COVID-19 vaccine trust and uptake: the role of media, interpersonal and institutional trust in a large population-based survey

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Summary

Background Vaccine uptake is critical to controlling COVID-19 and other infectious diseases, and trust in vaccines is a key determinant of vaccine coverage. This study aims to examine how individual characteristics and primary information sources during the pandemic influenced COVID-19 vaccine trust and uptake.

Methods We performed a secondary analysis of the EPICOVID 2.0 survey, a Brazilian nationwide study (March–April 2024) that used multistage probabilistic sampling. Participants aged 18 or older from the EPICOVID 2.0 study were included in the analyses. Machine learning algorithms were employed to predict COVID-19 vaccine trust and uptake, measuring the influence of each covariate on the predicted probabilities.

Findings Among 29,281 participants (63.9% women; median age 51 years), 60% reported trusting the COVID-19 vaccine and 72% had received ≥3 doses. Uptake strongly correlated with trust: 67% of unvaccinated or unsure participants distrusted the vaccine, while trust increased with the number of doses—62.6% (3 doses), 73.8% (4 doses), and 89.8% (≥5 doses). Gen Z adults (18–30 years) were less likely to trust the vaccine (negative influence of −0.07). Positive predictors of trust included higher education and trust in television or nurses as information sources (positive influences of 0.05, 0.09 and 0.07, respectively).

Interpretation Trust and uptake of the COVID-19 vaccine were moderate, 60% and 72%, respectively. Gen Z adults reported greater distrust and lower uptake, while higher education was associated with increased trust. These findings highlight the need for tailored communication and health literacy interventions to improve vaccine uptake.

Funding Brazilian Ministry of Health.

Keywords: Vaccine trust; Vaccine uptake; SARS-CoV2; Coronavirus; Survey

Introduction

The COVID-19 pandemic imposed a substantial global burden, characterized by high morbidity and excess mortality. As of 2025, more than 7 million deaths have been reported worldwide.[1] An unprecedent international effort led to the rapid development of vaccines, a cornerstone of the pandemic control, significantly reducing COVID-19 severity and mortality.[2] Beyond the role during the COVID-19 pandemic, vaccine uptake is a critical public health priority for the

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Research in context

Evidence before this study

"We systematically searched PubMed and Embase using the following search terms (("adults" OR "adult" OR "age groups") AND ("COVID-19 Vaccines" OR "covid-19 vaccin*" OR "coronavirus vaccin*" OR "SARS-CoV-2 vaccin*") AND ("information seeking behavior" OR "social media" OR "mass media" OR "television" OR "news" OR "information source*" OR "health communication" OR "health information") AND ("trust" OR "vaccine hesitancy" OR "vaccine acceptance" OR "vaccine uptake")). We included original studies published in English as of 2025-05-27. Prior evidence predominantly derived from high-income countries, with limited nationally representative data. Studies inconsistently categorized age groups, complicating cross-study comparisons, though older adults generally exhibited higher vaccine trust and uptake. Higher educational attainment and traditional media use (television, newspapers) were consistently associated with increased vaccination likelihood, while reliance on social media correlated with lower uptake.

Added value of this study

Prior evidence on vaccine trust lacked nationally representative data from low- and middle-income countries, particularly on the role of information sources. Our study addresses this gap by analyzing COVID-19 vaccine trust and uptake in a nationally probabilistic sample of Brazilians. Results showed high overall uptake alongside important age group differences: GenZ adults (18–30 years) were disproportionately likely to distrust and to have lower vaccine uptake. High educational attainment (≥12 years) was associated with increased trust in the vaccine. We further identified trust in television and nurses as key drivers of vaccine trust, offering actionable insights for public health messaging. Importantly, we found a dose–response relationship between vaccine trust and uptake, linking higher trust to increased likelihood of receiving booster doses.

Implications of all the available evidence

Available evidence confirms the positive impact of higher education on vaccine trust. Media consumption and technology use complicate public health communication, presenting both challenges and opportunities for engagement. The Brazilian experience, here presented, demonstrates that even in high-uptake settings, generational gaps exist—particularly among Gen Z. Innovative, youth-engaged communication strategies might be needed to address challenges in vaccine trust and uptake. Future research should further explore drivers of distrust in low-uptake subgroups, but immediate action should prioritize health literacy programs and culturally adapted public health messaging strategies designed to specific population subgroups delivered through platforms that are used and trusted by them.

control of other infectious diseases, with trust in vaccines being a key determinant of vaccine coverage.[3]

The level of trust that a person has towards vaccines is influenced by multiple factors including personal beliefs and knowledge which may be influenced by information sources and the spread of misinformation.[4] During the COVID-19 pandemic, the spread of misinformation (inaccurate information that is spread without the intent to deceive) and disinformation (inaccurate information that is deliberately created and spread with the intent to deceive) prompted the World Health Organization (WHO) to declare an "infodemic", defined as an overabundance of information, including misleading or false content, that can hinder the public's ability to make informed, evidence-based health decisions.[5]

Understanding how individual characteristics and main information sources used during the pandemic influenced COVID-19 vaccine trust and uptake is essential for designing more effective public health communication and health literacy strategies. This study assessed the predictive role of demographic and socioeconomic factors, as well as media, interpersonal and institutional trust in shaping COVID-19 vaccine trust and uptake. Furthermore, we evaluated the performance of innovative machine learning (ML) algorithms in predicting vaccine trust and uptake using data from a nationwide population-based survey conducted in Brazil between March and April 2024, identifying subpopulations most likely to distrust or reject COVID-19 vaccines.

Methods

Study design and population

EPICOVID 2.0 was a nationwide survey covering all 26 Brazilian states and the Federal District conducted in March and April of 2024.[6] The survey included the urban area of the most populous cities within each of the 133 intermediate regions defined by the Brazilian Institute of Geography and Statistics (IBGE). The study employed a multistage probabilistic sampling method such that, within each selected city, 25 census tracts—small geographic areas used to collect census data—were selected with probability proportionate to population size. From each census tract, 10 households were randomly chosen using maps and household listings provided by IBGE, resulting in a total sample of 250 households per city across all 133 cities in Brazil. Details on study design and sampling methods are available elsewhere.[6] Briefly, the study team visited the selected households and noted the age and gender of all

members. Household members aged one year or older were eligible for inclusion in the study. Within each household, one eligible member was randomly chosen to participate in the survey. If the initially selected individual declined to participate, a second household member was randomly selected. In cases where this second person also refused, the study team moved to the next household to the right. For single-person households where the sole resident declined participation, the team similarly proceeded to the next household. In total, the EPICOVID 2.0 study enrolled 33,250 participants. For this secondary analysis, only participants aged 18 years or older were included.

During the in-person enrollment visit, data collection was conducted using an interviewer-administered structured questionnaire programmed on a smartphone app. The study questionnaire consisted of 215 questions, including validated instruments and close-ended questions which covered four sections: (i) socio-demographic information (age, gender, race/ethnicity, education level, occupation, and household assets); (ii) COVID-19 symptoms and post-COVID clinical manifestations; (iii) the impact of COVID-19 on participant's life; and (iv) COVID-19 vaccination history.[6] Questions and instruments included in this secondary analysis are detailed in the Supplementary Material Table S1.

All participants provided written informed consent before participating in the study. Ethics approval was obtained from the School of Physical Education Ethics Committee at the Federal University of Pelotas (CAAE: 68382923.8.0000.5313).

Outcome

This study explored two main outcomes: COVID-19 vaccine trust and COVID-19 vaccine uptake. Vaccine trust was measured by asking, *"Considering all the information you received about COVID-19 vaccine, did it make you feel more motivated to …"* with response options: *"distrust the vaccine," "indifferent,"* and *"trust the vaccine."*

Vaccine uptake was determined using two questions: *"Have you ever been vaccinated against COVID-19?"* with response options *"yes," "no,"* or *"don't know,"* and, among those who answered "*yes*", *"How many doses have you received?"* with response options *"one," "two," "three," "four," "five,"* and *"six or more."* These responses were then combined into a new variable, *"vaccine uptake,"* with the following categories: *"none/don't know," "one dose," "two doses," "three doses," "four doses,"* and *"five or more doses."*

Covariates

The complete list of covariates (and possible responses) included in the initial XGBoost models is described in the supplementary material (Table S1). These include sociodemographic characteristics, place of residence (state and city), socioeconomic indicators (household characteristics and assets, employment, food insecurity), COVID-19 pandemic impacts across multiple domains (health, psychological, behavioral, social, financial, and lifestyle), comorbidities, information consumption patterns (media access and usage), trust in COVID-19 information sources (people, institutions, media), and face mask adherence during the pandemic.

Participants' age/birth generation (categories: 18–30 years [GenZ], 31–45 years [Millennials], 46–60 years [GenX], 61–79 years [Boomers], 80 years or older), sex, schooling (categorized in years of formal education: 1–4 years, 5–8 years, 9–12 years, ≥12 years [higher education]), race/skin color (White, Black, Pardo [Mixed], Asian, Indigenous), and religious affiliation were assessed. Household-related factors, including access to internet, number of TVs, and number of computers, were also evaluated.

Participants were asked about their use of various media sources (e.g., TV, printed newspapers, radio, WhatsApp, Twitter/X, Facebook, Instagram—see Supplementary Material Table S1 for the full list) to gather information about COVID-19 and health measures. They responded to the question, *"During the pandemic, how did you gather information about COVID-19 and health measures?"* for each medium, response options included: *"did not use," "a few times," "moderate use,"* or *"intense use"*.

Participants were also asked, *"How much do you trust the following media sources for information about COVID-19?"* (see Table S1 for the full list). For each source, participants could choose from the following response options: *"Never trust," "Rarely trust," "Neither trust nor distrust," "Moderately trust,"* and *"Always trust"*.

Participants were asked, *"How much do you trust the following people or institutions for information about COVID-19?"*. Trust sources included parents, friends, religious leaders, journalists, and others (see Table S1 for the full list). For each source, participants selected from the following response options: *"Never trust," "Rarely trust," "Neither trust nor distrust," "Moderately trust,"* and *"Always trust."*

Statistical analysis

We described the sociodemographic characteristics and the level of media, interpersonal and institutional trust of participants according to their response to the "COVID-19 vaccine trust" question (*"distrust the vaccine," "indifferent,"* and *"trust the vaccine"*) using frequency and percentages for categorical variables and median and interquartile range for numerical variables. Between-group comparisons were made using the chi-

squared and Wilcoxon tests, for categorical and numerical variables, respectively. We then assessed the association between COVID-19 vaccine trust and COVID-19 vaccine uptake using the chi-squared test.

Machine learning (ML) algorithms were employed to predict individuals' COVID-19 vaccine trust and uptake. For the outcome COVID-19 vaccine trust, we evaluated the predictive performance of demographic and socioeconomic factors, as well as of media, interpersonal and institutional trust. For the outcome COVID-19 vaccine uptake, with responses aggregated into four levels, *"none/don't know," "one dose," "two doses," "three doses or more"*, we assessed the predictive performance of these same factors while also considering COVID-19 vaccine trust as a potential predictor. Our algorithm explored the covariate space to generate interpretable models that predict levels of vaccine trust (*"distrust the vaccine," "indifferent,"* and *"trust the vaccine"*) and vaccine uptake (*"none/don't know," "one dose," "two doses," "three doses or more"*).

The implementation ML algorithms followed a consistent approach for both outcomes examined in this study (Fig. 1). The study data were randomly divided into three non-overlapping subsets: 75% of the data were allocated as a training dataset, 5% were reserved as a testing dataset for model validation and performance evaluation (assessed using metrics such as accuracy, precision, recall, Area Under the Receiver Operating Characteristic Curve [AUC-ROC] 'One versus Rest', Expected Calibration Error [ECE] and confusion matrices), and 20% were used for statistical inferences during the training of explainable models. The implementation steps are outlined below and described in detail in the Supplementary Material.

First, gradient boosted trees (XGBoost)[7] were trained using all covariates of interest of the training dataset (Table S1). Gradient boosted trees are a machine learning technique applicable to both regression and classification tasks. They operate by sequentially building an ensemble of decision trees, where each subsequent tree aims to correct the errors of the previous one. This approach allows the model to capture complex patterns in the data, often resulting in superior predictive performance compared to simpler, more parsimonious models. However, this increased predictive performance comes at the cost of higher model complexity. Gradient boosted trees are often considered 'black-box' models due to their lack of inherent explainability and the challenges associated with interpreting their high-dimensional structures.

Second, using the statistical inference dataset, we sought to identify smaller combinations of covariates that maintained high predictive performance while being more interpretable and actionable. To achieve this, we systematically explored various covariate combinations (detailed in the Supplementary Material and Table S2) using an iterative refinement process. For each subset of covariates, a Generalized Additive Model (GAM) was fitted.[8,9] These GAMs were then compared and ranked based on their predictive performance using an e-value-based test to assess the independence between each GAM's predictions and the predictions generated by the XGBoost models. E-values procedure details are described in the Supplementary Material.

Third, using the statistical inference dataset, we analyzed the GAMs developed during the previous step by quantifying the influence of each covariate in terms of its impact on the GAM's predicted probabilities, referred to as the 'delta in the probability'. This was achieved by directly examining the components of the GAMs. The effects of covariates on each outcome were estimated by calculating the delta in the probability of

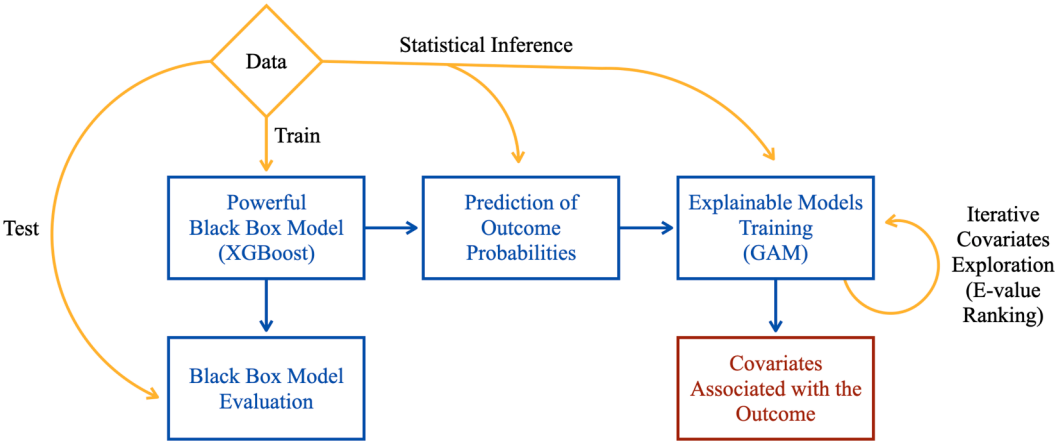

***Fig. 1:* Machine learning models implementation to estimate the outcomes probabilities predicted by a powerful black box model (blue), as well as split and utilization of the dataset (yellow).** Legend: The procedures described in this pipeline is model agnostic and could be used with different models than the ones used in this work.

%	Distrusts the vaccine	Indifferent	Trusts the vaccine	Total[a]	P value
	25.9	10.9	63.2	100	
Age					<0.001
Median (IQR)	48 (35, 60)	41 (29, 55)	55 (38, 67)	51 (35, 64)	
Age groups (%)					<0.001
18–30 (GenZ)	24.6	17.7	57.7	18.0	
31–45 (Millennials)	33.9	15.7	50.4	21.5	
46–60 (GenX)	28.7	8.8	62.6	28.0	
61–79 (Boomers)	19.3	5.9	74.7	28.7	
≥80	15.7	5.6	78.7	3.8	
Sex (%)					<0.001
Male	22.7	12.7	64.6	38.1	
Female	27.8	9.8	62.3	61.9	
Race/skin color (%)					0.019
White	24	10.6	65.4	33.5	
Pardo (Mixed Black)	26.9	11.1	61.9	46.9	
Black	25.3	10.7	64	16.5	
Asian	33.5	15.9	50.6	2.0	
Indigenous	26.9	8.6	64.5	1.2	
Schooling (%)					<0.001
1–4 years	18.8	6.5	74.7	9.2	
5–8 years	27	7.2	65.8	20.5	
9–12 years	29	12.7	58.3	52.2	
Higher education	20.8	13	66.2	18.1	
Religious affiliation (%)					<0.001
None	24	14.5	61.5	21.3	
Catholic	19.7	8.8	71.4	41.4	
Evangelical	36.7	11.1	52.3	30.7	
Kardecist spiritism	17.1	11.3	71.6	2.8	
Umbanda/Candomble	18.7	11.7	69.6	2.5	
Jewish	26	68.5	5.5	0.0	
Islamic	57.9	0	42.1	0.0	
Buddhist	5.8	5	89.2	0.1	
Other	30.2	13.8	56	1.2	
Access to internet (%)					<0.001
No	21.3	7.3	71.4	18.9	
Yes	27	11.7	61.3	80.7	
Ignored	4.2	50.9	44.9	0.2	
Don't know	28.3	14.3	57.5	0.2	
Number of TVs (%)					<0.001
0	41.3	10.7	47.9	5.0	
1	26.6	10.9	62.5	54.5	
2	23.9	10.4	65.7	28.6	
3	19.8	10.9	69.2	8.2	
≥4	18.8	16.5	64.7	2.3	
Ignored	25.5	17.2	57.3	1.3	
Don't know	63.8	12.5	23.8	0.2	
Number of computers (%)					0.377
0	26.4	9.8	63.7	61.1	
1	25.6	12.4	62	27.8	
2	23	12.1	64.9	7.4	
3	22.2	17.1	60.7	1.6	
≥4	24.8	10	65.1	0.5	
Ignored	26.1	16.1	57.9	1.6	
Don't know	35.6	9.6	54.8	0.0	
COVID-19 vaccine uptake (%)					<0.001
No/Unsure	67.0	18.0	15.0	5.2	
1 dose	51.6	15.1	33.3	4.1	

(Table 1 continues on next page)

%	Distrusts the vaccine	Indifferent	Trusts the vaccine	Total[a]	P value
	25.9	10.9	63.2	100	
(Continued from previous page)					
2 doses	40.5	18.3	41.2	18.4	
3 doses	26.1	11.4	62.6	26.4	
4 doses	17.6	8.6	73.8	26.6	
≥5 doses	6.4	3.8	89.8	19.3	

IQR, interquartile range; TV, television. [a]Refers to statistics of the total population included in the analysis.

Table 1: **Weighted demographic and socioeconomic characteristics, and COVID-19 vaccine uptake among participants according to reported level of trust in the COVID-19 vaccine.**

the outcome's occurrence, with 500 bootstrap resampling iterations. For each iteration, the top-ranked GAM was retrained, and deltas in the probability were recomputed. The resulting uncertainties associated with the estimated effects were visualized using boxplots.

All analyses accounted for the survey design, incorporating the city as a clustering variable to address within-city correlations and variability across cities using sampling weights.[6] Missing data in the covariates were handled by treating 'missing' as a separate category; for missing outcomes, a complete-case analysis was performed, excluding those observations. Descriptive analyses were performed using R version 4.4.2 and "Survey" package. ML analyses were performed in Python version 3.11 (packages numpy, jaxtyping, tqdm, matplotlib, scikit-learn, pandas and xgboost).

Role of funding source

The funders had no role in study design, data collection, data analysis, data interpretation, or writing of the report.

Results

This study included 29,281 adults (61.9% women). Most participants were Pardo/Mixed Black (46.9%) or White (33.5%). Most households had internet access (80.7%), one TV (54.5%), and no computers (61.1%). Vaccination status breakdown was as follows: 5.2% unvaccinated/unsure, 4.1% (1 dose), 18.4% (2 doses), 26.4% (3 doses), 26.6% (4 doses), and 19.3% (5+ doses). Most participants trusted the vaccine (63.2%) whereas 25.9% distrusted and 10.9% were indifferent.

Table 1 outlines demographic, socioeconomic, and vaccine uptake data by trust in the COVID-19 vaccine. Those who trusted the vaccine were older (median age 55, interquartile range [IQR]: 38, 67) compared to distrusting (48, IQR: 35, 60) and indifferent groups (41, IQR: 29, 55). Trust was highest among ages 80+ (78.7%) and Baby Boomers (age 61–79, 74.7%), while distrust was highest in Millennials (age 31–45, 33.9%) and Gen X (28.7%). Catholics showed the highest trust (71.4%), while Evangelicals had the highest distrust (36.7%). Vaccine uptake strongly correlated with trust: 67% of unvaccinated or unsure participants distrusted the vaccine, while trust increased with doses—62.6% (3 doses), 73.8% (4 doses), and 89.8% (5+ doses).

Table 2 shows engagement with COVID-19 information sources across trust groups. Television was the most used medium (51.3% frequent use). Traditional print newspapers had low engagement (63.0% no use). Social media platforms like Facebook (68.5% no use), Instagram (67.5% no use), TikTok (85.7% no use), and Twitter/X (90.9% no use) were rarely used. WhatsApp had higher engagement (28.7% frequent use).

Table S3 revealed that television had the highest trust (28.3% "always trust"), while social media platforms like WhatsApp, Facebook, Instagram, Twitter/X, and TikTok received lower trust (13–17%). Table S4 showed healthcare professionals (physicians 56.8%, nurses 51.7%) and scientists (47.1%) as the most trusted, while politicians were the least trusted (62.3% never trust).

The XGBoost models were found to display their best performance using a 'depthwise' growth policy, a learning rate of 0.3, maximum depth of 10, maximum number of leaves of 100, and 200 estimators. For COVID-19 vaccine trust, the model showed an accuracy of 67.4%, AUC-ROC of 71.6% (95% confidence interval [CI] 69.6%–73.6%) and ECE of 10.9% (95% CI 7.5%–14.9%). For COVID-19 vaccine uptake, accuracy was 67.9%, AUC-ROC was 67.5% (95% CI 65.6%–69.4%) and ECE was 11.2% (95% CI 8.1%–14.5%).

Table 3 presents the top four GAMs predicting COVID-19 vaccine trust, identifying age, education, religious affiliation, and trust in information sources as key predictors, with Fig. 2 showing Model 1A's covariate effects: GenZ participants (18–30) and Evangelicals were more likely to distrust the vaccine, while older adults (>60), those with higher education (≥12 years), and individuals trusting television or nurses were more likely to trust it, whereas trust in religious leaders was associated with vaccine distrust.

Table 4 shows the top four GAMs predicting COVID-19 vaccine uptake, with Fig. 3 illustrating Model 2A's covariate effects: GenZ participants (18–30)

	Distrust the vaccine (%)	Indifferent (%)	Trust the vaccine (%)	Total[a] (%)	P value
Television					<0.001
No use	38	16.2	45.8	13.6	
Infrequent use	29	12	59	19.4	
Moderate use	22.9	12.5	64.6	15.7	
Frequent use	22.4	8.7	68.9	51.3	
Newspaper (print)					0.031
No use	26.2	10.9	62.9	63.0	
Infrequent use	27.3	12.7	60	10.1	
Moderate use	25.7	13.6	60.7	8.2	
Frequent use	24	9	67	18.6	
Radio					<0.001
No use	26.9	11.4	61.7	68.3	
Infrequent use	25.3	11.6	63.1	12.8	
Moderate use	22.7	11.4	65.9	6.1	
Frequent use	22.3	7.6	70.1	12.8	
WhatsApp					<0.001
No use	22.3	9.5	68.2	46.1	
Infrequent use	26.7	13.4	59.9	14.5	
Moderate use	26.2	12.3	61.5	10.8	
Frequent use	31.1	11.5	57.4	28.7	
Twitter					0.873
No use	26	10.8	63.2	90.9	
Infrequent use	25.2	12.2	62.6	4.1	
Moderate use	25.4	12.2	62.4	1.6	
Frequent use	23.5	12.5	64.1	3.4	
Facebook					<0.001
No use	24.2	10.1	65.7	68.5	
Infrequent use	28.5	12.7	58.8	10.5	
Moderate use	27.9	15.2	57	6.9	
Frequent use	31.1	11.6	57.3	14.1	
Instagram					<0.001
No use	25.2	9.7	65.1	67.5	
Infrequent use	26.2	12	61.9	9.7	
Moderate use	24.3	13.8	61.9	6.6	
Frequent use	29.1	14.2	56.7	16.2	
Tik Tok					0.026
No use	24.9	10.9	64.2	85.7	
Infrequent use	29.5	11.7	58.8	5.1	
Moderate use	30.2	14.8	55	2.1	
Frequent use	33.4	9.9	56.7	7.1	
Telegram					0.015
No use	25.6	10.8	63.6	94.1	
Infrequent use	28	13.9	58.1	3.3	
Moderate use	36.1	17.7	46.2	0.8	
Frequent use	29.9	9.1	61	1.8	
YouTube					0.046
No use	24.6	10.7	64.7	72.8	
Infrequent use	28.3	10.5	61.2	9.2	
Moderate use	27.7	14.2	58.1	6.2	
Frequent use	30.8	10.9	58.4	11.8	
Official websites[b]					<0.001
No use	27.1	10.3	62.6	64.5	
Infrequent use	28.3	12.3	59.4	11.6	
Moderate use	21.7	15.9	62.4	8.8	
Frequent use	21	9.9	69.1	15.0	
Health professional					<0.001
No use	27.3	11.2	61.5	66.8	

(Table 2 continues on next page)

	Distrust the vaccine (%)	Indifferent (%)	Trust the vaccine (%)	Total[a] (%)	P value
(Continued from previous page)					
Infrequent use	24.8	11.3	63.9	15.7	
Moderate use	19.6	11.5	68.9	7.6	
Frequent use	22.8	8.4	68.8	9.9	
Specialized services[c]					0.252
No use	25.9	10.6	63.5	90.5	
Infrequent use	25.2	15	59.8	4.9	
Moderate use	22.8	17.3	59.9	1.9	
Frequent use	28.5	9.7	61.8	2.6	
Other					0.463
No use	25.8	11	63.3	98.3	
Infrequent use	32.1	11.9	56.1	0.7	
Moderate use	24.1	10.4	65.6	0.3	
Frequent use	33.9	7.2	58.9	0.7	

[a]Refers to statistics of the total population included in the analysis. [b]Webpages of the Ministry of Health or of State or Municipality health departments. [c]Specialized services related to occupational health hazards.

Table 2: **Weighted percentages of engagement with different sources of information about COVID-19 and other health measures according to the level of trust in the COVID-19 vaccine.**

Model	E-value	AUC-ROC (95% CI)	Covariates included
Model 1A	9.8	62.6% (60.2%–64.7%)	Age group Schooling Religious affiliation How much do you trust the following media sources for information about COVID-19? (television) How much do you trust the following people or institutions for information about COVID-19? (nurses) How much do you trust the following people or institutions for information about COVID-19? (religious leaders)
Model 1B	9.8	62.6% (60.5%–64.9%)	Age group Schooling Religious affiliation How much do you trust the following media sources for information about COVID-19? (television) How much do you trust the following people or institutions for information about COVID-19? (scientists) How much do you trust the following people or institutions for information about COVID-19? (religious leaders)
Model 1C	9.4	62.9% (60.6%–65.3%)	Age group Schooling Religious affiliation How much do you trust the following media sources for information about COVID-19? (television) How much do you trust the following people or institutions for information about COVID-19? (scientists) State
Model 1D	9.3	62.4% (60.2%–64.6%)	Age group Schooling Religious affiliation How much do you trust the following media sources for information about COVID-19? (television) How much do you trust the following people or institutions for information about COVID-19? (doctors) How much do you trust the following people or institutions for information about COVID-19? (religious leaders)

AUC-ROC, Area Under the Receiver Operating Characteristic Curve; CI, confidence interval.

Table 3: **Top 4 best performing GAM models for COVID-19 vaccine trust, ranked by e-value.**

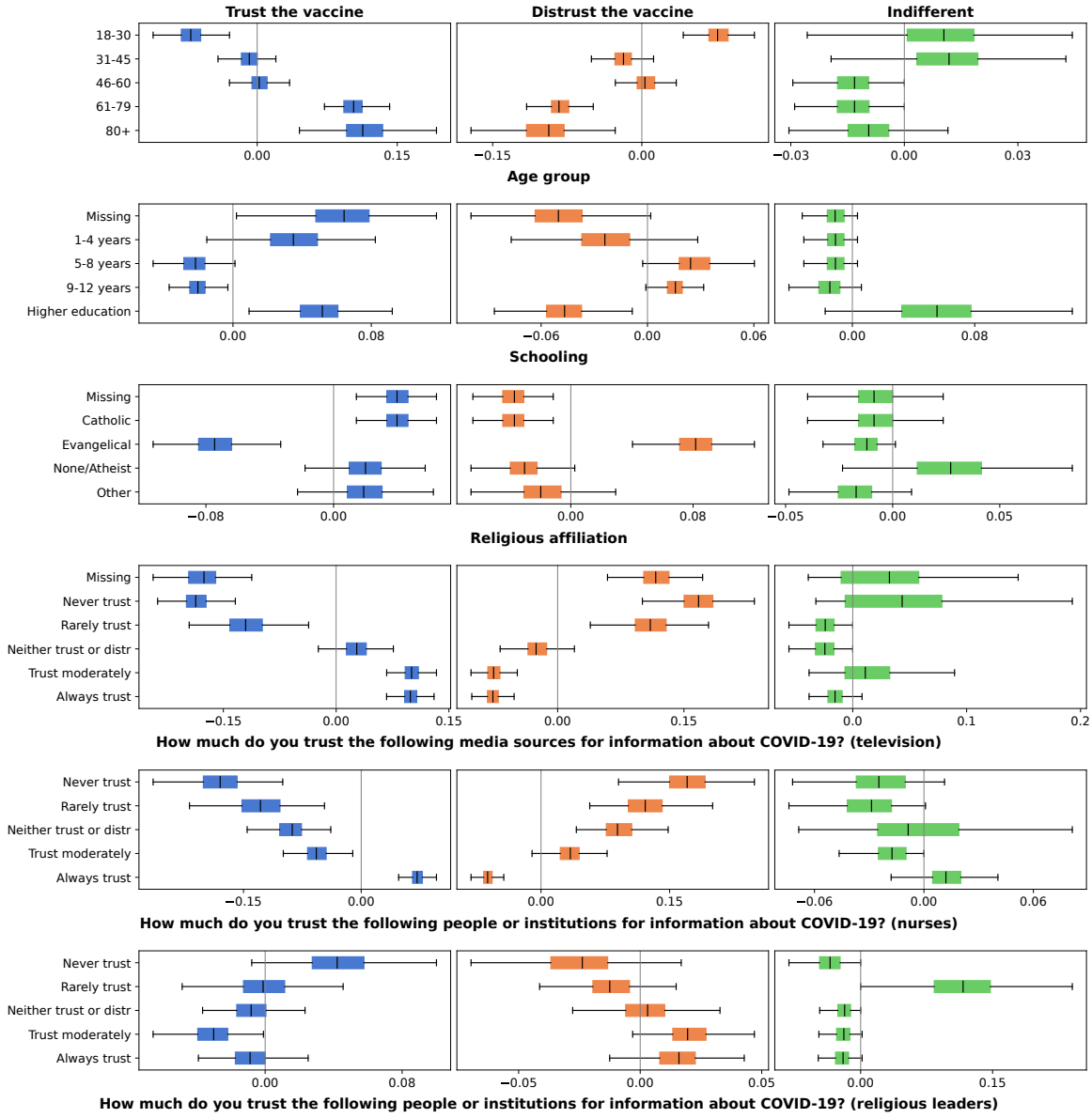

Fig. 2: **COVID-19 vaccine trust probability deltas for each covariate include in the model 1A. X-axis shows the probability deltas, box plots reflect variability from 500 bootstrap resampling steps; the colored boxes indicate the lower and upper quartile with the median indicated by the inner line, while the error bars are defined by the lower/upper quartile −/+1.5 × interquartile range.**

were more likely to report zero or one dose, while older adults (>60), females, and those trusting the vaccine were more likely to report three or more doses. Geographical disparities also emerged, with higher uptake in Brazil's Southeast and South regions.

Discussion

In this large population-based survey, we investigated the role of individual's demographic and socioeconomic characteristics as well as media, institutional and interpersonal trust in predicting COVID-19 vaccine trust and uptake. Gen Z group emerged as the most likely age generation to distrust the vaccine and to have lower vaccine uptake. Also, there was a significant association between levels of trust in the COVID-19 vaccine and vaccine uptake, including the number of doses received. These findings are consistent with international literature. A systematic review that included 43 studies reported that trust in the COVID-19 vaccine was strongly correlated with vaccine acceptance.[3] Likewise, a study from the United States showed that trust in the

Model	E-value	AUC-ROC (95% CI)	Covariates included
Model 2A	62.7	55.7% (53.0%–56.8%)	Age group Sex Race/skin color State COVID-19 vaccine trust State capital
Model 2B	59.9	55.1% (52.3%–56.3%)	Age group Schooling Race/skin color State COVID-19 vaccine trust State capital
Model 2C	58.4	55.4% (52.5%–56.7%)	Age group Race/skin color Religious affiliation State COVID-19 vaccine trust State capital
Model 2D	58.2	55.3% (52.5%–56.5%)	Age group Sex Schooling State COVID-19 vaccine trust State capital

The e-BH procedure showed in 97% confidence for the models 2A-D (see supplementary material for details). AUC-ROC, Area Under the Receiver Operating Characteristic Curve; CI, confidence interval.

Table 4: **Top 4 best performing GAM models for COVID-19 vaccine uptake, ranked by e-value.**

science behind vaccines was an important predictor of vaccine uptake and willingness to take future boosters.[10]

Previous studies show that trust in vaccines is high in Brazil, when compared to other countries. In a 2023 online survey, trust in COVID-19 vaccines was highest in Brazil (84.6%) and India (80.4%) and lowest in the United States (63.5%) and France (55.0%).[11] In our study, trust was high (60%), but lower than the Brazilian estimate observed in the above-mentioned study. This discrepancy may be due to multiple differences in study design. The cited study was conducted in 2023, recruitment was by telephone, social media and direct email, and a stratum-based sampling strategy was employed (N = 1000 participants in each country). Moreover, the study was conducted online, and participants self-reported their answers.[11] The present study enrolled over 29 thousand adults who were interviewed by trained personnel. Taken together, these differences might suggest that the present sample was able to gather information from a more diverse sample. Nevertheless, it is important to consider that the spread and reach of disinformation and misinformation fluctuates over time and space as well as the engagement with social media and news.

Our study highlights the high COVID-19 vaccine uptake in Brazil, with more than 96% of participants reporting to have received at least one dose, and 72% three or more doses. Brazil has a well-established National Immunization Program, instituted in 1973, that provides free access to over 11 different vaccines for children (including human papillomavirus vaccine), elderly (including shingles vaccine) and special populations.[12] In Brazil, COVID-19 vaccination started in mid-January 2021, initially prioritizing high-risk groups, like healthcare workers, institutionalized individuals, and Indigenous peoples. Subsequent phases followed an age-descendent strategy, from older to younger age groups.[2] By December, 2021, national coverage had reached 90% for the first dose and 70% for a full two-dose regimen.[13] This shows that despite difficulties due to the political context during the COVID-19 pandemic and the spread of misinformation, Brazilians attended in mass to vaccination campaigns as soon as they became available.[2]

Vaccine trust and uptake were generally higher among elders, while vaccine distrust and lower uptake were more pronounced among members of Gen Z. Indeed, prior studies show that even after the expansion of vaccine recommendations and the increase in availability of doses, young adults showed greater hesitancy and resistance toward COVID-19 vaccination than older groups.[14,15] The initial de-emphasis on young adults and dose shortages during COVID-19 vaccination campaigns may have enhanced an altruistic sentiment, which played a role alongside concerns about safety, side effects, and vaccine effectiveness in influencing the low willingness and uptake among young adults.[14,15] These findings align with prior research highlighting generational disparities in COVID-19 vaccine beliefs, particularly the ambivalence and unwillingness toward vaccination observed among Gen Z adults.[16,17] Achieving high vaccine coverage levels among young populations is particularly relevant giver their role in spreading the infection.[18] Furthermore, the under-immunization of younger populations coupled with the virus' mutational capacity creates a fertile ground for new variants to emerge.[19] Vaccine trust was also higher among participants with higher educational level ($\geq$12 years). The positive association between higher education attainment and vaccine trust, willingness to being vaccinated, and vaccine uptake have been documented previously.[20,21]

Interestingly, trust in vaccine varied by information source. Television was the most frequently used medium, particularly among those who trusted the vaccine. Similar patterns have been observed in other studies; for instance, a study across in 5 countries demonstrated that reliance on traditional media was associated with greater willingness to be vaccinated.[20] Social media played a crucial role in facilitating communication and sharing of information during the social distancing period. However, the spread of unverified information may have significantly impaired

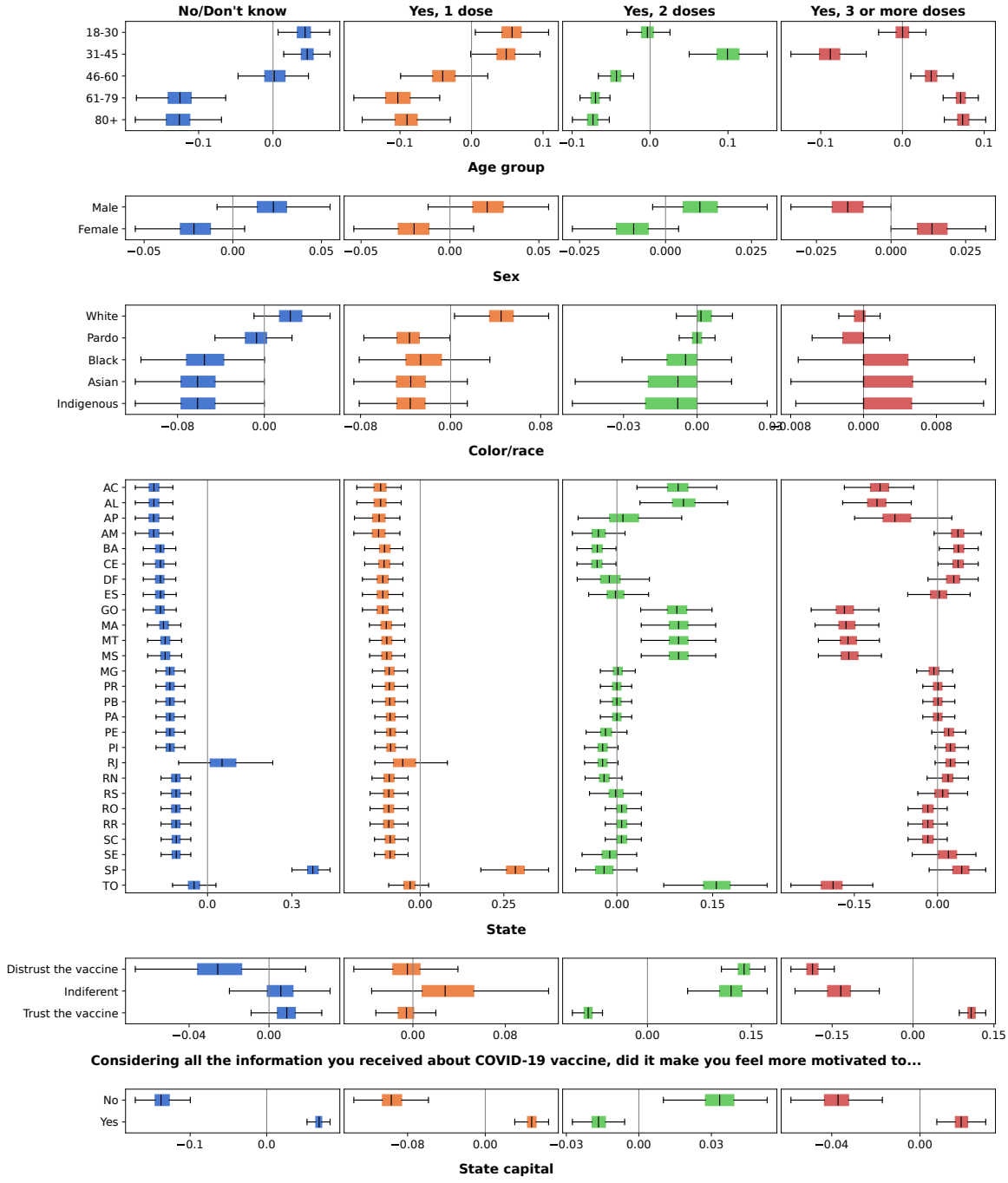

Fig. 3: **COVID-19 vaccine uptake probability deltas for each covariate include in the model 2A. X-axis shows the probability deltas, box plots reflect variability from 500 bootstrap resampling steps; the colored boxes indicate the lower and upper quartile with the median indicated by the inner line, while the error bars are defined by the lower/upper quartile −/+1.5 × interquartile range.**

a person's ability to make informed health decisions.[22] A Chinese study associated the frequent use of digital media with increased negative emotions, suggesting that this may contribute to widening trust gaps.[23] Similarly, in the United States, vaccine-resistant individuals often relied on social media—particularly Facebook—for COVID-19 information rather than traditional media sources. These individuals also tended to exhibit lower institutional trust.[24] Particularly among Gen Z, a study in the UK demonstrated that the

excess of information and social media exposure were associated to ambivalence and conspiracy beliefs about COVID-19 vaccines.[16]

Variations in vaccine trust were also observed across religious affiliations, with Evangelical groups exhibiting higher levels of vaccine distrust. The association between religious beliefs and vaccine hesitancy has been documented in numerous studies across diverse populations and geographic contexts.[25] A recent systematic review highlighted the need for comprehensive, intersectional research to better understand the relationship between religion and vaccine uptake. Furthermore, it underscored the importance of developing nuanced, culturally sensitive strategies to address vaccine hesitancy within religious communities.[25]

Some important limitations of the present study should be acknowledged. Participants were interviewed in early 2024, almost 3 years after the peak of the COVID-19 pandemic, which may have hindered the recall of information. Moreover, given the emotional nature of some of the variables explored in this study, like trust, participants' subjective perception may have changed over time, and responses captured during the survey may have been different from the emotion experienced during the pandemic. At the same time, we cannot rule out that persistent controversies and misinformation about COVID-19 vaccines (particularly related to mRNA vaccines) may have undermined public trust in vaccines, and therefore influenced participants' responses to the survey.[26] This is supported by a 2023 survey across 23 countries, including Brazil, which documented post-COVID-19 ongoing declines in population trust in vaccines for both COVID-19 and routine immunization programs.[27] Vaccine trust and vaccine hesitancy are complex issues, driven by individual and societal factors, and unmeasured factors could potentially have impacted our findings. These factors include vaccine safety beliefs, risk perceptions for the disease, conspiracism, satisfaction with democracy, psychological traits (interest in facts, need for cognition), including psychological ill-being (e.g., anxiety, depression, burnout), pandemic fatigue and vaccine fatigue.[26–28] It is important to highlight that most questions in the survey instrument were developed by the study team. As such, though we cannot measure the questions' validity, the objective nature of the information (for example, the outcome vaccine uptake) diminishes the likelihood of information bias.

Conclusion

In Brazil, trust in the COVID-19 vaccine and overall uptake were moderate, reaching 60% and 72%, respectively, but Gen Z stood out as a generational age group with higher distrust and lower uptake. Our findings underscore the positive impact of higher education on vaccine trust. Media consumption and technology use complicate public health communication, presenting both challenges and opportunities for engagement. Future research should explore the drivers of vaccine distrust to guide targeted interventions. Innovative strategies to enhance health literacy, build trust, and support informed decision-making must be developed and implemented to bridge these gaps and improve vaccine uptake.

Contributors

PCH conceived the project. PCH was responsible for funding acquisition. LEC, JG, DC, had access to the data. JG and DC performed the data analysis. All authors were involved in the interpretation. LEC, PML, CJS, LCP, GTG, JG drafted the manuscript, and all authors contributed to critically reviewing and revising the draft. All authors read and approved the final version of the manuscript before submission.

Data sharing statement

The Brazilian Ministry of Health is the owner of the data, and access to the data might be granted upon request to the Ministry of Health.

Use of artificial intelligence (AI) tools

The authors did not used any AI tools in the writing of the manuscript or the production of images.

Machine learning algorithms were implemented for data analysis.

Declaration of interests

We declare no competing interests.

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Appendix A. Supplementary data

The code for the ML models can be found on the repository: https://gitlab.com/ggoedert/epiCOVID-trust.

Supplementary data related to this article can be found at https://doi.org/10.1016/j.lana.2025.101324.

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