would like more information on antenatal vaccination before providing it
- [ ] Other (please specify)

MONASH University

Examining the Attitudes and Knowledge of Antenatal Care Providers and Consumers to Antenatal Pertussis Vaccination- Healthcare Provider Survey RANZCOG

Antenatal pertussis vaccination- your practice

21. Please tick the box that best reflects your routine current practice regarding PERTUSSIS VACCINE when women are pregnant:

- ◯ I do not provide care/ advice to pregnant women
- ◯ I recommend pertussis vaccination in the third trimester in every pregnancy
- ◯ I recommend pertussis vaccination in the third trimester to women who have not had the pertussis vaccine in the last 5 years
- ◯ I recommend pertussis vaccination in the third trimester to women who have not been vaccinated in the previous pregnancy
- ◯ I recommend pertussis vaccination postpartum
- ◯ I discuss both antenatal and postnatal vaccination and allow women to choose which they'd prefer
- ◯ I do not recommend pertussis vaccine to women during pregnancy or post-partum
- ◯ Other (please specify)

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Examining the Attitudes and Knowledge of Antenatal Care Providers and Consumers to Antenatal Pertussis Vaccination- Healthcare Provider Survey RANZCOG

Antenatal Pertussis Vaccination

22. Please rate your agreement with the following statements (tick response for each statement):

	Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
There is greater risk to pregnant women from pertussis vaccine than from the infection itself	○	○	○	○	○
Pertussis vaccine protects the unborn baby by preventing the pregnant woman from being infected with pertussis herself	○	○	○	○	○
Pertussis vaccine protects the unborn baby by passive transfer of maternal antibodies across the placenta	○	○	○	○	○
Pertussis vaccine protects the newborn by transfer of antibodies in breastmilk	○	○	○	○	○
Not enough is known about the safety of pertussis vaccination in pregnancy	○	○	○	○	○
Not enough is known about the safety of administering pertussis vaccination in EVERY pregnancy	○	○	○	○	○
Antenatal pertussis vaccination increases the risk of adverse pregnancy outcomes such as preterm labour	○	○	○	○	○

MONASH University

Examining the Attitudes and Knowledge of Antenatal Care Providers and Consumers to Antenatal Pertussis Vaccination- Healthcare Provider Survey RANZCOG

Antenatal pertussis vaccination- Program

23. Before completing this survey were you aware of the recent changes to the national guidelines to routinely recommend pertussis vaccine to all pregnant women in the third trimester in every pregnancy?

◯ Yes ◯ No ◯ Unsure

24. Who do you believe is funding the current pertussis vaccination program for pregnant women (tick one box only)?

◯ Commonwealth Department of Health and Ageing

◯ State health departments

◯ Local governments

◯ The programs are not funded (i.e. patients have to pay)

◯ Other (please specify)

MONASH University

Examining the Attitudes and Knowledge of Antenatal Care Providers and Consumers to Antenatal Pertussis Vaccination- Healthcare Provider Survey RANZCOG

Influenza Vaccine

25. Is influenza vaccination provided to pregnant women at your primary place of work?

- ◯ Yes
- ◯ No

26. Do you feel you have been provided enough information to feel confident to offer pregnant women advice about influenza vaccination during pregnancy?

- ◯ Yes
- ◯ No
- ◯ Unsure

27. Please tick the box that *best represents* your routine current practice regarding INFLUENZA vaccine when women are pregnant

- ◯ I do not provide care/ advice to pregnant women
- ◯ I recommend to pregnant women during flu season irrespective of gestation
- ◯ I recommend to pregnant women who will be in the second or third trimester during influenza season
- ◯ I recommend to pregnant women only if they have chronic medical conditions predisposing them to severe influenza
- ◯ I do not recommend influenza vaccine to women during pregnancy
- ◯ Other (please specify)

28. Please rate your agreement with each of the following statements:

	Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
The risks of influenza in pregnancy are overemphasised	○	○	○	○	○
Pregnant women are at increased risk of influenza-related morbidity and mortality	○	○	○	○	○
Influenza vaccine is more risk to pregnant women than if they acquired influenza itself	○	○	○	○	○
Influenza vaccine protects pregnant women but not their babies from influenza	○	○	○	○	○
Influenza vaccine given to pregnant women during pregnancy protects the baby from respiratory illness in the first 6 months of life	○	○	○	○	○

Appendix 8: Questionnaire for *"A survey of pharmacists' attitudes and practices regarding pharmacist-administered vaccination in Australia"*

MONASH University

Pharmacist delivered vaccination: Understanding the pharmacists experience

Welcome to My Survey

This questionnaire is part of my PhD examining various aspects of implementing antenatal vaccination programs including attitudes and knowledge of pregnant women and antenatal healthcare providers.

While traditionally vaccination has not been the remit of pharmacists, with the recent changes in legislation in Victoria, and the expanding role of pharmacist-led immunisation nationally, it is imperative we understand the needs of pharmacists and the barriers to provision of immunisation in this emerging area.

This project has been approved by the Monash University Human Research Ethics Committee and is being conducted in collaboration with the Pharmaceutical Society of Australia. Participation is voluntary and anonymous. The questionnaire should take approximately 10 minutes to complete.

Thank you for participating in our survey. Your feedback is important.

Dr Sushena Krishnaswamy

Demographics

*** 1. What is your primary professional role?**

- Pharmacist owner
- Pharmacist manager
- Employee pharmacist
- Pharmacy intern
- Pharmacy student
- Other (please specify)

*** 2. How old are you (in years)?**

*** 3. In which country were you born?**

- Australia
- Other (please specify)

*** 4. In which country did you complete your pharmacy training?**

- Australia
- Other (please specify)

*** 5. For how long have you been a practising pharmacist?**

- 0-5 years
- 6-10 years
- 11-15 years
- More than 15 years

* **6. Have you ever been immunised against influenza?**

- ◯ Yes
- ◯ No

* **7. Did you get the influenza vaccine in 2016?**

- ◯ Yes
- ◯ No

* **8. Have you received a pertussis-containing vaccine in the last 10 years?**

- ◯ Yes
- ◯ No
- ◯ Unsure

* **9. Have you undergone a recognised state government approved immunisation course?**

- ◯ Yes
- ◯ No

*** 10. In which State/ Territory is your primary place of work?**

- ACT
- NSW
- NT
- Queensland
- SA
- Tasmania
- Victoria
- WA

*** 11. In what setting is your primary place of work?**

- Metropolitan/ urban
- Rural or remote Australia
- Other (please specify)

*** 12. Which of the following best describes your primary place of work?**

- Public hospital pharmacy
- Independent community pharmacy
- Franchised banner group pharmacy
- Private pharmacy group
- Other (please specify)

* 13. How many pharmacists work on the floor during business hours Monday-Friday?

- ◯ 1
- ◯ 2
- ◯ 3
- ◯ Other (please specify)

* 14. How many trained immuniser pharmacists are there at your primary place of work?

- ◯ 0
- ◯ 1
- ◯ 2
- ◯ More than 2
- ◯ I don't know

*** 15. Is influenza vaccine administered at your primary place of work?**

- Yes- to adults including pregnant women
- Yes- to adults excluding pregnant women
- No
- Other (please specify)

*** 16. If influenza vaccination is administered at your primary place of work, who administers the vaccine (tick one option only)?**

- Immunisation services are not provided at my place of work
- Pharmacists only
- Nurse immuniser
- Pharmacists and nurse immuniser
- Pharmacy intern supervised by pharmacist
- General practitioner
- Other (please specify)

*** 17. If influenza vaccine is administered at your primary place of work, do you use an appointment system?**

- Influenza vaccination is not administered at my place of work
- Yes- during all trading hours
- Yes- during specified times only
- Yes combination- clients can make appointments but we also offer a walk in service
- No- clients can walk in anytime (we do not take appointments)
- Other (please specify)

*** 18. For each of the following groups, please indicate whether you charge a fee for the vaccine itself and/ or administration of the vaccine**

	Vaccine fee	Administration fee	No fee	Immunisation services are not provided at my primary place of work
National Immunisation Program eligible clients	☐	☐	☐	☐
Adults ineligible through the National Immunisation Program	☐	☐	☐	☐
Pensioners	☐	☐	☐	☐
Health care card holders	☐	☐	☐	☐

*** 19. Do you think charging a fee would be a barrier to clients choosing to be vaccinated at your primary place of work?**

- ◯ **Yes**
- ◯ **No**
- ◯ **Unsure**

*** 20. Please rate how important each of the following potential benefits of pharmacist-led immunisation are to you**

	Extremely important	Very important	Important	Not important	No opinion
Convenience for customers	◯	◯	◯	◯	◯
Increasing access to immunisation	◯	◯	◯	◯	◯
Public health benefit of increasing immunisation rates	◯	◯	◯	◯	◯
Expanding the role and professional image of pharmacists	◯	◯	◯	◯	◯
Providing more holistic care	◯	◯	◯	◯	◯
Monetary gains	◯	◯	◯	◯	◯
Professional satisfaction	◯	◯	◯	◯	◯

* **21. Do you feel you received adequate education about vaccines during your undergraduate pharmacy training?**

- ◯ Yes
- ◯ No
- ◯ I have not completed my undergraduate training

* **22. Do you feel appropriately supported by your professional body to provide an immunisation service?**

- ◯ Yes
- ◯ No

23. Are there other resources you feel would be helpful?

* **24. How comfortable do you feel DISCUSSING the risks and benefits of vaccination when asked by the following customers?**

	Very comfortable	Comfortable	Unsure	Uncomfortable	Very uncomfortable
Adults >65yo	◯	◯	◯	◯	◯
Adults <65y	◯	◯	◯	◯	◯
Pregnant women	◯	◯	◯	◯	◯
Adults with chronic medical conditions	◯	◯	◯	◯	◯

* **25. Please rate how comfortable you would be with ADMINISTERING vaccinations to each of the following groups**

	Very comfortable	Comfortable	Unsure	Uncomfortable	Very uncomfortable
Adults >65yo	◯	◯	◯	◯	◯
Adults <65yo	◯	◯	◯	◯	◯
Pregnant women	◯	◯	◯	◯	◯
Adults with chronic medical conditions	◯	◯	◯	◯	◯

* **26. How significant do you feel each of the following potential barriers to providing immunisation services are at your primary place of work (e.g.: Do you think the time required to complete a recognised training program is a very significant, significant or insignificant barrier to pharmacists providing immunisation services)?**

	Very significant	Significant	Insignificant	Unsure
Time required to complete a recognised training program	◯	◯	◯	◯
Cost of completing a recognised training program	◯	◯	◯	◯
Time for ongoing professional development/ training	◯	◯	◯	◯
Cost of ongoing professional development/ training	◯	◯	◯	◯
Meeting premises requirements	◯	◯	◯	◯
Meeting professional staffing requirements	◯	◯	◯	◯
Concern about liability	◯	◯	◯	◯
Managing anaphylaxis	◯	◯	◯	◯
Keeping up to date with vaccine indications and contraindications	◯	◯	◯	◯
Having adequate resources to meet the consumer demand for the service	◯	◯	◯	◯
Clients having to pay a fee for the service	◯	◯	◯	◯

* **27. Regarding the Adult Immunisation Register (AIR), please indicate your agreement with each of the following statements**

	Strongly agree	Agree	Neither agree or disagree	Disagree	Strongly disagree	Unable to comment
The AIR is a useful tool for healthcare providers to access an up to date vaccination history for clients	○	○	○	○	○	○
Registering to access the AIR was straightforward	○	○	○	○	○	○
The administrative requirements of contributing to the AIR are onerous	○	○	○	○	○	○
The current renumeration of pharmacists for contributing to the AIR is adequate	○	○	○	○	○	○
The requirement to contribute to the AIR is a barrier to providing immunisation services	○	○	○	○	○	○

28. Do you have any other comments about the Adult Immunisation Register?

* **29. Do you administer influenza vaccination to pregnant women at your primary place of work?**

- ◯ Yes
- ◯ No

* **30. Do you administer pertussis vaccination to pregnant women at your primary place of work?**

- ◯ Yes
- ◯ No

* **31. At your primary place of work, how often do pregnant women ask you for advice about vaccination during pregnancy?**

- ◯ Never
- ◯ Less than once a week
- ◯ A few times a week
- ◯ Every day

* **32. Do you feel comfortable offering pregnant women advice about influenza vaccination during pregnancy?**

- ◯ Yes
- ◯ No
- ◯ Unsure

* **33. Do you feel comfortable offering pregnant women advice about pertussis vaccination during pregnancy?**

- ◯ Yes
- ◯ No
- ◯ Unsure

*** 34. Please rate your agreement with each of the following statements about vaccinating pregnant women at your primary place of work**

	Strongly agree	Agree	Unsure	Disagree	Strongly disagree
I do not perceive vaccinating pregnant women any differently to other adults	○	○	○	○	○
I am more comfortable recommending influenza vaccine to pregnant women than pertussis vaccine	○	○	○	○	○
I am more comfortable recommending pertussis vaccine to pregnant women than influenza vaccine	○	○	○	○	○
I am worried about liability issues when vaccinating a pregnant woman	○	○	○	○	○
Not enough is known about the effects of antenatal vaccination on fetal development	○	○	○	○	○
The long term effects of antenatal vaccination on childhood development are unclear	○	○	○	○	○
I would like more information on antenatal vaccines before administering them	○	○	○	○	○

*** 35. If vaccinations are not currently administered to pregnant women at your primary place of work, is there an intention to?**

- ○ **Vaccinations are already administered to pregnant women at my primary place of work**
- ○ **Yes**
- ○ **No**

36. Do you have any other comments about pharmacist-led vaccination?

Appendix 9: Conference presentations during enrolment

Title	Conference	Presentation
Protecting newborns from pertussis: the role of cocooning in the era of maternal immunisation: a survey of parental vaccination in Melbourne, Australia	Infectious Diseases Society for Obstetrics and Gynecology 44th Annual Meeting 10–12 August 2017 Utah, US	Oral
Knowledge, attitudes and practices of Australian obstetricians to maternal vaccination: a national survey	Royal College of Obstetricians and Gynaecologists World Congress 2018 22–24 March 2018 Singapore	Poster
A study comparing the knowledge, attitudes and practice of maternity care providers to maternal vaccination in Australia	Australasian Society for Infectious Diseases Annual Scientific Meeting 10–12 May 2018 Gold Coast, Australia	Oral
Uptake of antenatal vaccination by women from culturally and linguistically diverse backgrounds: a cross-sectional study	Australasian Society for Infectious Diseases Annual Scientific Meeting 10–12 May 2018 Gold Coast, Australia	Poster
Delivering maternal vaccination: standing orders, a hospital based immunisation service, and primary care models	16th Public Health Association of Australia National Immunisation Conference 5–7 June 2018 Adelaide, Australia	Oral
Implementation of pharmacist delivered vaccination in Australia: the pharmacist's experience	16th Public Health Association of Australia National Immunisation Conference 5–7 June 2018 Adelaide, Australia	Oral