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Prevalence, predictors and reasons for COVID-19 vaccine hesitancy: Results of a global online survey

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ABSTRACT

Vaccine hesitancy has the potential to cripple efforts to end the COVID-19 pandemic. Policy makers need to be informed about the scale, nature and drivers of this problem, both domestically and globally, so that effective interventions can be designed. To this end, we conducted a statistical analysis of data from the CANDOUR survey (n = 15,536), which was carried out in 13 countries representing approximately half of the global population. Both pooled and country-level ordered regression models were estimated to identify predictors of vaccine hesitancy and reasons for not getting vaccinated. We found high levels of hesitancy, particularly in high-income countries. Factors driving moderate hesitancy differed from those driving extreme hesitancy. A lack of trust in health care providers was consistently the underlying driver of more extreme hesitancy. Predictors of moderate hesitancy varied across countries, though being younger and female was typically associated with greater hesitancy. While political ideology played a role in vaccine hesitancy in some countries, this effect was often moderated by income level, particularly in the US. Overall, the results suggest that different interventions such as mass-media campaigns and monetary incentives may be needed to target the moderately versus extremely hesitant. The lack of trust in health care professionals that drives extreme hesitancy may reflect deep societal mistrust in science and institutions and be challenging to overcome.

1. Introduction

The COVID-19 pandemic continues to impose substantial costs worldwide to human life and to the economy [1]. To tackle the virus, unprecedented efforts have been spent on developing and rolling out effective vaccines [2]. In late 2020, following the first successful results from randomized controlled trials, it became clear that availability of a number of effective vaccines was soon to become a reality, giving hope for a return to normalcy [3]. However, ending the COVID-19 pandemic remains an immense challenge, requiring not only global access to vaccines, but also very high levels of vaccine uptake. Whilst there had been hope that herd immunity would be obtained with COVID-19 vaccination rates of around 80 percent of populations [4,5], the emergence of more transmissible variants better equipped to evade existing vaccines means that almost 100% vaccination coverage is now desirable, likely including ongoing cycles of booster vaccinations [6–10].

As increasingly recognised by national and international authorities, a potentially serious barrier to overcoming this challenge is vaccine hesitancy [11]. While vaccine hesitancy, which has been on the rise in recent decades [12], has been a public health concern for some time [13], its potential for crippling efforts to end the pandemic have placed it uniquely under the spotlight. A prerequisite for enabling policy makers to tackle COVID-19 vaccine hesitancy is understanding the scale of the problem. Clearly, this requires gauging the prevalence of vaccine hesitancy in populations. However, it is increasingly recognized that vaccine hesitancy is a spectrum, ranging from full acceptance (i.e., no hesitancy) to refusal [14]. So, equally important is to estimate the degree to which hesitancy manifests itself. The factors driving moderate hesitancy may differ substantially from those driving strong hostility to

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vaccination [15] and such evidence is needed to inform the design of effective interventions, such as targeted communication strategies [16] or appropriate vaccine uptake incentives [17].

Since the start of the pandemic, a rapidly growing literature has investigated hesitancy towards vaccination against COVID-19. From country-level analyses [18–21] to systematic reviews and meta-analyses [22–25], many important contributions have been made, particularly toward estimating levels and extent of hesitancy and identifying which groups within society hold unfavourable attitudes toward vaccination. Most studies have been within high income countries, where vaccination campaigns are well underway, while in low- and middle-income countries, the evidence base on vaccine levels, extent and drivers remains limited [26].

Vaccine hesitancy has always been a contextual, multi-faceted phenomenon, which is influenced by a wide array of individual as well as social and economic factors [27]. However, in contrast to previous vaccinations, COVID-19 vaccination is central to public discourse and policy. The pandemic has dictated a sudden extraordinary mobilization of resources and measures limiting individual freedoms, hence undoubtedly putting pressure on the role and mandate of public institutions and agencies at all levels of society. Under such unprecedented circumstances, understanding what fundamentally drives hesitancy requires capturing and accounting for domains spanning across the social sciences. At the time of writing, several surveys are being conducted simultaneously to identify determinants and reasons for vaccine hesitancy and inform public policy design. From a conceptual standpoint, as with other vaccines, systematic differences in COVID-19 vaccine hesitancy can be reasonably expected to exist between different population subgroups, such as those based on age, gender, health and socio-economic status. However, additional information beyond socio-demographic characteristics such these can provide a more comprehensive picture of the underlying reasons for vaccine hesitancy [28]. Given the nature and scale of implications of the current pandemic it is therefore valuable to also consider factors such as political ideology and trust in health authorities, which are not typically included in health surveys [29], but could play a role in explaining vaccine hesitancy.

While some individual country-level studies have addressed these concerns [30,31], inconsistency in survey and analysis methods used presents a substantial barrier to reliable comparative assessments of study findings. In turn, this is a barrier to informing national and international authorities and governments on future coordinated actions and communication strategies. To address these information needs, we present findings from a statistical analysis of an unusually rich 13-country individual level dataset. This dataset, from the first wave of the CANDOUR study [32], represents approximately half the global population.

2. Methods

2.1. Data

A detailed report of the CANDOUR survey is available elsewhere [33]. In brief, 15,536 respondents (≥18 years old) from Australia, Brazil, Canada, Chile, China, Colombia, France, India, Italy, Spain, Uganda, UK and the USA were surveyed online between during the period November 24, 2020 to January 14, 2021. In all countries apart from Chile and Uganda, respondents were sampled by the sampling firm, Respondi. In Chile and Uganda, respondents were recruited using Facebook Ad Manager. All participants were aged 18 or older and signed a consent form before taking part in the survey. The median length of interview was 29.9 min. In the eleven Respondi-sampled countries, the modal incentive was £2.00. Respondents in Chile received payments of $3.00 and in Uganda $2.25. The final sample included an average of 1195 respondents per country (15,536 respondents overall). The average response rate across all countries (calculated as the fraction of complete responses over invited, eligible participants) was 21.3%. Duch et al. (2021) [33] compared the CANDOUR sample distributions with those obtained from the most recent available national census in each of the 13 countries. The CANDOUR sample and population age distributions were found to be similar in most countries, though with higher distributions of young respondents in Chile, China, Colombia and Uganda. The Chile sample over-represents women, while women are under-represented in India and Uganda. As is typical with online surveys, in virtually all countries (all except Italy and the UK), the highly educated are over-represented, and the lower-educated under-represented. Country-specific quota sampling based on age, gender, education and region was employed in order for the survey samples to roughly match the characteristics of the population of each country, except for India where target sample quotas were employed. To adjust for imbalances between the quotas and the final survey samples, post-stratification weights were constructed using a raking procedure and subsequently applied for statistical analysis. Demographic characteristics of the respondents are described in Table 1.

2.2. Measures

The outcome measures were:

1 The extent of vaccine hesitancy. This was surveyed using the following question: “If a vaccine that protected you from COVID-19 was available, would you get it?” (“definitely get it”; “probably get it”; “probably not get it”; “definitely not get it”; “do not know”; “prefer not to say”)
2 Reasons for not getting vaccinated against COVID-19 [‘check all that apply’ question asked to respondents who either indicated that they would “definitely” or “probably” not get the vaccine or would only “probably” get the vaccine]:
- Vaccine effectiveness - “I don’t believe the COVID-19 vaccine will be effective”;
- Potential side effects - “I am concerned about dangerous side effects from the COVID-19 vaccine”;
- Herd immunity - ”Enough other people will accept vaccination so I will benefit from herd immunity”;
- Infected - “I have already been infected with COVID-19 and believe I have developed natural immunity”;
- No harm - “The COVID-19 virus will not be very harmful to my health”;
- No trust – “I don’t trust the health care providers in this country”;
- Other

Socio-demographic characteristics of respondents selected for our analysis were: country of origin, age, gender, chronic health conditions, living with a partner, number of dependent children, education level, employment status, political ideology and quartile of the domestic income distribution. Political ideology was measured on a scale from 0 to 10 going from left to right, which we categorised into tertiles as left (0–3), centrist (4–7) and right (8–10). Income quartile was based on total household income, adjusted for household composition using the Modified OECD equivalence scale [34].

2.3. Statistical analysis

Summary statistics were used to describe levels of vaccine hesitancy across the 13 countries. Both pooled and country-level regression analyses were run to identify vaccine hesitancy determinants across and within the 13 countries under study, respectively. Ordered logistic regression models were estimated to identify individual-level predictors of vaccine hesitancy (five levels, in decreasing order: “definitely get it”; “probably get it”; “do not know”; “probably not get it”; “definitely not get it”).

Three regression models built progressively including all the variables identified above were estimated. Model 1 included variables

Table 1
Socio-demographic characteristics of respondents in the 13 countries.

		Australia (*n* = 1360)	Brazil (*n* = 1426)	Canada (*n* = 1150)	Chile (*n* = 1122)	China (*n* = 1294)	Colombia (*n* = 1237)	France (*n* = 1146)	India (*n* = 1191)	Italy (*n* = 1081)	Spain (*n* = 1153)	UK (*n*=,1165)	US (*n* = 1150)	Uganda (*n* = 1053)
Age group (years)	18–29	324 (23.8%)	381 (26.7%)	240 (20.9%)	489 (43.6%)	303 (23.4%)	337 (27.2%)	193 (16.8%)	468 (39.3%)	176 (16.3%)	177 (15.4%)	148 (12.7%)	187 (16.3%)	648 (61.5%)
	30–39	252 (18.5%)	307 (21.5%)	207 (18.0%)	185 (16.5%)	418 (32.3%)	336 (27.2%)	143 (12.5%)	468 (39.3%)	174 (16.1%)	199 (17.3%)	193 (16.6%)	229 (19.9%)	313 (29.7%)
	40–49	239 (17.6%)	279 (19.6%)	192 (16.7%)	170 (15.2%)	221 (17.1%)	279 (22.6%)	178 (15.5%)	120 (10.1%)	236 (21.8%)	243 (21.1%)	208 (17.9%)	244 (21.2%)	75 (7.1%)
	50–59	220 (16.2%)	233 (16.3%)	196 (17.0%)	185 (16.5%)	228 (17.6%)	194 (15.7%)	230 (20.1%)	84 (7.1%)	219 (20.3%)	211 (18.3%)	222 (19.1%)	176 (15.3%)	13 (1.2%)
	60–69	197 (14.5%)	187 (13.1%)	189 (16.4%)	80 (7.10%)	94 (7.30%)	74 (6.0%)	298 (26.0%)	42 (3.5%)	228 (21.1%)	264 (22.9%)	246 (21.1%)	195 (17.0%)	4 (0.4%)
	70+	128 (9.40%)	39 (2.70%)	126 (11.0%)	13 (1.20%)	30 (2.30%)	17 (1.4%)	104 (9.1%)	9 (0.8%)	48 (4.4%)	59 (5.1%)	148 (12.7%)	119 (10.4%)	0%
Gender	Male	646 (47.4%)	706 (49.5%)	617 (53.6%)	436 (38.9%)	684 (52.7%)	520 (42.0%)	634 (55.3%)	720 (60.4%)	488 (45.1%)	560 (48.6%)	625 (53.6%)	580 (50.4%)	762 (72.4%)
	Female	715 (52.4%)	713 (50.0%)	528 (45.9%)	679 (60.5%)	610 (47.0%)	709 (57.3%)	507 (44.2%)	468 (39.3%)	590 (54.6%)	591 (51.3%)	536 (46.0%)	565 (49.1%)	265 (25.2%)
Chronic health conditions	None	601 (45.4%)	610 (44.9%)	535 (48.4%)	504 (45.8%)	897 (70.6%)	762 (63.0%)	583 (53.0%)	505 (44.0%)	570 (54.7%)	560 (49.6%)	590 (51.9%)	397 (35.7%)	631 (62.7%)
	1	397 (30.0%)	749 (55.1%)	328 (29.7%)	406 (36.9%)	286 (22.5%)	334 (27.6%)	518 (47.1%)	374 (32.6%)	333 (32%)	401 (35.5%)	325 (28.6%)	376 (33.8%)	324 (32.2%)
	2+	325 (24.6%)	NA	242 (21.9%)	191 (17.4%)	87 (6.9%)	113 (9.4%)	NA	268 (23.4%)	139 (13.3%)	169 (15.0%)	221 (19.5%)	340 (30.6%)	51 (5.1%)
Education level	Primary	244 (17.9%)	251 (17.6%)	58 (5.0%)	12 (1.1%)	290 (22.3%)	185 (15%)	131 (11.4%)	329 (27.6%)	27 (2.5%)	110 (9.5%)	143 (12.3%)	44 (3.8%)	41 (3.9%)
	Secondary	525 (38.5%)	424 (29.7%)	549 (47.7%)	384 (34.2%)	206 (15.9%)	520 (42.0%)	538 (47.0%)	269 (22.6%)	741 (68.6%)	460 (39.9%)	606 (52.0%)	523 (45.5%)	337 (32.0%)
	University	575 (42.2%	638 (44.7%)	531 (46.2%)	690 (61.5%)	780 (60.1%)	516 (41.7%)	456 (39.8%)	593 (49.8%)	290 (26.8%)	570 (49.4%)	397 (34.1%)	571 (49.7%)	661 (62.8%)
	Other	20 (1.5%)	113 (7.9%)	12 (1.0%)	36 (3.2%)	22 (1.7%)	16 (1.3%)	21 (1.8%)	0%	23 (2.1%)	13 (1.1%)	19 (1.6%)	12 (1.0%)	14 (1.3%)
Living with a partner	No	516 (37.8%)	583 (40.9%)	503 (43.7%)	643 (57.3%)	266 (20.5%)	527 (42.6%)	368 (32.1%)	451 (37.9%)	377 (34.9%)	374 (32.4%)	441 (37.9%)	442 (38.4%)	444 (54.2%)
	Yes	822 (60.3%)	786 (55.1%)	639 (55.6%)	461 (41.1%)	1025 (79.0%)	679 (54.9%)	760 (66.3%)	733 (61.5%)	675 (62.4%)	761 (66.0%)	713 (61.2%)	702 (61.0%)	344 (42.0%)
		Australia (*n* = 1360)	Brazil (*n* = 1426)	Canada (*n* = 1150)	Chile (*n* = 1122)	China (*n* = 1294)	Colombia (*n* = 1237)	France (*n* = 1146)	India (*n* = 1191)	Italy (*n* = 1081)	Spain (*n* = 1153)	UK (*n*=,1165)	US (*n* = 1150)	Uganda (*n* = 1053)
Dependent children	no	903 (67.2%)	769 (55.2%)	833 (72.9%)	632 (57.0%)	488 (38.0%)	536 (44.2%)	783 (69.2%)	400 (34.7%)	634 (59.8%)	733 (64.4%)	849 (73.3%)	683 (59.9%)	231 (28.8%)
	Yes	441 (32.8%)	624 (44.8%)	309 (27.1%)	309 (43.0%)	798 (62.1%)	678 (55.9%)	348 (30.8%)	752 (65.3%)	427 (40.3%)	405 (35.6%)	310 (26.8%)	458 (40.1%)	571 (71.2%)
Employment status	Employed	685 (52.7%)	783 (57.7%)	611 (54.0%)	316 (29.2%)	870 (67.0%)	727 (61.0%)	651 (56.8%)	866 (73.6%)	639 (62.7%)	692 (60.9%)	639 (55.5%)	692 (61.2%)	456 (57.1%)
	Unemployed	103 (7.9%)	204 (15.0%)	81 (7.2%)	111 (10.3%)	22 (1.7%)	159 (13.4%)	NA	64 (5.4%)	125 (12.3%)	157 (13.8%)	78 (6.8%)	66 (5.8%)	283 (35.5%)
	Pension / Capital Income	NA	163 (12.0%)	252 (22.3%)	40 (3.7%)	218 (16.8%)	28 (2.4%)	NA	24 (2.0%)	81 (8.0%)	195 (17.2%)	284 (24.7%)	189 (16.7%)	2 (0.3%)
	Other	513 (39.4%)	207 (15.3%)	188 (16.6%)	616 (56.9%)	188 (14.5%)	277 (23.3%)	495 (43.2%)	222 (18.9%)	174 (17.1%)	93 (8.2%)	150 (13.0%)	183 (16.2%)	57 (7.1%)
Political ideology	Left	199 (17.5%)	277 (23.7%)	243 (24.3%)	324 (33.6%)	NA	224 (21.7%)	206 (24.0%)	62 (5.7%)	233 (26.6%)	419 (40.2%)	210 (21.4%)	202 (20.2%)	171 (18.1%)
	Centrist	670 (58.9%)	540 (46.2%)	636 (63.5%)	552 (57.3%)	NA	607 (58.9%)	488 (56.9%)	520 (48.1%)	452 (51.5%)	497 (47.7%)	629 (64.0%)	462 (46.1%)	564 (59.7%)
	Right	269 (23.6%)	351 (30.1%)	122 (12.2%)	87 (9.0%)	NA	200 (19.4%)	164 (19.1%)	499 (46.2%)	192 (21.9%)	127 (12.2%)	144 (14.7%)	338 (33.7%)	210 (22.2%)
Domestic income	Bottom 25%	10,573 (7651)	5044 (2366)	14,259 (6526)	78,980 (44,549)	21,232 (8335)	188,354 (95,879)	7771 (2941)	NA	4448 (1925)	6024 (2302)	7723 (3345)	10,409 (5222)	638,035 (187,495)
	26%–50%	31,400 (4987)	13,949 (2997)	31,535 (4502)	210,507 (43,886)	80,139 (29,255)	510,109 (109,541)	14,695 (1023)	NA	10,285 (1347)	12,002 (1676)	16,082 (1820)	27,902 (5421)	1750,493 (424,781)
	51%–75%	53,641 (7973)	27,827 (5335)	48,754 (5226)	429,514 (96,377)	151,233 (18,917)	1068,411 (230,295)	22,156 (2050)	NA	16,370 (2295)	18,977 (2152)	24,462 (2952)	49,535 (8614)	3886,272 (869,514)
	Top 25%	142,235 (226,678)	111,844 (110,470)	87,487 (33,548)	1275,219 (1159,727)	318,736 (159,292)	6834,591 (3972,647)	36,264 (10,888)	NA	35,357 (20,641)	32,594 (10,273)	45,694 (17,660)	141,790 (41,429)	1.88e+07 (3.81e+07)

Note: age expressed in years; domestic income: mean (SD) of quartile in local currency; residual%: other or not specified categories; NA=not available.

reflecting the context in which individuals lived (country of origin) and characteristics intrinsic to the person (age, gender and chronic health conditions). Model 2 included model 1 variables as well as education level, whether they lived with a partner and whether they had dependent children. Finally, model 3 included model 2 variables and respondent's employment status, political ideology and income level. The proportional odds assumption required by ordered logistic regression was tested using a likelihood ratio test. If this assumption was rejected by the test, partial proportional odds models [35] were estimated using an autofit procedure. Model selection was based on the AIC / BIC criteria [36]. Using the same approach, logistic regression models were estimated to identify predictors of each of the reasons for not getting vaccinated mentioned above. Statistical significance was set at $p < 0.05$. All analyses were performed using STATA 16 software [37]. Our quota sampling approach greatly limited the extent of missing information, hence we applied a complete case analysis approach.

3. Results

3.1. Prevalence

Marked disparities in COVID-19 vaccine hesitancy were found across the 13 countries under study. In Brazil, Uganda and India, around two thirds of the population stated that they would "definitely" get a vaccine, whereas only 15% (95% CI: 12.9 to 17.3) in France, 22% (95% CI: 17.7 to 27.0) in China and 29% (95% CI: 26.5 to 32.2) in Italy would do so. By contrast, France led in the proportion of individuals who said they would "definitely not" get a COVID-19 vaccine at 24% (95% CI: 21.0 to 26.4), followed by the US at 12% (95% CI: 10.0 to 14.4) and Italy at 10% (95% CI: 8.5 to 12.6). The proportion of those who would "probably" get a vaccine ranged between 22% (95% CI: 19.3 to 24.8) in Brazil and 55% (95% CI: 49.5 to 60.5) in China, bringing the combined proportion of individuals with favourable attitudes towards vaccination (i.e., definitively or probably accepting) to 85% (95% CI: 82.1 to 86.9) and 77% (95% CI: 71.6 to 81.8) in those two countries, respectively. On the other hand, in France this total only reached 44% (95% CI: 40.8 to 47.0), followed by Italy (62%, 95% CI: 59.2 to 65.3), and the US (64%, 95% CI: 60.6 to 67.1).

3.2. Predictors of vaccine hesitancy

3.2.1. Pooled analysis

The between-country disparities described in Fig. 1 are also evident in Table 2 where, compared to the UK, Brazil, Chile, Colombia, India and Uganda showed lower average levels of hesitancy, whereas France, Italy, the US, Spain and Canada showed significantly higher average levels of hesitancy. An older age starting from 50 years old, being diagnosed with a chronic condition and having children were all independently associated with lower hesitancy levels, relative to the respective reference categories. Women consistently reported greater hesitancy relative to men.

While there was some evidence to suggest that those with a primary education were less willing to get a vaccine than those with a university-level education, employment status did not predict attitudes toward vaccination in our survey. We found that belonging to the centre and right sides of the political spectrum was negatively associated with a willingness to get vaccinated compared to the left. However, we also found a non-linear association between income level and vaccine hesitancy, whereby the bottom quartile (poorest) in each country were more likely to be hesitant compared to the top 25%, but less or similarly hesitant to the two intermediate categories.

Model 3 was selected as providing the best fit based on the AIC / BIC criteria. Except for living with a partner, the likelihood ratio test (i.e., to check for which model variables the proportional odds assumption was not be justified) [38], failed for all the covariates included in the selected model, meaning that the average coefficients shown in Table 2 were not uniform across hesitancy levels.

Results from a partial proportional odds model (Supplementary material, Table A) revealed that the difference observed between the UK and the other four countries where hesitancy levels were lower (Brazil, Chile, Colombia and Uganda) was primarily driven by a positive difference in the proportion of respondents who would probably get vaccinated. In contrast, the higher levels of hesitancy observed for Canada, Italy and Spain were driven by a relatively smaller proportion of that group. In the US, the average higher level of hesitancy shown in Table 2 was primarily driven by a higher proportion of respondents who would "definitely not" get vaccinated.

For age, the oldest cohorts (> 70 years old) were consistently less

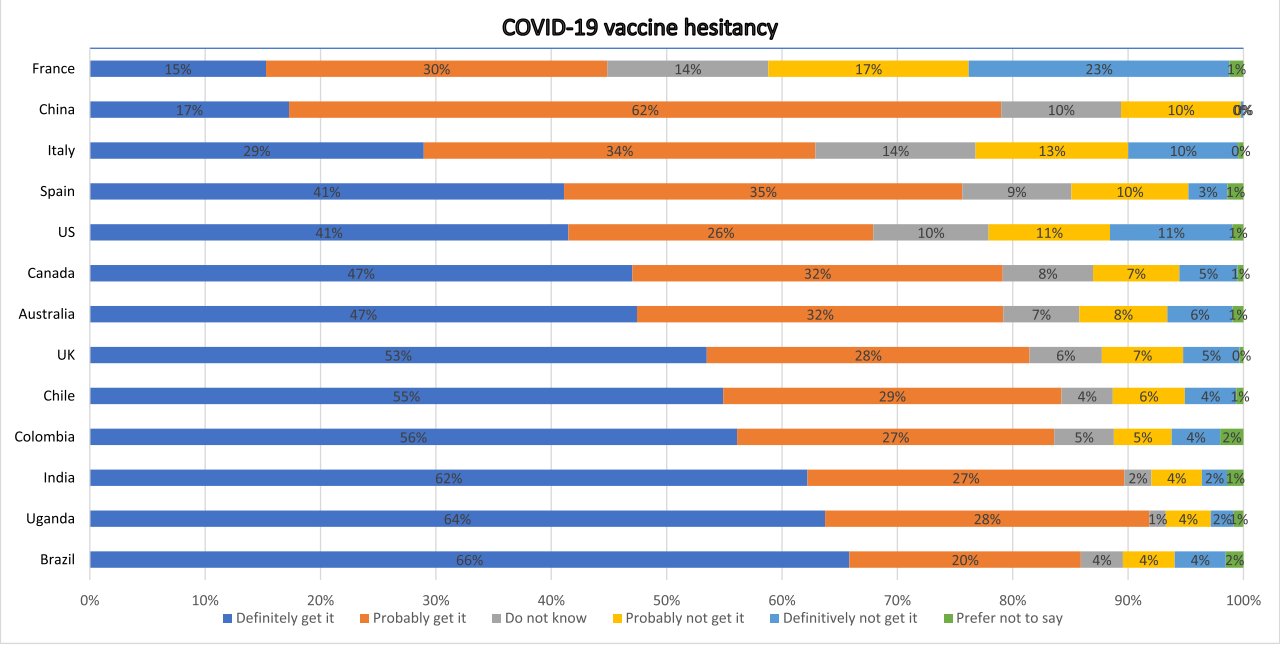

Fig. 1. COVID-19 vaccine hesitancy levels in the 13 countries.

Table 2
Predictors of COVID-19 vaccine hesitancy.

	Vaccine hesitancy[a]					
Variables	Model 1		Model 2		Model 3	
Ref: UK	B	SE	β	SE	β	SE
Australia	0.238***	−0.086	0.235***	−0.087	0.153	−0.102
Brazil	−0.594***	−0.101	−0.651***	−0.104	−0.766***	−0.123
Canada	0.163*	−0.085	0.212**	−0.086	0.168*	−0.097
Chile	−0.402***	−0.133	−0.393***	−0.126	−0.408**	−0.173
China	0.821***	−0.1	0.880***	−0.102	–	–
Colombia	−0.411***	−0.105	−0.405***	−0.106	−0.483***	−0.147
France	1.814***	−0.089	1.932***	−0.089	1.784***	−0.107
India	−0.607***	−0.09	−0.494***	−0.094	–	–
Italy	0.961***	−0.088	0.938***	−0.09	0.762***	−0.104
Spain	0.326***	−0.082	0.393***	−0.083	0.379***	−0.096
US	0.827***	−0.097	0.838***	−0.097	0.862***	−0.106
Uganda	−0.678***	−0.093	−0.708***	−0.105	−0.774***	−0.139
Ref: 18–29 years						
30–39	−0.154***	−0.058	−0.044	−0.062	−0.043	−0.079
40–49	−0.014	−0.063	0.103	−0.069	−0.024	−0.081
50–59	−0.194***	−0.063	−0.141**	−0.068	−0.138*	−0.081
60–69	−0.334***	−0.07	−0.316***	−0.075	−0.322***	−0.091
70+	−0.743***	−0.104	−0.742***	−0.107	−0.699***	−0.124
Ref: Male						
Female	0.398***	−0.04	0.400***	−0.041	0.458***	−0.049
Other	0.38	−0.257	0.236	−0.271	0.232	−0.333
Ref: Healthy						
N. of health conditions = 1	−0.181***	−0.046	−0.182***	−0.046	−0.240***	−0.054
N. of health conditions = 2+	−0.345***	−0.063	−0.341***	−0.063	−0.419***	−0.076
Ref: Primary education						
Secondary			0.065	−0.068	0.086	−0.101
University			−0.285***	−0.068	−0.181*	−0.104
Other			0.09	−0.154	−0.219	−0.272
Ref: Living alone						
Living with a partner (adult)			−0.146***	−0.046	−0.053	−0.055
Don't know/Prefer not to say			0.432**	−0.177	0.455	−0.298
ref: no dependent children						
dependent children			−0.144***	−0.048	−0.181***	−0.059
Ref: Employed						
Unemployed					−0.07	−0.09
Pension/Capital Income					−0.044	−0.104
Ref: Employed					−0.012	−0.068
Other						
Ref: Left political ideology						
Centre					0.286***	−0.057
Right					0.300***	−0.075
Ref: 0–25% domestic income						
26%−50%					0.198**	−0.099
51%−75%					−0.09	−0.111
75%−100%					−0.281**	−0.114
/cut1	−0.078	−0.078	−0.198*	−0.104	0.086	−0.164
/cut2	1.516***	−0.081	1.410***	−0.104	1.603***	−0.165
/cut3	2.034***	−0.081	1.931***	−0.104	2.047***	−0.165
/cut4	3.057***	−0.086	2.960***	−0.106	3.014***	−0.168
Observations	14,921		14,543		9235	

Note:
[a] five levels, in decreasing order: "definitely get it"; "probably get it"; "do not know"; "probably not get it"; "definitely not get it"). Ordered logistic models. Robust standard errors in parentheses.
*** $p < 0.01$,.
** $p < 0.05$,.
* $p < 0.1$.

likely to be vaccine hesitant, while for the 50–59- and 60–69 years old groups, the overall lower hesitancy was predominantly driven by greater numbers at the lowest levels of hesitancy. We also found that the positive effect of belonging to the political centre (higher hesitancy level) was mainly driven by a lower proportion of respondents who would "definitely" get vaccinated. However, this effect was driven by a higher proportion of those who would "definitely not" be vaccinated amongst those with a right-wing ideology.

3.2.2. *Country-level analysis*

The effects estimated across the 13 countries discussed above were confirmed only in part when we focused on the individual countries (Supplementary material, Table B). While in Australia, France, the UK and Uganda, the negative and broadly linear association previously found between an age above 50 years old and vaccine hesitancy was again observed, and at an even larger magnitude than across the panel, in the remaining countries this was no longer the case. In Brazil and Colombia, being only between 30 and 49 years old was negatively associated with hesitancy, while in the other countries either there was no evidence of age being a predictor or results indicated that an older age was in fact associated with higher levels of vaccine hesitancy, particularly so in the US.

In line with the pooled analysis, being diagnosed with a chronic condition was fairly consistently associated with higher willingness to get a vaccine (except in Brazil and Uganda). Women reported higher levels of hesitancy relative to men, except in China where they were more likely to get a vaccine. Level of education (Australia, Brazil and Chile), living with a partner (Australia and Chile) and having children (Canada, France and Spain) were found to play a role in attitudes toward vaccination only in a minority of countries. Unlike in the pooled model, employment status had a significant effect in five countries. In Chile, China and India being unemployed or receiving some form of income alternative to a salary, including from capital gains or pensions, was positively associated with vaccine hesitancy, while in Canada and the UK the latter category of respondents was more favourable toward getting vaccinated.

Political ideology was found to be a predictor of vaccine hesitancy in six countries, with evidence of a positive political gradient (higher hesitancy as we move further to the right) only in Brazil, Canada, Italy and Spain. Finally, in five countries (Australia, France, Spain, the UK and the US) a negative socio-economic gradient in hesitancy was observed. In Canada, only respondents from the top quartile of the income distribution were significantly less likely to be hesitant, whereas in Brazil and Uganda the third and top quartiles respectively were significantly more hesitant than those in the lowest quartile.

3.2.3. Reasons for not getting vaccinated

Reasons for not getting a vaccine were fairly uniformly distributed across the 13 countries (Supplementary material, Table C), with concerns regarding the potential side effects of vaccination against COVID-19 being consistently the most frequent, from 37.8% (95 CI 33.2–42.6) in India to 67.7% (95 CI 63.4–71.5) in Spain (Supplementary material, Table D). The probability of reporting reasons for not getting vaccinated increased with hesitancy levels, especially those regarding vaccine effectiveness and trust in health care providers.

Overall, patterns of heterogeneity differed markedly across countries both in terms of individual beliefs and attitudes toward vaccination against COVID-19 (Supplementary material, Tables E to Q). Worthy of note however, gender seemed to play a consistent role across most countries in terms of its association with specific types of reason for not getting a vaccine. Men were more likely than women to indicate lack of effectiveness (Australia and United Kingdom), no trust in the health care providers (Australia and US), a belief that enough people will be vaccinated to reach herd immunity (Australia, Brazil Canada and US) and that the virus will not be harmful to their health (Australia, Colombia, France and US) as reasons for not getting a vaccine. In Chile only, men were more likely to offer a belief of having been already infected as a reason for not getting vaccinated, whereas in India and Uganda this seemed to be the case for women. By contrast, women were consistently more likely than men to report concerns over the potential side effects in France, Spain, US and Uganda.

Evidence for age-dependent patterns for the reasons for not getting a vaccine was found, although less uniformly across countries than for gender. Except for India and Uganda, where age groups were similarly likely to give any of the six specified reasons, in all the remaining 11 countries age was significantly associated with specific reasons. In particular, concerns regarding vaccine effectiveness appeared to be more of an issue for the younger cohorts, compared to respondents aged at least 60 years old, in Australia, Canada, China, France and Italy. Conversely, these concerns were associated with being older in Colombia and Brazil. In all countries except France, age was associated with offering lack of trust in health care providers as a reason for not getting vaccinated, but there was no consistent direction of this association. In the US, concerns regarding the potential side effects of a vaccine were particularly prevalent across respondents aged 40 years old or above, whereas a belief of having been already infected was particularly associated with the youngest cohort of 18–29 years old as a reason for not vaccinating.

4. Discussion

4.1. Main findings

This study provided a global assessment and multi-country comparison of the prevalence, predictors and reasons for hesitancy toward vaccination against COVID-19 in the general adult population. We analysed data from the CANDOUR project, which surveyed 13 countries around the world, from high and low and middle-income settings, representing about half the global population and very diverse social and economic contexts. Overall, like many other studies [23,24,39,40], we found high levels of vaccine hesitancy, particularly amongst high income countries, with France leading with almost a quarter of respondents saying they would definitely not get vaccinated and less than half who would definitely or probably get vaccinated. Compared to the UK, which appeared to hold a median position in terms of average hesitancy levels, between-country differences were found, in most cases, to be primarily driven by differences in the proportion of those with degrees of indecision about whether or not to get vaccinated. An exception was the US, where respondents who would definitely not get vaccinated were disproportionally represented.

We found that the drivers of more extreme hesitancy differed from drivers of more moderate hesitancy. Lack of trust in health care providers was found to play a central role in extreme hesitancy, consistently across the large majority of countries. This may relate to, and be deeply rooted in, a wider lack of trust in public institutions as previously found in comparable research studies [30,31,41]. Although there may not be a quick and simple solution to this broader challenge, we believe that this should be recognized as a major reason for strong hesitancy against COVID-19 vaccination by policymakers and stakeholders trying to develop effective strategies, particularly multi-country interventions and campaigns. To support such endeavours future research should consider how to improve trust in public institutions and in science. Even with Delta and possibly more so with Omicron [42], it is unfortunately not the case that, as originally hoped, 70–80% of coverage would generate herd immunity and eliminate the threat from COVID [43]. This means that very high levels of coverage will need to be achieved and maintained over time, so the hardest to convince people will remain an issue for the foreseeable future.

More moderate hesitancy was also associated with a lack of trust in health care professionals in many countries, but to a lesser degree than in extreme hesitancy, and other factors such as gender and age played a more important role in many countries. Political ideology also played a role, but less consistently across countries and with this effect often being modified by income level, such as in the US where those on the political right at top income levels were similarly hesitant as those on the left side of the political ideology spectrum. Moreover, concerns regarding potential side effects were the most frequent reason for vaccine hesitancy in all the countries studied. Reasons for not getting vaccinated differed between genders across countries. Hesitant females were generally more motivated by safety concerns, while men were motivated by a belief that herd immunity would be reached, irrespectively of their behaviour, or that the virus would not be harmful to their personal health.

4.2. Comparison with previous studies

Together with a few other studies of this kind, our study has collected data from multiple countries and analysed them using a single methodological approach. Our consistent comparative approach facilitates ascertaining whether the heterogeneity in vaccine hesitancy between countries observed across individual country-level assessments stems from actual heterogeneity across countries or simply from different methodological approaches. Our findings align partly with those reported in another global survey conducted in 19 countries ($n = 13{,}426$) in June 2020 which found that, overall, 71.5% of respondents would

accept a vaccine against COVID-19 and that vaccine acceptance was generally higher in low and middle-income countries [23]. In line with our findings in terms of levels of vaccine acceptance, another survey [24] conducted in eight Western countries (n = 18,231) found France being the most hesitant, with only 45% of respondents being willing to accept a vaccine at the end of 2020, while the UK was amongst the top countries with around three quarters.

Both those multi-country studies found an overall negative association between age and vaccine hesitancy in their pooled analyses. Our results on greater hesitancy amongst females are consistent with Lindholt et al. (2021) [24] and a recent meta-analysis [44]. In contrast, Lazarus et al. (2021) [23] found that men were less likely than women to accept a vaccine. such divergence could be explained by the different groups of countries considered and the way the vaccine hesitancy questions were asked. In fact, in our study we found that women were more hesitant than men primarily in Western countries, while in China – which was included in the study by Lazarus et al. (2021) [23] - the opposite was the case and in India, Uganda and Brazil no difference was found. However, as mentioned above, differences in data collection and analysis methods make it difficult to identify the real reasons for the observed differences.

Interestingly, Lazarus et al. (2021) [23] included political ideology in their regression models and found it to be significantly associated with vaccine hesitancy, although only in a bivariate analysis. These authors however used a different set of covariates in their fully adjusted model, including conspiracy beliefs and trust in the government, which are likely to moderate the effect of political ideology on hesitancy. We instead found political ideology to interact with income level, which was not included in the analysis by Lindholt et al. (2021) [24]. Nonetheless, the effect of political ideology has been found inconsistent across countries as it is likely to be moderated by what governing party is responsible for tackling the pandemic in each country [45].

4.3. Strengths and limitations

A strength of the CANDOUR survey is that it provides insights into the attitudes and concerns that people held right at a time when the prospect of imminent COVID-19 vaccination was becoming a reality, that is between November and December 2020, but before later public concerns emerged over the safety of specific vaccines. For this reason, the findings from this study provide a valuable baseline of stated preferences (i.e., what if a vaccine would be available), which can be compared with actual vaccine uptake levels in the population, particularly in countries with advanced vaccine programmes. At the time of writing, in the UK rates of doses administered have been relatively stable since they became available to the public, with double-vaccinated reaching over 90% in the elderly and 75% of the total adult population [46]. In the US instead, while a steep increase in the number of doses administered has been observed until April 2021, a likewise decrease has also been observed since then [47], with faltering rates amongst certain subgroups (e.g., over 75 years old) and double-vaccinated reaching 68% of the adult population [48]. In many LMICs, however, distribution of vaccines doses is still only in the early stages [49] and calls for donation of vaccine doses from high income countries have been made [50].

The present study was limited to a cross-sectional design, and individuals' attitudes toward vaccination might have changed over time due to a dynamic and changing scenario, especially considering the relatively high levels of vaccine coverage in many countries. Nevertheless, longitudinal analyses have shown that attitudes toward vaccination remain relatively stable over time especially amongst individuals holding the most extreme views [23]. This makes the heterogeneity analysis presented here a potentially valuable source of information about subgroups to target and communication strategies for health authorities around the world. However, the urgency of providing timely and accurate information to public authorities imposed a constraint on the extent and depth of our investigation and analyses, hence limiting the number of dimensions and vaccine hesitancy drivers considered.

The CANDOUR survey was designed to investigate attitudes towards a hypothetical vaccine, whereas several vaccines have been developed over the last 12 months. Some of these vaccines have been met with scepticism. For example, evidence of an extremely low possibility of blot clots led to the Oxford AstraZeneca vaccine being temporarily banned from distribution in some countries and restricted for use only by certain age groups in others. Unfortunately, these very low risks have been blown out of proportion in much popular discourse via fearmongering and the spread of conspiracy theories [51]. Plans are currently in place to carry out a series of future CANDOUR survey waves, which will enable future research to better track the dynamics of vaccine hesitancy over time.

The CANDOUR study shares the same limitations as other online surveys. Selection bias could have arisen as only individuals who had access to the web and were internet-literate could provide a response. This limits the generalisability of our findings accordingly, especially in countries where that is not the norm for large sections of the population. In addition, data were incomplete for part of the samples and variables (e.g., no income data for India), hence increasing the probability of selection bias being induced in our analyses. However, quota sampling strategies were implemented, generating samples that roughly matched the populations on key characteristics (i.e., age, gender, education and region). Furthermore, post-stratification weights were calculated and applied to all the regression models to account for remaining imbalances. Nonetheless, unobserved heterogeneity may be present and could not be accounted, especially in LMICs where representativeness was likely more limited [33].

5. Conclusions

COVID-19 vaccine hesitancy is a major challenge for many countries around the world. With the emergence of the more transmissible variants, herd immunity is now unlikely, meaning that there is no threshold beyond which increasing vaccination rates would cease to be valuable. The evidence on vaccine hesitancy provided in this study can help inform the targeting and nature of interventions, such as communication strategies and vaccination incentives, that will be required for life in many countries to safely return to some form of normalcy. Future efforts should focus on monitoring attitudes towards vaccination and identifying the degree to which these stated preferences can predict actual behaviour in the population and be modified by interventions such as informational campaigns or incentives. The ongoing pandemic provides public authorities with an opportunity to build trust in institutions upon which public policy crucially hinges, and vaccine literacy which is important for managing the current pandemic, as well as preparing for the next health emergency.

Declaration of Competing Interest

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.healthpol.2023.104895.

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