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Vaccine intention and hesitancy among Australian women who are currently pregnant or have recently given birth: the Birth in the Time of COVID-19 (BITTOC) national online survey

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ABSTRACT

Objective To examine the prevalence of COVID-19 vaccination, and factors associated with vaccination intention and hesitancy in pregnant and postnatal women in Australia.

Design and setting A national online survey was conducted over 6 months between 31 August 2021 and 1 March 2022 and responses to vaccination status were categorised as: 'vaccinated', 'vaccine intended' and 'vaccine hesitant'. The data were weighted to reflect the proportion of women of reproductive age. Potential confounding variables were examined using multinomial logistic regression analyses, and all comparisons were made against vaccinated pregnant and postnatal women.

Participants 2140 women responded to the survey (838 pregnant; 1302 recently post partum).

Results Amongst pregnant women, 586 (69.9%) were vaccinated, 166 (19.8%) indicated intention and 86 (10.3%) were hesitant. In postnatal women, this was 1060 (81.4%), 143 (11.0%) and 99 (7.6%), respectively. Only 52 (6.2%) of pregnant women stated never wanting a COVID-19 vaccine. Vaccine hesitancy increased over time, and for pregnant women was associated with: living in a state other than New South Wales (NSW) (Adjusted Relative Risk (ARR) 2.77, 95%CI: 1.68-4.56 for vaccine intention and ARR=3.31, 95%CI: 1.52-7.20 for vaccine hesitancy), younger age <30 years, not having a university education, income <80K AUD, gestation <28 weeks, having no pregnancy risk factors, and being less satisfied with life (ARR=2.20, 95%CI: 1.04-4.65 for vaccine intention and ARR=2.53, 95%CI: 1.02-6.25 for vaccine hesitancy) . For postnatal women: living in a state other than NSW or Victoria, income <80K AUD and having private obstetric care (ARR=2.06, 95%CI: 1.23-3.46) were significantly associated with vaccine hesitancy.

Conclusions Around 1 in 10 pregnant women and just over 1 in 13 postnatal women reported vaccine hesitancy in this Australian survey, and hesitancy was higher in the latter 3-month period. Tailored messages to younger mothers and those from lower-middle socioeconomic groups, alongside advice from midwives and obstetricians, could help to reduce hesitancy among pregnant and postnatal women. Financial incentives may help to facilitate COVID-19 vaccine uptake. A real-time surveillance system and additional pregnancy fields added to the Australian immunisation register would support the safety monitoring of multiple vaccines in pregnancy and may build confidence.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ This is one of the largest and most recent surveys of childbearing women's vaccines intentions in Australia.
⇒ The use of sample weighting by maternal age increases generalisability.
⇒ There were higher numbers of women responding from New South Wales and Victoria, where COVID-19 had the greatest impact on everyday life.
⇒ The survey was distributed through social media and perinatal/pregnancy online groups and so may not have been accessible to women with limited computer access or where English was not their first language.
⇒ It is not possible to estimate a response rate due to the open online sampling approach.

INTRODUCTION

In Australia, women can access a range of antenatal services in both hospital and community-based settings. The public sector provides services options to women that include general practitioner (GP) shared care, and hospital-based midwifery (continuity and non-continuity models) and obstetric services. Women can in addition access continuity of care from privately practising midwives or obstetricians, although availability may be restricted in rural and remote regions. Antenatal visits are scheduled early in pregnancy, and according to the woman's physical, cultural and emotional needs, different models of care are recommended. For example, low-risk pregnancies

are typically managed by midwives, whereas obstetricians specialise in those considered to be of high-risk, however assessment continues throughout pregnancy, and care may be adjusted as required. During routine antenatal visits, guidelines specify that discussions regarding the administration of recommended influenza and pertussis vaccinations should occur.[1] On 9 June 2021, the Royal Australian and New Zealand College of Obstetricians and Gynaecologists (RANZCOG) updated its advice regarding COVID-19 vaccination for pregnant women in a joint statement with the Australian Technical Advisory Group on Immunisation.[2] The recommendation was that: '*pregnant women are routinely offered Pfizer mRNA vaccine (Cominarty) at any stage of pregnancy. This is because the risk of severe outcomes from COVID-19 is significantly higher for pregnant women and their unborn baby*'.[2] This change in advice followed the publication of studies from the USA[3] and Israel[4] showing the safety of mRNA vaccines during pregnancy. On 18 August, further advice came from RANZCOG stating that for breastfeeding women either '*Pfizer, Moderna or AstraZeneca vaccine is considered safe*'.[5] Unfortunately, there are no published randomised controlled trials to guide clinicians' advice because pregnant and breastfeeding women are very rarely ever included in vaccine trials. However, large population databases now provide information on the risks to both mothers and babies of COVID-19 in pregnancy and reassuring evidence of the safety of COVID-19 vaccines in pregnancy.[6]

Data from the UK[7 8] and the USA[9] have shown that pregnant women who contract COVID-19 are at increased risk of severe illness requiring intensive care and their babies are more likely to be born preterm. Increased numbers of pregnant and postpartum women in the UK have been admitted to hospital and required intensive care because of COVID-19 infection, with 98% of these women being unvaccinated.[7 8] In 2021, maternal mortality reportedly has risen in the USA,[10] doubled in Brazil[11] and nearly tripled in India[12] since the pandemic began.

In Australia, inactivated influenza vaccine (IIV), whooping cough (pertussis) coverage and now COVID-19 vaccinations are recommended in pregnancy. However, data on the numbers of pregnant/postpartum women getting vaccinated are lacking as the national immunisation database does not have identifiers for pregnancy or postpartum status. A recent media report showed much of the data on COVID-19 vaccination uptake in pregnant women is anecdotal and clinicians reported estimates of somewhere between 30% and 70%.[13] A prospective cohort study (FluMum, 2012–15) (n=~10 000) identified vaccine uptake in pregnancy of IIV to be 36% (n=3651/9878) with only 3%–4% during the first trimester.[14] Predictors of IIV uptake in pregnancy were: healthcare provider recommendation (pharmacists and nurses, GPs, obstetricians and midwives), previous IIV within 12 months of their current pregnancy and pertussis vaccination during the current pregnancy.[14] In a retrospective analysis in Victoria (n=153 980 pregnancies 2015–17), pertussis vaccination uptake in pregnancy was found to be higher than influenza, at 64% and 39%, respectively.[15] A lack of safety data can lead to vaccine hesitancy in pregnant women, but it can also influence the advice clinicians give. This is important as clinicians are key influencers in women's decision-making during pregnancy. Safety has been found to be a concern among 40% of unvaccinated FluMum participants.[14] The Centers for Disease Control and Prevention in the USA in 2021 reported that the rates of pregnant women fully vaccinated against COVID-19 were 35.5%[16] and in the UK these rates were reported to be as low as 15%.[8] During the same timeframe, COVID-19 vaccine hesitancy/resistance in the general population had been reported to be sitting at around 35% in Ireland and 31% in the UK[17] with more women than men, especially pregnant women, and younger people being vaccine hesitant. A review of the literature examining COVID-19 vaccination found the main reasons for vaccine hesitancy were lack of information about vaccination, opinion that the vaccine is unsafe and fear of adverse events.[18]

The Birth in the Time of COVID-19 (BITTOC) study is a mixed-method, longitudinal study investigating the pandemic-related experiences and mental health of an initial cohort of 3191 women who were pregnant or had given birth during the pandemic. The BITTOC study was conducted in Australia from March to December 2020 (BITTOC 2020), and again from August 2021 to March 2022 (BITTOC 2021). In this paper, we use data from the second survey (BITTOC 2021). This captured data during a surge in COVID-19 cases in Australia resulting from the Delta variant from May 2021 onwards, with subsequent prolonged lockdowns in the states of NSW and Victoria. We sought to determine vaccine intent in this cohort by examining the prevalence of vaccination, vaccination intention and vaccine hesitancy among pregnant women and women who had given birth since May 2021, and the associated factors with vaccination intention and vaccine hesitancy.

METHODS

Study design and populations

The BITTOC 2021 online survey was distributed over a 6-month period (31 August 2021 to 1 March 2022) through social media and relevant perinatal websites and communities. Paid Facebook advertisements were used along with national parenting websites, the Australian Breastfeeding Association, Playgroup Australia, multicultural groups and over 200 dissemination platforms to reach as many women as possible. Women who were pregnant or had given birth since May 2021 were asked to respond to a series of questions about their demographics, COVID-19-related and maternity care experiences, mental health and social support and vaccine intention/uptake. In this study, sample weights were introduced to reduce bias associated with the online survey, including an oversampling of certain maternal age groups. The sampling weight was computed by dividing proportion of women who gave birth by maternal age in Australia in 2019[19] by

the proportion of women by maternal age in our sample proportions.

Ethics approval

Information about the study was built into the front of the survey and a hyperlink embedded into this with access to a full participant information sheet. Women responding to the survey were then given two options: 'yes' they consented to participate in the survey or 'no' they did not consent to participate in the survey. If they chose 'no', they were taken to the end of the survey and did not complete it.

Patient and public involvement

This study collected data from participants through a national online survey. A consumer advisor was a member of the advisory committee for the BITTOC study. The results of the study will be made available to women and families through a Conversation article.

Sample size

The sample size was based on a study reporting the willingness to have the pertussis vaccine during pregnancy and post partum were 80% and 34%, respectively.[20] Assuming 80% power and an alpha level of 5%, a power analysis for a one-sample proportion test 'power oneproportion' command in STATA V.17 (see below) yielded an approximate sample size of 852 for pregnant and 1301 for postnatal women to give a CI of about ±7.5%.[20] The calculated sample sizes would be large enough to answer our research questions and to detect any statistical difference in this study.

Outcome variables

In the BITTOC 2021 online survey, pregnant and postnatal women were asked "Will you get the COVID-19 vaccination during your pregnancy once it is made available to you?" The questions were grouped as category 1—'vaccinated', category 2—'vaccine intended' and category 3—'vaccine hesitant' (see online supplemental file 1 for survey questions).

Potential confounding factors

The potential confounding factors included in the analysis were guided by previous studies.[21] Variables included: State or Territory in Australia (due to high COVID-19 incidence in some states), age in years, level of education, employment status, combined income, country of birth, language other than English spoken at home, marital status, living or working in a suburb of high COVID-19 incidence, weeks of pregnancy (gestation), weeks post partum, parity, risk factors during pregnancy, suspected COVID-19 infection for self or immediate family and life satisfaction.

Statistical analysis

Analyses were performed using STATA V.17 (StataCorp, College Station, Texas, USA). Preliminary analyses involved frequency tabulations of all selected characteristics for pregnant and postnatal women, followed by estimation of the prevalence of the outcome variables by the potential confounding factors for pregnant and postnatal women.

In this analysis, there is no intrinsic ordering to the outcome variables. Hence, multinomial logistic regression analyses were used to identify associated factors. In the bivariate analysis, all confounding variables with p value <0.20 were retained and used to build a multivariate model.[22] For multivariate multinomial logistic regression, a manual backward elimination procedure was applied to remove non-significant variables (p>0.05). Only variables significantly related to the study outcomes at a 0.05 significance level were retained and reported as associated factors with vaccination status for both pregnant and postnatal women; and any collinearity was tested and reported in the final model. The relative risks (RR) and associated 95% CIs derived from the adjusted multinomial logistic regression models were used to measure the level of association of the factors with 'vaccine intended' and 'vaccine hesitancy' for both pregnant and postnatal women in Australia. The survey prefix 'Svy' command to adjust for sampling weight was used in all our analyses.

RESULTS

A weighted total of 2140 women who were pregnant (n=838) or had given birth since May 2021 (n=1302) responded to the BITTOC 2021 survey between 31 August 2021 and 1 March 2022. Table 1 and figure 1 show the categorisation of women into the three groups of 'vaccinated', 'vaccine intended' and 'vaccine hesitant'. Grouping of women as 'vaccinated', 'vaccine intended' and 'vaccine hesitant' by first and second half of the survey are also presented in online supplemental tables 1A,B.

In online supplemental tables 2 and 3, the sample characteristics and prevalence of pregnant and postnatal women who were vaccinated, intended to get vaccinated or were vaccine hesitant are reported. Findings revealed that the sample characteristics of the weighted and unweighted sample were similar. Vaccine hesitancy appeared to increase over the 6-month period in pregnant women, but this was not observed for postnatal women. For pregnant women, a significantly higher prevalence of vaccine hesitancy was associated with women's age (<30 years), education level (TAFE (Technical and Further Education) or diploma), family income (<$A80 000) and greater dissatisfaction with life (see online supplemental table 2 for details). A higher prevalence of vaccine intention and hesitancy was also observed among postnatal women who completed year 12 or less, worked in an unpaid job, had a family combined income of <$A80 000 and reported greater dissatisfaction with their lives (see online supplemental table 3 for details). Further analysis showed that vaccine hesitancy was higher among pregnant women <28 weeks gestation in the period from 1 December 2021 to 1 March 2022 compared with

Table 1 Vaccinated, vaccine intended and vaccine hesitancy among pregnant and postnatal women in Australia (31 August 2021 and 1 March 2022, n*=2139)

Intention to receive COVID-19 vaccination during pregnancy once available	(n=876, %)	(n*=838, %*)	Likelihood categories combined	N (%)	N* (%)*
Yes, I have already had 1 vaccine dose	135 (15.4)	127 (15.1)	Vaccinated	633 (72.2)	586 (69.9)
Yes, I have already had 2 vaccine doses	498 (56.8)	459 (54.8)			
Yes, I will book soon	7 (0.8)	9 (1.0)	Vaccine intention	166 (19.0)	166 (19.8)
Yes, I have booked to have the vaccine	45 (5.1)	45 (5.5)			
I will have a vaccine after the baby is born	72 (8.2)	70 (8.3)			
I will have a vaccine after I finish breastfeeding	42 (4.8)	42 (5.0)			
Unsure	32 (3.7)	34 (4.1)	Vaccine hesitancy	77 (8.8)	86 (10.3)
No, I will not have a COVID-19 vaccine	45 (5.1)	52 (6.2)			
Intention to receive COVID-19 vaccination once available (postnatal women)	**(n=1352, %)**	**(n*=1302, %*)**	**Likelihood categories combined**	**N (%)**	**N* (%)**
Yes, I have already had 1 vaccine dose	211 (15.6)	201 (15.4)	Vaccinated	1119 (82.8)	1060 (81.4)
Yes, I have already had 2 vaccine doses	908 (67.2)	859 (65.9)			
Yes, I have booked to have the vaccine	66 (4.9)	62 (4.8)	Vaccine intention	142 (10.5)	143 (11.0)
Yes, I will book soon	24 (2.5)	24 (1.9)			
Want to be vaccinated but waiting for Pfizer	30 (2.2)	32 (2.5)			
Want to be vaccinated but not until I stop breastfeeding	22 (1.6)	25 (1.9)			
Unsure	34 (2.5)	39 (3.0)	Vaccine hesitancy	91 (6.7)	99 (7.6)
No, I will not have a COVID-19 vaccine	57 (4.2)	60 (4.6)			

*Weighted sample.

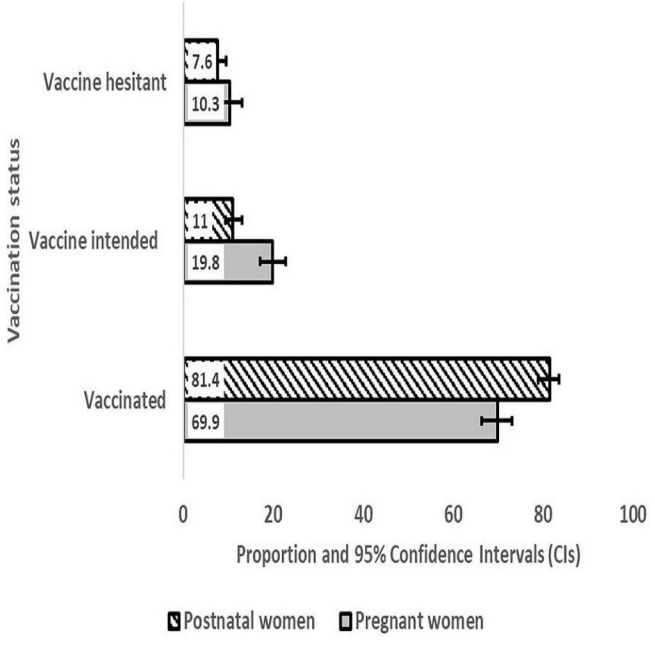

Figure 1 Vaccination status in pregnant and postnatal women.

31 August 2021 to 30 November 2021 (19.4% vs 12.5%, respectively).

Factors influencing COVID-19 vaccine intentions among pregnant and postnatal women

In tables 2 and 3, the unadjusted and adjusted RR of vaccine intention and vaccine hesitancy for pregnant and postnatal women are reported, with vaccinated women as the standard comparison. A higher likelihood of vaccine hesitancy was observed among pregnant women who lived in States or Territories other than NSW, whose family income was <$A80 000, were under 30 years of age, did not have a university education, were <28 weeks pregnant, had no pregnancy risk factors or said they were dissatisfied with life (see table 2). As pregnant women who were more dissatisfied with life were more likely to be vaccine hesitant, we undertook further analysis to explore the relationship between life satisfaction and mental health treatment during the perinatal period. We found those who sought treatment for mental health during pregnancy and the postnatal period were more likely to report being dissatisfied with life compared with those who reported being very satisfied with life (26.2% vs 12.5%, p=0.001 for pregnant and 40% vs 13.6%, p<0.001

Table 2 Predictors of vaccine intended and vaccine hesitancy among pregnant women in Australia: using vaccinated as the standard of comparison (n*=838)

	Vaccination intentions (n=782)†		Vaccine hesitancy (n=782)†	
Variable	**Unadjusted RR (95% CI)**	**Adjusted RR (95% CI)**	**Unadjusted RR (95% CI)**	**Adjusted RR (95% CI)**
Month of survey				
31 August 2021 to 30 November 2021	1.0	1.0	1.0	1.0
1 December 2021 to 1 March 2022	5.27 (3.35 to 8.28)	6.85 (4.11 to 11.42)	1.82 (1.05 to 3.13)	2.29 (1.16 to 4.52)
State/Territory in Australia (n=833)				
NSW	1.0	1.0	1.0	1.0
VIC	0.96 (0.61 to 1.50)	1.34 (0.82 to 2.16)	1.80 (0.95 to 3.42)	2.68 (1.29 to 5.55)
Others	1.58 (1.03 to 2.45)	2.77 (1.68 to 4.56)	2.36 (1.23 to 4.49)	3.31 (1.52 to 7.20)
Age (years) in category				
<30	1.0	1.0	1.0	1.0
30+	0.44 (0.30 to 0.64)	0.66 (0.40 to 0.94)	0.36 (0.21 to 0.61)	0.42 (0.23 to 0.76)
Education status				
Graduate	1.0	1.0	1.0	1.0
TAFE or diploma	2.56 (1.66 to 3.95)	1.84 (1.08 to 3.11)	4.01 (2.25 to 7.13)	2.16 (1.17 to 4.18)
Year 12 or less	2.92 (1.60 to 5.32)	2.65 (1.37 to 5.12)	2.80 (1.14 to 6.88)	1.03 (0.37 to 2.84)
Employment status				
Paid	1.0		1.0	
Part-time	1.47 (0.90 to 2.39)		3.26 (1.57 to 6.78)	
Unpaid	1.54 (1.02 to 2.32)		3.67 (1.88 to 7.16)	
Combined income ($A) (n=788)				
<80 000	1.0	1.0	1.0	1.0
80 000 to <150 000	0.74 (0.41 to 1.33)	1.05 (0.54 to 2.01)	0.21 (0.11 to 0.43)	0.29 (0.14 to 0.61)
150 000 to >200 000	0.44 (0.24 to 0.81)	0.79 (0.39 to 1.58)	0.14 (0.07 to 0.27)	0.22 (0.09 to 0.49)
Country				
Australia	1.0		1.0	
Others	0.90 (0.53 to 1.52)		0.82 (0.38 to 1.74)	
Speak language other than English at home				
No	1.0		1.0	
Yes	1.46 (0.78 to 2.73)		2.29 (0.99 to 5.28)	
Marital status				
Partner	1.0		1.0	
Single	1.09 (0.41 to 2.90)		3.15 (1.15 to 8.61)	
Lived or work in a suburb of high COVID-19				
Yes	1.0		1.0	
No	1.72 (1.16 to 2.56)		1.34 (0.77 to 2.32)	
How many weeks pregnant are you now?				
<28	1.0	1.0	1.0	1.0
≥28	1.08 (0.73 to 1.61)	0.96 (0.63 to 1.47)	0.39 (0.22 to 0.66)	0.39 (0.21 to 0.71)
Parity				
Primiparous	1.0		1.0	
Multiparous	1.06 (0.68 to 1.67)		1.70 (0.96 to 2.98)	

Continued

Table 2 Continued

Variable	Vaccination intentions (n=782)†		Vaccine hesitancy (n=782)†	
	Unadjusted RR (95% CI)	Adjusted RR (95% CI)	Unadjusted RR (95% CI)	Adjusted RR (95% CI)
Do you have any risk factors for your pregnancy?				
No, I believe I have no risk factors	1.0	1.0	1.0	1.0
Yes, I have been told I have some mild	1.01 (0.64 to 1.57)	0.65 (0.41 to 1.03)	1.31 (0.70 to 2.45)	0.89 (0.47 to 1.68)
Yes, I have been told I have some serious	0.60 (0.39 to 0.93)	0.37 (0.19 to 0.73)	0.58 (0.31 to 1.09)	0.28 (0.10 to 0.79)
Who is your main maternity care provider				
GP shared public others	1.0		1.0	
Private obstetrician/GP obstetrician	0.76 (0.50 to 1.13)		0.94 (0.52 to 1.71)	
Midwifery continuity of care	0.50 (0.26 to 0.96)		0.65 (0.27 to 1.53)	
Suspected that you, or anyone else you know personally, has had COVID-19 (n=828)				
Yes	1.0		1.0	
No	2.67 (1.76 to 4.06)		2.33 (1.31 to 4.12)	
How satisfied are you with your life				
Very satisfied	1.0	1.0	1.0	1.0
Satisfied	1.26 (0.85 to 1.87)	1.01 (0.65 to 1.54)	1.31 (0.73 to 2.36)	0.90 (0.48 to 1.71)
Dissatisfied	3.17 (1.68 to 6.01)	2.20 (1.04 to 4.65)	3.92 (1.83 to 8.38)	2.53 (1.02 to 6.25)

If 95% CIs around RRs that lies between 1.00 indicate not statistically significant.
All comparisons were made against vaccinated pregnant women (RR=1.0).
*Weighted sample.
†Total number for the adjusted RR and the total sample for the unadjusted RR was stated within brackets.
GP, general practitioner; NSW, New South Wales; RR, relative risk; VIC, Victoria.

for postnatal women). Vaccine hesitancy was significantly higher among postnatal women who did not live in NSW or Victoria, had a combined income <$A80 000 and whose main maternity care provider was a private obstetrician (see table 3).

DISCUSSION

In this study, we sought to determine vaccine intention and hesitancy in women who were pregnant or had given birth in Australia since May 2021. It was clear in this population that there was a high uptake of vaccines against COVID-19 with 69.9% already vaccinated and 19.8% indicating intention to vaccinate, particularly in states most affected by the pandemic and recent lockdowns (NSW and Victoria). This differs markedly from the 36% uptake of IIV in pregnancy.[14] The proportion of pregnant women vaccinated in Australia reported in this study was similar to those reported in other studies,[23 24] even though these studies were conducted at different times during the COVID-19 pandemic. Our study indicated that around 1 in 5 pregnant women were hesitant and 1 in 10 pregnant women intended to be vaccinated. These findings are similar to another hospital-based multicentre cross-sectional survey conducted in two metropolitan hospitals (Westmead and Royal North Shore Hospital) in New South Wales (NSW) which revealed that 17% indicated an intention to vaccinate and 9% indicated vaccine hesitancy.[23]

Multivariate analysis showed that the common factors associated with vaccine hesitancy in both pregnant and recently postpartum women were a combined income <$A80 000 and living outside of NSW or Victoria. There was higher vaccine hesitancy under 28 weeks of pregnancy despite advice that pregnant women can get vaccinated before 28 weeks of pregnancy.[2] Similar hesitancy to the influenza vaccine was found, whereby only 3%–4% of vaccinations occurred during the first trimester.[14]

Model of maternity care also played a role, with those women cared for by for private obstetricians having higher vaccine hesitance in postnatal women only. This is perplexing considering women with higher socioeconomic status tend to be cared for by private obstetricians and develop relationships of trust, and furthermore conflicts with the findings of Bradfield *et al*, in which greater encouragement of COVID-19 vaccines was found among doctors compared with midwives.[25] Murphy *et al* found vaccine-resistant individuals have lower trust in health professionals[17] and there is evidence of lower rates

Table 3 Predictors of 'vaccine intended' and 'vaccine hesitancy' among postnatal women in Australia: using vaccinated as the standard of comparison (n*=1302)

Variable	Vaccination intentions (n=1290)†		Vaccine hesitancy (n=1290)†	
	Unadjusted RR (95% CI)	Adjusted RR (95% CI)	Unadjusted RR (95% CI)	Adjusted RR (95% CI)
Month of survey				
31 August 2021 to 30 November 2021	1.0	1.00	1.0	1.00
1 December to 2021 to 1 March 2022	7.31 (4.18 to 12.78)	7.55 (4.48 to 12.75)	1.21 (0.74 to 1.96)	1.32 (0.83 to 2.08)
State/Territory in Australia (n=1297)				
NSW	1.0	1.00	1.0	1.0
VIC	0.75 (0.47 to 1.22)	0.91 (0.55 to 1.48)	0.82 (0.43 to 1.59)	1.08 (0.58 to 1.99)
Others	1.34 (0.86 to 2.09)	1.87 (1.18 to 2.94)	1.96 (1.13 to 3.39)	2.08 (1.23 to 3.53)
Age (years) in category				
<30	1.0		1.0	
30+	0.62 (0.41 to 0.92)		0.44 (0.27 to 0.71)	
Education status				
Graduate	1.0		1.0	
TAFE or diploma	1.33 (0.83 to 2.14)		2.34 (1.36 to 4.01)	
Year 12 or less	1.42 (0.74 to 2.70)		3.14 (1.58 to 6.28)	
Employment status				
Paid	1.0		1.0	
Part-time	0.79 (0.36 to 1.72)		0.84 (0.31 to 2.23)	
Unpaid	1.39 (0.93 to 2.07)		1.66 (1.01 to 2.74)	
Combined income ($A) (n=1249)				
<80 000	1.0	1.0	1.0	1.0
80 000 to <150 000	0.49 (0.28 to 0.85)	0.50 (0.29 to 0.85)	0.32 (0.17 to 0.60)	0.22 (0.13 to 0.39)
150 000 to >200 000	0.28 (0.16 to 0.49)	0.32 (0.18 to 0.57)	0.17 (0.09 to 0.32)	0.17 (0.09 to 0.30)
Country				
Australia	1.0		1.0	
Others	0.85 (0.49 to 1.44)		1.12 (0.54 to 2.31)	
Speak language other than English at home				
No	1.0		1.0	
Yes	1.37 (0.77 to 2.45)		1.24 (0.61 to 2.52)	
Marital status				
Partner	1.0		1.0	
Single	1.03 (0.41 to 2.55)		2.50 (0.82 to 7.66)	
Lived or work in a suburb of high COVID-19				
Yes	1.0		1.0	
No	1.44 (0.90 to 2.28)		1.29 (0.71 to 2.36)	
Postpartum period (weeks)				
≤7	1.0	1.0	1.0	1.0
>7	0.40 (0.27 to 0.58)	0.45 (0.30 to 0.66)	0.89 (0.51 to 1.56)	1.06 (0.63 to 1.78)
Parity (n=1301)				
Primiparous	1.0		1.0	
Multiparous	1.06 (0.71 to 1.53)		1.25 (0.77 to 2.02)	
Do you have any risk factors for your pregnancy?				

Continued

Table 3 Continued

Variable	Vaccination intentions (n=1290)†		Vaccine hesitancy (n=1290)†	
	Unadjusted RR (95% CI)	Adjusted RR (95% CI)	Unadjusted RR (95% CI)	Adjusted RR (95% CI)
No, I believe I have no risk factors	1.0	1.0	1.0	1.0
Yes, I have been told I have some mild	0.88 (0.58 to 1.33)	0.97 (0.63 to 1.48)	0.46 (0.27 to 0.78)	0.56 (0.33 to 0.95)
Yes, I have been told I have some serious	1.02 (0.58 to 1.78)	0.92 (0.52 to 1.63)	0.38 (0.18 to 0.78)	0.50 (0.23 to 1.06)
Who is your main maternity care provider				
GP shared public others	1.0	1.0	1.0	1.0
Private obstetrician/GP obstetrician	0.89 (0.59 to 1.34)	0.79 (0.50 to 1.27)	2.26 (1.42 to 3.62)	2.06 (1.23 to 3.46)
Midwifery continuity of care	0.37 (0.23 to 0.59)	0.41 (0.24 to 0.70)	0.42 (0.21 to 0.82)	0.54 (0.27 to 1.09)
Suspected that you, or anyone else you know personally, has had COVID-19 (n=1281)				
Yes	1.0		1.0	
No	1.13 (0.65 to 1.96)		1.44 (0.74 to 2.82)	
How satisfied are you with your life				
Very satisfied	1.0		1.0	
Satisfied	1.16 (0.78 to 1.72)		1.86 (1.10 to 3.16)	
Dissatisfied	0.80 (0.36 to 1.74)		2.37 (1.08 to 5.21)	

If 95% CIs around RRs that lies between 1.00 indicate not statistically significant.
All comparisons were made against vaccinated postnatal women (RR=1.0).
*Weighted sample.
†Total number for the adjusted RR and the total sample for the unadjusted RR was stated within brackets.
GP, general practitioner; NSW, New South Wales; RR, relative risk; VIC, Victoria.

of childhood vaccinations in higher socioeconomic areas, such as Byron Bay and Inner Sydney.[26 27] This may reflect the desire of well-resourced women for agency around health-related decisions, consistent with findings demonstrating higher locus of control among vaccine-hesitant individuals.[17] Our finding also suggests a potential role of private obstetricians in addressing the concerns of vaccine-hesitant women, however, respecting women's desire for agency around this decision will be essential.

It is also important to note that only 32% of FluMum participants had the influenza vaccine recommended by a healthcare provider in pregnancy, and 67% of unvaccinated participants (n=3652/5472) stated they would have accepted it if it was recommended by their doctor. Of the unvaccinated participants, 10% reported being told not to have the vaccine in pregnancy with a quarter of these recommendations coming from healthcare providers (GP, obstetrician, midwife, immunisation nurse, pharmacist).[14] Another Australian study found an increase in uptake of influenza and pertussis vaccines following the introduction of a midwife delivered maternal immunisation programme into an antenatal clinic.[28]

WHO has listed vaccine hesitancy as one of the top 10 threats to global health[29] and early COVID-19 vaccine surveys indicated this would present a major challenge.[30] In 2020, an international survey looking at acceptability of COVID-19 vaccines among pregnant women and mothers of young children in 16 countries found Australia had low levels of vaccine acceptance in pregnant women; with the authors suggesting a phenomenon of COVID-19 denial in low incidence countries.[21] When the BITTOC 2021 survey was undertaken reassuring data from vaccine studies involving pregnant women[3 4] combined with a recent surge in cases and lockdowns in a couple of key states clearly changed this position. We found a more positive uptake or intent to have the vaccine in women from NSW and Victoria, where there were higher incidences and associated lockdowns. Similar to the current study, Skjefte *et al* reported younger age, lower income, lower education level and being single was associated with vaccine hesitancy.[21] Targeted messaging is needed for younger mothers, and those from lower-middle socioeconomic groups, and the role financial incentives may play in facilitating uptake of COVD-19 vaccines in these groups needs further exploration.

We also found dissatisfaction with one's life was associated with vaccine hesitancy in pregnant women, consistent with other studies reporting attitudes towards COVID-19 vaccines in the general population[31]; and studies associating greater life satisfaction with more engagement with protective health behaviours.[32] The association between life dissatisfaction and treatment for mental health problems observed in the current study,[33] is also consistent with research identifying that more negative vaccine intentions and attitudes are associated with psychological factors that may be amenable to intervention, such as

greater COVID-19-related anxiety symptoms[26] and disgust around blood and needles.[34 35] However, many vaccine-hesitant and vaccine-resistant individuals endorse lower trust for scientists and health professionals, have higher religiosity or more individualistic world views and exhibit greater symptomologies of paranoia and neuroticism,[8 26] suggesting that greater involvement of trusted community leaders in public health messaging may be important.[8] Further research is crucial to understanding how to best address the multifaceted concerns of COVID-19 vaccine-hesitant individuals to improve vaccination rates, including increasing understanding of the predictors of attitude change from vaccine hesitancy to vaccine acceptance in perinatal women.

Strengths and limitations

There are strengths and limitations to this survey. Limitations include the fact it was distributed through social media and perinatal/pregnancy online groups and so may not have been accessible to women with limited computer access or where English was not their first language. Being an online survey, residents who lived in very remote area with limited or no access to the internet may be unduly excluded from this study. The use of online surveys distributed through multiple media/social media sites means it is hard to track how many women saw the survey and chose not to click on the links/QR code provided, so it is not possible to estimate a response rate or assess the potential for sampling bias. This means there could be bias in responses varying by vaccine status. However, the survey was about vaccines and these questions came halfway through the survey, among many others, reducing the likelihood they would not have responded based on vaccine preference specifically. The possibility that bot, or responses from non-pregnant or recently postnatal women were received was assessed by examining fast response times, as well as those flagged by Qualtrics as potentially fraudulent (RelevantIDFraudScore). It was determined that no cases needed to be excluded. Despite these limitations, this study has several strengths. The data are very recent, examine the changes over a 6-month period and were weighted to reflect the proportion of women of reproductive age in Australia. However, with the sample weighting we were only able to include age and could not get access to other important variables such as income, education, geographic location or other relevant sociodemographic data. Comments made by women as to their decision-making regarding COVID-19 vaccines will be reported in another paper.

CONCLUSION

Around 1 in 10 pregnant women and just over 1 in 13 postnatal women reported vaccine hesitancy in this Australian survey, and hesitancy increased slightly in the latter 3-month period. Tailored messages to reduce the percentage of vaccine hesitancy among pregnant and postnatal women should target younger mothers and those from lower-middle socioeconomic groups, and financial incentives may play a role. Additionally, the role of private obstetricians and mental health professionals for addressing barriers to COVID-19 vaccines warrants further exploration. This study provides some interesting insights into characteristics and potential drivers of vaccine hesitancy and may provide guidance on more effective, responsible health messaging. Pharmaceutical companies must include pregnant women in trials, taking their responsibility to provide level 1 evidence of vaccines in pregnancy seriously. Until this occurs, there are likely to be some clinicians and women who remain hesitant. Australia would benefit from a 'real-time' national antenatal surveillance system for all three recommended vaccines in pregnancy (influenza, pertussis and COVID-19) to enable safety and effectiveness monitoring. This will be particularly important given vaccines for group B *Streptococcus* and respiratory syncytial virus in pregnancy are also being trialled. The Australian immunisation register should also add a field for pregnancy status.

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