Preferences for a COVID-19 vaccine in Australia

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Abstract

In absence of a COVID-19 vaccine, testing, contact tracing and social restrictions are among the most powerful strategies adopted around the world to slow down the spread of the pandemic. Citizens of most countries are suffering major physical, psychological and economic distress. At this stage, a safe and effective COVID-19 vaccine is the most sustainable option to manage the current pandemic. However, vaccine hesitancy by even a small subset of the population can undermine the success of this strategy.

The objective of this research is to investigate the vaccine characteristics that matter the most to Australian citizens and to explore the potential uptake of a COVID-19 vaccine in Australia. Through a stated preference experiment, preferences towards a COVID-19 vaccine of 2,136 residents of the Australian states and territories were collected and analysed via a latent class model.

Results show that preferences for mild adverse cases, mode of administration, location of administration, price and effectiveness are heterogeneous. Conversely, preferences for immediacy and severe reactions are homogeneous, with respondents preferring a shorter period until vaccine availability and lower instances of severe side effects. The expected uptake of the vaccine is estimated under three different scenarios, with the value of 86% obtained for an average scenario. By calculating individual preferences, the willingness to pay is estimated for immediacy, effectiveness, mild and severe side effects.

KEYWORDS: COVID-19; Vaccine; Acceptance; Willingness to pay; Uptake;

1. Introduction

COVID-19 continues to have a profound impact across the globe. As at 13 September 2020, there have been approximately 30 million confirmed cases of COVID-19 and almost 1 million COVID-19 related deaths [43]. In the absence of a COVID-19 vaccine, non-pharmaceutical suppression strategies remain the first and only line of defence. In Australia, this response has focussed on widespread COVID-19 testing, contact tracing, limiting private and public gatherings, restricting attendance at schools and universities, social distancing and closing borders [27]. Australia had 26,607 confirmed cases of COVID-19 and 803 deaths as at 13 September 2020[43].

Whilst there is growing evidence non-pharmaceutical suppression strategies have 'flattened the curve', they come at significant economic and social costs [35]. A safe and effective COVID-19 vaccine has been identified as the most sustainable option to manage the current pandemic. This has resulted in an unprecedented international collaborative research effort to develop a COVID-19 vaccine using an accelerated pathway [18], [19].

Developing a vaccine is both complex and resource intensive. The time from initial development to final licensure is typically measured in decades rather than months, and reflects strong stakeholder preferences for safety and effectiveness over immediacy. Concerns about vaccine safety is a major contributing factor to increasing vaccine hesitancy which is defined by the WHO as a "delay in acceptance or refusal of vaccines despite availability of vaccination services" and is a significant and increasing public health concern [41], [23]. Vaccine hesitancy is complex and context specific, varying across time, place and vaccines [41], [1]. In additional to safety, vaccine hesitancy is also influenced by confidence (trust of the vaccine, the provider, regulatory authority or medical professionals), complacency (perceived need for the vaccine and/or risk of catching the disease) and convenience (access to vaccines including cost) [42], [1], [32]. Yet, vaccine safety remains a primary concern as vaccines are given to healthy individuals, often children, to ward off diseases now only known by name, and whose effects are long forgotten [21].

Public trust in vaccines was significantly eroded by the pertussis vaccine controversy in the mid-1970s, and more recently by a publication in the Lancet proposing a causal relationship between the measles–mumps–rubella (MMR) vaccine and autism [39]. Other events that eroded public trust in vaccines include reporting of the H1N1 influenza vaccine increasing the risk of narcolepsy [33], the RotaShield rotavirus vaccine causing intussusception in healthy infants [2] and the HPV vaccine safety recall in 2013 [36].

In addition to the forgone benefit of disease prevention in individuals, vaccine hesitancy also limits positive externalities offered by vaccine programs [10], [38], [8]. Vaccine hesitancy by even a small subset of the population can have a disproportionate effect on herd immunity and disease spread [22], [26]. Given vaccine uptake is a critical factor in the success of an immunisation program, understanding vaccine preferences and the potential for vaccine hesitancy within a population is critical for public health officials. This is especially the case in

the current COVID-19 pandemic when vaccines have been developed according to an accelerated pathway and safety concerns have attracted significant community and media attention.

This paper addresses the above issue by providing an assessment of preferences for a COVID-19 vaccine during a global pandemic. Preference data was collected from a sample of Australian residents using a stated preference discrete choice experiment (DCE). Respondents were presented with choice tasks containing three hypothetical COVID-19 vaccines and a no-choice option and asked to select their most preferred option. The hypothetical COVID-19 vaccines were described according to an attributes profile which included measures for immediacy, safety, effectiveness, administration and price.

In addition, estimates of the uptake of a COVID-19 vaccine in Australia under three different vaccine scenarios is also provided.

2. Methods

Data was collected through an online questionnaire completed by 2151 Australian residents between 27 and 31 March 2020. The questionnaire was distributed by The Online Research Unit (The ORU, http://www.theoru.com/index.htm) with respondents paid a small incentive (less than $5) to complete the questionnaire. To ensure the quality of the data collected, The ORU invites respondents to participate to a survey via an email invitation which does not include the topic to avoid respondent bias. As a general practice, The ORU invites respondents to two surveys a week on average to ensure a healthy response rate among panellists and to keep the average response rate around 10 percent. After inspecting the data, 15 responses were removed due to quality concerns resulting in a final sample of 2136 responses[1].

Table 1 compares various socio-demographic characteristics of the final sample with those of the Australian population. Compared to the Australian population, the sample has a higher median age (59 versus 45 years old) and a higher percentage of individuals holding a bachelor degree and above (42.28 percent vs 22 percent). The sample is representative of the Australian population with regard to gender and median income. A greater number of responses were deliberately obtained from less populated states and territories (Australian Capital Territory, Tasmania and the Northern Territory) in order to have a uniform distribution of respondents across the various Australian states and territories. During the estimation process, the sample was weighted to reflect the distribution of gender and age in the population.

[1] These responses were removed for speeding (completing the survey in less than 120 s) and inconsistent responses to open-ended type questions.

Table 1: Sample characteristics

VARIABLE	CATEGORIES	SAMPLE	POPULATION
Residence	*New South Wales*	14.14%	32.00%
	Victoria	14.37%	25.80%
	Queensland	14.47%	20.10%
	South Australia	14.42%	6.90%
	Western Australia	14.51%	10.40%
	Australian Capital Territory	12.78%	1.70%
	Tasmania	10.02%	2.10%
	Northern Territory	5.29%	1.00%
Gender	*Female*	50.70%	50.70%
Age	*10th percentile*	31	20
	50th percentile	59	45
	90th percentile	76	74
Income	*10th percentile*	$199	$1 - $149
	50th percentile	$699	$650 - $799
	90th percentile	$2000	$1,750 - $1,999
Occupation	*Student*	2.53%	16.87%
	Employed	49.16%	45.65%
	Unemployed and Seeking	2.43%	3.36%
	Retired/Pensioner	35.81%	16.67%
	Other	10.07%	17.44%
Education	*Year 10 or below*	10.58%	18.80%
	Year 11 and 12	15.03%	31.40%
	Certificate I or II	1.83%	0.10%
	Certificate III or IV	9.04%	15.70%
	Advanced Diploma or Diploma	13.62%	8.90%
	Bachelor degree and above	42.28%	22.00%
	Other	7.63%	3.10%

The questionnaire consisted of three main sections. The first section provided respondents with introductory text detailing the scope of the questionnaire and establishing eligibility using quota and screening questions. The second section presented respondents with a DCE to determine vaccine preferences. The final section of the survey captured socio-demographic information of respondents including age, gender, level of education and occupation.

The DCE section presented respondents with eight choice tasks with each choice tasks containing three vaccines alternatives and a no-choice option. The vaccine alternatives were described by seven attributes and their corresponding levels (Table 2). Given the significant uncertainty regarding a potential COVID-19 vaccine, the attributes and levels used in the choice tasks were informed by a review of the literature, and judgement regarding what respondents were most likely to understand and consider plausible. For example, the levels for vaccine effectiveness reflect those of routine childhood vaccines in Australia.

Table 2: Attributes and attributes level

Attribute	Attribute description	Levels
Mild side effects	Number of incidences per 10,000 citizens	10, 20, 100, 200
Major side effects	Number of incidences per 10,000 citizens	1, 2, 10, 20
Vaccination effectiveness	The percentage of individuals given the vaccine who become immune to the virus	84%, 89%, 94%, 99%
Mode of administration	How the vaccine is administered	Oral, Injection
Location	Where the vaccine is administered	Doctor's office, Hospital, Pharmacy
When available	How long (in months) until the vaccine becomes available	0, 2,4,6,8,10,12, 14
Cost	The out of pocket expense to the respondent	$0, $20, $40, $60, $80, $100, $120, $140

To determine the combination of attribute levels presented to respondents, a Bayesian D-efficient design with uniformly distributed priors was generated using Ngene [4][2]. The design was programmed to ensure attribute level balance over alternatives, and to avoid dominated alternatives. The design was optimized using a generic algorithm employing 2000 Sobol draws (see [14]). The Bayesian D-error for the design is 0.4468.

The final experimental design contains forty individual choice tasks. Four tasks were drawn from these and designated as 'common' block and undertaken by all respondents. The remaining 36 tasks were grouped into 9 blocks with 4 choice tasks in each block. These blocks were then randomly assigned to respondents. Therefore, respondents undertook a total of eight tasks, the four choice tasks contained within the common block, and four choice tasks contained within the randomly allocated block. Fig. 1 provides an example of choice task presented in the questionnaire.

	Vaccine A	Vaccine B	Vaccine C	None
Mild side effects	10 per 10,000 individuals	200 per 10,000 individuals	100 per 10,000 individuals	
Major side effects	2 per 10,000 individuals	2 per 10,000 individuals	20 per 10,000 individuals	
Vaccination effectiveness	84.00%	84.00%	89.00%	
Administration	Injection	Injection	Injection	
Location	Dr's office	Pharmacy	Pharmacy	
When will it be available (months from now)	10 month(s)	14 month(s)	12 month(s)	
Price	$100.00	$60.00	$120.00	
I would choose	○	○	○	○

Figure 1: Example of choice task

Vaccine preferences are heterogeneous and exist on a continuum with active demand for vaccines at one end and complete refusal of all vaccines at the other [9], [38], [30]. To account for preference heterogeneity, a latent class model (LCM) has been used to identify preference segments within the sample (see [17], [34], [20]). The theoretical foundation of the LCM assumes preferences are determined jointly by observable attributes and unobservable or

[2] The priors were derived from a pilot study of 10 respondents.

latent heterogeneity [14]. Furthermore, it is assumed this latent heterogeneity reflects 'preference groups' or 'classes' within the sample and individuals can be sorted into these classes up to some probability. After determining the number of classes required to account for preference heterogeneity, the analyst can link the probability of class membership to covariates such as the socio-demographic characteristics of individuals. In additional to various statistical advantages (see Shen, 2009), the LCM provides the practical advantage of segmenting the population according to preferences which can be used to inform and guide policy development.

The final specification of the LCM used in this analysis consists of a class assignment model, (1a) and (1b), and the choice model described by the class utility functions (2).

$$Cl^1 = \beta_0^1 + \beta_1^1 SINGLE + \beta_2^1 FT\_WORK \quad (1a)$$

$$Cl^2 = \beta_0^2 + \beta_1^2 AGE + \beta_2^2 GENDER + \beta_3^2 INCOME \quad (1b)$$

where Cl^1 and Cl^2 are the class assignment functions for the classes 1 and 2 respectively and are described by are described by a constant term, and various socio-demographic characteristics. The assignment function for class 3 is set to zero as this is the reference class. After testing several specifications for the discrete choice component, the following utility model was estimated:

$$V^{Cl} = \beta_0^{Cl} + \beta_1^{Cl} MILD_{REAC} + \beta_2^{Cl} SEVERE_{REAC} + \beta_3^{Cl} EFFEC + \beta_4^{Cl} NEEDLE + \beta_5^{Cl} DOC + \beta_6^{Cl} PHARM + \beta_7^{Cl} MONTHS + \beta_8^{Cl} PRICE \quad (2)$$

where *V* is the observable (relative) utility and is function of a constant (β_0) and eight parameters ($\beta_1, \cdots, \beta_8$) measuring the effect of the vaccine attributes described in Table 2. Finally, the superscript *Cl* refers to the latent class (*Cl* = 1, 2, 3).

3. Results

The results are presented in three sections. The first section reports preferences according to classes identified using the LCM. The second section provides a brief discussion on the marginal rate of substitution between vaccine characteristics, including willingness to pay measures. The final section reports the potential uptake of a COVID-19 vaccine under three scenarios.

The results of the LCM are provided in Table 3 including the parameter estimates for the class assignment model, the discrete choice model (DCM) and the goodness of fit measures. As per (1a), (1b), five socio-demographic variables were used to define three latent classes. Heterogeneous preferences between the three classes were found for the mild reactions, the mode of administration, location of administration, price and effectiveness attributes. There was no difference in preferences between classes for availability and severe reactions: irrespective of the class, Australian residents prefer a vaccine available in a shorter time, highlighting the immediacy due to the urgency of the situation; and lower instances of severe side effects.

Table 3: Model results

	Class 1		Class 2		Class 3	
	Est.	(*t*-ratio)	Est.	(*t*-ratio)	Est.	(*t*-ratio)
Class assignment model						
Constant	-1.490***	-11.760	1.090***	4.330	-	-
Age	-	-	-0.007*	-1.920	-	-
Female	-	-	-0.419***	-3.740	-	-
Income	-	-	1.58E-04***	2.010	-	-
Single	0.584***	2.750	-	-	-	-
Full time worker	-0.603***	-2.410	-	-	-	-
Choice model						
ASC1	-3.280*	-1.730	-9.130***	-8.090	0.582	1.180
ASC2	-3.000	-1.620	-9.040***	-8.380	0.460	0.950
ASC3	-3.540**	-1.980	-9.160***	-8.400	0.372	0.760
Mild reactions (*n* in 10,000)	0.001	0.690	-0.003***	-6.140	-0.002***	-6.490
Severe reactions (*n* in 10,000)	-0.076***	-5.200	-0.064***	-8.580	-0.060***	-12.600
Effectiveness	0.030	1.570	0.163***	12.380	0.034***	6.990
Mode of Administration (Needle)^	0.055	0.570	-0.165***	-5.440	-0.072***	-2.840
Performed at doctor's surgery^^	0.352***	3.740	-0.042	-0.870	-0.046***	-1.550
Performed at pharmacy^^	0.206*	1.860	0.377***	9.290	-0.011	-0.390
Months till available	-0.139***	-3.500	-0.311***	-16.980	-0.048***	-4.590
Price	-0.018***	-3.700	-0.008***	-6.930	-0.001	-1.520
Model Fit						
LL(0)	-23,689.00					
LL(β)	-11,228.03					
ρ^2	0.526					
Adj. ρ^2	0.524					
AIC	22,536.07					
BIC	22,762.74					
N	2,136					
K	40					

^ Effects coded (base is pill)

^^ Effects coded (base is performed at hospital)

* Significance at 90%; ** Significance at 95%; *** Significance at 99%

Older respondents and females are more likely to belong to Class 1 and Class 3 compared to Class 2. A higher income is more likely to be associated with Class 2, whilst being single was more likely to be associated with Class 1. Finally, full-time workers are more likely to belong to Classes 2 and 3. Respondents are not deterministically assigned to any specific class, but rather display a probability to belong to any class according to socio-demographic characteristics. The class assignment probabilities summary statistics are reported in Table 4. Class 2 has the highest assignment probability with 61.56 percent of respondents assigned to this class on average, whilst Class 1 has the lowest assignment probability with 6.81 percent of respondents assigned to this class on average.

Table 4: Summary statistics of class assignment probabilities

	Class 1	Class 2	Class 3
Min	2.59%	43.51%	19.36%
Max	16.20%	76.30%	41.78%
(Weighted) Average	6.96%	61.56%	31.47%
Median	6.81%	62.42%	30.98%

The parameter measuring the number of cases of mild reactions to the vaccine was negative for respondents in Class 2 and Class 3, indicating a preference for lower instances of mild reactions, whilst the parameter for Class 1 was found not to be significantly different from 0 suggesting indifference to the occurrence of mild reactions. In the case of the vaccine administration, respondents in Class 2 and 3 have a preference for oral over intravenous, whilst respondents in Class 1 are indifferent between the two modes of administration. The three classes expressed strong differences in their preference for location. Class 1 prefers the vaccine to be administered at doctor's surgery, followed by pharmacies and lastly at hospitals; Class 2 prefers pharmacies over hospitals and doctor's surgery (these two locations share the same rank); Finally, respondents in Class 3 prefer hospitals over doctor's surgery. The parameter associated with the price attribute is similar for Class 1 and Class 2 with a preference for a lower, rather than higher price, all else being equal. Price was not relevant for Class 3. In terms of effectiveness, Class 2 and Class 3 prefer, a more effective vaccine whilst the same parameter is not significantly different from 0 for Class 1 indicating indifference towards the vaccine effectiveness.

4. Trade-offs

The parameters reported in Table 3 indicate the preferences at the population level given the three classes identified. No information on the individual specific preferences can be inferred by these coefficients. Using Bayes theorem, it is possible to compute the individual specific parameter estimates (see [12]), which can then be used to derive individual marginal rates of substitutions (MRS). Given the linear functional form of the utility functions in the DCM, the MRS is calculated as the ratio of the two parameter estimates of interest. Whilst it is mathematically possible to derive the MRS for all possible combinations of attributes, some estimates are conceptually more interesting and useful than others. Table 5 reports the average MRS between attributes relevant for this analysis.

Table 5: Marginal rate of substitutions

	MRS – Price (WTP)	MRS - Availability	MRS - Effectiveness	MRS - Mild side effect	MRS - Severe side effect
Availability	$ 34.44		-1.54%	19.08	0.92
Effectiveness	-$ 23.92	-0.68 months		-15.59	-0.60
Mild side effect	$ 1.42	0.04 months	-0.06%		0.03
Severe side effect	$ 41.94	1.2 months	-1.77%	25.42	

The estimated MRS can be interpreted as follows: where the MRS is positive, respondents are willing to increase the quantity of the column attribute by that amount for a reduction in the quantity of the row attribute by one unit. Conversely, where the MRS is negative, respondents are willing to increase the quantity of the column attribute by that amount for an increase in one extra unit of the row attribute. When the column attribute is Price, the MRS is expressed as a willingness to pay (WTP).

All other things being equal, respondents are willing to pay $34.44 to reduce wait time until the vaccine is available by one month, willing to pay $41.94 to reduce the number of severe reactions by one individual in 10,000 and $23.92 to increase the effectiveness of the vaccine by one percent. Respondents are only willing to pay $1.42 to reduce the number of mild reactions experience by one individual in 10,000. The relative importance of safety, effectiveness and immediacy can also be expressed in terms of trade-offs.

Respondents are willing to wait an additional 0.68 months on average (equivalent to approximately 21 days) to increase the effectiveness of the vaccine by one percent; or willing to wait an additional 0.04 (1.2 days) and 1.2 months (36 days) to reduce the number of cases reporting mild and severe side effects by one individual in 10,000 respectively. In terms of effectiveness, respondents are willing to trade an additional month until the vaccine is available to increase vaccine effectiveness by 1.54%. Similarly, respondents would be willing to substitute an increase of the effectiveness of the vaccine by 0.06% and 1.77% for an extra case reporting mild and severe side reactions, respectively.

Respondents are willing to accept 25.42 additional cases of mild reactions per 10,000 to reduce the number of cases of severe reactions by 1 individual in 10,000. In terms of mild reactions, respondents are willing to trade an additional 19.08 cases per 10,000 to have the vaccine one month earlier and 15.59 cases to increase the effectiveness of the vaccine by one percent. In comparison, respondents would only trade 0.92 and 0.60 additional cases of a

severe reaction in 10,000 to obtain the vaccine one month earlier or increase the effectiveness by one percent.

5. Expected uptake of the vaccine

To assess the expected uptake of a COVID-19 vaccine, a scenario analysis was undertaken for three hypothetical scenarios (Table 6).

Table 6: Expected uptake of the COVID-19 vaccine under different scenarios

	Scenario 1 (Average)	**Scenario 2 (Pessimistic)**	**Scenario 3 (Optimistic)**
Mild side effects	82.5 per 10,000 citizens	200 per 10,000 citizens	10 per 10,000 citizens
Major side effects	8.25 per 10,000 citizens	20 per 10,000 citizens	1 per 10,000 citizens
Effectiveness	91.50%	84%	99%
Mode of administration	Needle	Pill	Pill
Location	Dr's office	Dr's office	Pharmacy
When available	7 months	12 months	Available now
Cost	$70	$140	$0
Probability of getting the vaccine	**86.03%**	**20.95%**	**99.56%**

Scenario 1 is based on the average levels of the continuous attributes. Under this scenario, the hypothetical COVID-19 vaccine will be available in seven months, will only be available at doctors' offices via injection at a cost of $70. In terms of safety, 82.5 persons per 10,000 experience mild side-effects and 8.25 persons per 10,000 experience severe side effects and the effectiveness is 91.50%. Under this scenario, the estimated uptake of a COVID-19 vaccine will be 86.03%.

In addition to the average scenario described above, the uptake under "pessimistic" and "optimistic" scenarios are also provided. The 'pessimistic' scenario uses the worst available attribute levels whilst the 'optimistic' scenario uses the best available attribute levels. These two scenarios are detailed in the last two columns of Table 6. Under the 'pessimistic' and 'optimistic' scenarios, the expected uptake of the COVID-19 vaccine is 20.95% and 99.56%, respectively.

6. Discussion

Vaccine uptake is a critical factor in the success of immunisation programs. Given increasing vaccine hesitancy and the accelerated development pathway of COVID-19 vaccines, insights into the heterogeneity of vaccine preferences during a global pandemic are of material value to public health officials and policy makers. The findings of this study reflect the individual preferences for a COVID-19 vaccine. Whilst we expect these results to be of interest of public health officials, they do not necessarily reflect public health priorities in Australia.

This study has demonstrated that vaccine safety and effectiveness strongly influence vaccine preferences. These findings are consistent with those in other health policy settings such as influenza on a sample of health workers [25], rotavirus on a sample of young parents [37], [31], invasive pneumococcal disease on young mothers [31], meningococcal B on Australian adults and adolescents [28], hepathitis B on a sample of Chinese residents[13]and the South African population [38].

In addition to the above listed findings, from the analyses it emerges that respondents have a strong preference for vaccine immediacy, expressed as months until a vaccine is available. This result is not unexpected, given this study was undertaken during the COVID-19 pandemic when it would be reasonable to expect higher relative preferences for immediacy.

Although a direct comparison of the WTP values with other studies is difficult given the difference in diseases and treatment of attributes (e.g., [13]), several studies have similarly reported positive and significant WTP for an increase in effectiveness and a decrease in adverse cases. For example, Determann et al. [7] found a positive WTP for a vaccine in three different hypothetical scenarios of outbreak (mild/moderate/severe pandemic) and Marshall et al. [28] found positive WTP values when the effectiveness of a vaccine for meningococcal B is above 80%. Guo et al. [13] compute WTP values for a change in effectiveness as well as for changes in the risk of side effects for a hepatitis B vaccine.

The present study also reports the marginal rates of substitution (or trade-offs) between other vaccine characteristics. For example, the MRS between effectiveness and adverse cases suggests that respondents would be willing to accept 0.60 more cases reporting severe side effects (out of 10,000) to increase the vaccine effectiveness by one percent. Although the literature does not offer similar findings on COVID-19, other studies report the MRS between the risk of side effects and the other attributes. For instance, Veldwijk et al. [37] estimated the percentage of effectiveness for a vaccine against rotavirus (for their babies) that young parents are willing to trade to decrease the probability of serious side effects. Similarly, de Bekker-Grob et al. [5] calculated trade-offs between effectiveness of protection against cervical cancer and risk of serious side effects (mild and serious) on a sample of girls aged 12–16. Hofman et al. [15], [16] computed the same MRS on a sample of Dutch parents and girls aged 11–15 for a vaccine against papillomavirus.

An estimate of trade-off between mild and severe adverse cases is also provided. In this regard, Australian residents would be willing to accept 25.42 more cases reporting mild side effects (out of 10,000) to reduce by one unit the number of serious side effects. A similar high trade-off has been reported by de Bekker-Grob et al. [5], who estimated that girls would be willing to accept a steep increase (9.7%) risk of mild side effects to decrease the risk of serious side-effects.

Other characteristics that could favour the uptake of COVID-19 vaccine are the administration mode and the location. Respondents expressed a strong preference for oral over intravenous administration. Although the diseases investigated are different, similar preferences have

also been reported in the literature (see [29], [3]). In terms of location, the Australian government would observe a larger uptake if allows pharmacies to administer the vaccines.

By simulating the population's preference obtained through a LCM, the expected uptake of a potential COVID-19 vaccine under three different scenarios is estimated. The percentage of citizens that would get a vaccine varies from a minimum of around 21% to a maximum of almost full uptake, and the average scenario is estimated to be 86.03%. Unlike other studies conducted outside global pandemics, our results capture any perceptions of urgency that respondents may have had at the time the experiment was conducted. Unfortunately, perceptions of the urgency are not able to be controlled for due to the wide spread of COVID-19 and therefore the lack of a control counterpart. However, the expected uptake under the average scenario is consistent with that estimated by Determann et al. [7], who found that 88% of the sample would accept a vaccination in a hypothetical severe pandemic outbreak.

The expected uptake for a potential COVID-19 vaccine in the average scenario presented in this study is in line with other findings in the literature. To the best of our knowledge, Dadd et al.'s [6] is the only other study that investigates the Australian population and it reports an expected uptake of 85.80%. Other studies around the world report similar uptakes, ranging from 86% in UK [40]to 90.6% in Chile[11]. A more comprehensive survey conducted by Lazarus et al. [24] involving 35 countries across the globe estimates that on average 86% of the population would not oppose to a potential COVID-19 vaccine.

The results reported in this study were derived from a representative sample of Australian residents in terms of gender and median income. The sample was subsequently weighted to reflect the age distribution of the population. Unfortunately, it was not possible to compare the sample to the population in regards to more specific traits, such as the rate of people having chronic diseases and of frontline workers because of lack of data. Further research could investigate the acceptance of a potential COVID-19 vaccine for these categories that are likely to receive the vaccine first.

7. Conclusions

In this study, we identified the factors that would increase the vaccine uptake in Australia using a stated preference discrete choice experiment and a latent class model with three classes. We found that effectiveness of the vaccine has a positive impact on the individual utilities (the higher the better), whilst number of cases reporting mild and severe side effects, months until the vaccine is available and price have a negative effect (the lower the better). We provide different marginal rates of substitutions between the different attributes as well as forecast the uptake of the potential COVID-19 vaccine under three different scenarios.

To achieve higher uptake of a potential COVID-19 vaccine, public health officials should consider preferences for an oral COVID-19 vaccine over an injectable form. Although there was not a strong preference for location within the sample, a preference for pharmacies over hospitals and doctor's offices was found for class 2 in the LCM (this class is the most

represented in the study). To increase uptake, the vaccine should therefore be made available at pharmacies in addition to hospitals and doctor's offices. Finally, public health officials should consider the willingness to trade additional cases of mild reactions for increased immediacy and effectiveness as well as a reduction in cases of severe reactions.

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