BMC Public Health

RESEARCH

Open Access

COVID-19 vaccine hesitancy in Ethiopia: a latent class analysis

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Abstract

Background Despite evidence demonstrating the effectiveness of the COVID-19 vaccine, vaccine hesitancy has emerged as a major challenge for vaccine uptake. The objective of this study was to classify latent typologies of vaccine hesitant adults in Ethiopia and identify predictors of the latent classes.

Methods We employed a cross-sectional household survey among 1,112 individuals aged 18 and above who were partially vaccinated (one dose) or not vaccinated at the time of the survey. Data was collected in August 2022. We collected information on participant socio-demographics, COVID-19 knowledge, prevention practices, disease history, and vaccine hesitancy. Latent class analysis was used to classify individuals into categories of vaccine hesitancy. We conducted multinomial logistic regression to test the associations between latent typologies and different demographic and COVID-19 related characteristics of study participants.

Results Using latent class analysis we found a four-class solution for vaccine hesitancy typologies. The identified classes were *strong vaccine acceptors* (30%); *vaccine acceptors with some concerns* (7%); *vaccine sceptics* (13%); and *vaccine rejectors* (50%). In adjusted models with *vaccine sceptics* as the referent group, those with high COVID-19 vaccine knowledge were significantly more likely to belong to the *strong vaccine acceptors* class compared to those with low vaccine knowledge (adj. RRR: 17.36, 95% CI: 10.94–27.55). Better COVID-19 prevention practices were also significantly associated with belonging to the *vaccine acceptors with some concerns* class than the *vaccine sceptics* class (adj. RRR: 2.13, 95% CI: 1.09–4.16). Those who had one dose of the COVID-19 vaccine were significantly more likely to belong in the *vaccine acceptors* class than the *vaccine sceptics* class compared to those who had no dose (adj. RRR: 6.82, 95% CI: 3.06–15.21).

Conclusions Half of the study participants were in the vaccine rejectors class. Individuals in the vaccine sceptics and rejector classes evidenced lower vaccine knowledge and worse COVD-19 prevention practices and were less likely to have been partially vaccinated. Future program interventions should focus on improving knowledge around the vaccine, decrease rumors and misconceptions, and target individuals who may be more amenable to changing their vaccination attitudes or behaviors like vaccine sceptics or acceptors with some concerns.

Keywords COVID-19, Vaccine hesitancy, Ethiopia, Latent class analysis

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Introduction

Cases of coronavirus (COVID-19) were first detected in China in December 2019, with the virus spreading quickly to other countries across the world [1, 2]. The United States, China, India, Brazil and several European countries were among the countries with the highest number of cases and COVID-19 related deaths [3]. Africa was the last continent to be hit by the virus and compared to other continents experienced slower growth and lower case counts and mortality rates. By November 2022, the number of confirmed cases in Africa was an estimated 12.7 million which represented only 2% of infections globally [4].

The first case of COVID-19 in Ethiopia was confirmed by the Ministry of Health (MOH) on March 13th, 2020 [4, 5]. The MOH immediately established several non-pharmaceutical measures to minimize the spread of COVID-19 infection which included testing, contact tracing, quarantine, social distancing, and use of masks. Although these measures were necessary and somewhat effective, they also had negative effects on the economy and healthcare system [6]. One year after the pandemic started, Ethiopia received its first donation of the AstraZeneca vaccine, followed by SinoPharm, Janssen, Sinovac, Moderna and Pfizer. Vaccines were and remain readily available across the country. Estimates from August 2023 showed that 38% of the population had been fully vaccinated (2 doses), 46% had received 1 dose and only 4% had received boosters [4].

To minimize the risk of morbidity and mortality from vaccine preventable diseases, herd immunity must be achieved. Herd immunity occurs when a large portion of the population becomes immune to the disease through previous infection or vaccination [7, 8]. COVID-19 vaccination is key to reducing new infections and highly effective at reducing severe illness and death [7]. Despite the evidence on the effectiveness of vaccination in preventing disease, vaccine hesitancy is a growing concern. In 2019, the World Health Organization (WHO) listed vaccine hesitancy as one of the top ten threats to global health [9, 10].

Vaccine hesitancy is defined as the delay in acceptance or refusal of vaccination despite availability of vaccination services [10]. It is a result of complex and context specific factors, varying across time, place and vaccine brands [10]. Vaccine hesitancy is also caused by misinformation and conspiracy theories that spread online through social media. Other key drivers of vaccine hesitancy include social and cultural factors, structural inequalities, and barriers to access [11, 12].

Vaccine hesitancy studies published during the height of the COVID-19 pandemic showed correlations between the perceived safety of the COVID-19 vaccine and intent to vaccinate, negative attitudes towards the vaccine and unwillingness to get vaccinated, and religiosity and lower intent to vaccinate [13–15]. COVID-19 vaccine studies from Ethiopia focused on knowledge, attitude, and practices. The findings from these studies showed that in addition to socio-demographic characteristics, people's religious beliefs, attitudes, and knowledges towards the COVID-19 vaccine were significantly associated with vaccine acceptance [11–13, 16–25].

Understanding what types of individuals are more likely to reject or accept a vaccine is important for developing targeted vaccination campaigns and messaging. Vaccine hesitancy in Ethiopia is common even before the COVID-19 pandemic and most parents hesitate to get their children vaccinated especially in rural areas [26, 27]. While there has been a substantial body of research on vaccine hesitancy in Ethiopia, few studies have attempted to categorize individuals into latent groups based on their demographics and perceptions of vaccination and COVID-19. To better understand and characterize individuals who are resistant to COVID-19 vaccination, we conducted a cross-sectional study on vaccine hesitancy among unvaccinated and partially vaccinated (one dose) adults in nine major towns in Ethiopia. We performed latent class analysis (LCA) to categorize individuals into latent typologies of COVID-19 vaccine hesitancy and tested associations with demographic characteristics, vaccine knowledge, COVID-19 prevention practices, and chronic disease and vaccine history. Results from this study may be used by policy makers and the MOH to help inform future vaccination strategies.

Methods

The study was conducted in August 2022. At the time, cases of COVID-19 were decreasing compared to the year before [4]. The study employed a cross-sectional quantitative study design consisting of a household survey. The study population included men and women aged 18 and above who were partially vaccinated (one dose) or not vaccinated at the time of the survey. The study was administered in nine major towns with high COVID-19 case counts (Addis Ababa, Dire Dawa, Jimma, Bishoftu, Wolaita Sodo, Arba Minch, Asossa, Bahir Dar and Debre Tabor). Probability proportional to size (PPS) sampling was used to select clusters (Kebeles/Ketenas) within each city. For the selected Kebels/Ketenas, household listings were used as a sampling frame. Households were selected randomly from the sampling frame and one adult aged 18 or older who was not vaccinated or partially vaccinated (one dose) was enrolled in the study. If more than one person per household was eligible, the Kish method was used to select the study participant [28]. The study received ethical approval from the Ethiopian Public Health Association Institutional Review Board (EPHA

IRB) and Population Services International's Research Ethics Board (PSI REB).

Measures

Vaccine knowledge

Vaccine knowledge was measured by six items with Likert-scale response options corresponding to the level of agreement or disagreement (1=Strongly agree, 2=Somewhat agree, 3=Neutral, 4=Disagree, 5=Strongly disagree). The six items included: "the vaccine is helpful"; "the vaccine can be helpful to fight the infection"; "the vaccine can be helpful for prevention of severe morbidity due to COVID-19"; "the COVID vaccine is generally good to get"; "the vaccine does not have any efficacy"; and "the vaccine has severe health complications" [29–32]. Participant responses were summed to create a composite vaccine knowledge score with a range of 6–30. The composite score was cut at the median to create a binary variable categorized as "high knowledge" for scores above the median and "low knowledge" for scores below the median.

COVID-19 vaccine hesitancy

Vaccine hesitancy was measured using the validated Oxford COVID-19 vaccine hesitancy scale [33]. The scale includes seven items with response options coded 1 to 5. The seven items include: "Would you take a covid-19 vaccine, if offered?: definitely, probably, I may or may not, probably not, definitely not"; "If there is a covid-19 vaccine available, I will: get it as soon as possible; I will take it when offered; I'm not sure what I will do; I will put off (delay) getting it; or I will refuse to get it"; "I would describe my attitude towards receiving a COVID-19 vaccine as: very keen; pretty positive; neutral, quite uneasy; against it"; "If a COVID-19 vaccine was available at my local pharmacy, I would: get it as soon as possible; get it when I have time; delay getting it; avoid getting it for as long as possible; or never get it"; "If my family or friends were thinking of getting a COVID-19 vaccination, I would: strongly encourage them; encourage them, not say anything to them about it; ask them to delay getting the vaccination; suggest that they do not get the vaccination"; "I would describe myself as: eager to get a COVID-19 vaccine; willing to get the COVID-19 vaccine; not bothered about getting the COVID-19 vaccine; unwilling to get the COVID-19 vaccine; anti-vaccination for COVID-19"; "Taking a COVID-19 vaccination is: really important; important; neither important nor unimportant; unimportant, really unimportant." The scale has a reliability of alpha=0.94 [33].

COVID-19 prevention practices

COVID-19 preventive practices were measured by a composite score of five items with Likert-scale response options corresponding to the level of agreement or disagreement (1=Strongly agree, 2=Somewhat agree, 3=Neutral, 4=Disagree, 5=Strongly disagree): "I have maintained a social distancing guideline"; "I use face masks"; "I avoid unnecessary touching of things and people"; "I use hand sanitizers before touching my face"; and "I wash my hands." The composite measure ranged from 5 to 25. A binary variable was created with scores above the median categorized as "high" and scores below the median categorized as "low".

Covariates and confounders

The following covariates and potential confounders were also included: age, sex, education, employment status, marital status, religion, monthly income, vaccine doses, and history of chronic disease.

Statistical analysis

A total of 1,112 people participated in the survey. Descriptive statistics were used to characterize participant demographics, COVID-19 prevention practices, vaccine knowledge, COVID-19 testing and vaccine history, and chronic disease history. Vaccine hesitancy typologies were derived using latent class analysis (LCA) in SAS 9.4. LCA derives a latent variable from observed characteristics. The latent variable is a categorical variable comprised of latent classes. Numerous models were tested with varying numbers of classes and specifications of the observed variables (i.e., binary vs. multi-category). The final decision on the number of classes was determined by model-fit statistics (e.g., Akaike information criterion (AIC), Bayesian information criterion (BIC), entropy). Specifically, the selected model was such that the AIC and adjusted BIC were minimized, entropy was strong (close to 1), and the smallest class had>5% of participants. Bivariate associations between the latent classes and participant demographic characteristics, vaccine knowledge, COVID-19 prevention practices, and COVID-19 vaccine doses and chronic disease history were assessed with Pearson chi-square tests. Adjusted associations were tested using multinomial logistic regression models to estimate relative risk ratios. Significance testing was conducted at $p<0.05$ and 95% confidence intervals (CI). Due to under-representation of male participants, population demographic weights were created using population data to reflect the actual population proportion of men and women in the survey towns.

Results

Demographic characteristics are presented in Table 1. Participants' mean age was 35 years (95% CI: 34.5–36.2). Fifty-six percent (95%CI: 48.3–63.6) of individuals were married and 60% (95%CI 55.4–63.6) were employed. Most individuals had some level of education, with only

Table 1 Socio-demographic characteristics of sampled population (*N* = 1112)

	Unweighted number	Weighted %	Weighted 95% CI
Sex			
Male	404	48.5	46.8–50.3
Female	708	51.5	49.7–53.2
Age			
18–40	819	72.7	67.9–77.1
41+	293	27.3	22.9–32.1
Relationship status			
Single	328	30.7	24.1–38.2
Married or living together	613	56.1	48.3–63.6
Divorced/separated/ Widowed	171	13.2	10.6–16.4
Employment status			
Unemployed	495	40.4	36.4–44.6
Employed (part or full time)	617	59.6	55.4–63.6
Education			
Illiterate/ Informal education	108	8.5	5.7–12.4
Primary education	310	27.2	23.0-31.8
Secondary education	362	33.1	27.9–38.7
Above secondary	331	31.2	23.1–40.6
Religion			
Orthodox Christian	799	71.4	57.6–82.1
Muslim	157	14.2	9.1–21.6
Protestant	149	13.6	4.7–33.6
Other	7	0.7	0.2- 3.0
Monthly income (Birr)			
<=4,500	553	49.2	41.2–57.2
4,501 – 8,000	351	32.8	29.3–36.5
Above 8,001	185	18.0	13.2–24.0
Town			
Addis Ababa	389	35.3	3.9–88.0
Debre Tabor	72	6.5	0.5–50.5
Bahir Dar	117	9.6	0.7–61.0
Assosa	51	4.6	0.3–41.3
Dire Dawa	116	10.5	0.8–63.5
Bishoftu	90	8.2	0.6–56.6
Jimma	100	9.1	0.7–59.5
Wolaita Sodo	88	8.0	0.6–56.0
Arba Minch	89	8.1	0.6–56.3
History of chronic disease	201	18.1	14.1–22.8

Notes. Less than 5% missing cases for all variables; data were weighted by population sex demographics to reflect the actual proportion of males and females in the population

9% (95%CI: 5.7–12.4) reporting no formal education. Approximately three-fourths (71%, 95%CI: 57.6–82.1) were Orthodox Christians. About half of the population earned less than 4,501 Birr per month (95%CI: 41.2–57.2), and 18% (95%CI:14.1–22.8) reported a history of chronic disease.

Table 2 presents self-reported COVID-19 prevention practices, COVID-19 vaccine knowledge, and history of COVID-19 infection, testing and vaccination. Slightly more than 50% (95%CI: 39.6–56.4) of individuals had low prevention practices. Approximately 54% (95%: 43.8–64.5) had high knowledge about the COVID-19 vaccine. Only 4% (95%CI: 2.4–5.5) reported having been infected with COVID-19 and 34% (95%CI: 25.0-44.1%) had ever tested for COVID-19. Vaccine hesitancy items were dichotomized, presenting the percent of participants who strongly agreed/agreed or strongly disagreed/disagreed with each item. More than 36% reported they would get the COVID-19 vaccine if offered; 32% reported they would get the vaccine as soon as possible; 40% had positive attitudes towards receiving the vaccine; 32% stated they would get the vaccine if it was available at the pharmacy; 48% would encourage family and friends to get the

Table 2 Descriptive statistics of COVID-19 prevention practices, COVID-19 vaccine knowledge, COVID-19 infection, testing, and vaccine history, and vaccine hesitancy (*N* = 1112)

	Unweighted number	Weighted %	Weighted 95% CI
COVID-19 prevention practices			
High	528	47.9	39.6–56.4
Low	580	52.1	43.6–60.4
COVID-19 vaccine knowledge			
High knowledge	579	54.3	43.8–64.5
Low knowledge	513	45.7	35.5–56.2
History of COVID-19 infection	36	3.6	2.4–5.5
Ever tested for COVID-19	373	33.9	25.0-44.1
Tested positive for COVID-19	39	10.0	4.3–21.5
At least 1 dose of the vaccine	227	20.5	13.9–29.3
Vaccine hesitancy items (dichotomized)			
Would get the COVID-19 vaccine if offered	403	36.8	35.8–37.8
Get a COVID-19 vaccine as soon as possible if available	350	31.9	31.0-32.9
Positive attitude towards receiving a COVID-19 vaccine	430	39.3	38.3–40.1
If a COVID-19 vaccine was available at my local pharmacy, I would get it as soon as possible	351	32.0	31.1–33.0
If my family or friends were thinking of getting a COVID-19 vaccination, I would encourage them	521	47.7	46.7–48.7
I would describe myself as willing to get the COVID-19 vaccine	396	36.4	35.4–37.3
Taking a covid-19 vaccination is important	674	62.3	61.3–63.3

Notes. Less than 5% missing cases for all variables; data were weighted by population sex demographics to reflect the actual proportion of males and females in the population

Table 3 Model-fit statistics- LCA of vaccine hesitancy measures

No. classes	Log Likelihood	DF	*P*	AIC	BIC	Adjusted BIC	Entropy	Smallest class
2	-2810.46	112	1	435.17	510.37	462.72	0.98	34%
3	-2689.01	104	1	208.27	323.57	250.52	0.86	17%
4	-2656.09	96	1	158.43	313.84	215.37	0.86	7%
5	-2644.04	88	1	150.34	345.85	221.98	0.88	0.60%

Notes. DF = degrees of freedom; AIC = Akaike information criterion, BIC = Bayesian information criterion (BIC); Input variables included: I would take a COVID-19 vaccine if offered; If there is a COVID-19 vaccine available I will get it as soon as possible; I would describe my attitude towards receiving a COVID-19 vaccine as positive; if a COVID-19 vaccine was available at my local pharmacy, I would get it as soon as possible; if my family or friends were thinking of getting a COVID-19 vaccination, I would (strongly) encourage them; I would describe myself as eager/willing to get a COVID-19 vaccine; taking a COVID-19 vaccination is important. Best-fitting model highlighted

Table 4 Vaccine hesitancy probabilities given latent class membership

	CLASS 1: strong vaccine acceptors (30%)	CLASS 2: vaccine acceptors with some concerns (7%)	CLASS 3: vaccine sceptics (13%)	CLASS 4: vaccine rejectors (50%)
Would get the COVID-19 vaccine if offered	0.92	0.61	0.01	0.08
Would get a COVID-19 vaccine as soon as possible if available	0.99	0.22	0.01	0.00
Positive attitude towards receiving a COVID-19 vaccine	1.00	0.62	0.16	0.04
If a COVID-19 vaccine was available at my local pharmacy, I would get it as soon as possible	0.94	0.35	0.03	0.00
If my family or friends were thinking of getting a COVID-19 vaccination, I would encourage them	0.94	0.70	0.77	0.08
I would describe myself as willing to get the COVID-19 vaccine	0.99	0.69	0.09	0.00
Taking a covid-19 vaccination is important	1.00	0.90	0.96	0.26

vaccine; 36% described themselves as willing to get the vaccine; and 62% stated that the vaccine was important.

Table 3 presents fit statistics for several numbers of latent classes. Based on decreasing AIC and adjusted BIC, class size, entropy and theoretical plausibility, the four-class solution for vaccine hesitancy typologies was selected. Table 4 depicts probabilities of affirming each vaccine hesitancy item by class membership. Class

names were determined by dominant characteristics. The identified classes were strong vaccine acceptors (30% of sample); vaccine acceptors with some concerns (7% of sample); vaccine sceptics (13% of sample); and vaccine rejectors (50% of sample).

Bivariate results

Crude bivariate associations between vaccine hesitancy latent classes and participant demographics, COVID-19 knowledge and prevention practices, and vaccine status are presented in Table 5. The only demographic variable marginally significantly associated with the latent typologies was income. Vaccine rejectors had a higher proportion of high-income individuals than the other typologies (21% vs. 16% class1, 12% class 2, and 11% class 3) and vaccine acceptors with some concerns had more middle-income individuals compared to other typologies (48% vs. 27% class 1, 34% class 3, and 35% class 4). In terms of COVID-19 vaccine knowledge, significant differences were seen across typologies, with higher knowledge among strong vaccine acceptors than other classes. Similar differences were seen for COVID-19 prevention practices. Strong vaccine acceptors and vaccine acceptors with some concerns evidenced a higher proportion of individuals who had one vaccine compared to vaccine sceptics and vaccine rejectors.

Table 5 Vaccine hesitancy class by demographic characteristics, COVID-19 vaccine knowledge, prevention practices, vaccine dose and history of chronic diseases ($N = 1111$)

	CLASS 1: strong vaccine acceptors (30%)	CLASS 2: vaccine acceptors with some concerns (7%)	CLASS 3: vaccine sceptics (13%)	CLASS 4: vaccine rejectors (50%)	*p*-value
Sex					
Female	45.8 [37.2,54.6]	54.5 [42.5,65.9]	62.9 [47.8,75.8]	52.3 [50.4,54.2]	0.146
Male	54.2 [45.4,62.8]	45.5 [34.1,57.5]	37.1 [24.2,52.2]	47.7 [45.8, 49.6]	
Age					0.379
18–40	74.5 [61.9,84.1]	82.2 [66.7,91.5]	67.8 [59.1,75.5]	71.9 [67.5, 76.0]	
41+	25.5 [16.0,38.1]	17.8 [8.6, 33.3]	32.2 [24.5, 40.9]	28.1 [24.1, 32.5]	
Relationship					
Married	59.7[51.4, 67.6]	59.1 [45.9, 71.1]	55.5 [46.6, 64.2]	53.5 [43.1, 63.7]	0.256
Single	29.2[22.9, 36.5]	33.0 [20.9, 47.9]	26.1 [16.3, 39.0]	32.5 [24.1, 42.1]	
Divorced/separated	11.1[7.4, 16.2]	7.9 [2.0, 26.7]	18.4 [11.8, 27.4]	14.0 [11.3, 17.4]	
Education					0.075
Illiterate/No formal education	10.3 [6.4, 16.1]	2.5 [0.7, 8.1]	9.4 [6.3, 13.8]	7.9 [4.9, 12.4]	
Primary education	30.7 [24.4, 37.9]	22.7 [9.7, 44.3]	35.8 [26.9, 45.9]	23.5 [19.3, 28.3]	
Secondary education	31.7 [23.2,41.5]	40.6 [26.6, 56.3]	26.1 [22.1, 30.5]	34.8 [28.4, 41.8]	
Above secondary	27.4 [18.6, 38.4]	34.2 [24.8, 45.1]	28.7 [19.3, 40.4]	33.8 [24.3, 44.9]	
Currently unemployed	36.5 [28.9, 44.8]	40.6 [26.7, 56.1]	47.8 [33.8, 62.2]	41.0 [38.7, 43.3]	0.271
Average monthly income (Birr)					0.053
<=4,500	56.5 [43.3, 68.9]	40.3 [27.2, 55.0]	55.8 [43.8, 67.1]	44.0 [35.0, 53.5]	
4,501 – 8,000	27.3 [21.7, 33.6]	47.7 [33.4, 62.4]	33.7 [27.8, 40.0]	34.6 [29.4, 40.1]	
Above 8,001	16.2 [9.4, 26.6]	12.0 [4.7, 27.6]	10.6 [5.6, 19.2]	21.4 [16.4, 27.4]	
Religion					
Orthodox	65.8 [45.3, 81.8]	59.7 [39.4, 77.1]	70.6 [50.7, 84.9]	77.1 [67.7, 84.5]	0.209
Muslim	16.8 [7.7, 32.7]	18.1 [7.7, 36.8]	15.5 [9.3, 24.7]	12.2 [8.2, 17.8]	
Protestant	17.4 [5.0, 46.0]	22.2 [10.5, 41.1]	13.9 [2.3, 52.2]	10.7 [4.6, 22.6]	
COVID-19 knowledge					
Low	3.0 [1.4, 6.1]	33.8 [20.1, 50.9]	31.1 [24.1, 39.2]	76.6 [66.7, 84.2]	0.000
High	97.0 [93.9, 98.6]	66.2 [49.1,79.9]	68.9 [60.9,75.9]	23.4 [15.8,33.3]	
COVID-19 prevention practices					
Low	45.3 [35.3,55.8]	36.9 [26.4, 48.9]	53.1 [44.5, 61.4]	57.5 [47.7, 66.8]	0.010
High	54.7 [44.2, 64.7]	63.1 [51.1, 73.6]	46.9 [38.6, 55.5]	42.5 [33.2,52.3]	
Chronic disease history					
Yes	17.3 [13.9, 21.3]	12.4 [6.1, 23.7]	20.6 [14.5, 28.6]	18.3 [13.2, 25.0]	0.399
Vaccine dose					
One	42.9 [30.9, 55.6]	24.0 [15.3, 35.6]	14.4 [8.1, 24.4]	8.0 [5.9, 10.8]	0.000

Notes. Less than 5% missing cases for all variables; data were weighted by population sex demographics to reflect the actual proportion of males and females in the population

Multinomial regression results

Adjusted associations between vaccine knowledge, COVID-19 prevention practices, history of chronic disease and vaccine history and vaccine hesitancy typologies are presented in Table 6. Controlling for demographic variables, chronic disease history, prevention practices and vaccine dose, those with high COVID-19 vaccine knowledge were significantly more likely to belong to the strong vaccine acceptors class than the vaccine sceptics class (the referent group) compared to those with low vaccine knowledge (adj. RRR: 17.36, 95% CI: 10.94–27.55). Likewise, compared to those with low vaccine knowledge, those with high vaccine knowledge had a significantly lower probability of being in class 4 (vaccine rejectors) compared to class 3 (vaccine sceptics) (adj. RRR: 0.12, 95% CI: 0.06–0.24). Higher or better COVID-19 prevention practices were significantly associated with belonging to the vaccine acceptors with some concerns

Table 6 Adjusted relative risk ratio (RRR) and 95% confidence intervals predicting latent class membership

	CLASS 1 $_{adj}$RRR, 95% CI	CLASS 2 $_{adj}$RRR, 95% CI	CLASS 4 $_{adj}$RRR, 95% CI
Class 3 (vaccine skeptics) as referent group			
Age			
18–40 (ref)			
41+	0.48 [0.28, 0.82]*	0.57 [0.14, 2.26]	1.11 [0.52, 2.40]
Sex			
Male (ref)			
Female	0.54 [0.22, 1.37]	0.89 [0.62, 1.28]	0.78 [0.42, 1.45]
Employment			
Unemployed (ref)			
Employed	1.23 [0.65, 2.35]	1.38 [0.68, 2.79]	1.12 [0.66, 1.89]
Martial status			
Married (ref)			
Single	0.77 [0.47, 1.25]	0.97 [0.24, 3.90]	1.40 [0.75, 2.58]
Divorced/Separated/Widowed	0.56 [0.28, 1.11]	0.67 [0.12, 3.67]	0.99 [0.55, 1.76]
Education			
No education (ref)			
Primary school	0.40 [0.18, 0.92]*	1.73 [0.48, 6.25]	0.90 [0.36, 2.27]
Secondary school	0.56 [0.23, 1.37]	3.61 [1.55, 8.42]*	1.69 [0.97, 2.96]
Above secondary	0.39 [0.14, 1.11]	2.43 [1.25, 4.70]*	1.25 [0.77, 2.04]
Religion			
Orthodox (ref)			
Muslim	0.91 [0.31, 2.64]	1.37 [0.60, 3.12]	0.68 [0.47, 0.97]*
Protestant	1.00 [0.30, 3.34]	1.95 [0.58, 6.64]	0.79 [0.29, 2.16]
Monthly Income (Birr)			
<=4500 (ref)			
4501–8000	0.67 [0.38, 1.18]	1.49 [0.64, 3.48]	1.40 [0.79, 2.48]
8001 plus	1.37 [0.66, 2.83]	1.23 [0.23, 6.53]	2.85 [1.22, 6.65]*
History of chronic disease			
No (ref)			
Yes	0.89 [0.58, 1.37]	0.57 [0.19, 1.70]	0.82 [0.35, 1.91]
Vaccine knowledge			
Low (ref)			
Acceptable knowledge	17.36 [10.94, 27.55]***	0.78 [0.33, 1.86]	0.12 [0.06, 0.24]***
COVID-19 prevention practices			
Low (ref)			
High	1.32 [0.88, 1.97]	2.13 [1.09, 4.16]*	0.70 [0.44, 1.11]
Vaccine doses			
None (ref)			
One	6.82 [3.06, 15.21]**	2.34 [1.03, 5.32]*	0.54 [0.27, 1.09]

*$p<0.05$, **$p<0.005$, ***$p<0.001$

Notes. data were weighted by population sex demographics to reflect the actual proportion of males and females in the population; CLASS 1: strong vaccine acceptors, CLASS 2: vaccine acceptors with some concerns, CLASS 3: vaccine sceptics and CLASS 4: vaccine rejectors

class than the vaccine sceptics class (adj. RRR: 2.13, 95% CI: 1.09–4.16). Vaccine dose was significantly associated with class membership, such that those who had one dose of the COVID-19 vaccine were significantly more likely to belong in the vaccine acceptors or the vaccine acceptors with some concerns class than the vaccine sceptics class compared to those who had no dose (adj. RRR: 6.82, 95% CI: 3.06–15.21; adj. RRR: 2.34, 95% CI: 1.03–5.32). For demographic differences, models suggest that older individuals (40+yrs) compared to younger (18–40 yrs) were less likely to be in the strong vaccine acceptors class than the vaccine sceptics class (adj. RRR: 0.48, 95% CI: 0.28–0.82) and individuals with secondary education or higher compared to those with no education were more likely to be in the vaccine acceptors with some concerns than the vaccine sceptics class (adj. RRR: 3.61, 95% CI: 1.55–8.42; adj. RRR: 2.43, 95% CI: 1.25–4.70). Individuals with higher monthly income earnings (8001 birr) compared to those with the lowest monthly income earnings were more likely to be in the vaccine rejectors class than the vaccine sceptics class (adj. RRR: 2.85, 95% CI: 1.22–6.65). Finally, people who were Muslim compared to those who were Orthodox were less likely to be in the vaccine rejectors class than the vaccine sceptics class (adj. RRR: 0.68, 95% CI: 0.47–0.97).

Discussion

This study investigated COVID-19 vaccine hesitancy in nine towns with high COVID-19 case counts in Ethiopia and used LCA to categorize individuals into vaccine hesitancy typologies. The total analytic sample was 1,112. Participants' mean age was 35 years (95% CI: 34.5–36.2); 56% (95%CI: 48.3–63.6) of individuals were married; 60% (95%CI 55.4–63.6) were employed and most individuals had some level of education.

We found support four latent typologies of vaccine hesitancy among adults who were unvaccinated or had one dose of the COVID-19 vaccine in Ethiopia: a strong vaccine acceptors class with more positive attitudes toward the vaccine and willingness to be vaccinated (class 1); a class of vaccine acceptors with some concerns who generally perceived the vaccine as positive, but were more resistant to getting the vaccine as soon as possible (class 2); a vaccine sceptics class who were against taking the vaccine themselves, but did perceive the vaccine as important and would even encourage others to get the vaccine (class 3); and a vaccine rejectors class who had negative attitudes toward the vaccine, were unwilling to get the vaccine, and would not recommend that others get the vaccine (class 4). These findings align with the general understanding of the vaccine hesitancy continuum where vaccine hesitant individuals are heterogenous with a gradation of concerns and varying levels of indecision [34].

Findings from the LCA revealed that among study participants, 30% were strong vaccine acceptors. This finding is slightly lower compared to other studies from Ethiopia [35]. A systematic review and meta-analysis on vaccine acceptance in the country found a pooled acceptance rate of 51.6% [36]. A possible explanation for the difference could be due to the study period and study population. Data collection in the studies referenced in the meta-analysis and systematic review was more than a year before our data collection period. Acceptance rates at this time may have been higher due to the higher rate of transmission of the virus. As case counts declined, and more information (and misinformation) about the vaccines became available, it is possible that vaccine acceptance declined slightly. It is also important to recognize that the systematic review and meta-analysis reported a pooled acceptance rate which included health worker and university student populations who may have been more willing to get vaccinated than the general adult population. Estimates on vaccine rejectors in Ethiopia vary slightly depending on the sub-population, but our finding of 50% is similar to results found by previously published studies among adult populations which ranged from 45 to 54% [22, 35, 37]. The high proportion of vaccine rejectors may be explained by misinformation and rumors about the vaccine which were fueled by the widespread 'infodemic' [23, 37]. While not explored here, other studies have shown that false information on the side effects of the vaccine (e.g., that it could cause COVID-19 or other respiratory diseases) was a primary driver for vaccine hesitancy in Ethiopia and in other African countries [35, 38]. Furthermore, a study of over 40 countries investigating vaccine acceptance and misinformation found that people in low-and middle-income countries (LMICs) like Ethiopia were more exposed to the 'infodemic' than wealthier countries and more susceptible to trusting misinformation, underscoring the importance of fact-checking and correcting falsehoods [39].

Significant predictors of latent class membership included education, age, income, religion, vaccine knowledge, COVID-19 prevention practices, and vaccine dose. Congruent with other studies, higher vaccine knowledge, education levels, and prevention practices were positive determinants of belonging to the vaccine acceptors class [16, 17, 22]. Our finding that younger individuals (<41 years) were more willing to accept the vaccine compared to older individuals contrasts with findings from previous studies in Ethiopia [19, 20]. This discrepancy could be due to differences in study methodology or when the study was administered. Given that our study was conducted in major towns, it is possible that the younger population had more access to accurate and reliable information and were better able to filter out misinformation compared to younger populations in more rural areas.

While not surprising, the finding that higher knowledge about the vaccine was associated with membership in the vaccine acceptors or vaccine acceptors with some concerns highlights the importance of providing individuals with accurate information about the vaccine and its benefits [40–42]. Our models also showed that having received one dose of the vaccine was indicative of vaccine acceptance, but we cannot exclude the possibility of reverse causality such that vaccine acceptance may have preceded and contributed to the decision to get the first dose. Nonetheless, encouraging vaccinated people to share about their experiences with vaccination may motivate others to get vaccinated. Finally, our results demonstrated the correlation between vaccine acceptance and better COVID-19 prevention practices [43, 44].

Results from this study should be interpreted with an understanding of the limitations. The study was cross-sectional with outcomes and exposures measured at the same time. Given the lack of temporality, causal inference cannot be established. The study sample only included individuals living in major towns with high COVD-19 case counts. Thus, results cannot be generalizable to more rural areas where COVID-19 may have been less prevalent. Selection bias is a concern given the inclusion of those who had one dose of the COVID-19 vaccine. Data on type of vaccine (brand) was not collected. While LCA is a powerful statistical analytic method, it has limitations. The probability of class assignment is based on the observed distribution of responses, as such, there is no guarantee of proper class assignment. Furthermore, LCA assumes that individuals belong to one latent class and that latent classes are mutually exclusive, yet true latent class membership is unknown for each individual due to measurement error. Uncertainty in class assignment may be recast as measurement error and result in biased estimates.

Conclusion

Our study findings indicated that 20% of adults in major towns in Ethiopia neither fully accepted nor fully rejected the COVID-19 vaccine, but fell into "acceptors with some concerns" or "vaccine sceptics" classes. These people may be particularly amenable to interventions to encourage vaccine uptake. Alongside evidence from other studies, our findings suggest that improving vaccine knowledge may have potential to increase vaccine acceptance rates. Future program interventions should focus on improving the knowledge around the vaccine and to decrease rumors around misconceptions. With appropriate messaging and engagement of trusted leaders and the MOH to discuss preventative measures, some individuals in the "acceptors with some concerns" or "vaccine sceptics" classes may be convinced to get vaccinated and engage in other prevention behaviors.

Abbreviations

MOH	Ministry of Health
LCA	Latent class analysis
PPS	Probability proportional to size
EPHA IRB	Ethiopian Public Health Association Institutional Review Board
PSI REB	Population Services International's Research Ethics Board
AIC	Akaike information criterion
BIC	Bayesian information criterion
CI	Confidence intervals
RRR	Relative risk ratio

Acknowledgements

We wanted to acknowledge USAID Ethiopia for funding this research and all individuals who participated in the data collection, supervision and data management.

Author contributions

AA is responsible for the conceptualization of the study and oversight of data collection, made the analysis, interpretation and drafted the manuscript. AG contributed for the conceptualization, oversight of data collection and revised the draft manuscript. MK contributed for the conceptualization and revised the draft manuscript. AS contributed for the conceptualization and revised the draft manuscript. FK revised the draft manuscript. BB revised the draft manuscript. EFK is responsible for the conceptualization of the study, made the analysis and interpretation of the data, and drafted the manuscript.

Funding

This research is funded by USAID Ethiopia, but the funding organization has no role in the conceptualization, design, data collection, analysis, decision to publish, or preparation of the manuscript.

Data availability

The data for the current study are not publicly available due to institutional policies, but may be available upon request to Erica Felker-Kantor (email: efkantor@psi.org).

Declarations

Ethics approval and consent to participate

The Ethiopian Public Health Association Ethical Review Board and PSI REB approved the research protocol and data collections tools before data collection. Informed consent was collected from all study participants. If the participant was illiterate a witness was available to confirm the consent was read clearly as it appeared in the consent form by the data collector.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Received: 21 September 2023 / Accepted: 10 October 2024
Published online: 21 October 2024

References

1. Platto S, Wang Y, Zhou J, Carafoli E. History of the COVID-19 pandemic: origin, explosion, worldwide spreading. Biochem Biophys Res Commun. 2021;538:14–23.
2. Morens DM, Breman JG, Calisher CH, Doherty PC, Hahn BH, Keusch GT, et al. The origin of COVID-19 and why it matters. Am J Trop Med Hyg. 2020;103:955–9.
3. Wagner AL, Porth JM, Wu Z, Boulton ML, Finlay JM, Kobayashi LC. Vaccine hesitancy during the COVID-19 pandemic: a latent class analysis of Middle-aged and older US adults. J Community Health. 2022;47:408–15.
4. World Health Organization (WHO). WHO Health Emergency Dashboard WHO (COVID-19) Homepage. 2022. https://covid19.who.int/region/afro/country/et
5. EPHI. COVID-19. https://covid19.ephi.gov.et/covid-19/
6. Denano T. COVID-19's effects on Macroeconomic indicators in Ethiopia: systematic review of Articles. ClinicoEconomics Outcomes Res. 2023;15:573–8.

7. Daher-Nashif S, Al-Anany R, Ali M, Erradi K, Farag E, Abdallah AM, et al. COVID-19 exit strategy during vaccine implementation: a balance between social distancing and herd immunity. Arch Virol. 2022;167:1773–83.
8. She J, Hou D, Chen C, Bi J, Song Y. Challenges of vaccination and herd immunity in COVID-19 and management strategies. Clin Respiratory J. 2022;16:708–16.
9. World Health Organization (WHO). Ten threats to global health in 2019. 2019. https://www.who.int/news-room/spotlight/ten-threats-to-global-health-in-2019
10. Sudaxshina Murdan. NA& DA-O. How to address vaccine hesitancy. Pharm J, PJ,. 2021;306.
11. Tesfaye A, Tamene B, Alemeshet D, Abe H, Tesfa N, Gedion S et al. COVID-19 vaccine hesitancy in Addis Ababa, Ethiopia: a mixed-methods study. medRxiv. 2021;:2021.02.25.21252443.
12. Zewude B, Habtegiorgis T. Willingness to take COVID-19 vaccine among people most at risk of exposure in Southern Ethiopia. Pragmat Obs Res. 2021;12:37–47.
13. Mekonnen BD, Mengistu BA. COVID-19 vaccine acceptance and its associated factors in Ethiopia: a systematic review and meta-analysis. Clin Epidemiol Glob Health. 2022;14:101001.
14. Cooper S, van Rooyen H, Wiysonge CS. COVID-19 vaccine hesitancy in South Africa: how can we maximize uptake of COVID-19 vaccines? Expert Rev Vaccines. 2021;20:921–33.
15. Huang Y, Su X, Xiao W, Wang H, Si M, Wang W, et al. COVID-19 vaccine hesitancy among different population groups in China: a national multicenter online survey. BMC Infect Dis. 2022;22:1–12.
16. Tegegne MD, Girma S, Mengistu S, Mesfin T, Adugna T, Kokeb M et al. Willingness to receive COVID-19 vaccine and associated factors among adult chronic patients. A cross-sectional study in Northwest Ethiopia. PLoS ONE. 2022;17 7 July.
17. Liga AD, Jabir YN, Bacha RH. COVID-19 vaccine acceptance and adherence to non-pharmaceutical interventions among employees of public transportations company in Addis Ababa, Ethiopia. Hum Vaccin Immunother. 2023;19.
18. Niguse S, Gebremariam S, Terefa DR, Biset Y, Mekasha E, Meskele K. Assessment of COVID-19 vaccine take-up and its predictors among healthcare professionals in public hospitals, Addis Ababa, Ethiopia: facility-based cross-sectional study. Hum Vaccin Immunother. 2023;19.
19. Tolossa T, Fetensa G, Ayala D, Wakuma B. Health professionals' COVID-19 vaccine acceptance and associated factors in Wollega University referral hospital, Western Ethiopia: a cross-sectional study. Hum Vaccin Immunother. 2022;18.
20. De Waure C, Shakeel S, Martin P, Agyekum W, Sertsu A. Acceptance of COVID-19 vaccine and associated factors among health care workers at public hospitals in Eastern Ethiopia using the health belief model. Front Public Health 10:957721 doi: 103389/fpubh2022957721. 2022.
21. Pan H-F, Mekonen E, Bhattacharya M, Asmare Adella G. Knowledge, attitude, and intention to accept COVID-19 vaccine among patients with chronic diseases in southern Ethiopia: Multi-center study. Front Public Health 10:917925 doi: 103389/fpubh2022917925. 2022.
22. Getachew T, Negash A, Degefa M, Lami M, Balis B, Debela A, et al. COVID-19 vaccine acceptance and associated factors among adult clients at public hospitals in eastern Ethiopia using the health belief model: multicentre cross-sectional study. BMJ Open. 2023;13:e070551.
23. Abay ES, Belew MD, Ketsela BS, Mengistu EE, Getachew LS, Teferi YA et al. Assessment of attitude towards COVID-19 vaccine and associated factors among clinical practitioners in Ethiopia: a cross-sectional study. PLoS ONE. 2022;17 6 June.
24. Mohammed R, Nguse TM, Habte BM, Fentie AM, Gebretekle GB. COVID-19 vaccine hesitancy among Ethiopian healthcare workers. PLoS ONE. 2021;16(12 December):1–15.
25. Abebe H, Shitu S, Mose A. Understanding of COVID-19 vaccine knowledge, attitude, acceptance, and determinates of COVID-19 vaccine acceptance among adult population in Ethiopia. Infect Drug Resist. 2021;14:2015–25.
26. Wagner AL, Masters NB, Domek GJ, Mathew JL, Sun X, Asturias EJ et al. Comparisons of vaccine hesitancy across five low- and middle-income countries. Vaccines (Basel). 2019;7.
27. Tefera YA, Wagner AL, Mekonen EB, Carlson BF, Boulton ML. Predictors and barriers to full vaccination among children in Ethiopia. Vaccines (Basel). 2018;6.
28. Németh R, Hungary RN. Respondent selection within the Household-A modification of the Kish Grid of the International Program Committee View project Respondent selection within the household-A modification of the Kish grid. 2018.
29. Gallè F, Sabella EA, Roma P, De Giglio O, Caggiano G, Tafuri S et al. Knowledge and acceptance of COVID-19 vaccination among undergraduate students from central and southern Italy. Vaccines (Basel). 2021;9.
30. Elyeli K, Bebiş H. The COVID-19 vaccine knowledge and attitude scale: a methodological study. Cyprus J Med Sci. 2022;7:312–20.
31. Aklil MB, Temesgan WZ. Knowledge and attitude towards COVID-19 vaccination and Associated Factors among College students in Northwest Ethiopia,2021. Health Serv Res Manag Epidemiol. 2022;9.
32. Duong MC, Duong BT, Nguyen HT, Nguyen Thi Quynh T, Nguyen DP. Knowledge about COVID-19 vaccine and vaccination in Vietnam: a population survey. J Am Pharmacists Association. 2022;62:1197–e12054.
33. Freeman D, Loe BS, Chadwick A, Vaccari C, Waite F, Rosebrock L et al. COVID-19 vaccine hesitancy in the UK: the Oxford coronavirus explanations, attitudes, and narratives survey (Oceans) II. Psychol Med. 2021. https://doi.org/10.1017/S0033291720005188
34. Dubé E, MacDonald NE. COVID-19 vaccine hesitancy. Nat Rev Nephrol. 2022;18:409–10.
35. Mesele M. Covid-19 vaccination acceptance and its associated factors in Sodo town, wolaita zone, southern ethiopia: cross-sectional study. Infect Drug Resist. 2021;14:2361–7.
36. Mose A, Wasie A, Shitu S, Haile K, Timerga A, Melis T et al. Determinants of COVID-19 vaccine acceptance in Ethiopia: a systematic review and meta-analysis. PLoS ONE. 2022;17 6 June.
37. Tadesse TA, Antheneh A, Teklu A, Teshome A, Alemayehu B, Belayneh A, et al. COVID-19 vaccine hesitancy and its reasons in Addis Ababa, Ethiopia: a cross-sectional study. Ethiop J Health Sci. 2022;32:1061–70.
38. Ackah BBB, Woo M, Stallwood L, Fazal ZA, Okpani A, Ukah UV et al. COVID-19 vaccine hesitancy in Africa: a scoping review. Global Health Res Policy. 2022;7.
39. Singh K, Lima G, Cha M, Cha C, Kulshrestha J, Ahn YY et al. Misinformation, believability, and vaccine acceptance over 40 countries: takeaways from the initial phase of the COVID-19 infodemic. PLoS ONE. 2022;17 2 February.
40. Moola S, Gudi N, Nambiar D, Dumka N, Ahmed T, Sonawane IR et al. A rapid review of evidence on the determinants of and strategies for COVID-19 vaccine acceptance in low- and middle-income countries. J Glob Health. 2021;11.
41. Muluneh MD, Negash K, Tsegaye S, Abera Y, Tadesse D, Abebe S et al. COVID-19 knowledge, attitudes, and Vaccine Hesitancy in Ethiopia: A Community-based cross-sectional study. Vaccines (Basel). 2023;11.
42. Oche OM, Adamu H, Yahaya M, Illo HG, Danmadami AM, Ijapa A et al. Perception and willingness to accept COVID-19 vaccines: a cross-sectional survey of the general population of Sokoto State, Nigeria. PLoS ONE. 2022;17 12 December.
43. Ali M, Uddin Z, Banik PC, Hegazy FA, Zaman S, Ambia ASM, et al. Knowledge, attitude, practice, and fear of COVID-19: an online-based cross-cultural study. Int J Ment Health Addict. 2023;21:1025–40.
44. Qalati SA, Ostic D, Fan M, Dakhan SA, Vela EG, Zufar Z, et al. The General Public Knowledge, attitude, and practices regarding COVID-19 during the Lockdown in Asian developing countries. Int Q Community Health Educ. 2021. https://doi.org/10.1177/0272684X211004945.

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