BMJ Open

Which older Brazilians will accept a COVID-19 vaccine? Cross-sectional evidence from the Brazilian Longitudinal Study of Aging (ELSI-Brazil)

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ABSTRACT

Objectives Vaccine hesitancy may represent a barrier to effective COVID-19 immunisation campaigns. This study assesses individual, disease-specific and contextual factors associated with COVID-19 vaccine acceptance among a nationally representative sample of older Brazilian adults.

Design Cross-sectional analysis of data from household interviews and a supplementary telephone survey.

Setting Brazil and its five geographic regions.

Participants Data are derived from 6584 individuals aged 50 years and over who participated in the second wave of the Brazilian Longitudinal Study of Aging.

Primary and secondary outcome measures Survey-weighted multinomial logistic regression assesses factors associated with intending, not intending or being uncertain about one's intention to vaccinate against COVID-19.

Findings Seventy-one per cent of study participants intend to receive a COVID-19 vaccine once available, while 17% (representative of nearly 9 million people) have no intention to vaccinate, and 12% are still undecided. Besides age, demographic and health-related factors related to COVID-19 severity and complications were not associated with intention to vaccinate. Those who most trusted social media or friends and family for COVID-19 information and those who did not trust any information source were 68% and 78% more likely to refuse vaccination, respectively, as compared with those who trusted official information sources. People who inconsistently used face masks when outside were 3.4 times more likely than consistent face mask users to intend to refuse vaccination. Higher municipal COVID-19 fatality rates were negatively associated with vaccine refusal.

Conclusions Most national COVID-19 immunisation strategies identify older individuals as among those prioritised for early vaccination, given their increased risk of more severe symptoms and complications of the disease. Because individual, disease-specific, and contextual factors were associated with vaccine acceptance, there is a clear need for multilevel and multichannel information and outreach campaigns to

Strengths and limitations of this study

► To our knowledge, no previous studies have quantified the level of COVID-19 vaccine hesitancy among older Brazilian adults after the results of most COVID-19 vaccine trials were made public, nor systematically tested the relationship between vaccine intention and individual, disease-specific and contextual factors related to the full range of COVID-19 vaccine intentions.

► The study's advantages include its large sample size, representative at both national and regional levels and its inclusion in a well-defined population-based cohort, allowing for examination of an array of factors obtained from in-person interviews as well as via telephone survey.

► The limitations of the study include those related to the self-reported nature of the data, potential recall bias, respondents not answering calls or refusing to provide information via this means and incorrect or non-existent phone numbers.

► A final limitation is that positive vaccine intentions may not automatically translate into receipt of a vaccine as such decisions are complex and may be driven by factors that change over time.

increase COVID-19 vaccine acceptance among vulnerable older populations.

INTRODUCTION

The community transmission of the SARS-CoV-2 was officially recognised in Brazil on 20 March 2020[1]; since then, the number of new cases and deaths have grown considerably. As of 5 July 2021, the total number of new infections reached 18.8 million and there had been 524 417 deaths, making Brazil the second most affected country in terms of mortality, after the USA.[2]

Globally, the syndrome caused by SARS-CoV-2 (COVID-19) affects older adults and

those with pre-existing chronic conditions more severely.[3] Brazil has one of the world's largest older populations: a quarter of the population is aged 50 years or more and 30 million Brazilians are aged 60 and over.[4] By May–June 2020, 2.4% of Brazilians aged 50 years and older reported being told by their doctor they had COVID-19. Demographic factors (age 50–60 years), socioeconomic factors (lower household income), health-related factors (obesity, three or more chronic conditions) and geography (living in the North region of the country) were all positively associated with reporting a COVID-19 diagnosis.[5]

For COVID-19 vaccines to turn the course of the pandemic, governments must engage in an unprecedented campaign to procure sufficient quantities of vaccine, develop distribution and logistics systems and ensure equitable access to them—a challenge that is even more acute in middle and low-income countries.[6] In this context, the public's acceptance of the vaccine is crucial. Mistrust in local authorities, misinformation, confusion and fear may all affect the level of acceptance of a COVID-19 vaccine. In many countries, increasing vaccine hesitancy combined with rapidly propagated misinformation present substantial obstacles to achieving sufficiently high levels of immunisation to adequately slow viral transmission. For example, an analysis from 19 countries showed that in June/July 2020 about 72% would accept a COVID-19 vaccine, ranging from a low of 55% in Russia to 85% in Brazil and 89% in China.[7] It is important to note, however, that these figures refer to the entire adult population and do not focus on older populations that have been prioritised for early vaccine delivery.

Larson *et al*[8] suggest there are three main domains associated with vaccine hesitancy—defined as a continuum between vaccine acceptance and refusal. These include individual and group influences, such as demographic and socioeconomic factors that affect people's perceptions of vaccines and the behaviour of their peers; vaccination-specific issues related to the disease, the vaccine and the immunisation process; and contextual influences stemming from macrolevel factors such as the social, cultural, political, health system and other environmental factors. While a recent global survey[9] found that 80% of Brazilians express the view that vaccines are safe, there has been increased evidence of vaccine hesitancy reported in the country for the past few years, resulting in declining rates for some immunisations among children (eg, Bacille Calmette-Guérin or BCG and rotavirus) and adults (eg, hepatitis B and influenza).[10 11] The Brazilian Longitudinal Study of Aging (ELSI-Brazil)[12] has surveyed cohort participants on COVID-19-related topics through its ELSI-COVID initiative.[13] In November/December 2020, cohort members were given a supplementary telephone-based survey on acceptance of vaccines against COVID-19. In this study, we present findings from this first nationally representative survey on factors affecting the COVID-19 vaccine intentions among older Brazilian adults.

METHODS
Data
ELSI-Brazil is a nationally representative population-based cohort study composed of community-dwelling Brazilians aged 50 years and older. The study uses probability sampling clustered in strata that combine municipalities, census tracts and households. The final sample included 70 municipalities in all five major geographic regions of the country. The baseline survey included 9412 participants and was conducted from 2015 to 2016. The second ELSI-Brazil wave started in August 2019 but was interrupted on 17 March due to the SARS-CoV-2 pandemic. Until its interruption, 9177 wave 2 participants had been interviewed in-person and their physical measurements were taken. Public use ELSI-Brazil wave 2 data will be made publicly available online.[12]

All individuals who participated in the second wave of ELSI-Brazil were eligible for the subsequent ELSI-COVID-19 telephone interviews, carried out between May and November 2020. A description of the ELSI-COVID-19 telephone survey initiative and its methods are available elsewhere.[13]

Measures
Measures come from the face-to-face interviews from the second wave of ELSI-Brazil (pre-COVID-19), the subsequent telephone surveys and from administrative data sources providing information about the respondent's municipality of residence.

Variables derived from the in-person household interviews (conducted pre-COVID-19) included sex, age, conjugal status (married/partnered vs others), years of schooling (up to 4, 5–8, 9 and over), self-reported skin colour (white vs others), urban versus rural residence, geographic region (North, Northeast, Southeast, South and Mid-West), having a private health plan, and affiliation with Brazil's community-based primary healthcare programme, the Family Health Strategy (FHS). Health-related factors included current smoking, self-rated health (fair/poor vs good/very good/excellent), previous diagnosis of a list of chronic conditions (asthma, congestive heart failure, myocardial infarction, angina pectoris, chronic obstructive pulmonary disease, hypertension, cancer), any limitations in basic activities of daily living, receipt of a influenza shot in the past year and obesity calculated from a measured body mass index of ≥ 30 kg/m^2.

Variables from the post-COVID-19 telephone survey include the main outcome variable: acceptance of a COVID-19 vaccine based on the question, 'When the vaccine for COVID-19 is released, do you intend to get it?'. Responses were categorised as 'yes', 'no' and 'don't know/unsure'. Explanatory variables from the telephone interview included the respondent's most trusted source of information about the pandemic, 'given the amount of information about COVID-19, what is the source of information about the disease that you trust the most?' which was coded into the following categories: (1) official

sources (Ministry of Health, mayor, governor), (2) traditional media (television, newspaper, journalists), (3) social media (WhatsApp, Twitter, Facebook, internet), friends/family, or other source(s) or (4) trusts no listed sources. The interview asked whether the participant had ever received a diagnosis of COVID-19, if any family members or neighbours had been diagnosed with COVID-19, and the respondent's use of face masks when outside the home in the past week ('always' was defined as consistent use vs 'less than always' defined as inconsistent use).

Municipal-level variables obtained from the Brazilian Ministry of Health's online portal included: hospital beds per capita, population size (in 1000 s), FHS municipal population coverage (categorised as <40% vs higher). Cumulative COVID-19 cases (per 1000) and deaths (per 100 000) as of 23 November 2020 were obtained online.[14] Municipal-level COVID-19 fatality rates were calculated as deaths/cases×100.

Statistical analysis

Descriptive results are reported as percentages or means and their respective 95% CIs. A design-corrected F-test (similar to a χ^2 test, but adjusted for survey-weighted data) and survey-weighted linear regression were used to examine the statistical significance of differences between proportions and means, respectively. These bivariate analyses were used to describe the relationship between a range of explanatory variables identified in the literature and the outcome (the three categories of vaccine intention) to determine potential candidates for multivariable analysis. Multinomial logistic regression was used for multivariable analyses, with the most prevalent outcome category (will accept a vaccine) set as the reference. The final regression model was built on the descriptive analysis and previous literature. Predicted probabilities for the main, statistically significant explanatory variables (inconsistent face mask use, municipal COVID-19 case and fatality rates and most trusted source of health information) were calculated from the final model and displayed graphically. Analyses controlled for the complex sample design and survey weights specifically designed for the telephone survey. Sensitivity tests that included adjusting for municipal-level clustering of standard errors did not substantially modify any main result. Analyses were performed using Stata V.16. We used the Strengthening the Reporting of Observational Studies in Epidemiology cross-sectional checklist when writing our report.

Patient and public involvement

Neither study participants nor the public were involved in the study design, conduct, data analysis, reporting, interpretation or planning of dissemination of our research.

RESULTS

Table 1 presents participant characteristics by vaccination intention. Of the 9177 eligible ELSI-Brazil participants, 6681 (72.8%) participated in the telephone interviews,

conducted in mid-November, 2020. Of these, 97 (1.4%) had missing values for one or more measures and were dropped. Seventy-one per cent of participants expressed the intention to receive a COVID-19 vaccine once available, 16.9% expressed no intention to vaccinate and 12.2% were uncertain about whether they would vaccinate. The mean age was 63.2 years and was slightly lower (62.9) among those who intended to accept a vaccine. None of the sociodemographic factors (sex, educational attainment, household income, conjugal status, white skin colour), health conditions, healthcare coverage categories differed across vaccination intention categories. Those who intend to vaccinate had the highest rates of face mask use and were slightly more concentrated in rural areas and in municipalities with the highest municipal hospital beds per capita. One-third of participants know someone who had COVID-19, but this proportion did not vary significantly by vaccine intention. The most trusted source of information on COVID-19 for all participants was government/official sources (43.1%) followed by traditional media (31.4%), social media or family/friends (14.4%) and no trusted source (11.1%). The latter two categories were lowest among those who intended to receive a vaccine (p<0.001). Statistically significant differences across vaccine intention categories were found within the North, South and Southeast regions.

Figure 1 shows the relative frequency of participants' most trusted source of COVID-19 information, by region and vaccine intention. Across all regions and vaccine intentions, official sources or traditional media was the most common source of trusted health information, ranging from 94% among vaccine accepters in the North to 50% among those with uncertain vaccine intentions in the South. Having social media, friends or family as the most trusted source of health information or having no trusted sources was consistently more common among those who intend to refuse a vaccine, ranging from 44% in the Northeast to 23% in the South. Vaccine uncertainty generally followed the same pattern as vaccine acceptance within each region.

Table 2 shows relative risk ratios from the multinomial logistic regression of intention to vaccinate against COVID-19. Positive intention to vaccinate is the reference category for both outcomes (vaccine refusal and undecided). In comparison to those aged 50–59, individuals aged 60–74 are 1.59 times more likely and those aged 75 and over are 2.46 times more likely to express no intention to vaccinate. Inconsistent face mask users (compared with consistent users) are 3.41 times more likely to refuse vaccination. Individuals who most trust social media or friends and family or who have no trusted media sources are approximately 70% more likely than those who rely on official sources to express no intention to vaccinate against COVID-19. Regional variations are also statistically significant predictors of vaccine refusal, with the lowest rates (as compared with the Southeast) observed in the North and South. Different measures of COVID-19 severity were negatively associated with the two outcomes:

Table 1   Intention to vaccinate against COVID-19 among participants in the telephone survey of the *Brazilian Longitudinal Study of Aging* (ELSI-COVID-19 initiative), by socio-demographic, health status, COVID-19 risk factors, and municipal-level characteristics, 16–29 November 2020

	Intends to vaccinate	Does not intend to vaccinate	Unsure or does not know	Total	P value
Age (mean)	62.87	64.36	63.22	63.20	0.027
	(61.96, 63.77)	(62.72, 66.00)	(61.47, 64.98)	(62.3, 64.1)	
Female	47.69	54.74	45.89	48.67	0.1122
	(43.92, 51.48)	(47.32, 61.95)	(40.62, 51.26)	(45.62, 51.72)	
<5 years formal education	18.36	17.52	21.42	18.59	0.1652
	(15.11, 22.12)	(13.48, 22.46)	(16.48, 27.36)	(15.50, 22.13)	
5–8 years education	25.64	25.63	30.94	26.28	
	(23.03, 28.44)	(21.79, 29.88)	(24.68, 38.00)	(23.97, 28.73)	
9+ years education	56	56.85	47.64	55.13	
	(51.27, 60.63)	(50.82, 62.69)	(39.98, 55.41)	(50.93, 59.27)	
Lowest household income quintile	20.42	19.31	22.28	20.46	0.7173
	(17.71, 23.44)	(13.20, 27.34)	(16.87, 28.83)	(17.42, 23.88)	
Married/partnered	62.64	58.96	57.2	61.35	0.2823
	(58.84, 66.30)	(52.27, 65.32)	(48.37, 65.60)	(57.73, 64.85)	
White skin colour	52.29	56.91	53.55	53.23	0.4736
	(44.59, 59.88)	(48.36, 65.07)	(43.39, 63.42)	(46.09, 60.24)	
Current smoker	12.86	10.95	13.26	12.59	0.5036
	(10.70, 15.40)	(8.18, 14.50)	(10.32, 16.90)	(10.77, 14.66)	
No chronic conditions	35.08	30.96	36.27	34.52	0.4192
	(30.62, 39.81)	(25.49, 37.02)	(27.93, 45.53)	(30.84, 38.40)	
1–2 conditions	51.21	51.25	50.35	51.11	
	(48.01, 54.40)	(46.74, 55.74)	(42.54, 58.13)	(48.61, 53.61)	
3+ conditions	13.71	17.79	13.38	14.36	
	(11.29, 16.56)	(14.15, 22.14)	(9.22, 19.02)	(12.07, 17.01)	
Obese (BMI ≥30)	31.90	29.08	30.07	31.20	0.6527
	(28.69, 35.28)	(25.58, 34.02)	(22.89, 38.37)	(28.63, 33.9)	
Fair/poor self-rated health	11.72	13.29	13.42	12.19	0.5609
	(9.75, 4.03)	(9.87, 17.67)	(9.61, 18.43)	(10.34, 14.33)	
Any BADL limitation	10.31	13.03	9.77	10.71	0.4424
	(8.07, 13.08)	(8.49, 19.49)	(6.81, 13.81)	(8.70, 13.11)	
Family Health Strategy household registration	43.64	44.17	50.04	44.8	0.2496
	(37.44, 50.05)	(38.23, 50.28)	(40.72, 59.35)	(39.10, 50.63)	
Private health plan	28.59	31.87	24.16	30.37	0.4820
	(23.47, 34.34)	(27.68, 36.37)	(16.65, 33.68)	(26.50, 34.54)	
Received influenza shot in the past 12 months	66.38	58.89	63.15	64.72	0.0791
	(62.08, 0.43)	(51.44, 65.95)	(55.85, 69.89)	(60.68, 68.56)	
Inconsistent use of face mask when outside*	2.3	4.47	2.42	2.68	0.0098
	(1.63, 3.24)	(2.93, 6.77)	(1.81, 3.23)	(2.08, 3.46)	
Knows someone who had COVID-19†	34.47	34.36	26.04	33.43	0.0867
	(29.95, 39.29)	(28.28, 41.0)	(19.65, 33.64)	(29.39, 37.72)	
Previous COVID-19 diagnosis	5.33	6.63	4.83	5.49	0.5539
	(3.72, 7.58)	(3.93, 10.98)	(3.60, 6.45)	(4.18, 7.18)	

Continued

Table 1 Continued

	Intends to vaccinate	Does not intend to vaccinate	Unsure or does not know	Total	P value
Official‡ sources for COVID-19 information	44.42	36.59	44.46	43.11	<0.0001
	(40.47, 48.45)	(31.36, 42.14)	(37.30, 51.86)	(39.70, 46.58)	
Traditional media§ is the most trusted information source	33.83	25.38	25.34	31.41	
	(30.49, 37.33)	(20.81, 30.57)	(20.42, 30.98)	(28.71, 34.23)	
Social media/family/ others as most trusted information	12.65	21.0	15.56	14.4	
	(10.72, 14.87)	(16.96, 25.69)	(10.71, 22.06)	(12.45, 16.59)	
No trusted source of COVID-19 information	9.1	17.03	14.64	11.09	
	(7.61,10.84)	(13.69, 21.00)	(10.84, 19.49)	(9.44, 12.98)	
Rural residence (vs urban)	15.26	10.71	14.03	14.34	0.0295
	(11.02, 20.75)	(7.64, 14.82)	(9.27, 20.69)	(10.43, 19.40)	
North region¶	75.21	7.15	17.64	7.62	0.0021
	(66.8, 82.07)	(4.08, 12.24)	(12.54, 24.24)	(3.96, 14.17)	
Northeast region	75.85	14.6	9.55	26.32	0.1475
	(69.08, 81.53)	(9.95, 20.92)	(7.33, 12.36)	(18.13, 36.57)	
Southeast region	64.23	23.79	11.98	39.28	0.0000
	(58.64, 69.46)	(19.32, 28.92)	(9.73, 14.67)	(28.30, 52.72)	
South region	75.14	10.31	14.55	16.73	0.0002
	(71.9, 78.11)	(8.22, 12.86)	(12.31, 17.11)	(8.15, 31.26)	
Mid-west region	73.5	14.24	12.26	9.91	0.7456
	(63.03, 81.86)	(9.75, 20.32)	(5.77, 24.19)	(5.09, 18.41)	
Low municipal FHS (<40% population)	17.54	23.69	19.8	18.86	0.3281
	(9.77, 29.47)	(8.84, 49.85)	(8.88, 38.49)	(9.60, 33.72)	
Municipal hospital beds/ capita (mean)	25.17	21.84	23.59	24.29	0.014
	(21.66, 28.68)	(17.96, 25.71)	(20.21, 26.96)	(20.95, 27.63)	
Municipal population in thousands (mean)	1096	1159	860	1064	0.099
	(903, 1289)	(816, 1503)	(595, 1125)	(891, 1236)	
Municipal COVID-19 cases per 1000	22.46	23.01	21.65	22.47	0.121
	(20.12, 24.80)	(20.85, 25.18)	(18.90, 24.40)	(20.24, 24.71)	
Municipal COVID-19 case fatality rate (%)**	3.72	3.44	3.62	3.66	0.449
	(3.35,4.13)	(2.96, 3.93)	(2.89,4.34)	(3.25, 4.07)	
Weighted proportion	70.82	16.98	12.20	100	
N (weighted)	37 324 954	8 950 783	6 429 516	52 705 253	
N (unweighted)	4524	1186	874	6584	

All numbers are weighted percentages except where specified; 95% CIs are in brackets; p values come from design-corrected F-test for difference between groups.

*Those who left the home in the past 7 days and reported less frequent face mask use than 'always'.

†Knows either a household member or neighbour who was diagnosed with COVID-19.

‡Ministry of Health and political leaders, governors/authorities.

§Traditional media are radio, television, newspapers or journalists.

¶Regional analyses present weighted proportions of individuals in each vaccine intention category, within that region. The numbers in the total column represent the relative population size of each region. The p values are from a design-corrected F-test of the hypothesis that within-region proportions are equivalent across vaccine intention categories.

**Total cumulative municipal deaths/total cumulative municipal cases *100.

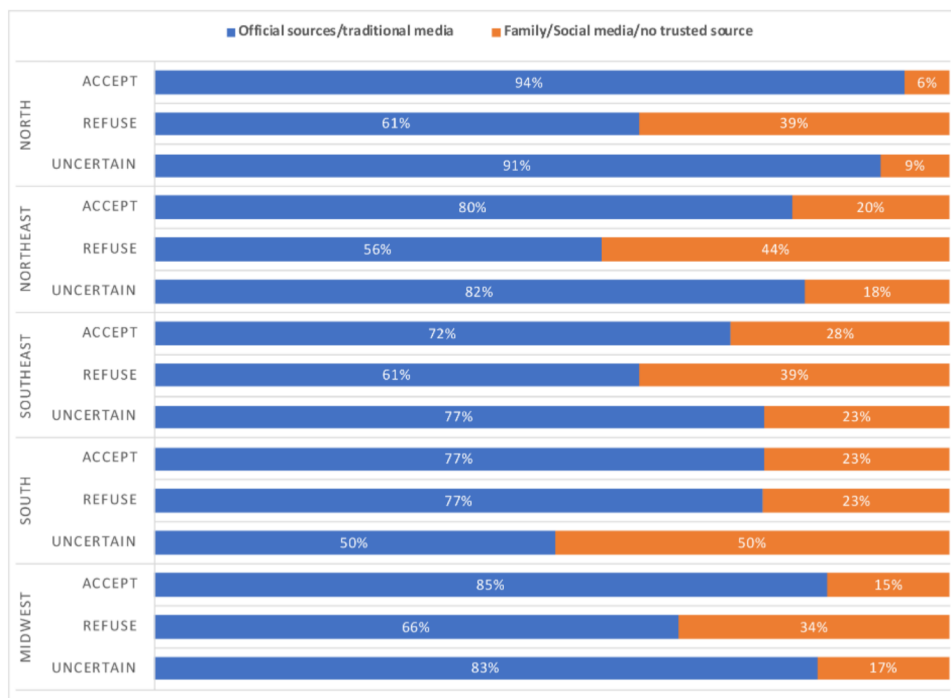BADL, basic activities of daily living; BMI, body mass index; FHS, Family Health Strategy.

Figure 1 Proportion of most trusted source of information on COVID-19, by intention to receive COVID-19 vaccine and region, among participants in the telephone survey of the *Brazilian Longitudinal Study of Aging* (ELSI-COVID-19 initiative), 16–29 November 2020. Numbers are weighted proportions of most trusted information source by vaccine intention category within each region. Due to rounding, totals may not always add to 100.

vaccine refusal falls as municipal fatality rates rise, and vaccine uncertainty likewise falls as cumulative municipal cases per 1000 population rise. No statistically significant associations were observed for gender, educational attainment, chronic conditions, rural/urban residence or municipal population size in fully adjusted analyses. There was little evidence of multicollinearity in the final model (average variance inflation factor=1.20).

Figure 2 shows predicted probabilities of intention not to vaccinate against COVID-19 stratified by the main explanatory variables found to be statistically significant predictors of vaccine refusal. Those who most trust social media/friends/family and those who trust no information sources are about two times as likely to report intending to refuse a COVID-19 vaccine than those who most trust official sources or traditional media outlets. For all trusted information sources, the probability of vaccine refusal is lowest where municipal COVID-19 fatality rates are highest. For all trusted information sources, inconsistent (as compared with consistent) face mask use is associated with about two times the probability of vaccine refusal.

Figure 3 shows predicted probabilities of the main factors associated with being uncertain about receiving a COVID-19 vaccine as presented in table 2. Uncertainty slightly decreases for all participants as the rate of municipal COVID-19 cases increases. Among those with consistent face mask use, those who most trust traditional media have the lowest predicted rates of vaccine uncertainty, while those who trust no information sources have the highest predicted probability of vaccine uncertainty. Among those with inconsistent face mask use, the lowest

rates of vaccine uncertainty are observed among those who most trust social media, while the highest predicted rates are observed among those who most trust official sources and among those who trust no information sources.

DISCUSSION

Our results show that 71% of participants intended to vaccinate when COVID-19 vaccines become available, while 17% had no intention to vaccinate and 12% were still uncertain. Given the nationally representative nature of the survey, this translates to about 8.9 million Brazilians aged 50 and over who do not intend to vaccinate and 6.4 million who are unsure. These results have implications for Brazil's National COVID-19 Vaccination Plan,[15] which identifies four priority groups, totalling 50 million people. In addition to frontline health workers, the first priority group is made up of people aged 75 and over and the second group consists of people aged 60 and over. Together, the number of refusals and unsure older adults identified in this study represent about 17% of the population prioritised for early vaccination.

Most demographic factors, except age, were not associated with vaccine refusal or uncertainty. Among those aged 60–74 and 75 years or older, respectively, 18% and 22% do not intend to be vaccinated, while 12% and 14% are undecided about vaccination. This finding contrasts with worldwide patterns identified in a systematic review that shows age is positively associated with being more receptive to a COVID-19 vaccine.[16] One explanation for

Table 2 Multinomial logistic regression of intention to vaccinate against COVID-19 among participants in the telephone survey of the *Brazilian Longitudinal Study of Aging* (ELSI-COVID-19 initiative), 16–29 November 2020

	Does not intend to vaccinate (vs does intend)	Unsure/does not know (vs does intend)
Ages 60–74 years (vs 50–59 years)	1.59** 1.13, 2.21	0.89 0.62, 1.27
75+ years	2.46*** 1.53, 3.95	1.31 0.81, 2.14
Female	1.3 0.94, 1.79	0.88 0.66, 1.18
5–8 years education (vs fewer)	0.99 0.73, 1.34	0.95 0.65, 1.40
9+ years of education	1.25 0.88, 1.78	0.79 0.56, 1.12
1–2 chronic conditions (vs none)	0.97 0.68, 1.38	0.84 0.55, 1.29
3+ chronic conditions	1.13 0.70, 1.82	0.72 0.40, 1.31
Received influenza shot in the past 12 months	0.63*** 0.49, 0.79	0.86 0.55, 1.34
Inconsistent face mask use	3.41*** 1.90, 6.09	0.96 0.55, 1.69
Knows someone diagnosed with COVID-19	1.18 0.90, 1.54	0.69 0.44, 1.08
Source of COVID-19 information is traditional media (vs official sources)	0.77 0.58, 1.02	0.73 0.48, 1.10
Social media/family/other sources	1.67** 1.14, 2.44	1.27 0.73, 2.21
No trusted source of information	1.71*** 1.25,2.34	1.6* 1.03,2.48
Rural (vs urban)	0.91 0.71, 1.18	0.77 0.55, 1.09
North region (vs Southeast)	0.24*** 0.11, 0.50	1.72 0.98, 3.02
Northeast region	0.63 0.36, 1.10	0.77 0.50, 1.18
South region	0.5** 0.33, 0.77	1.16 0.76, 1.78

Continued

Table 2 Continued

	Does not intend to vaccinate (vs does intend)	Unsure/does not know (vs does intend)
Midwest region	0.79 0.37, 1.68	1.56 0.86, 2.82
Municipal hospital beds per capita	0.98** 0.96, 0.99	0.99 0.98, 1.01
Log municipal population	1.08 0.97, 1.21	0.97 0.90, 1.05
Municipal COVID-19 cases, 1000	0.99 0.98, 1.01	0.99* 0.98, 1.00
Municipal COVID-19 fatality rate*	0.89* 0.79, 1.00	0.94 0.89, 1.01

*p<0.05; **p<0.01; ***p<0.001.
Numbers are relative risk ratios and 95% CIs of survey-weighted multinomial logistic regression. Reference value is those who intend to receive a COVID-19 vaccine when available.
*Total municipal deaths/total municipal cases *100.

this discrepancy may be that other studies have surveyed the entire adult population, whereas this study focused only on older adults, using age 50–59 as the reference category.

Heart conditions, chronic obstructive pulmonary diseases, diabetes mellitus and obesity are thought to be associated with more severe COVID-19 symptoms.[17] A study conducted in Scotland found that those at higher risk of COVID-19 complications and death were almost two times as likely to accept a COVID-19 vaccine than those without such risk factors.[18] However, our study did not find any association between health conditions that raise the risk of COVID-19 complications and death and respondents' intention to be vaccinated. This suggests that at least part of the population at risk for such complications has not understood, has not been informed or has chosen to ignore information about their high-risk status. It may also suggest that vaccine intentions are driven by more than one's potential risk for more severe forms of the disease.

Several COVID-19-specific factors were associated with the intention to vaccinate. Potential vaccine refusal was highly correlated with protective measures such as consistent use of face masks when going outside the home. There is evidence that face mask use is associated with lower risk of contracting SARS-CoV-2.[19 20] Moreover, at least some of those who do not use face masks may be subjected to COVID-19-related misinformation regarding the severity of the disease or the effectiveness of cloth face coverings in reducing infection and transmission.[21] This result implies there is a need for additional promotion of the benefits of face mask wearing in public, from both self-protection and altruistic perspectives.[22] Neither
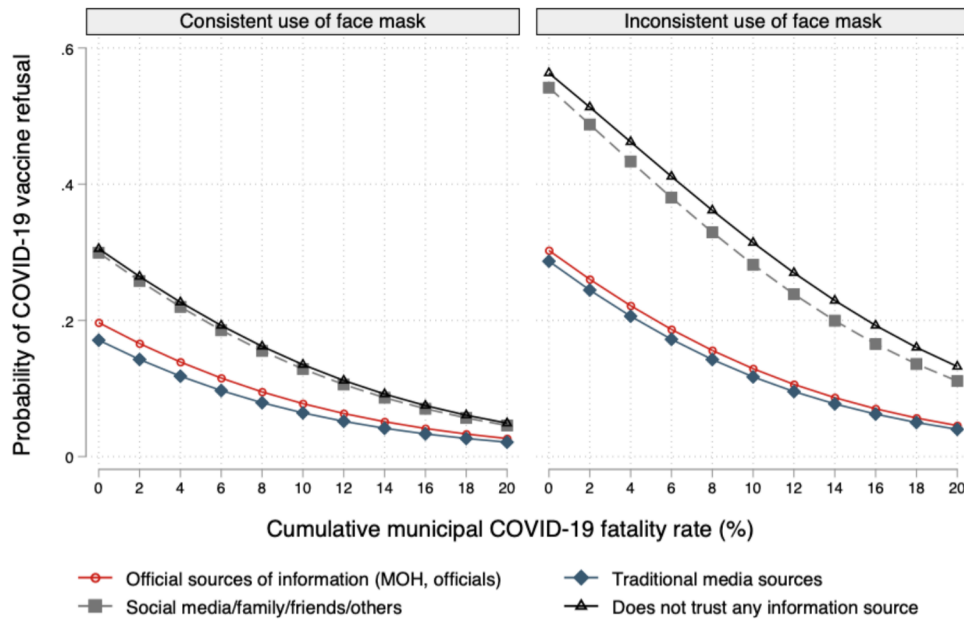
Figure 2 Predicted probability of intention to refuse a COVID-19 vaccine, by most trusted source of information, consistency of face mask use, and municipal COVID-19 fatality ratio among participants in the telephone survey of the *Brazilian Longitudinal Study of Aging* (ELSI-COVID-19 initiative), 16–29 November 2020.

a previous COVID-19 diagnosis nor knowledge of an individual who had contracted the disease was significantly associated with intention to vaccinate against the disease, similar to results found in previous studies.[7]

A strong and consistent predictor of vaccine intention was an individuals' most trusted source of information about COVID-19. Official sources (Ministry of Health or state or local government), followed by the traditional press, were the most prevalent among all groups and was associated with greater intention to vaccinate. Still, a sizeable proportion of individuals in each region (ranging from 29% in the Northeast to 52% in the North) who most trusted official sources nevertheless had negative vaccine intentions. Given the novelty of COVID-19 and the preliminary nature of early announcements of vaccine efficacy, some level of uncertainty or doubt is probably warranted. Examination of open-ended responses as to why individuals said they would not receive a vaccine indicated 'fear' or 'lack of confidence' in safety or efficacy as the most common explanations, closely followed by doubt about the integrity of the vaccine manufacturer—especially if not produced in Brazil, and antivaccine statements such
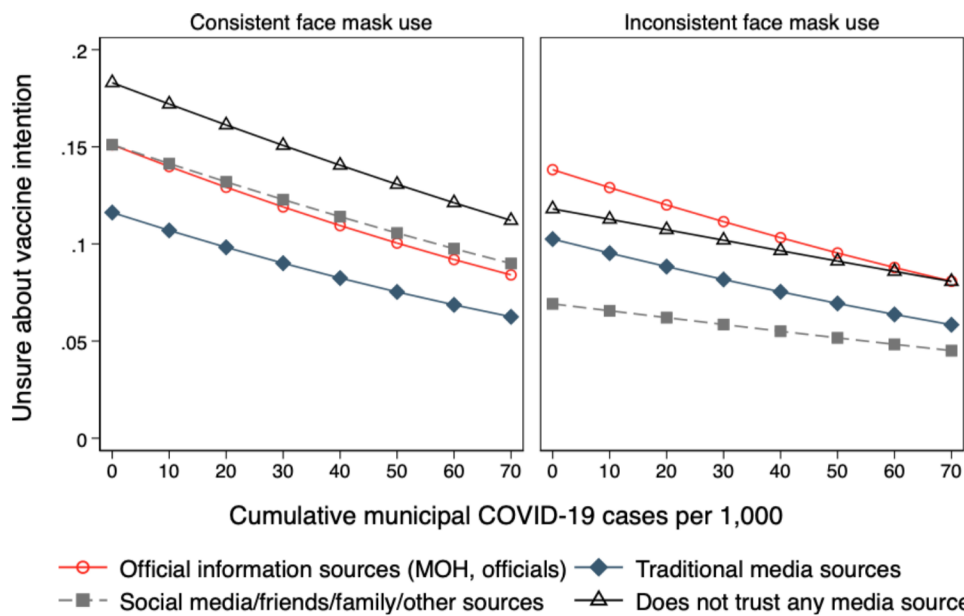
Figure 3 Predicted probability of being unsure about one's intention to receive a COVID-19 vaccine, by most trusted source of COVID-19-related information, consistency of face mask use, and municipal COVID-19 cases among participants in the telephone survey of the *Brazilian Longitudinal Study of Aging* (ELSI-COVID-19 initiative), 16–29 November 2020.

as, 'vaccines kill' (data not shown). For these reasons, public health officials must demonstrate more effectively the safety of the vaccine and work to counteract antivaccine messaging through official channels as well as social media and other informal sources that are more heavily relied on among those with negative or uncertain vaccine intentions.[16 23–25]

Contextual factors were more consistently associated with vaccine refusal than with vaccine uncertainty. The SARS-CoV-2 epidemic has progressed heterogeneously in different regions of the country. The Southeast, Northeast and North regions first presented the initial cases, while in the South and Midwest regions, cases increased later.[26] The highest proportion of vaccine refusal was observed in the Southeast (23.8%) and the lowest in the North region (7.2). This is in spite of the fact that, at the time of the interview, the Southeast and South regions (most populous) had the highest absolute numbers of reported cases and deaths (not rates).[26] Analysis of municipal-level (rather than regional-level) COVID-19 cases and fatality rates showed that the higher the municipal rates, the lower the likelihood of vaccine uncertainty and refusal, respectively. This suggests that the severity of the epidemic in one's own municipality (as opposed to trends at the regional level, which would mask municipal-level heterogeneity) may be an important contributor to vaccine intentions.

Brazil has one of the most extensive immunisation programmes in the world. Since 1999, influenza vaccines are provided free-of-charge to all adults aged 60 years or more.[27] While influenza immunisation coverage has remained close to the 75% target proposed by the WHO, only 65% of participants reported receiving a influenza shot in past year (pre-COVID-19). Moreover, previous receipt of a influenza shot was negatively associated with vaccine refusal (OR 0.63; 95% CI 0.49 to 0.79). There may, therefore, be a contingent of older adults who have become less receptive even to better-known vaccines such as those for influenza and this attitude or experience may affect their acceptance of a COVID-19 vaccine.

The importance of the Brazilian health system and its unique community-based primary healthcare model, the FHS, should also not be underestimated. Older adults affiliated with the FHS were found to be 36% more likely than those not affiliated to be vaccinated against influenza.[27] The reach of the FHS (covering about 61% of the Brazilian population) and its nearly 260 000 community health agents who make household visits on a regular basis provides an opportunity to involve primary care units in vaccine delivery as well as in communications efforts. The use of population-based registers of households covered by the FHS may provide an additional tool to identify individuals who should be prioritised to receive a COVID-19 vaccine and those who have not been vaccinated.[28] Nevertheless, neither household enrollment in the FHS nor municipal-level FHS coverage rates were associated with the intention to vaccinate. This may be because, at least up until the time of the interview, these

resources were not actively incorporated into a national anti-COVID-19 strategy.[29]

The major strength of this study is its large population base, with over 6500 interviews carried out among older adult residents prioritised for COVID-19 vaccination in 70 municipalities in all five major Brazilian regions. Another advantage is its inclusion in a well-defined population-based cohort, allowing for examination of an array of factors obtained from pre-COVID in-person interviews as well as via the post-COVID telephone surveys. Furthermore, this study goes beyond a dichotomy of vaccine acceptance/refusal to include the category of vaccine uncertainty, which has not been as well explored in the context of COVID-19. Unfortunately, there were few factors identified that were significantly associated with vaccine uncertainty, as compared with vaccine refusal. This suggests the importance of continuing to separate vaccine refusal from uncertainty in any study. It also suggests the need for further investigation into the determinants of vaccine uncertainty in general and to explicitly test the assumption that it may be easier to sway someone who is uncertain to accept a vaccine than someone who intends to refuse it.

The limitations of the study are those inherent to cross-sectional telephone surveys, including self-report and recall bias, respondents not answering calls or refusing to provide information via this means and incorrect or non-existent phone numbers.[13] To compensate for non-response, we used weights specifically derived for respondents for each wave of the telephone interview. Using these weights and sample parameters, the distribution of sociodemographic characteristics of study participants was similar to that of the Brazilian population in the same age group (see online supplemental appendix). However, we cannot rule out the possibility of bias due to unmeasured factors that could affect phone availability or response. Finally, it is important to note that positive vaccine intentions may not automatically translate into receipt of a vaccine as such decisions are complex and may be driven by factors that change over time.[7]

CONCLUSION

The task ahead of the Brazilian government is to deliver vaccines as quickly as possible, with a priority for vulnerable populations, such as the elderly and those with specific health conditions. This task will require clear, unambiguous and targeted messaging to convince those who are unsure about the importance and urgency of receiving a COVID-19 vaccine. A far greater challenge will likely be reaching and changing the minds of those nearly 9 million older Brazilians who have said they will not take a COVID-19 vaccine. This task that will require intensive, evidence-based social marketing and other approaches carried out on a massive scale. It will require mobilisation of the nation's health system as well as political leaders and civil society to explain consistently and clearly the benefits (and risks) of each vaccine and to counteract

unfounded claims regarding such important protective measures.

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