

COVID-19 vaccine hesitancy and resistance: Correlates in a nationally representative longitudinal survey of the Australian population

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Abstract

High levels of vaccination coverage in populations will be required even with vaccines have high levels of effectiveness to prevent and stop outbreaks of coronavirus. The World Health Organisation has suggested that governments take a proactive response to vaccine hesitancy ‘hotspots’ based on social and behavioural insights and this paper provides the first representative longitudinal survey of over 3000 participants from Australia that examines the demographic, attitudinal, political and social attitudes and COVID-19 health behavior correlates of vaccine hesitancy and resistance to a COVID-19 vaccine.

We distinguish between those who may get the vaccine but are not sure (hesitant) from those who will definitely get the vaccine because they are usually a large percentage of the population, and are more likely to be convinced about public health messaging and information about vaccine safety. We find that 59 per cent of Australians say that they will definitely get the vaccine, a further 29 per cent were likely to get the vaccine but are not certain (low levels of hesitancy), 7 per cent will probably not get the vaccine (high levels of hesitancy) and 6 per cent will definitely not get the vaccine (resistant).

We find that females, those living in disadvantaged areas, those who reported that risks of COVID-19 was overstated, those who had more populist views and higher levels of religiosity were more likely to be hesitant or resistant while those who had higher levels of household income, those who had higher levels of social distancing, who downloaded the COVID-Safe App, who had more confidence in their state or territory government or confidence in their hospitals, or were more supportive of migration were more likely to intend to get vaccinated. Our findings suggest that vaccine hesitancy, which accounts for a significant proportion of the population can be addressed by public health messaging but that for a significant minority of the population with strongly held beliefs, alternative policy measures may well be needed to achieve sufficient vaccination coverage to end the pandemic.

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1 Introduction

For most countries the development of a safe and effective vaccination for COVID-19 is seen as the long-term solution to the COVID-19 pandemic. A critical step in extinguishing the pandemic will be vaccination a high proportion of the population in the context of increasing misinformation, vaccine hesitancy and lack of trust in science. In this paper we present evidence from a large nationally representative survey of vaccination intentions to a safe and effective COVID-19 vaccine. We document the demographic, attitudinal, political and social attitudes and COVID-19 health behaviour correlates of vaccine hesitancy and resistance to a COVID-19 vaccine. We focus on lower and higher levels of hesitancy and resistance to vaccination, as tailored public health information campaigns may well be more effective for those who are less hesitant.

Herd immunity of populations is a product of several factors, the infectivity of the coronavirus ($R_0 = 3.1$, Yadav & Yadav, 2020), the effectiveness of the vaccine and the percentage of the population vaccinated. Estimates of infectivity of the coronavirus suggest that with a 100 per cent effective vaccine, 67 per cent of the population needs to be vaccinated (Randolph & Barreiro, 2020) but that vaccination coverage needed varies by infectivity (55 per cent when $R_0 = 2.2$ to 82 per cent when $R_0 = 5.7$ (Sanche et al., 2020). Simulations suggest that solely relying on a vaccine to extinguish a COVID-19 epidemic would require vaccination coverage of 100 per cent with vaccine effectiveness of 60 per cent (Bartsch et al., 2020). For 80 per cent effectiveness of a vaccine, coverage of 75 per cent of the population would be required (Bartsch et al., 2020). Assuming that initial vaccines are less than 80 per cent effective (flu has been found to have an average effectiveness of 67 per cent, Osterholm et al., 2012) then very high vaccination rates are needed to ensure eradication or control of the coronavirus in populations.

Research to date suggests that COVID-19 vaccination intentions vary substantially between countries (e.g. Neumann et al., 2020). Vaccine hesitancy (being unsure about getting a vaccine) usually accounts for a more substantial share of the population who will not be vaccinated than vaccine resistance (those who object to vaccines). For instance, in the United States 21 per cent were probably willing and 31 per cent were not willing to have the COVID-19 vaccine (Reiter, Pennell, & Katz, 2020) while nationally representative surveys in the United Kingdom reported 25-27 per cent were hesitant, and 6-9 per cent resistant (Murphy et al., 2020; Sherman et al., 2020) and in Canada reported 19 per cent somewhat likely, 9 per cent did not know and 14 per cent unlikely to get the COVID-19 vaccine when available (Frank & Arim, 2020). A cross-national representative survey of over 7,000 participants in seven European countries (Denmark, France, Germany, Italy, Portugal, the Netherlands, and the UK) reported that across these countries 19 per cent were hesitant (not sure) and 7 per cent would not get vaccinated (Neumann et al., 2020). However there was substantial variation between countries with vaccine hesitancy 12-28 per cent while resistance ranged from 5-10 per cent (Neumann et al., 2020). In Australia vaccine hesitancy to a COVID-19 vaccine has been reported at 9 per cent and vaccine resistance 5 per cent however this evidence was from a non-representative online survey (Dodd et al., 2020).

The World Health Organisation's Strategic Advisory Group of Experts (SAGE) have

suggested governments take a proactive response to vaccine hesitancy ‘hotspots’ based on social and behavioural insights (Hickler, Guirguis & Obregon, 2015). Therefore, nationally representative information is important for an agile response to COVID-19 vaccination. Using a representative longitudinal survey of over 3000 participants from Australia we examine the demographic, attitudinal, political and social attitudes and COVID-19 health behaviour correlates of vaccine hesitance and resistance to a COVID-19 vaccine. We distinguish between those who may get the vaccine but are not sure (hesitant) from those who will definitely get the vaccine because they are usually a large percentage of the population, and unlike vaccine resistant individuals, are likely to be convinced about public health messaging and information about vaccine safety (Dubé, Vivion & MacDonald, 2015). We also examine those who will not get the vaccine (resistant). Given the Australian government has indicated that the COVID-19 vaccine would be provided free to the population, consistent with previous research on vaccine hesitancy (Murphy et al., 2020; Thunstrom et al., 2020) we hypothesise that confidence in government and science, attitudes towards COVID-19 and adherence with public health messages, conservative and authoritarian political attitudes will be more important than demographic characteristics (Murphy et al., 2020; Sherman et al., 2020; Thunstrom et al., 2020). We also test whether downloading the COVID-Safe app was related to vaccine hesitancy or resistance.

The remainder of the paper is as follows, Section 2 outlines the methodology including the study design and participants, survey questions and statistical analyses. Section 3 shows the results and Section 4 discusses the results in the context of previous research and their implications.

2 Methods

2.1 Study design and participants

The primary source of data for this paper is the August ANUpoll, which collected data from 3,061 respondents aged 18 years and over across all eight States/Territories in Australia, and is weighted to have a similar distribution to the Australian population across key demographic and geographic variables. Data for the vast majority of respondents was collected online (94.1 per cent), with a small proportion of respondents enumerated over the phone. A limited number of telephone respondents (17 individuals) completed the survey on the first day of data collection, with a little under half of respondents (1,222) completing the survey on the 11th or 12th of August.

The contact methodology for offline Life in Australia™ members was an initial SMS (where available), followed by an extended call-cycle over a two-week period. A reminder SMS was also sent in the second week of fieldwork. Taking into account recruitment to the panel, the cumulative response rate for the most recent survey is 7.8 per cent, a slight decline from previous waves of data collection in 2020.

Unless otherwise stated, data in the paper is weighted to population benchmarks. For Life in Australia™, the approach for deriving weights generally consists of the following steps:

1. Compute a base weight for each respondent as the product of two weights:
 - a. Their enrolment weight, accounting for the initial chances of selection and subsequent post-stratification to key demographic benchmarks
 - b. Their response propensity weight, estimated from enrolment information available for both respondents and non-respondents to the present wave.

2. Adjust the base weights so that they satisfy the latest population benchmarks for several demographic characteristics.

We make use of a limited amount of longitudinal data in this paper. Of those who completed the August 2020 wave of data collection, 2,916 individuals (95.3 per cent) also completed the May 2020 ANUpoll, 2,833 individuals (92.6 per cent) also completed the April 2020 ANUpoll, 2,828 individuals (92.4 per cent) also completed the February 2020 Life in Australia™ surveyⁱ, and finally, 2,790 individuals (91.1 per cent) also completed the January 2020 ANUpoll (during the height of the Black Summer Bushfire crisis).

The ethical aspects of the ANUpolls have been approved by the ANU Human Research Ethics Committee (2014/241). Data is available through the Australian Data Archive.ⁱⁱ

2.2 Survey questions

Dependent variable: Vaccine intention was measured by the following question: ‘The next questions ask about your views on a vaccine for COVID-19’ and then we ask ‘If a safe and effective vaccine for COVID-19 is developed, would you...’ with the following four response categories, alongside the weighted percentage of respondents:

- Definitely not (5.5 per cent);
- Probably not (7.2 per cent);
- Probably (28.7 per cent); and
- Definitely (58.5 per cent)

Consistent with previous literature on vaccine acceptability, we define those who are definitely not going to get the vaccine as vaccine resistant (Murphy et al., 2020). High levels of hesitancy was defined as those who would probably not get vaccinated while low levels of vaccinated was categorised as low levels of hesitancy because of the uncertainty given that the decision was about a vaccine would be safe and effective (Murphy et al., 2020).

Independent variables: Detailed descriptions of independent variables included in the analyses are provided in the Appendix. Demographic variables included sex, age, indigenous status, born overseas (English speak or non-English speaking country), speaks a language other than English at home, education, socio-economic status of the area, capital or non-capital city, employed, and household income. The state of Victoria was experiencing an outbreak in August 2020 marked by a score of 79.7 on COVID-19 Stringency index compared to 52.3 and we identified participants living in Victoria through a dummy variable (Hale et al., 2020). As a point of comparison the COVID-19 Stringency index was 67.1 in the United States and 69.9 in the United Kingdom on 12 August 2020. Health related variables included self-rated health and disability or chronic illness. COVID-19 related variables included been tested for COVID-19, worried about yourself or family or friends contracting COVID-19, extent of social distancing behavior, downloaded the COVID-Safe app and considering that there was too much worry about COVID-19. Political, and social attitudes included voting intentions, populism, authoritarianism, religiosity, attitudes towards immigration, social trust, altruism, confidence in Federal government, state government or hospital and health system.

2.3 Statistical analyses

We estimated an ordinal probit model using oprobit command in STATA 15.1. Given the large number of independent variables we estimated several models. Model 1 included

demographic variables. Model 2 included demographic and health variables. Model 3 included demographic and COVID-19 related variables. Model 4 included demographic and political and social attitudes. To understand the relative importance of the variables included in the models, Model 5 included demographic variables and statistically significant variables ($p < 0.05$) from models 2-4. We weighted to population benchmarks in all analyses to account for survey design and non-response.

2.4 Funding source

This research was supported by the Australian Institute of Health and Welfare (AIHW).

3 Results

3.1 Vaccine hesitancy and resistance

Almost three-in-five Australians (58.5 per cent) would definitely get the vaccine. We divided vaccine hesitancy into two levels. Low levels of vaccine hesitancy were those who indicated they were likely to get the vaccine but not certain (28.7 per cent) and high levels of vaccine hesitancy those who will probably not get the vaccine (7.2 per cent). We defined those who were resistant as those who indicated that they were definitely not going to get the vaccine (5.5 per cent).

3.2 Correlates of vaccine hesitancy and resistance

Descriptive statistics for covariates in the statistical modelling can be found in the Appendix. Table 1 shows the marginal effects from model 1, which included demographic, socioeconomic and geographic variables.

Females were less likely than males to intend to get the vaccine, and more likely to be hesitant and resistant. Those who were older (55-64, 65-74 and those over 75 years) were less likely to be resistant or hesitant and more likely to intend to get vaccinated when it became available than those aged 35-44 years old. Compared to those had Year 12 only, those with an undergraduate or postgraduate university degree were less likely to be resistant or hesitant and more likely to intend to get vaccinated.

There were neighbourhood differences, those living in the 4th most disadvantaged quintile of disadvantage were less likely to intend to get vaccinated when compared to those living in the 3rd quintile. Individuals living in households with more household income were less likely to be resistant or hesitant and more likely to intend to get vaccinated. All other demographic variables were not statistically significant.

Table 1 Demographic correlates of vaccine resistance and hesitancy, marginal effects

Explanatory variables	Resistant		Hesitant -High		Hesitant - Low		Likely	
	Marginal effect	Signif.	Marginal effect	Signif.	Marginal effect	Signif.	Marginal effect	Signif.
Victoria	-0.003		-0.003		-0.006		0.012	
Female	0.011	*	0.010	*	0.021	*	-0.042	*
Aged 18 to 24 years	-0.013		-0.012		-0.026		0.052	
Aged 25 to 34 years	0.006		0.005		0.010		-0.021	
Aged 45 to 54 years	0.007		0.006		0.011		-0.025	
Aged 55 to 64 years	-0.021	**	-0.020	**	-0.047	**	0.089	**

Aged 65 to 74 years	-0.030 ***	-0.030 ***	-0.075 ***	0.134 ***
Aged 75 years plus	-0.038 ***	-0.041 ***	-0.112 ***	0.191 ***
Indigenous	0.003	0.003	0.006	-0.013
Born overseas in a main English speaking country	0.009	0.007	0.013	-0.029
Born overseas in a non-English speaking country	0.003	0.003	0.005	-0.011
Speaks a language other than English at home	0.015	0.012	0.022	-0.049
Not completed Year 12 or post-school qualification	0.009	0.008	0.014	-0.031
Has a post graduate degree	-0.024 **	-0.024 **	-0.056 **	0.105 **
Has an undergraduate degree	-0.019 *	-0.018 **	-0.041 **	0.079 **
Certificate III/IV, Diploma or Associate Degree	0.001	0.001	0.002	-0.005
Lives most disadvantaged areas (1st quintile)	0.024 *	0.019 **	0.032 *	-0.075 *
Lives next most disadvantaged areas (2nd quintile)	0.001	0.002	0.003	-0.006
Lives in next most advantaged areas (4th quintile)	0.022	0.017	0.029	-0.068 *
Lives in the most advantaged areas (5th quintile)	0.002	0.002	0.004	-0.008
Lives in a non-capital city	0.009	0.007	0.013	-0.029
Employed	0.001	0.001	0.001	-0.002
Household income	-.00003 ***	-.00003 ***	-.00005 ***	0.0001 ***
Proportion	0.051	0.070	0.298	0.593

Source: ANUpoll, April, May and August 2020.

Notes: Ordered probit model. N = 2,717. Base case is estimated from Victorian, female, 35-44 year old, non-indigenous, Australian born, speaks English at home, Year 12 education, 3rd SEIFA neighbourhood quintile, capital city, not employed and mean household income at the mean (\$670.81) Marginal effects that are statistically significant at the 1 per cent level of significance are labelled ***; those significant at the 5 per cent level of significance are labelled **, and those significant at the 10 per cent level of significance are labelled *.

Health and disability status were not associated with vaccine intentions (model 2, see Appendix).

In model 3 COVID-related variables were included as well as demographic variables (see Appendix). Contrary to other research on the likelihood of getting vaccinated to COVID-19 (Thunstrom et al., 2020) individual concerns or concerns about relatives or friends contracting COVID-19 were not related to vaccination intentions. Being tested for coronavirus was also not related to vaccination intentions.

People who reported greater levels of social distancing behaviour were less likely to be resistant and more likely to intend to get vaccinated. Similarly, those that had downloaded the COVID-Safe App were less likely to be resistant (-3.0 percentage points lower) or hesitant (high: -2.7 percentage points and low: -5.1 percentage points) and more likely to intend to get vaccinated (+10.8 percentage points). Those who thought too much fuss had been made about COVID-19 were more likely to be resistant (8.1 percentage points) or have high levels of hesitancy (4.2 percentage points) and less likely to intend to get vaccinated (-14.9 percentage points less likely).

In Model 4 we added political and social attitudes to demographic characteristics (see Appendix). There were no statistically significant differences by levels of social trust, altruism or support for authoritarianism. Compared to those who voted for the Coalition, those who voted for Labor were less likely to be resistant (-1.6%, $p < 0.10$), hesitant (high: -1.5%; low: -3.2%) and more likely to intend to get vaccinated (6.3%, $p = 0.05$).

Those who had confidence in their state or territory government or in their hospitals and health system were less likely to be resistant (-3.4 and -4.4 percentage points respectively) or have high levels of hesitancy (-2.8 and -3.4 percentage points respectively) or have low levels

of hesitancy (-4.8 and -5.2 percentage points respectively) and more likely to intend to get vaccinated (11.1% and 13.0% respectively).

Those who were more religious were less likely to intend to get vaccinated. People who had more populist views were more likely to be resistant or hesitant (at high or low levels) and less likely to intend to get vaccinated. Finally, those who were more likely to support migration were less likely to be resistant and more likely to intend to get vaccinated.

The final model included statistically significant variables from models 2 to 4 and demographic variables (Table 2). Females were less likely to intend to get vaccinated while those aged 55 and over were more likely to intend get vaccinated. Those with higher household income were less likely to be resistant and more likely to intend to get vaccinated. Differences by levels of education observed in model 1 were explained by other variables. Neighbourhood differences by socio-economic index for areas were evident with those living in the most disadvantaged area more likely to be resistant or hesitant (at high levels) and less likely to intend to get vaccinated.

People exercising greater levels of social distancing were less likely to be resistant and more likely to be vaccinated. Those who downloaded the COVID-Safe App were less likely to be resistant or hesitant and more likely to intend to get vaccinated. Those who reported too much fuss had been made about COVID-19 were still more likely to be resistant or hesitant and less likely to intend to get vaccinated.

Those who had confidence in their state or territory government or confident in their hospitals and health system were less likely to be resistant or hesitant (at high or low levels) and more likely to intend to get vaccinated. People who were more supportive of migration were more likely to get vaccinated.

Those who reported more populist views were more likely to be resistant or hesitant (at high or low levels) and less likely to intend to get vaccinated. This pattern of results was also evident in terms of level of religiosity although this finding should be treated with caution as there was a higher level of uncertainty around the estimates (statistical significance was only at the 90% level). Similarly, those living in Victoria, with by far the highest numbers of COVID-19 infections in Australia in August 2020, were significantly less likely than Australians from other states to get vaccinated but this was not evident in other statistical modelling, bivariate analyses and should not be considered a robust finding.

Table 2 Correlates of vaccine resistance and hesitancy – Final model, marginal effects

Explanatory variables	Resistant		Hesitant - High		Hesitant - Low		Likely	
	Marginal effect	Sig	Marginal effect	Sig	Marginal effect	Sig	Marginal effect	Sig
Victoria	0.023		0.020	*	0.036	**	-0.079	*
Female	0.018	*	0.016	**	0.027	*	-0.061	**
Aged 18 to 24 years	-0.024		-0.022		-0.039		0.085	
Aged 25 to 34 years	0.001		0.000		0.001		-0.002	
Aged 45 to 54 years	0.005		0.004		0.005		-0.013	
Aged 55 to 64 years	-0.030	**	-0.028	**	-0.052	**	0.110	**
Aged 65 to 74 years	-0.039	**	-0.037	***	-0.077	***	0.153	***
Aged 75 years plus	-0.049	**	-0.050	***	-0.116	***	0.216	***
Indigenous	-0.010		-0.008		-0.013		0.032	
Born overseas in a main English speaking country	0.019		0.014		0.018		-0.050	
Born overseas in a non-English speaking country	0.000		0.000		0.000		-0.001	
Speaks a language other than English at home	0.019		0.014		0.018		-0.052	

Not completed Year 12 or post-school qualification	0.014		0.011		0.014		-0.038	
Has a post graduate degree	-0.022		-0.019		-0.034		0.075	
Has an undergraduate degree	-0.018		-0.016		-0.027		0.061	
Has a Certificate III/IV, Diploma or Associate Degree	0.014		0.011		0.014		-0.040	
Lives most disadvantaged areas (1st quintile)	0.033	*	0.023	*	0.027		-0.084	*
Lives next most disadvantaged areas (2nd quintile)	0.001		0.001		0.001		-0.002	
Lives in next most advantaged areas (4th quintile)	0.025		0.018		0.022		-0.066	
Lives in the most advantaged areas (5th quintile)	0.010		0.008		0.011		-0.029	
Lives in a non-capital city	0.006		0.005		0.007		-0.018	
Employed	-0.004		-0.003		-0.004		0.011	
Household income	-.00003	**	-.00002	***	-.00004	**	.00009	***
Too much fuss made about COVID-19	0.059	**	0.038	***	0.037	**	-0.135	***
Social distancing behaviour	-0.023	**	-0.018	***	-0.027	***	0.069	**
Downloaded the COVID-Safe App	-0.031	**	-0.028	***	-0.053	***	0.112	***
Voting intention: Labor	-0.022	*	-0.019	**	-0.034	**	0.076	**
Voting intention: Greens	-0.004		-0.004		-0.005		0.013	
Voting intention: Other	-0.020		-0.017		-0.030		0.067	
Voting intention: Don't know	0.005		0.004		0.005		-0.013	
Confident in state or territory government	-0.029	**	-0.021	**	-0.025	*	0.021	
Confident in hospitals and health system	-0.044	**	-0.030	***	-0.032	*	0.075	**
Support for migration	-0.005		-0.003		-0.004		0.106	***
Populism	0.003	*	0.002	**	0.004	**	-0.009	**
Religiosity	0.003	*	0.002	*	0.004	*	-0.009	*
Proportion	0.070		0.088		0.355		0.487	

Source: ANUpoll, April, May and August 2020.

Notes: Ordinal probit model. N = 2,261. Base case is estimated from Victorian, female, 35-44 year old, non-indigenous, Australian born, speaks English at home, Year 12 education, 3rd SEIFA neighbourhood quintile, capital city, not employed and mean household income at the mean (\$670.81), Coalition voter, has confidence in their state/territory government, has confidence in hospitals and health system. Other variables estimated at the sample means (social distancing behaviour, support for migration, populism, religiosity). Coefficients that are statistically significant at the 1 per cent level of significance are labelled ***; those significant at the 5 per cent level of significance are labelled **, and those significant at the 10 per cent level of significance are labelled *.

4 Discussion

In August 2020 36 per cent of Australians are hesitant and 6 per cent resistant to being vaccinated with a safe and effective vaccine for COVID-19 if one was available. Given previous research suggests that the factors associated with vaccine resistance might be different to vaccine hesitancy, we examined demographic, health, COVID-19 related health behaviour and attitudes, and political and social attitudinal correlates.

Many factors were associated with vaccine resistance and hesitancy. Consistent with previous research, females, those with lower levels of household income and living in disadvantaged areas were associated with increased likelihood of vaccine resistance or hesitancy (Murphy et al., 2020; Thunstrom et al., 2020). However, in contrast to previous research, younger people were not less likely to intend to get vaccinated than those aged 35-44 years.

Less adherence to COVID-19 health behaviours was consistently associated with lower likelihood of being vaccine resistant or hesitant (social distancing and downloading the COVID-Safe app) and these were strongly related to vaccine intentions (Thunstrom et al., 2020). For example, downloading the COVID-Safe app was associated with an increase of 11 percentage points in the likelihood of being vaccinated. Similarly, there was a seven-percentage point increase in the likelihood of intending to be vaccinated for COVID-19 if an individual moved from the 16th percentile in terms of social distancing to the 50th percentile

(a one standard deviation increase). Given that many governments have tracking surveys about social distancing, this information could be used to support targeted campaigns to encourage vaccination in areas of low social distancing.

Consistent with other studies of COVID-19 several variables that could be considered associated with broader societal dissatisfaction and anti-establishment sentiments were also associated with vaccine resistance or hesitancy. Specifically in this study, attitudes about too much fuss being made about COVID-19, lack of confidence in state or territory government, and having more populist sentiments (Murphy et al., 2020; Rozbroj Lyons & Lucke, 2019). Other studies have also independently reported that religious beliefs associated with declining a COVID-19 vaccine (Thunstrom et al., 2020).

For many with low levels of hesitancy, providing information about the safety and efficacy of the COVID-19 vaccine will be critical as other studies have highlight this as important hesitancy (Thunstrom et al., 2020). Our analyses suggest that those with resistance or hesitancy are likely to lack trust in those providing health services (e.g. state governments or health systems) and therefore the misinformation about the COVID-19 vaccine that will occur may be even more effective for these groups. Pre-emptively using cognitive inoculation techniques and pre-bunking techniques (Habersaat et al., 2020) to actively work against the likely misinformation that will be generated in the development and preparation phase of a vaccine for COVID-19 will be important but probably requires more targeted and nuanced public health messages by trusted members of the community (e.g. community or religious leaders).

Those with higher vaccine resistance or hesitancy are more likely to have a set of strongly held beliefs, a lack of trust in those responsible for health (state or territory government and hospitals or health systems) and lower levels of compliance with public health advice for COVID-19 (e.g. lower levels of social distancing, not downloading the COVID-Safe App). If large scale surveys collect information on the extent of compliance with health advice, further nuanced targeting could be employed. Beyond more sophisticated and nuanced public health messaging, it should be noted that a systematic review of research on compulsory vaccination policies suggests that the majority of the population supports these programs (Gualano, Olivero, Voglino et al., 2019). However, none of the studies in the systematic review were conducted during a pandemic where civil liberties were restricted due to lockdowns (Gualano et al., 2019) so it is unclear whether public sentiment would be different during the current pandemic.

While we used a rich set of variables to predict vaccine intentions some factors were not collected in our surveys. In particular, we did not collect information about concerns about vaccine safety which may be important determinant of vaccine hesitancy and may also explain why females were more likely to be hesitant or resistant than males. Another robust correlate in other studies of vaccine intentions is previous vaccination such as for influenza (Thunstrom et al., 2020). Vaccine safety and public discourse will likely be particularly important as media and public scrutiny of vaccine trials is unprecedented for COVID-19 vaccines and further monitoring of public sentiment (Murphy et al., 2020).

Another issue that we did not address in this paper is if there are initial shortages of a vaccine how would these be distributed? A survey experiment using these participants suggests that essential health workers, those with a health condition, those in areas with high levels of

COVID-19 and with caring responsibilities should get priority (Biddle et al., 2020). Moreover, vaccine intentions of respondents did not change these priorities.

In conclusion, given that over 75 per cent of the population are likely to need to be vaccinated with a highly effective vaccine to extinguish the epidemic (Bartsch et al., 2020) our findings that only 59 per cent of Australians will definitely get vaccinated is sobering and suggests that as noted by WHO (Hickler et al., 2020), proactive measures need to be adopted by countries to encourage vaccination in the community. Our findings suggest that vaccine hesitancy, which accounts for a further significant proportion of the population, and can be addressed by public health messaging. However for a significant minority of the population with strongly held beliefs that are the likely drivers of vaccination intentions, alternative policy measures may well be needed to achieve sufficient vaccination coverage.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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5 Appendix

5.1 Covariates

Demographic variables included sex, age (18-24, 25-34, 35-44, 45-54, 55-64, 65-74 and 75 years or more), indigenous status, education (less than Year 12, Year 12, above Year 12 but below a bachelor's degree and bachelor's degree or above), born overseas (English speak or non-English speaking country), speaks a language other than English at home, capital or non-capital city, and employment status (employed, not employed). Continuous household income was estimated based on an interval regression model using responses to a categorical income question (with ten possible income categories). Socio-economic status of the area: Socio-economic indexes for areas (SEIFA) quintiles from most disadvantaged to most advantage. SEIFA was measured using the Index of Relative Social Advantage or Disadvantage (ABS, 2016).

Health related variables included self-rated health and disability or chronic illness. Self-rated health was measured using "How is your health in general? Would you say it is...?" with participants reporting very good, good, fair, bad or very bad. Disability or chronic illness was measured using an item from the European Social Survey "Are you hampered in your daily activities in any way by any longstanding illness, or disability, infirmity, or mental health problem?" Participants reported "Yes, a lot", "Yes, to some extent" or "No".

5.1.1 COVID-19 related variables.

Social distancing: Participants were asked whether they did any of the following in the past week: avoid crowded places, avoid public places, keep your distance from others (1.5 metres), quarantine yourself if you have symptoms, wore a face mask indoors when in a public place, and wore a mask outdoors when in a public place. These variables were highly correlated with each other, and were combined using principal components analysis to create a COVID-19 behaviour index that has been scaled to have mean of zero and standard deviation of one.

Tested for COVID-19 was measured by the whether participants reported that they had been tested by a doctor or nurse for COVID-19.

Concerns about COVID-19 was measured by "You felt anxious or worried for the safety of yourself, close family members or friends, due to COVID-19".

Scepticism about the COVID-19 was captured by asking participants the extent to which they agreed with the following statement "There has been too much unnecessary worry about the COVID-19 outbreak" (strongly agree to strongly disagree).

COVIDSafe app. The Australian Federal Government developed the COVIDSafe app to help state and territory health officials to quickly contact people who may have been exposed to COVID-19. However, some people have expressed concern about the security of the COVIDSafe app and whether it will be used for mass surveillance so therefore we asked a question about the whether participants had downloaded the app. We asked "Have you installed the COVIDSafe app on your phone?", participants could respond yes or no.

5.1.2 Political, and social attitudes.

Voting intentions. Participants were asked "If a federal election for the House of Representatives

was held today, which one of the following parties would you vote for?" they could indicate they would vote for the conservative coalition (Liberal Party and National Party), the Labour party, the Greens, some other party or they did not know.

Religiosity was measured using the following item from the European Social Survey "Regardless of whether you belong to a particular religion, how religious would you say you are?" on a scale of 0 (Not at all) to 10 (Very) asked in February 2020.

Support for migration was measured by asking "Is Australia made a worse or a better place to live by people coming to live here from other countries?" on a scale of 0 (Not at all) to 10 (Very). Participants were asked this item in February 2020 and is taken from the European Social Survey.

Social trust was measured using the following questions "Generally speaking, would you say that most people can be trusted, or that you can't be too careful in dealing with people?", "Do you think that most people would try to take advantage of you if they got the chance, or would they try to be fair?", and "Would you say that most of the time people try to be helpful or that they are mostly looking out for themselves?". For each item participants were asked to rate these items on a scale of 0 to 10 and for our analyses we averaged ratings on these three items.

Confidence in the Federal, state government and hospitals and the health system was rated by each participant (1: a great deal, 2: quite a lot, 3: not very much, 4: none at all).

Populism was measured using items from the June 2019 Comparative Study of Electoral Systems (CSES): "What people call compromise in politics is really just selling out on one's principles", "Most politicians do not care about the people", "Politicians are the main problem in Australia", "The people, and not politicians, should make our most important policy decisions", and "Most politicians care only about the interests of the rich and powerful" (reversed). Respondents were given five options: 1. Strongly agree; 2. Somewhat agree; 3. Neither agree nor disagree; 4. Somewhat disagree; and 5. Strongly disagree and items were added to form an index.

Authoritarianism was asked in February 2020 using the following item from the European Social Survey: "Having a strong leader in government is good for Australia even if the leader bends the rules to get things done". Participants were asked to rate strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, or strongly disagree.

Altruism is based on responses to a question in February 2020 as to whether the individual thought the following description matched themselves: 'It's very important to him/her to help the people around him/her. He/She wants to care for their well-being'

Table A.1 Descriptive statistics – Model 1

Variable	Mean	SD	Minimum	Maximum
Vaccination intentions	3.40	0.85	1.00	4.00
Victoria	0.26	0.44	0.00	1.00
Female	0.50	0.50	0.00	1.00
Aged 18 to 24 years	0.08	0.27	0.00	1.00
Aged 25 to 34 years	0.22	0.41	0.00	1.00
Aged 45 to 54 years	0.17	0.38	0.00	1.00
Aged 55 to 64 years	0.15	0.36	0.00	1.00
Aged 65 to 74 years	0.13	0.34	0.00	1.00
Aged 75 years plus	0.06	0.24	0.00	1.00
Indigenous	0.02	0.14	0.00	1.00
Born overseas in a main English speaking country	0.11	0.31	0.00	1.00
Born overseas in a non-English speaking country	0.23	0.42	0.00	1.00
Speaks a language other than English at home	0.24	0.42	0.00	1.00
Has not completed Year 12 or post-school qualification	0.14	0.35	0.00	1.00
Has a post graduate degree	0.09	0.28	0.00	1.00
Has an undergraduate degree	0.17	0.38	0.00	1.00
Has a Certificate III/IV, Diploma or Associate Degree	0.40	0.49	0.00	1.00
Lives in the most disadvantaged areas (1st quintile)	0.18	0.39	0.00	1.00
Lives in next most disadvantaged areas (2nd quintile)	0.20	0.40	0.00	1.00
Lives in next most advantaged areas (4th quintile)	0.21	0.40	0.00	1.00
Lives in the most advantaged areas (5th quintile)	0.21	0.41	0.00	1.00
Lives in a non-capital city	0.33	0.47	0.00	1.00
Employed	0.60	0.49	0.00	1.00
Household income	670.81	541.96	-8.86	6421.05

Source: ANUpoll, April, May and August 2020.

Notes: Descriptive statistics from Ordered probit model. N = 2,717.

Table A.2 Descriptive statistics – Final model

Variable	Mean	SD	Minimum	Maximum
Vaccination intentions	3.40	0.86	1.00	4.00
Victoria	0.25	0.44	0.00	1.00
Female	0.49	0.50	0.00	1.00
Aged 18 to 24 years	0.08	0.27	0.00	1.00
Aged 25 to 34 years	0.21	0.41	0.00	1.00
Aged 45 to 54 years	0.17	0.38	0.00	1.00
Aged 55 to 64 years	0.16	0.36	0.00	1.00
Aged 65 to 74 years	0.13	0.34	0.00	1.00
Aged 75 years plus	0.06	0.24	0.00	1.00
Indigenous	0.02	0.13	0.00	1.00
Born overseas in a main English speaking country	0.11	0.31	0.00	1.00
Born overseas in a non-English speaking country	0.24	0.42	0.00	1.00
Speaks a language other than English at home	0.24	0.43	0.00	1.00
Has not completed Year 12 or post-school qualification	0.14	0.34	0.00	1.00
Has a post graduate degree	0.08	0.28	0.00	1.00
Has an undergraduate degree	0.17	0.38	0.00	1.00
Has a Certificate III/IV, Diploma or Associate Degree	0.40	0.49	0.00	1.00
Lives in the most disadvantaged areas (1st quintile)	0.19	0.39	0.00	1.00
Lives in next most disadvantaged areas (2nd quintile)	0.21	0.41	0.00	1.00
Lives in next most advantaged areas (4th quintile)	0.21	0.41	0.00	1.00
Lives in the most advantaged areas (5th quintile)	0.19	0.39	0.00	1.00
Lives in a non-capital city	0.33	0.47	0.00	1.00
Employed	0.62	0.49	0.00	1.00
Household income	674.36	545.28	-8.86	5668.75
Too much fuss made about COVID-19	0.20	0.40	0.00	1.00
Social distancing behaviour	-0.04	1.02	-2.46	1.71
Downloaded the COVID-Safe App	0.46	0.50	0.00	1.00
Voting intention – Labour	0.32	0.47	0.00	1.00
Voting intention – Greens	0.12	0.32	0.00	1.00
Voting intention – Other	0.06	0.24	0.00	1.00
Voting intention – Don't know	0.04	0.20	0.00	1.00
Confident in state or territory government	0.71	0.45	0.00	1.00
Confident in GPs	0.87	0.34	0.00	1.00
Support for migration	6.55	2.44	0.00	10.00
Populism	18.76	4.22	6.00	30.00
Religiosity	3.44	3.12	0.00	10.00

Source: ANUpoll, April, May and August 2020.

Notes: Descriptive statistics from Ordered probit model. N = 2,261.

Table A.3 Correlates of vaccine resistance and hesitancy – Demographics only, ordered probit

Explanatory variables	Vaccine likelihood	
	Coeff	Signif.
Victoria	0.031	
Female	-0.109	*
Aged 18 to 24 years	0.135	
Aged 25 to 34 years	-0.052	
Aged 45 to 54 years	-0.063	
Aged 55 to 64 years	0.233	**
Aged 65 to 74 years	0.363	***
Aged 75 years plus	0.538	***
Indigenous	-0.033	
Born overseas in a main English speaking country	-0.074	
Born overseas in a non-English speaking country	-0.028	
Speaks a language other than English at home	-0.124	
Has not completed Year 12 or post-school qualification	-0.079	
Has a post graduate degree	0.278	**
Has an undergraduate degree	0.206	**
Has a Certificate III/IV, Diploma or Associate Degree	-0.012	
Lives in the most disadvantaged areas (1st quintile)	-0.189	*
Lives in next most disadvantaged areas (2nd quintile)	-0.016	
Lives in next most advantaged areas (4th quintile)	-0.172	*
Lives in the most advantaged areas (5th quintile)	-0.020	
Lives in a non-capital city	-0.073	
Employed	-0.005	
Household income	0.000	***
Cut1	-1.506	
Cut2	-1.056	
Cut3	-0.097	

Source: ANUpoll, April, May and August 2020.

Notes: Ordered probit model. N = 2,717. Coefficients that are statistically significant at the 1 per cent level of significance are labelled ***; those significant at the 5 per cent level of significance are labelled **, and those significant at the 10 per cent level of significance are labelled *.

Table A.4 Correlates of vaccine resistance and hesitancy – Demographics plus health variables, ordered probit

Explanatory variables	Vaccine likelihood	
	Coeff	Signif.
Victoria	0.030	
Female	-0.130	**
Aged 18 to 24 years	0.176	
Aged 25 to 34 years	-0.045	
Aged 45 to 54 years	-0.073	
Aged 55 to 64 years	0.232	**
Aged 65 to 74 years	0.438	***
Aged 75 years plus	0.563	***
Indigenous	-0.071	
Born overseas in a main English speaking country	-0.056	
Born overseas in a non-English speaking country	-0.052	
Speaks a language other than English at home	-0.113	
Has not completed Year 12 or post-school qualification	-0.104	
Has a post graduate degree	0.250	**
Has an undergraduate degree	0.177	*
Has a Certificate III/IV, Diploma or Associate Degree	-0.057	
Lives in the most disadvantaged areas (1st quintile)	-0.220	**
Lives in next most disadvantaged areas (2nd quintile)	-0.030	
Lives in next most advantaged areas (4th quintile)	-0.171	
Lives in the most advantaged areas (5th quintile)	-0.016	
Lives in a non-capital city	-0.083	
Employed	0.050	
Household income	0.000	***
Self rated health - good	0.087	
Impact of disability or chronic illness on activities of daily living - a lot	0.078	
Impact of disability or chronic illness on activities of daily living - a little	-0.038	
Cut1	-1.487	
Cut2	-1.043	
Cut3	-0.074	

Source: ANUpoll, April, May and August 2020.

Notes: Ordered probit model. N = 2,510 . Coefficients that are statistically significant at the 1 per cent level of significance are labelled ***; those significant at the 5 per cent level of significance are labelled **, and those significant at the 10 per cent level of significance are labelled *.

Table A.5 Correlates of vaccine resistance and hesitancy – Demographic plus COVID-19 variables, ordered probit

Explanatory variables	Vaccine likelihood	
	Coeff	Signif.
Victoria	-0.192	*
Female	-0.156	**
Aged 18 to 24 years	0.270	
Aged 25 to 34 years	-0.030	
Aged 45 to 54 years	-0.078	
Aged 55 to 64 years	0.259	**
Aged 65 to 74 years	0.359	***
Aged 75 years plus	0.536	***
Indigenous	0.076	
Born overseas in a main English speaking country	-0.072	
Born overseas in a non-English speaking country	-0.011	
Speaks a language other than English at home	-0.163	
Has not completed Year 12 or post-school qualification	-0.116	
Has a post graduate degree	0.156	
Has an undergraduate degree	0.172	
Has a Certificate III/IV, Diploma or Associate Degree	-0.085	
Lives in the most disadvantaged areas (1st quintile)	-0.160	
Lives in next most disadvantaged areas (2nd quintile)	0.006	
Lives in next most advantaged areas (4th quintile)	-0.129	
Lives in the most advantaged areas (5th quintile)	-0.025	
Lives in a non-capital city	-0.033	
Employed	0.019	
Household income	0.000	***
Worried about yourself or family or friends contracting COVID-19	0.104	
Tested for COVID-19	0.077	
Downloaded the COVID-Safe App	0.333	***
Too much fuss made about COVID-19	-0.395	***
Social distancing behaviour	0.151	***
Cut1	-1.545	
Cut2	-1.089	
Cut3	-0.078	

Source: ANUpoll, April, May and August 2020.

Notes: Ordered probit model. N = 2,374. Coefficients that are statistically significant at the 1 per cent level of significance are labelled ***; those significant at the 5 per cent level of significance are labelled **, and those significant at the 10 per cent level of significance are labelled *.

Table A.6 Correlates of vaccine resistance and hesitancy – Demographics plus political and social attitudes and trust variables, ordered probit

Explanatory variables	Vaccine likelihood
Victoria	0.056
Female	-0.129 *
Aged 18 to 24 years	0.179
Aged 25 to 34 years	-0.024
Aged 45 to 54 years	-0.009
Aged 55 to 64 years	0.294 ***
Aged 65 to 74 years	0.432 ***
Aged 75 years plus	0.626 ***
Indigenous	0.136
Born overseas in a main English speaking country	-0.125
Born overseas in a non-English speaking country	-0.041
Speaks a language other than English at home	-0.099
Has not completed Year 12 or post-school qualification	-0.079
Has a post graduate degree	0.243 *
Has an undergraduate degree	0.177 *
Has a Certificate III/IV, Diploma or Associate Degree	-0.031
Lives in the most disadvantaged areas (1st quintile)	-0.223 **
Lives in next most disadvantaged areas (2nd quintile)	-0.043
Lives in next most advantaged areas (4th quintile)	-0.183 *
Lives in the most advantaged areas (5th quintile)	-0.050
Lives in a non-capital city	-0.072
Employed	0.016
Household income	0.000 ***
Voting intention – Labour	0.162 *
Voting intention – Greens	-0.003
Voting intention – Other	-0.028
Voting intention – Don't know	-0.117
Confident in Federal Government	-0.122
Confident in state or territory government	0.280 ***
Confident in GPs	0.328 ***
Altruism	-0.007
Support for migration	0.029 *
Religiosity	-0.018 *
Social trust	-0.008
Populism	-0.031 ***
Authoritarianism	-0.010
Cut1	-1.639
Cut2	-1.178
Cut3	-0.190

Source: ANUpoll, April, May and August 2020.

Notes: Ordered probit model. N = 2,359. Coefficients that are statistically significant at the 1 per cent level of significance are labelled ***; those significant at the 5 per cent level of significance are labelled **, and those significant at the 10 per cent level of significance are labelled *.

Table A.7 Correlates of vaccine resistance and hesitancy – Final model, ordered probit

Explanatory variables	Vaccine likelihood	
	Coeff	Signif.
Victoria	-0.200	*
Female	-0.153	**
Aged 18 to 24 years	0.213	
Aged 25 to 34 years	-0.004	
Aged 45 to 54 years	-0.033	
Aged 55 to 64 years	0.279	**
Aged 65 to 74 years	0.391	***
Aged 75 years plus	0.565	***
Indigenous	0.080	
Born overseas in a main English speaking country	-0.127	
Born overseas in a non-English speaking country	-0.003	
Speaks a language other than English at home	-0.132	
Has not completed Year 12 or post-school qualification	-0.096	
Has a post graduate degree	0.190	
Has an undergraduate degree	0.154	
Has a Certificate III/IV, Diploma or Associate Degree	-0.100	
Lives in the most disadvantaged areas (1st quintile)	-0.212	*
Lives in next most disadvantaged areas (2nd quintile)	-0.005	
Lives in next most advantaged areas (4th quintile)	-0.166	
Lives in the most advantaged areas (5th quintile)	-0.073	
Lives in a non-capital city	-0.045	
Employed	0.028	
Household income	0.000	***
Too much fuss made about COVID-19	-0.346	***
Social distancing behaviour	0.172	***
Downloaded the COVID-Safe App	0.282	***
Voting intention – Labour	0.190	**
Voting intention – Greens	0.034	
Voting intention – Other	0.169	
Voting intention – Don't know	-0.033	
Confident in state or territory government	0.190	**
Confident in GPs	0.270	***
Support for migration	0.023	
Populism	-0.022	**
Religiosity	-0.022	*
Cut1	-1.563	
Cut2	-1.090	
Cut3	-0.054	

Source: ANUpoll, April, May and August 2020.

Notes: Ordered probit model. N = 2,261. Coefficients that are statistically significant at the 1 per cent level of significance are labelled ***; those significant at the 5 per cent level of significance are labelled **, and those significant at the 10 per cent level of significance are labelled *.

ⁱ The February wave of data collection was conducted as Australian Social Survey, in parallel with the European social Survey

ⁱⁱ <https://dataverse.ada.edu.au/dataset.xhtml?persistentId=doi%3A10.26193%2FZFGFNE>