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Trust in government, intention to vaccinate and COVID-19 vaccine hesitancy: A comparative survey of five large cities in the United States, United Kingdom, and Australia

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ABSTRACT

Background: There is widespread hesitancy towards COVID-19 vaccines in the United States, United Kingdom, and Australia.
Objective: To identify predictors of willingness to vaccinate against COVID-19 in five cities with varying COVID-19 incidence in the US, UK, and Australia.
Design: Online, cross-sectional survey of adults from Dynata's research panel in July-September 2020.
Participants, setting: Adults aged 18 and over in Sydney, Melbourne, London, New York City, or Phoenix.
Main outcomes and measures: Willingness to receive a COVID-19 vaccine; reason for vaccine intention.
Statistical methods: To identify predictors of intention to receive a COVID-19 vaccine, we used Poisson regression with robust error estimation to produce prevalence ratios.
Results: The proportion willing to receive a COVID-19 vaccine was 70% in London, 71% NYC, 72% in Sydney, 76% in Phoenix, and 78% in Melbourne. Age was the only sociodemographic characteristic that predicted willingness to receive a COVID-19 vaccine in all five cities. In Sydney and Melbourne, participants with high confidence in their current government had greater willingness to receive the vaccine (PR = 1.24; 95% CI = 1.07–1.44 and PR = 1.38; 95% CI = 1.74–1.62), while participants with high confidence in their current government in NYC and Phoenix were less likely to be willing to receive the vaccine (PR = 0.78; 95% CI = 0.72–0.85 and PR = 0.85; 95% CI = 0.76–0.96).
Limitations: Consumer panels can be subject to bias and may not be representative of the general population.
Conclusions: Success for COVID-19 vaccination programs requires high levels of vaccine acceptance. Our data suggests more than 25% of adults may not be willing to receive a COVID-19 vaccine, but many of them were not explicitly anti-vaccination and thus may become more willing to vaccinate over time. Among the three countries surveyed, there appears to be cultural differences, political influences, and differing experiences with COVID-19 that may affect willingness to receive a COVID-19 vaccine.

1. Introduction

On March 11th, the WHO declared coronavirus disease 19 (COVID-19) a pandemic [1]. Nations have taken a variety of approaches to combating the COVID-19 pandemic, including border closures, stay-at-home orders, and increased testing and surveillance [2]. While some countries, such as Australia, have achieved a level of control over the pandemic, many countries continue to see substantial disease incidence, including the United States and United Kingdom [3]. By November 1, 2020, the United Kingdom and United States had reported a total of approximately 15,000 and 28,000 COVID-19 cases per million people, respectively [3]. Meanwhile, Australia had only reported about 1000 cases per million people [3].

The COVID-19 pandemic will continue to cause recurrent epidemic waves and disrupt daily life until an effective vaccine is

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widely used [4]. As of November 2020, there are 44 vaccine candidates in clinical evaluation, including 10 in phase three trials [5]. Once an effective vaccine is approved for use, the next challenge will be ensuring high uptake of the vaccine to achieve community or herd immunity (estimated to be 60–70% for COVID-19).

Early research has shown there is widespread hesitancy towards receiving a COVID-19 vaccine [6–13]. One key barrier appears to be concern about side effects and safety given the accelerated development and testing timeline [6,7,14]. Trust in government and health authorities may also be a factor. Early in the COVID-19 pandemic, adoption of social-distancing measures was associated with trust in government [10]. This is important, given there is considerable evidence that trust and confidence in government authorities plays a role in vaccine decision-making [15–17]. Furthermore, the COVID-19 pandemic has been characterised by misinformation and conspiracy theories [18], which may cause further mistrust in COVID-19 vaccine recommendations, since research has shown that exposure to vaccine misinformation and conspiracy theories influences vaccination attitudes and behaviours [19–21].

As countries begin to develop plans for vaccine rollout, it is crucial to understand attitudes towards COVID-19 vaccines and to identify barriers to vaccination. We aimed to identify predictors of willingness to vaccinate against COVID-19 in five cities with varying COVID-19 incidence in the US, UK, and Australia.

2. Methods

2.1. Study design

We conducted an online survey of adults from Sydney, Melbourne, London, New York City (NYC), and Phoenix in July-August of 2020. We surveyed additional adults from Sydney and Melbourne in September. These five cities were chosen due to their varying COVID-19 incidence both at the time of the survey and prior. The cumulative number of confirmed cases per 1 million residents on 1 July 2020 for each region was as follows: 393 in Sydney (New South Wales) [22], 333 in Melbourne (Victoria) [23], 20,431 in New York City (New York State) [24], 12,007 in Phoenix (Arizona) [3], and 2353 in London [25].” The Human Research Ethics Committee at the University of New South Wales granted approval (HC #200460) for this study.

Dynata (https://www.dynata.com/), a global market research firm, provided the sample for this study. Dynata’s global consumer research panel includes participants from over 45 countries, including Australia, the United States, and United Kingdom. To obtain a diverse and representative consumer panel, Dynata recruits panel members through thousands of websites, social media platforms, mobile applications, and brand loyalty programs. To ensure reliability and accuracy of data, panel members undergo a rigorous verification process and incoming data undergoes various quality checks, including participation limits, digital fingerprinting, and removing panel members that provide illogical responses or do not spend sufficient time answering survey questions. Dynata uses a point system for participation that allows panel members to exchange their points for cash, airline miles, or other prizes.

Dynata distributed the survey link to a random sample of their panel members residing in Sydney, Melbourne, London, New York City, and Phoenix. Panel members that opened the survey were screened for eligibility. They were eligible to participate if they were 18 years or older and currently reside in Sydney, Melbourne, London, New York City, or Phoenix. Before beginning the survey, eligible participants provided informed consent. If a participant began a survey but did not complete it, we considered this withdrawal of consent and their data was not used. To prevent missing data, all fields in the survey were required, but sensitive questions included the option ‘prefer not to answer’. The survey took between ten and twelve minutes to complete.

2.2. Sample size

Our original sample only included Sydney, London, and New York City. We powered the study to detect a 20% difference in the rate of mask use between Sydney and the other two cities with 95% confidence and 80% power, which would require at least 200 participants from each city. We decided to also include Melbourne and Phoenix and sampled cities to be proportionate to their country’s population size. As mentioned above, we also repeated the survey in Melbourne and Sydney after an outbreak and mask mandate occurred in the state of Victoria.

2.3. Survey questions

This survey included a combination of close- and open-ended questions. Our primary outcome in this study, intention to receive a COVID-19 vaccine, was assessed using the question, “if an effective and safe vaccine against COVID-19 is available, would you get vaccinated?”. After answering yes or no, participants were asked to “please explain your choice”.

Questions on trust and confidence in government authorities were adapted in-part from a previous study on COVID-19 avoidance behaviours [10]. To measure general confidence in government, we asked, “how much confidence do you have in your national government?” and “how much confidence do you have in your state/territorial/government?”, with response options: a great deal, moderate amount, some, very little, none at all. To measure trust in government regarding COVID-19, we asked, “what level of trust do you have in the information about COVID-19 from your national government?” and “what level of trust do you have in the information about COVID-19 from your state/territorial government?”, with response options on a 5-point scale from very low to very high.

To capture perceived susceptibility and severity of COVID-19, we asked participants, “what do you think is your level of risk of catching COVID-19 during this pandemic?” and “how severe do you think COVID-19 would be if you got it?”, which they answered using a visual sliding scale. To understand participants’ health status, we asked a series of questions regarding their health history. We also collected demographic information, including age, gender, level of education completed, annual household income, country of birth, employment status, and ethnicity. The full list of survey questions can be found in the Supplementary Information.

2.4. Data analysis

We first calculated descriptive statistics for all variables of interest. To identify predictors of intention to receive a COVID-19 vaccine, we used Poisson regression with robust error estimation to produce prevalence ratios. In cross-sectional studies with common outcome variables, Poisson regression with robust error estimation yields prevalence ratios directly and outperforms logistic regression [26]. For the purpose of this analysis, predictor variables were dichotomised, with the exception of age. We divided age into three categories (under 45, 45–64, and over 65) because we were interested in modelling vaccine intention for both older adults, who are at higher risk of severe disease [27], as well as younger adults, who are at greater risk of disease transmission [28]. For a full list of original and recoded predictor variables, please see the Supplementary Information. We considered associations to be statistically significant if $p < 0.05$.

To understand individuals' reasons for not wanting to receive a COVID-19 vaccine, thematic analysis was used to describe data from the open-ended question, "Please explain your choice", in reference to the question "If an effective and safe vaccine against COVID-19 is available, would you get vaccinated?" [29]. Responses were reviewed and assigned one or more codes to each. The codes that emerged from the data were categorised into broader thematic units. Thematic units were reviewed to ensure they were distinct and coherent. Codes or thematic units were not defined *a priori*.

2.5. Role of funding source

This study was supported by a grant from the NHRMC Centre for Research Excellence in Integrated Systems for Epidemic Response (ISER) (grant number 1107393). The funding source had no role in the study's design, conduct, and reporting.

3. Results

A total of 4898 people opened the survey. Among eligible participants, 2712 (78%) completed the survey. Participants flagged by Dynata for low quality data were excluded from the analysis (n = 17), for a final sample of 2695. The proportion that stated they would receive a COVID19 vaccine if it were available was 70% (95% CI = 65–75%) in London, 71% (95% CI = 68–73%) in NYC, 72% (95% CI = 68–77%) in Sydney, 76% (95% CI = 72–79%) in Phoenix, and 78% (95% CI = 72–82%) in Melbourne. Among these participants, 94% said they would still receive the vaccine even if a booster was recommended every year.

Table 1 summarizes characteristics of the study participants by city. The proportion of participants over age 65 varied considerably. For example, in London, 12% of participants were over 65, while 38% of participants in Phoenix were over 65. The proportion of participants with private insurance was higher in the two American cities (75% in Phoenix and 79% in NYC) compared to London (32%) and the two Australian cities (65% in Sydney and 55% in Melbourne). The proportion of participants that smoke tobacco daily was also higher in the Australian cities compared to the American cities. For example, 21% of participants in Sydney reported daily smoking, whereas 10% of our sample in NYC reported daily smoking. The proportion of participants that rated their confidence in their national government as high or very high was 68% in Sydney, 66% in Melbourne, 45% in London, 37% in NYC, and 33% in Phoenix.

The demographic and health predictors of willingness to vaccinate against COVID-19 are summarized in Table 2 by city of residence. Age was the only variable that significantly predicted willingness to receive a COVID-19 vaccine in all five cities. In Sydney, Melbourne, NYC, and Phoenix, willingness to receive a COVID-19 vaccine was significantly associated with influenza vaccination in the previous 12 months.

Beliefs and attitudes were associated with willingness to receive the COVID-19 vaccine but differed across the five cities (Table 3). In Sydney and Melbourne, participants with high or very high confidence in their current national government were more likely to be willing to receive the vaccine (PR = 1.24; 95% CI = 1.07–1.44 and PR = 1.38; 95% CI = 1.17–1.62), whereas in NYC and Phoenix participants with high or very high confidence in their current national government were less likely to be willing to receive the vaccine (PR = 0.78; 95% CI = 0.72–0.85 and PR = 0.85; 95% CI = 0.76–0.96). In Sydney, having a friend or family member that was diagnosed with COVID-19 was associated with lower willingness to receive the vaccine (PR = 0.76; 95% CI = 0.62–0.95). However, in NYC, Phoenix, and London, participants with a friend or family member diagnosed with COVID-19 had greater willingness to receive the vaccine, but this was only statistically significant in NYC (PR = 1.12; 95% CI = 1.04–1.20).

Among the 741 participants that said they would not receive a vaccine for COVID-19 if it were available, 627 explained their choice. Thematic analysis resulted in five themes, three of which were broken down into two or more sub-themes. The frequencies

Table 1
Characteristics of study participants, by city of residence.

	Sydney, AUS (n = 402)	Melbourne, AUS (n = 298)	London, UK (n = 291)	New York City, USA (n = 1204)	Phoenix, USA (n = 500)
Gender					
Female	205 (51%)	146 (49%)	150 (52%)	638 (53%)	256 (51%)
Male	196 (49%)	152 (51%)	140 (48%)	564 (47%)	242 (48%)
Non-binary/third gender	1 (<1%)	0 (0%)	1 (<1%)	2 (<1%)	2 (<1%)
Age					
<45	222 (55%)	153 (51%)	143 (49%)	433 (36%)	147 (29%)
45–64	118 (29%)	87 (29%)	112 (38%)	389 (32%)	163 (32%)
>65	61 (15%)	58 (19%)	36 (12%)	382 (32%)	190 (38%)
Tertiary degree	241 (60%)	146 (49%)	176 (60%)	855 (71%)	318 (64%)
Born overseas	111 (28%)	77 (26%)	54 (19%)	109 (9%)	21 (4%)
Private health insurance	263 (65%)	165 (55%)	93 (32%)	956 (79%)	374 (75%)
Annual household income > $85526	157 (39%)	92 (31%)	77 (26%)	579 (48%)	214 (43%)
Smokes tobacco daily	86 (21%)	56 (19%)	59 (20%)	123 (10%)	64 (13%)
Has at least 1 chronic health condition (including hypertension)	230 (57%)	150 (50%)	121 (42%)	676 (56%)	322 (64%)
Received influenza vaccine in previous 12 months	199 (50%)	162 (54%)	74 (25%)	626 (52%)	270 (54%)
Has ever worn a mask during COVID-19 pandemic	232 (58%)	192 (64%)	206 (71%)	932 (77%)	378 (76%)
Has ever been tested for COVID-19	105 (26%)	110 (37%)	48 (16%)	364 (30%)	93 (19%)
Knows someone that has had COVID-19	66 (16%)	45 (15%)	97 (33%)	557 (46%)	173 (35%)
High/very high trust in information from national government on COVID-19	282 (70%)	188 (63%)	92 (32%)	390 (32%)	111 (22%)
High/Very high confidence in national government	272 (68%)	198 (66%)	131 (45%)	450 (37%)	165 (33%)
Would receive COVID-19 vaccine if it were available	291 (72%)	231 (78%)	205 (70%)	849 (71%)	378 (76%)
Would vaccinate family members against COVID-19 if a vaccine were available					
Yes, everyone	273 (68%)	213 (71%)	175 (60%)	789 (66%)	328 (66%)
Yes, some	39 (10%)	17 (6%)	35 (12%)	120 (10%)	45 (9%)
Unsure	51 (13%)	32 (11%)	47 (16%)	150 (12%)	58 (12%)

Table 2
Demographic and health predictors of intention to vaccinate against COVID-19, by city of residence.

	Sydney, AUS (n = 402)				Melbourne, AUS (n = 298)				London, UK (n = 291)				New York City, USA (n = 1204)				Phoenix, USA (n = 500)			
	Would receive COVID-19 vaccine				Would receive COVID-19 vaccine				Would receive COVID-19 vaccine				Would receive COVID-19 vaccine				Would receive COVID-19 vaccine			
	No	Yes	PR[a] (95% CI)	p-value	No	Yes	PR (95% CI)	p-value	No	Yes	PR (95% CI)	p-value	No	Yes	PR (95% CI)	p-value	No	Yes	PR (95% CI)	p-value
Age																				
<45	86 (39%)	136 (61%)	**0.73 (0.64, 0.83)**	**<0.01**	46 (30%)	107 (70%)	**0.86 (0.74, 0.99)**	**0.04**	58 (41%)	85 (59%)	**0.76 (0.64, 0.89)**	**<0.01**	194 (45%)	239 (55%)	**0.76 (0.68, 0.84)**	**<0.01**	55 (37%)	92 (63%)	**0.83 (0.71, 0.97)**	**0.02**
45–64	19 (16%)	99 (84%)	–		16 (18%)	71 (82%)			24 (21%)	88 (79%)	–		106 (27%)	283 (73%)	–		40 (25%)	123 (75%)	–	
>65	6 (10%)	56 (90%)	1.08 (0.96, 1.21)	0.20	5 (9%)	53 (91%)	1.12 (0.99, 1.27)	0.08	4 (11%)	32 (89%)	1.13 (0.97, 1.32)	0.11	55 (14%)	327 (86%)	**1.18 (1.09, 1.27)**	**<0.01**	27 (14%)	163 (86%)	**1.14 (1.02, 1.26)**	**0.02**
Gender																				
Male/Other	63 (32%)	134 (68%)			34 (22%)	118 (78%)			45 (32%)	96 (68%)			166 (29%)	400 (71%)			57 (23%)	187 (77%)		
Female	48 (23%)	157 (77%)	1.13 (1.00, 1.27)	0.06	33 (23%)	113 (77%)	1.00 (0.88, 1.13)	0.96	41 (27%)	109 (73%)	1.07 (0.92, 1.24)	0.40	189 (30%)	449 (70%)	1.00 (0.93, 1.07)	0.91	65 (25%)	191 (75%)	0.97 (0.88, 1.08)	0.60
Tertiary degree																				
No	38 (24%)	123 (76%)			32 (21%)	120 (79%)			31 (27%)	84 (73%)			117 (34%)	232 (66%)			61 (34%)	121 (66%)		
Yes	73 (30%)	168 (70%)	0.91 (0.81, 1.03)	0.13	35 (24%)	111 (76%)	0.96 (0.85, 1.09)	0.54	55 (31%)	121 (69%)	0.94 (0.81, 1.09)	0.42	238 (28%)	617 (72%)	1.09 (1.00, 1.18)	0.06	61 (19%)	257 (81%)	**1.21 (1.08, 1.37)**	**<0.01**
Born overseas																				
No	85 (29%)	206 (71%)			53 (24%)	168 (76%)			72 (30%)	165 (70%)			317 (29%)	778 (71%)			116 (24%)	363 (76%)		
Yes	26 (23%)	85 (77%)	1.08 (0.95, 1.23)	0.23	14 (18%)	63 (82%)	1.08 (0.95, 1.22)	0.26	14 (26%)	40 (74%)	1.06 (0.89, 1.27)	0.50	38 (35%)	71 (65%)	0.92 (0.80, 1.06)	0.23	6 (29%)	15 (71%)	0.94 (0.72, 1.24)	0.67
Private health insurance																				
No	44 (32%)	95 (68%)			38 (29%)	95 (71%)			55 (28%)	143 (72%)			85 (34%)	163 (66%)			42 (33%)	84 (67%)		
Yes	67 (25%)	196 (75%)	1.09 (0.95, 1.25)	0.20	29 (18%)	136 (82%)	**1.15 (1.01, 1.31)**	**0.03**	31 (33%)	62 (67%)	0.92 (0.78, 1.09)	0.35	270 (28%)	686 (72%)	1.09 (0.99, 1.20)	0.08	80 (21%)	294 (79%)	**1.18 (1.03, 1.35)**	**0.02**
Income[b]																				
<$85,536	68 (28%)	177 (72%)			40 (19%)	166 (81%)			64 (30%)	150 (70%)			224 (36%)	401 (64%)			86 (30%)	200 (70%)		
$85,536+	43 (27%)	114 (73%)	1.01 (0.89, 1.14)	0.94	27 (29%)	65 (71%)	0.88 (0.76, 1.02)	0.08	22 (29%)	55 (71%)	1.02 (0.86, 1.20)	0.82	131 (23%)	448 (77%)	**1.20 (1.12, 1.30)**	**<0.01**	36 (17%)	178 (83%)	**1.19 (1.08, 1.31)**	**<0.01**
Current daily smoker																				
No	75 (24%)	241 (76%)			49 (20%)	193 (80%)			63 (27%)	169 (73%)			300 (28%)	781 (72%)			102 (23%)	334 (77%)		
Yes	36 (42%)	50 (58%)	**0.76 (0.63, 0.92)**	**0.01**	18 (32%)	38 (68%)	0.85 (0.70, 1.03)	0.10	23 (39%)	36 (61%)	0.84 (0.67, 1.04)	0.11	55 (45%)	68 (55%)	**0.77 (0.65, 0.90)**	**<0.01**	20 (31%)	44 (69%)	0.90 (0.75, 1.07)	0.22
1 or more chronic health condition[c]																				
No	56 (33%)	116 (67%)			39 (26%)	109 (74%)			53 (31%)	117 (69%)			198 (37%)	330 (63%)			64 (36%)	114 (64%)		
Yes	55 (24%)	175 (76%)	1.13 (0.99, 1.28)	0.06	28 (19%)	122 (81%)	1.10 (0.98, 1.25)	0.12	33 (27%)	88 (73%)	1.06 (0.91, 1.23)	0.47	157 (23%)	519 (77%)	**1.23 (1.14, 1.33)**	**<0.01**	58 (18%)	264 (82%)	**1.28 (1.13, 1.45)**	**<0.01**
Influenza vaccine in previous 12 months[d]																				
No	80 (39%)	123 (61%)			46 (34%)	90 (66%)			69 (32%)	148 (68%)			252 (44%)	326 (56%)			95 (41%)	135 (59%)		
Yes	31 (16%)	168 (84%)	**1.39 (1.23, 1.58)**	**<0.01**	21 (13%)	141 (87%)	**1.32 (1.15, 1.50)**	**<0.01**	17 (23%)	57 (77%)	1.13 (0.97, 1.32)	0.12	103 (16%)	523 (84%)	**1.48 (1.37, 1.60)**	**<0.01**	27 (10%)	243 (90%)	**1.53 (1.37, 1.72)**	**<0.01**

[a] Prevalence ratio estimated using Poisson regression with robust error estimation
[b] Currency in USD
[c] Any self-reported chronic condition, including hypertension
[d] Self-reported

Table 3
Beliefs and attitudes associated with intention to receive the COVID-19 vaccine, by city of residence.

	Sydney, AUS (n = 402)				Melbourne, AUS (n = 298)				London, UK (n = 291)			
	Would receive COVID-19 vaccine				Would receive COVID-19 vaccine				Would receive COVID-19 vaccine			
	No	Yes	PR (95% CI)[a]	p-value	No	Yes	PR (95% CI)	p-value	No	Yes	PR (95% CI)	p-value
How much confidence do you have in your national government?												
None/very little/some	49 (38%)	81 (62%)			38 (38%)	62 (62%)			46 (29%)	114 (71%)		
Moderate/great deal	62 (23%)	210 (77%)	**1.24 (1.07, 1.44)**	**0.01**	29 (15%)	169 (85%)	**1.38 (1.17, 1.62)**	**<0.01**	40 (31%)	91 (69%)	0.97 (1.84, 1.13)	0.74
What level of trust do you have in the information about COVID-19 from your national government?												
Very low/low/intermediate	46 (38%)	74 (62%)			42 (38%)	68 (62%)			55 (28%)	144 (72%)		
High/very high	65 (23%)	217 (77%)	**1.25 (1.07, 1.46)**	**0.01**	25 (13%)	163 (87%)	**1.40 (1.20, 1.64)**	**<0.01**	31 (34%)	61 (66%)	0.92 (0.77, 1.09)	0.31
Has someone you know (such as a family member, work colleague or friend) had COVID-19?												
No	83 (25%)	253 (75%)			53 (21%)	200 (79%)			64 (33%)	130 (67%)		
Yes	28 (42%)	38 (58%)	**0.76 (0.62, 0.95)**	**0.02**	14 (31%)	31 (69%)	0.87 (0.71, 1.07)	0.19	22 (23%)	75 (77%)	1.15 (1.00, 1.34)	0.06
On a scale from 1 to 100, what do you think is your level of risk of catching COVID-19 during this pandemic?												
≤50	63 (26%)	178 (74%)			47 (26%)	137 (74%)			46 (27%)	127 (73%)		
>50	48 (30%)	113 (70%)	0.95 (0.84, 1.08)	0.43	20 (18%)	94 (82%)	1.11 (0.98, 1.25)	0.10	40 (34%)	78 (66%)	0.90 (0.77, 1.05)	0.19
On a scale of 1–100, how severe do you think COVID-19 would be if you got it?												
≤50	58 (33%)	119 (67%)			34 (29%)	85 (71%)			42 (29%)	105 (71%)		
>50	53 (24%)	172 (76%)	**1.14 (1.00, 1.29)**	**0.05**	33 (18%)	146 (82%)	**1.14 (1.00, 1.30)**	**0.05**	44 (31%)	100 (69%)	0.97 (0.84, 1.13)	0.71

	New York City, USA (n = 1204)				Phoenix, USA (n = 500)			
	Would receive COVID-19 vaccine				Would receive COVID-19 vaccine			
	No	Yes	PR (95% CI)	p-value	No	Yes	PR (95% CI)	p-value
How much confidence do you have in your national government?								
None/very little/some	175 (23%)	579 (77%)			69 (21%)	266 (79%)		
Moderate/great deal	180 (40%)	270 (60%)	**0.78 (0.72, 0.85)**	**<0.01**	53 (32%)	112 (68%)	**0.85 (0.76, 0.96)**	**0.01**
What level of trust do you have in the information about COVID-19 from your national government?								
Very low/low/intermediate	205 (25%)	609 (75%)			93 (24%)	296 (76%)		
High/very high	150 (38%)	240 (62%)	**0.82 (0.75, 0.90)**	**<0.01**	29 (26%)	82 (74%)	0.97 (0.86, 1.10)	0.64
Has someone you know (such as a family member, work colleague or friend) had COVID-19?								
No	214 (33%)	433 (67%)			84 (26%)	243 (74%)		
Yes	141 (25%)	416 (75%)	**1.12 (1.04, 1.20)**	**<0.01**	38 (22%)	135 (78%)	1.05 (0.95, 1.16)	0.35
On a scale from 1 to 100, what do you think is your level of risk of catching COVID-19 during this pandemic?								
≤50	190 (31%)	427 (69%)			79 (29%)	195 (71%)		
>50	165 (28%)	422 (72%)	1.04 (0.97, 1.12)	0.31	43 (19%)	183 (81%)	**1.14 (1.03, 1.26)**	**0.01**
On a scale of 1–100, how severe do you think COVID-19 would be if you got it?								
≤50	142 (31%)	321 (69%)			72 (35%)	133 (65%)		
>50	213 (29%)	528 (71%)	1.03 (0.95, 1.11)	0.48	50 (17%)	245 (83%)	**1.28 (1.14, 1.43)**	**<0.01**

[a] Prevalence ratios estimated using Poisson regression with robust error estimation.

Table 4
Frequencies of reported reasons not to take the COVID-19 vaccine by city of residence.

Theme	Sub-theme	Sample responses	Sydney (n = 96)	Melbourne (n = 58)	London (n = 72)	New York City (n = 290)	Phoenix (n = 111)	Total (n = 627)
Vaccine-specific concerns	COVID-19 vaccine will not be safe	'Not sure it will be safe'; 'Vaccines are prone to side effects, especially new ones'	6 (6%)	8 (14%)	9 (13%)	36 (12%)	9 (8%)	68 (11%)
	COVID-19 vaccine development is "rushed"	'Afraid of issues later on as testing has to be rushed'; 'In this "rush to the cure" who knows what the vaccine contains'	5 (5%)	1 (2%)	2 (3%)	9 (3%)	9 (8%)	26 (4%)
Vaccine is not necessary	COVID-19 vaccine will not be effective	'I don't think it will work'; 'I'm not sure how effective it would be because it mutates easily and quickly'	6 (6%)	2 (3%)	5 (7%)	6 (2%)	1 (1%)	20 (3%)
	Low perceived risk of disease	'I think my chances of getting it are low and if I did get I would expect to be ok as I am fit and healthy'; 'do not feel the need'	11 (11%)	7 (12%)	7 (10%)	18 (6%)	15 (14%)	58 (9%)
	Preference to take other measures or strengthen immune system	'BUILD YOUR IMMUNE SYSTEM AND WASH YOUR HANDS'; 'I like to build up my own immunity'	4 (4%)	0 (0%)	2 (3%)	5 (2%)	1 (1%)	12 (2%)
Lack of trust	Distrust government or pharmaceutical industry	'I don't trust the current government enough to get their vaccine'; 'I don't trust for profit pharmaceutical companies in the U.S. they're already cutting corners to make as much profits as possible.'	2 (2%)	3 (5%)	6 (8%)	6 (2%)	10 (9%)	27 (4%)
	Distrust of COVID-19 vaccine or vaccination in general	'Not sure if I would trust the vaccine'; 'I don't trust vaccines at all I feel that they make you sick even more purposeful.'	3 (3%)	6 (10%)	5 (7%)	38 (13%)	12 (12%)	65 (10%)
Not sure or waiting for more information		'Want to wait a while to see if there are side effects'; 'I'm not sure yet would have to know more about it'	19 (20%)	17 (29%)	14 (19%)	46 (16%)	33 (30%)	129 (21%)
No reason/ don't know		'Nothing to add'; 'Don't know'	40 (42%)	14 (24%)	22 (31%)	121 (42%)	19 (17%)	216 (34%)

of each theme by city of residence are listed in Table 4. The most frequent theme was "No reason/Don't know" (34%). The second most frequently reported theme was "Not sure yet or waiting for more information" (21%). Other frequently mentioned themes/sub-themes included "COVID-19 vaccine will not be safe" (11%), "Distrust of COVID-19 vaccine or vaccination in general" (10%), and "Low perceived risk of disease" (9%).

4. Discussion

We found that 70–78% of participants, depending on city, would receive a COVID-19 vaccine if it were available. These findings are similar to other surveys [8,10], and would result in coverage too low to achieve community or herd immunity with a vaccine of moderate efficacy [30]. However, when asked to explain their choice, nearly a third of participants that said they would not take the vaccine did not give a reason for not wanting to receive the vaccine, and another 21% are not sure yet or want to wait for more information. This suggests that many vaccine-hesitant participants do not hold fixed anti-vaccination views, and therefore may be supported to vaccinate against COVID-19. One key barrier appears to be concern about safety given the accelerated development timeline [7]. Thus, clinicians need to develop their understanding of the COVID-19 vaccine development and approval process so they can confidently explain it to their patients.

Age was positively associated with willingness to receive a COVID-19 vaccine in all five cities. A similar trend has been observed in other surveys on COVID-19 vaccine intentions [7,9,31,32] and influenza vaccine intentions and behaviours [33]. However, the relationship between age and vaccine willingness does not appear to be perfectly liner. While willingness tends to be greatest in adults aged 65 and over, it is also high amongst those aged 18–24 [7,32,34]. A further complication is the risk of thrombosis and thrombocytopenia syndrome, which was not known at the time the survey was done but is contributing to hesitancy in adults over age 50 recommended for the AstraZeneca (ChAdOx1) COVID-19 vaccine in Australia [35]. Thus, efforts to improve COVID-19 vaccine willingness should focus on adults between the ages of 25 and 64.

Other than age, predictors of willingness to receive the COVID-19 vaccine differed between the five cities. This may reflect cultural differences between the cities, as well as differing experiences with COVID-19. For example, knowing someone with COVID-19 was positively associated with willingness to receive the vaccine in NYC, but was negatively associated with willingness to receive the vaccine in Sydney. This may be because COVID-19 incidence is relatively low in Australia compared to the US [1].

The cities also differed in terms of trust and confidence in national government. Lack of trust and confidence in government authorities increases the likelihood of vaccine hesitancy and refusal [16,17]. In Sydney and Melbourne, higher trust and confidence in government were associated with greater likelihood of willingness to receive the vaccine. However, in NYC and Phoenix, where trust and confidence in government were relatively low overall, individuals with higher trust were less likely to intend to vaccinate. This is unsurprising, given that in the US, routine public health measures such as masks and vaccines have been politicised. Willingness to receive the vaccine in the US appears to be related to one's political affiliations [8], with the government in power at the time of this survey contributing to COVID-19 misinformation [18].

This study had some limitations. We conducted these surveys in five cities in the US, UK, and Australia, but they may not be representative of the general population in those countries. Consumer panels can also be subject to bias and may not be truly representative of the general population [36]. Given that surveys are completed online, panel members are tend to have greater internet access and higher socioeconomic status compared to the general population, particularly amongst older adults [36]. To reduce bias, panel members are given a mobile phone and sim card if they do not have their own internet access. Furthermore, comparisons between the five cities should be interpreted with caution. Because the samples were smaller in Sydney, Melbourne, and London compared to the US cities, they may have lacked statistical power to identify factors associated with willingness to vaccinate. Another important limitation is that willingness to vaccinate changes over time [37], and this data was collected prior to any candidate vaccines being licensed for use. Finally, our primary outcome, willingness to receive a COVID-19 vaccine, was measured using a "yes" or "no" question, without the option of answering "unsure". Thus, participants that were truly unsure at the time of the survey may have been forced select "no", and thus our study may be overestimating vaccine hesitancy. However, it should be noted that our estimate of vaccine willingness is comparable to other estimates from the same time period [8,9,12,38].

COVID-19 vaccine willingness and trust in government varies across different cities with low (Sydney, Melbourne) and high (NYC, Phoenix, London) incidence of COVID-19. Cultural differences and political influences between countries may also affect COVID-19 vaccine acceptance.

Data statement

The data used in this research will not be made publicly available.

CRediT authorship contribution statement

Mallory Trent: Investigation, Formal analysis, Writing - original draft. **Holly Seale:** Conceptualization, Methodology, Writing - review & editing. **Abrar Ahmad Chughtai:** Conceptualization, Methodology, Writing - review & editing. **Daniel Salmon:** Formal analysis, Supervision, Writing - review & editing. **C. Raina MacIntyre:** Conceptualization, Methodology, Supervision, Writing - review & editing.

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Dr. Daniel Salmon has had consulting and/or grant support from Merck, Walgreens, and Pfizer. Dr. C Raina MacIntyre is receiving funding from Sanofi for influenza research. Dr Holly Seale has previously received funding from drug companies for investigator driven research and consulting fees to present at conferences/-workshops and develop resources (bio-CSL/Sequiris, GSK and Sanofi Pasteur). Dr Holly Seale has participated in advisory board meeting for Sanofi Pasteur.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.vaccine.2021.06.048.

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